

**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
FACULTY OF INFORMATICS
DEPARTMENT OF INFORMATION SCIENCE**

**INFORMATION SYSTEM FOR PATIENT MEDICAL
RECORD OF BUTAJIRA RURAL HOSPITAL**

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN
INFORMATION SCIENCE**

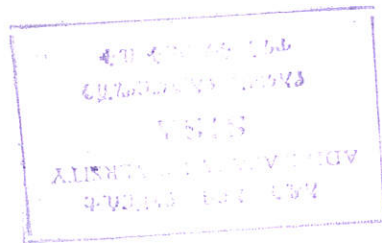
**BY
NEWAYNEH KETSELA**

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Dedication

This work is dedicated to sons: Edomias Newayneh and Alazar Newayneh who have lost their father's daily follow-up and protection for solid two years in my stay far away from them.



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List of abbreviations

1NF	First Normal Form
2NF	Second Normal Form
3NF	Third Normal Form
4GL	Forth Generation Languages
ADT	Admission Discharge & Transfer
BP	Blood Pressure
BRHP	Butajira Rural Health Program
CASE	Computer Aided Systems Engineering
CC	Chief Compliant
CNS	Central Nerves System
CPR	Computer-Based Patient Record
CVS	Cardiovascular System
DBMS	Database Management System
DD	Discharge Diagnosis
DD _x	Differential Diagnosis
DFD	Data Flow Diagram
DSS	Decision Support System
D _x	Diagnosis
EIS	Executive Information System
EMR	Electronic Medical Record
EPR	Electronic Patient Record
ERD	Entity Relationship Diagram
FD	Functional Dependency
FH	Family History
FMoH	Federal Ministry of Health
GA	General Appearance
GIS	Geographic Information System
GIT	Gastrointestinal Track
GUI	Graphical User Interface

GUS	Genitourinary System
HEENT	Head, Eye, Ear, Nose, and Throat
HIS	Health Information System
HMIS	Health Management Information System
HPI	History of Present Illness
ICD	International Classification of Diseases
ICT	Information and Communication Technology
INDEHELA	Information Systems Development for Healthcare in Africa
IS	Information System
ISD	Information System Development
IT	Information Technology
I _x	Investigation
LAN	Local Area Network
LC	Library of Congress
LGS	Lymph glandular System
MH	Marital History
MIS	Management Information System
MoH	Ministry of Health
MS	Microsoft
MSS	Masculoskeletal System
NF	Normal Form
OPD	Out Patient Department
PMH	Past Medical History
PR	Pulse Rate
RDBMS	Relational Database Management System
RHB	Regional Health Bureau
ROS	Review of Systems
RR	Respiratory Rate
RS	Respiratory System
R _x	Treatment
SDLC	System Development Life Cycle

SH	Social History
SK	Skin
SNNPRS	Southern Nations Nationalities & People Regional State
SOAP	Subjective, Objective, Assessment and Plan
SQL	Structured Query Language
T	Temperature
TIS	Transaction Information System
UPS	Uninterrupted Power Supply
USA	United States of America
VDRL	Venereal Disease Research Laboratory
WHO	World Health Organization
WSS	Working Support System

ABSTRACT

No clinical computing topic is being given more attention than that of computer-based medical records. Efficient and effective healthcare depends upon accurate information and timely decision. Computer-based medical records are increasingly becoming a necessary and critical tool in healthcare to achieve those goals.

This study aims at examining the current paper-based patient medical record system at Butajira Hospital and develops a patient medical database. The main objective of the study is to propose and develop an improved and effective information system for patient medical record of Butajira Hospital. On the process of analyzing the existing system, document analysis and semi-structured interview data collection methods have been implemented. Structured system analysis and prototype system designs had been selected as system development methodologies. Attempts were made to investigate problems with the existing system and analyze requirements for the proposed system.

The study reveals that, the existing paper medical record system is subject to several drawbacks. Potential misplacement, destruction, and storage space consumption of patient charts, illegibility, inconsistency, incompleteness, disorganization and redundancy of information on the chart are major ones. To overcome these and other defects, and meet the analyzed requirements, a computer-based patient record system (CPR) has found to be the best solution. As appropriate software packages for African or developing countries hospitals cannot be found off the shelf, to alleviate this problem, it was decided to develop a database in-house. A RDBMS 'Microsoft Access' has been used to build a database locally. The capturing format of clinical data is also a point of concern of the study. Both coded and free texts with narration are formats applied to capture patient medical data in the database.

In summary, within the database development, intuitive and easy to use interfaces have been created. Valuable recommendations have also been stated for better implementation of the proposed system.

CHAPTER ONE

1. INTRODUCTION

The digital age is transforming our world at a dramatic speed. Effective application of information technology has transformed many facets of modern life such as, manufacturing, education, finance, etc, but has had little measurable effect on medicine (Pollak and Lorch, 2001). Yet today, at the beginning of a new millennium, HealthCare's reluctant to truly embrace the power of information and knowledge systems is causing dramatic and to some extent inexcusable shortcomings in how care is delivered and health is maintained (McGuire, 2001).

Healthcare is a field of high development priority. The wealth of a nation depends on the health of its population, since health is wealth (Soriyan, 1998). Thus, healthcare organizations are searching for ways to improve the quality of care they deliver while simultaneously attempting to reduce costs and improve levels of services. This improvement can be practical through accurate and well-organized patient medical information.

The purposes of the patient medical record are, to record information from the patient, to record the caregiver's findings and treatments, to communicate information to latter caregivers who see the patient, to coordinate caregivers and organize their activities in the care to the patient, to serve as formal, legal and

financial record of care and to provide information for public health, epidemiological studies and clinical research (McGuire, 2001).

Currently, most healthcare providers use and rely on paper-based patient chart as a primary source to handle patient's medical and demographic information to be used for the above mentioned purposes. This practice is becoming laborious, time-consuming and expensive and prone to error. In addition, delayed and inappropriate patient treatment is often due to miscommunication, lost or destroyed records, and the overall inefficiency of the paper patient record system.

But, paper-based medical records have several advantages. As stated by eHealth Coach (2003), these advantages can be stated as; flexibility of input; often dictation (transcription) is fastest and easiest input method for physicians, especially for non-routine events; less initial start-up expense and no special training required beyond clinical professional training.

Substantial improvements in patient care can be realized through the use of the automated patient medical records. The automated medical records provide the ability to capture, organize, and present relevant clinical information in a manner superior to the physical paper records (Frolick, 2000). Unlike the paper-based records, automated medical records allow all caregivers to access the patient records at the same time. In general, automated medical systems benefits

include, improved quality of care, improved information management, increased efficiency of practice, decrease practice variability, and improved cost structure (Krall, 1998).

Of all other benefits, automated medical records are not without their difficulties. According to eHealth Coach (2003), lack of universal patient, provider, or facility identifier; lack of universal vocabulary for clinical findings; lack of coding standards necessary for modeling query languages; lack of underlying conceptual data model (database schema) and being often more costly are some of its challenges.

This study examines the implementation of an automated patient medical records system at Butajira Rural Hospital. It tries to address the benefits and problems with the existing paper-base medical records and explains the advantages and drawbacks of using automated medical records. Data capturing format in medical records is a point that has gotten a strong emphasis in the study. On the implementation of this automated patient medical record, patients of the hospital would have a record that provide both demographic and medical information, with a single point of access for all employees seeking information both for clinical treatment of patients and for clinical research.

1.1 STATEMENT OF THE PROBLEM AND ITS JUSTIFICATION

Providing excellent medical care for a patient requires an accurate and organized record of the patient's medical history. At the current situation of Butajira Rural Hospital, the only complete source of a patient's medical history founds to be the paper medical records. These paper medical records are subject to several drawbacks.

Studies in USA indicate that, nurses and physicians spend 50% and 33% respectively, of their time on paper work. Thirty percent of the time spent in the care of an inpatient is spent on filling out paperwork for the patient chart. It is also estimated that 11% of tests are reordered because the previous tests cannot be found in the patient's chart (Pallak and Lorch, 2001).

As many as 98000 patients die a year, and 10 times as many are injured each year again in USA due to medical mistakes. Many of these errors are medication errors with 2 of 3 of these errors due to misinterpretation of handwriting on prescriptions or medication orders (McGuire, 2001).

On any given day, caregivers and medical researchers need to access the information of a patient in a medical record. Typically charts are searched and pulled from the chartroom of the hospital and transported to the specific department or facility where the patient would be seen and returned to the chartroom at the end of the day to be filed again. These patient charts are

available only at one location at a time with the need for transportation to other departments if needed by other caregivers.

While the task of retrieving patient records, extracting and adding information, and returning these records to their appropriate place of storage each day is burdensome, managing the information in the records is even more tedious.

Since the paper medical record consisted of many individual pages from different sources, pages could easily be misfiled or even misplaced entirely. In some cases, if information could not be located in the chart, tests and procedures can simply be repeated. Such actions led to redundant information being filed in the patient's record. Most institutions find that such documentation is often incomplete, inaccurate, illegible and difficult to access when needed (Protti, 1998). Additionally, some patients often have large volume of medical records containing information necessary to properly care for the patient. As a result, all the volumes have to be accessible to the caregivers.

Over a patient's lifetime, a patient may be seen by many different caregivers in many departments or facilities. The patient is therefore likely to have many separate paper charts in different facilities or departments like inpatient, outpatient, antenatal, maternity, etc. Since information is scattered in different charts, caregivers couldn't have or not able to perceive general information of a single patient. Besides, the paper patient medical record can be organized only in a limited number of ways.

A properly structured automated patient medical record could get rid of all these problems. The patient record touches, in some way, everyone associated with providing, receiving, or reimbursing healthcare services. This wide range of application and use has led to efforts to automate the collection, storage, and management of the data that constitute these records. An automated patient medical record system can reduce or eliminate the costs of transporting, finding, copying, storing, filing and organizing the patient medical record. It also improves patient care by making the patient medical record always available.

Adams (2002) stated that, complete and continually updated electronic patient records are the key to cost-effective, efficient and competitive medical administration systems, whether on a small scale in rural areas or in major hospitals. Adams added, "Trying everything together allows the medical service provider, be it a clinic or hospital to handle an increased number of patients using the same amount of resources".

The introduction of an automated patient medical record at the Butajira Rural Hospital will afford the possibility of records to be created, processed, stored and retrieved more efficiently. It includes all of the information stored in the paper-based medical record. It allows caregivers to access patient's medical records from any personal computer in the hospital. In addition, information can be easily sorted or grouped according to certain criteria such as the date on which the patient seen, the name of caregiver, disease type, treatment type, etc.

Improved access to records means dramatically improve efficiencies in variety of areas. In addition to achieving greater efficiency and higher quality of care, patients can be save time, since the ubiquity of the records means the patient is no longer asked the same questions numerous times by a variety of caregivers throughout the hospital.

Since all the mentioned problems and drawbacks of the current paper-based patient medical records system are not uncommon to Butajira Rural Hospital, it becomes significant, quite critical and timely issue to create an automated patient medical record system. This is to exploit all its advantages and fulfill the objectives of the Butajira Rural Health Program, which is improving patient care, and provide data for medical research.

All clinical information should be held in a structured representation, which can be manipulated by the system. Structure is essential if the system is to be active in organizing information for the clinician as well as to support valid aggregation of data (Rector, 1991). With the current, paper medical record system, different physicians may have different ways of recording diagnosis; so different physicians will produce different visit records. Physicians are accustomed to documenting their encounters by handwriting. Although there is a rough format to be followed in general, these creations vary tremendously in completeness and legibility.

The transition to a computer-based record necessitates fundamental changes in the way clinical information is expressed (Al-Ghamid, 2000). This is one of the challenges facing healthcare computing since the presentation of patient data has to be in a useful format (Cimino, 1996).

It is widely agreed that in order to meet many anticipated requirements, a modern CPR must be a structured document that can be decomposed into discrete elements containing data whose meaning is unambiguous and standardized wherever possible. This is to be achieved by coding those elements with standardized and unique concepts or entity identifiers (PKC Corporation, 1998). For any automatic operation on data entry, the need to coded data entered or to use even more pre-structured forms is a demand that is inevitable when electronic medical records are developed-but that should not be taken lightly (Berg, 2002)

Clinicians have been using words, terms, and clinical vocabularies on the process of capturing patient medical records since the modern patient record began. The advent of CPR has fundamentally changed this practice. Standardized vocabularies are needed to support the entry of clinical data, and enhance communication between clinicians. Coded terminologies are needed by the computer database in order to store and retrieve data (Al-Ghamdi, 2000).

The use of medical text narratives in medical record improves patient-physician communication in addition to their nature of flexibility, expressiveness and familiar to clinicians. However, in the current technology, computers are able to make only limited use of information stored in free text format (Rector, 1991).

CPRs, which are represented in coded format, have a variety of uses, including direct patient care, statistical reporting, decision support, and clinical research. The typical approach is to encode the information using some standard terms taken from controlled vocabulary (Al-Ghamdi, 2000). Although many coding schemes have been developed and used in CPRs, none of those schemes support all the desired functions. The lack of standards for coding patient data is one of the greatest problems in medical computing today. This has forced application developers to create their own coding schemes in-house. More than 150 different coding sets defining terms for use with the medical record have been created. Although there has been progress in developing individual coding standards for data elements, none has emerged as a comprehensive standard (Tang and Hammond, 1998).

There is usually a wide degree of choice as to how much of the information to be entered can be done by means of 'free text' and how much can be entered using coded entries or a combination of the two. The more coded data that is entered, the easier the record is to manipulate. On the other hand, clinicians need to have the freedom of expression that comes with unlimited free text entry. Where

codification of certain data is not left to be important or definitive code could not be found for the information, it might be decided to use only free text entries (PKC Corporation, 1998).

As stated in the previous paragraphs, it is obvious that the use of free text versus coded data remains a great challenge in the design of CPRs. There is also a need for an internationally standardized controlled vocabulary in order to make coding of data expressive, versatile, and acceptable by the clinical users. Use of free text might become more yielding in the near future as the technology of free text utilization advances. At this time, with the available technology and resources, supplementing coded data with free text might be a temporary solution, to get a reasonable balance between users needs and the ability to integrate different components of the computer based patient record system.

The problem of deciding which data-capturing format has to be used in which situation and condition is an inevitable problem to happen in constructing a CPR for Butajira Hospital. Therefore, for this study, it becomes a justifiable issue trying to overcome this common problem by implementing a combination of techniques. The study tries to represent patient medical records by using the combination of standardized and homemade coded data, and free text and medical narrative data capturing formats when and where it is necessary and applicable.

The reason for the selection of this particular rural hospital is primarily to support or make complete the available information at Butajira Rural Health Program's community based epidemiological database established earlier in 1987 by providing a clinical epidemiological database, perhaps from the same region that the epidemiological data has been collected.

The other important point is due to the Butajira Rural Hospital as being relatively young and small in size, it can be estimated somehow appropriate to implement a new CPR information system and can be easy to convert the retrospective patient chart to electronic format. The concern and interest of the Butajira Rural Health Program to automate the hospital's patient record is also a great initiative, which advocates the student researcher to conduct the study at the Butajira Rural Hospital.

1.2 OBJECTIVES

1.2.1 General objective

The overall objective of the study was to design, develop and propose an information system for patient medical record of Butajira Rural Hospital, which can be used as a role model for other healthcare organizations in Ethiopia.

1.2.2 Specific objectives

The specific objectives were to:

- Assess and analyze the existing system to investigate and identify the problems with it,
- Propose alternative solutions for the identified problems,
- Observe the benefits of implementing an automated record keeping system in Butajira Hospital,
- Locally develop an attractive and easy to use prototype electronic database for the entire clinical practice which handles patient's medical record by applying the combination of both free text and coded data capturing formats,
- Produce and propose improved and adaptable system to new findings and future change practice,
- Give recommendations on actions and measures to be taken for the implementation of the proposed system.

1.3 SIGNIFICANCE OF THE STUDY

Since a complete, comprehensive, clinically relevant, time oriented, digitally coded automated patient medical database can dramatically improve patients care (Blair, 2002), and provide relevant data for clinical and medical epidemiological research, this study is significant in fulfilling objectives of the intended organization.

Currently, the Butajira Rural Health Program (a project at the Medical Faculty of Addis Ababa University under the Department of Community Health) is collecting a community based epidemiological and primary health care data from Butajira district. This data aimed to be used by researchers and students of the faculty for different medical research purpose. But, the database becomes more sufficient and complete in satisfying the needs of researchers in the area with the availability of patient's clinical data. The proposed electronic patient record system can bridge this gap by creating clinical database for the patients. Healthcare organizations and researchers can use data mining techniques and tools on the patients' clinical data, which can be valuable to predict the effectiveness of medical processes, tests and/or medications (Two Crows Corporation, 1999) in order to raise the quality and efficiency of health and health related services. Thus, this study becomes significant for that it creates patients' clinical database, which can be used for medical research purpose, and able researchers to undertake data mining techniques on their research by providing quality and large amount of clinical data.

The output of the study also can be used as a model for other healthcare organizations to initiate and facilitate them with developing standardized and compatible automated patient record. Thus, it is highly significant for creation of universal patient record countrywide, which is the state-of-the-art of the time and paves the way for the future development of the healthcare industry.

The coding issue is important because uncoded data is almost impossible to analyze in any comprehensive, automated fashion given today's information systems. Data that is coded using organization-specific coding schemes can be analyzed locally, but unless it is mapped to some universal scheme, it can not be analyzed across organizations.

The coding problem is further complicated by the extensive variation in healthcare terminology. The National Library of medicine (NLM) is trying to create a Unified Medical Language System, which uses a metathesaurus to provide a walkway between terms to achieve a universal healthcare language. Other research projects have focused on the development of a "medical entities dictionary" to allow information systems to recognize coded and uncoded synonyms or event. While these efforts are certain to be significant to solve the problem in the long range, till its realization, it is important and quite necessary to use other available data capturing methods and if necessary implement homemade codes. This is the point of concern of the study that gives more emphasis on the adoption of coded and free text data capturing methods in CPR.

In general, some of the importance of the automated patient medical record system which strengthens the significance of this study can be stated as follows:

- Provide caregivers with relevant, complete and lifetime patient medical record with immediate access to it that enhance and improve the quality of patient care,
- Provide policy makers, program developers, decision makers and managers with aggregate data for future planning and allocation of appropriate budget and personnel for healthcare sector in the country,
- Minimize redundant medical record storage, retrieval, and handling; reduce reorder tests, and eliminate documentation errors,
- Use the patient's medical database to support and accelerate medical research,
- Reduce and simplify documentation to decrease costs, by utilizing healthcare personnel effectively, i.e. minimize time spent on paper work and maximize patient care time,
- Provide automated assistance to caregivers in providing care by continuity and coordination of patient care among themselves.

1.4 SCOPE & LIMITATIONS OF THE STUDY

The scope of the study is limited to analyze and automate or create a database for the hospital's clinical activities such as inpatient, outpatient, and emergency records of the patients. Activities concerning patient's administrative and/or financial information with the exception of patients paying status' could not be included due to the limitation of time and the need to be specific for taking on the project properly and complete it on time.

The time constraint has a significant impact on limiting the scope of this study in its coverage and depth. In addition to the complicated nature of medical record keeping system, the available three-month time can not allow the student researcher to produce a complete and perfect information system for the concerned hospital. Thus, on creating a database for the system, prototyping database design methodology has been implemented.

Again, based on users' current requirements, some parts of the system with less priority are excluded from the study. These can be mentioned as the financial and administrative processes of the hospital concerning patients and the personnel, the Pharmacy prescription and inventory processes, patient legal agreement and referral processes, and detailed preventive care processes such as antenatal, postnatal, contraception and the like.

The next and also equally important chapter of the study is Chapter Four.

Chapter Four is a system design chapter. It is a prototype database design that incorporates parts like database design (Conceptual database design, choice of the DBMS, Logical database design, database normalization, integrity constraints, data capturing formats and Graphical User Interface design). Its last part is devoted to the user interface design.

Last chapter succeeded by References and Appendices is the conclusion and recommendation chapter. It recommends suggestions that are possible practices to be considered in implementing the new information system. And it also presents a general conclusion on the study.

1.6 METHODOLOGY

In order to have a clear picture on the existing system problems and to attain the stated objectives, the nature of the study has been descriptive method of research. This method is selected since it deals with depicting the present situation of a subject under investigation using instruments such as interview, questionnaire, observation and document analysis.

1.6.1 Data collection

For information system development, collecting an appropriate data is one of the fundamental necessities. To obtain detailed and comprehensive information on the operations, processes, limitations and drawbacks of the existing system the following data collection methods have been implemented.

1.6.1.1 Document analysis

To have preliminary information and gain an insight into the structure, activities, patterns of information flow and problems of the existing information system, analysis of documents, forms, reports, and registers had been held at the concerned hospital. These kinds of documents are useful sources of information on system's activities and processes, and they can generate ideas for questions that can be pursued through observation and interviewing. The major advantage of this method is the documents were generated contemporaneously with the events they refer to. Hence, they are less likely to be subject to memory decay or memory distortion compared with data obtained from an interview.

1.6.1.2 Interview

Semi-structured interview, with users of the information system at different positions and levels that includes the medical director, the matron nurse, two professionals (physicals), a nurse, and laboratory technician from different departments and a hospital's registrar instead of the statistician has been conducted. This method is selected in order to gain comprehensive and detailed information of the current information system, which can be used to investigate, and analysis the system and suggest a new improved information system.

The importance of using semi-structured interview lies on that it uses the advantages of both structured and unstructured interviews. It involves the preparation of an interview guide that lists a predetermined set of questions that are to be explored during an interview. This guide serves as a checklist during the interview and ensures that basically whether the same information is obtained from a number of people. Yet, there is a great deal of flexibility. Within a list of questions, the interviewer is free to pursue certain questions in greater depth.

1.6.2 System development methodology

Systems analysis and design is a problem solving activity concerned with the process of investigating organizational situations and setups with the aim of improving the system through better procedures and methods. To develop an automated patient medical record system, structured systems analysis methodology has been implemented.

This methodology is selected due to that it provides a formal and organized way of working with the stages of design to ensure consistency, documentation, and change of control. Also, it recognizes that potential users of the system should have the ultimate voice in the system development process (Whitten, Bentley and Dittman, 1998). In addition to modeling the process, structured analysis includes data organization and structure, relational database design and user interface issues (Shelly, Cashman and Rosenblatt, 2001). Besides, structured analysis and design makes it easier to go back to earlier phases in the life cycle when necessary (Hoffer, George and Valacich, 1996).

System analysis is a relatively young field in mankind's knowledge; but demand for system analysis existed many years before the introduction of computers. With the development of information technology, system analysis science also developed more and more vigorously. At the moment, there is no single methodology that ensures success and that can be viewed as a right way for analysis. But the application of structured systems analysis increases the chance

of success for most of typical applications. Until today, system approach is still viewed as a sound foundation for structured system analysis.

To depict the process requirements and to model data requirements, Data Flow Diagrams (DFD) and Entity Relationship Diagrams (ERD) information system modeling tools have been used respectively.

For creating a database to the system, prototyping design method has been implemented. Having the major advantages of being relatively inexpensive and quick to build, prototyping can help to clarify the requirements and evaluate the feasibility of a particular system design (Nhampossa, 2000). The process of prototyping is almost certainly the best way to find a solution. In this process the partners discuss the problems, and reach an understanding of each other's goals and limits. A prototype solution is then created quickly to see if it meets the needs. This prototyping is evaluated, and changes are identified, and these changes are incorporated speedily into the next prototype, and so on, until the production model is agreed on and built (New Zealand Health Information System, 1997).

Structured analysis, when put together with the prototype method, can help users and analysts have an idea about the new system and help make best use of both methods.

Relational Database Management System (RDBMS) application software was used for creating the prototype database. RDBMS becomes preferable over others such as hierarchical or network database management systems because it is simple and relatively flexible. The selected RDBMS has also been used for creating user interfaces, forms, and reports.

1.7 REVIEW OF RELATED LITERATURE

Under this section, concepts on health information system, patient medical record, paper and electronic patient medical record, coded and free text data capturing methods and related research works were reviewed.

1.7.1 Health Information System (HIS)

The ultimate aim of HIS is to promote the utilization of data and information emanating from it for decision making from the implementation level to the policy making level (World Health Organization, 2001). Without reliable, relevant health information, healthcare managers and policy makers cannot make decisions to allocate resources effectively, and improve health services.

The demand for sound information and the skills to manage and use information becomes increasingly significant. All countries need national health management information system based on modern ICT technologies linking the various levels of the health system and addressing the information needs of policy makers, health programmers, service providers, staff and patients (WHO, 2001).

According World Health Organization (2001), all countries need to prioritize development of HMIS, which are integrating aggregated and anonymous information from various sources within the framework of national information systems. Key issues are:

- Strengthening primary health care delivery including a basic hospital structure within a district based decentralized health system,
- Strengthening health management and good governance at all levels of the health system, but with a focus on the local levels,
- Develop a health information infrastructure integrating, linking and networking the various data flows and sub-systems,
- Sustainability: develop institutional capacity in information management and use.

1.7.2 Health information system for developing countries.

Narrowing the gap between Africa and the industrialized countries, information technology must be considered as a key ingredient. It can accelerate development; enhance the effectiveness and efficiency of the highest-priority sectors of socio-economic development, for instance healthcare, by introducing appropriate information system. Appropriate information system for developing countries has to take into account the cultural, social, economic, organizational, and industrial context: being social systems, information systems requirements differ from the software package ones (Nhampossa, 2000).

Except for those providers who work in solo or small group practices, there are virtually no off-the-shelf solutions for the existing needs; solutions will need to be developed to meet the specific needs imposed by the structure and function of each organization. When the time comes to install and/or develop a system,

there will be a large number of issues involved in making this change successful (New Zealand Health Information Service, 1997). It is unlikely that a universal solution would be of any use, even if it were available. Each organization has developed differently, because of its structure and function. This idea is applicable for organizations in the health sector.

Information system is a resource that enables the collection, management, control and dissemination of data/information throughout the organization. Therefore, the need for design and development of context-oriented information system is of essential importance especially when the focus is health sector (Nhampossa, 2000). Nhampossa continued that, the poor human resource and technical infrastructure in developing countries represent important obstacle to sustainable health information system development. Furthermore, methodologies for information system development as well as most software applications in health are developed within industrialized countries and are not necessarily appropriate in the very different context of developing countries.

Since healthcare is one of the highest-priority sectors for socio-economic development, this implies that introducing appropriate healthcare information system, too, should enhance the effectiveness and efficiency of African health institutions.

Regarding producing appropriate information system, according to Korpela (2001), prior experiences show that:

- I) Appropriate software packages to facilitate health care management, suitable for African requirements and particularly to the district level, are not-existent,
- II) There is a dearth of experienced indigenous system development personnel and centers capable of producing such packages for the health sector,
- III) The standard information system development methodologies of the 'North' are too technical, complex, and formal to the African context, and do not address issues like how to achieve socio-economic (health) impact, and sustainability of information system and information system development.

1.7.3 Patient medical record

All medical records are more or less successful depending upon their ability to communicate to others, to their authors overtime and now to their subjects what was the essence of the patient's condition and experience and clinicians' appreciation of them at the time of recording (The Joint Computing Group of the General Practitioners' Committee and the Royal College of General Practitioners, 2000).

The committee discusses that the purpose of the patient records as clinical purposes, non-clinical purposes and additional purposes.

As a clinical purpose, it can be used to assist in the clinical care of individual patients by assisting the physician to structure his/her thoughts and make appropriate decisions and subsequent consultation, making information available to others, storing information received from other parties; and assist in the clinical care of the particular population.

As non-clinical purpose, it can be used to meet administrative, legal and contractual obligations by providing medico-legal evidence and in respect to claims by patient against a third party.

For additional purpose, a patient record can be used to interact with a decision support system, support teaching and continuing medical education, to enable epidemiological monitoring and clinical research.

1.7.7 Paper vs. electronic medical records

According to the Joint Group of the General Practitioner's Committee and the Royal College of General Practitioners (2000), the general characteristics of electronic and paper records has described as follows:

- Electronic Patient Records (EPR) depends for their existence on the presence of supporting hardware and software. Paper records do not. In so far as EPRs have a physical presence, this exists at the point of

data storage on the machine involved. Paper records exist in the space that they themselves occupy.

- EPRs may be available to the clinician at any point where electronic access is provided to the record data. Paper records have to be physically present at the point of use.
- Paper records are cheap in themselves; in comparison EPRs are not. EPRs require investment in the necessary hardware, software, maintenance, upgrades and training. This may be offset against savings in filing, storage and retrieval costs for the paper equivalents but there remains a different order of investment type and magnitude for computerized records.
- Paper records are generally regarded as intuitive in their use. Most EPRs are not usable without additional training investment both because individual EPR systems are idiosyncratic in their construction and require specific training for their use, and because full exploitation of the potential of EPRs requires some understanding of the more general possibilities inherent in computerized records vis-à-vis paper.
- Data entry in paper records is relatively easy. Data entry for EPRs is more complex because of problems in entering data into EPRs from remote sources, and for the different semantic implications of information in an EPR to that in paper record.

- Data retrieval from EPRs is easier than from paper- not just because EPRs are physically more accessible to their users than paper records, but also because the ability to interrogate the content of EPRs for audit and analysis purpose is arguably their single greatest advantage over their paper equivalent.
- Paper records generally depend for their meaning on the intention and semantic competence of their author(s). The crucial aspect of the paper record is that it provides considerable freedom of expression for its authors in communicating their meaning. EPRs on the other hand, always contain to the greater or lesser degree what is possible to be entered into them.

Paper records are growing part of the information management problem. They are disorganized, illegible, inconsistent, and provide a forbidding challenge to anyone tries to understand what is happening to the patient. Paper records are costly and difficult to research. It is difficult to find and abstract data from them, because of inconsistency and incompleteness as well as disorganization, which may create difficulties in internal management, as well as in providing information, related to service contracts (New Zealand Health Information Services, 2000).

The inefficiencies of paper medical record absorb large amount of hospital's budget and are directly responsible for many of the failures in the quality of care delivered, such as medication errors (Frolick, 2000).

McGuire, (2001), defined electronic patient record as a health care record stored in electronic format synonyms with automated patient medical record or electronic health record.

Electronic medical records can help the provider by organizing and displaying data in more flexible, appropriate and meaningful way. Clinical decisions are made on the basis of confidence, and confidence is a result of the collection and meaningful display of adequate information. Electronic records can aggregate and collate the data, and contribute to boosting confidence and making definitive care decision early. This in turn can affect the costs of providing care. Data from multiple sources and modalities can all be displayed together on the one workstation (New Zealand Health Information Services, 1997).

The electronic patient record is very readable; thus, eliminating errors often made when transcribing hand-written information. A computerized database allows the electronic storage, retrieval and backup of information from any computer terminal with secured access. Simply stated, an electronic patient record system should make it easier to record, report and interpret complex clinical information (Blair, 2002).

Electronic medical records provide healthcare workers with an extensive option for improving patient care. Not only electronic records not be misplaced as paper records can, but the information in the record is more accurate as well as legible.

1.7.5 Free text vs. coded medical record

The transmission from paper based to computer based patient record necessitates fundamental changes in the way clinical information is expressed. This is one of the challenges facing healthcare computing since the presentation of patient data has to be in a usable form.

Clinicians have been using words, terms, and clinical vocabularies since the modern patient record began. Each healthcare discipline taught the students about the correct vocabulary to use in the process of documenting the identification of patient problem, goals for treatment, interventions or therapies to use, and patient response to treatment. The advent of CPR has fundamentally changed this practice. Standardized vocabularies are needed to support the entry of clinical data, and enhance communication between clinicians (Shortliffe, 1999).

Medical narratives are flexible, expressive, and familiar to clinicians. In addition, it has also been shown that the use of medical text narratives in medical record improves patient physician communication. However, with the current technology, computers are able to make only limited use of information stored in free text format (Al-Ghamdi, 2000).

One requirement of CPR is to have a consistent coding system or vocabulary for the values entered to the database. This is due to the potential medical

3.3.4 Transaction requirements

Frequently performed transactions of the proposed system are the following:

- The system should register newly arrived patients or patients with initial visit into patient table. Here, patient's demographics data is recorded. Every patient has to be assigned a unique identifier, i. e. chart number.
- It should be able to display list of appointed patients matching a particular date, caregiver, or department.
- It also has to list out scheduled patients for a specific caregiver on a given day.
- Should accept updates and additional insertions of patient medical information entered by authorized users.
- Accept and retrieve patient's epidemiological data with any additional clinical information as needed.
- The system should be able to retrieve data on a single patient, specified through his chart number. The data can be patient's demographics information, retrospective medical history, or a combination of two.
- Also it should be able to retrieve data by identifying a set of patients, who happen to match a particular attribute or set of attributes. This can be done, for instance, for patients having similar encounter, identified with the same disease, having got the same treatment, seen by a particular caregiver, of the same sex group, or within the same age group.
- Accept and display laboratory and X-ray request orders and also results.
- Display the status of beds in each ward as being occupied or vacant.

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knowledge space is extremely large and complex, and represents a wide spectrum of data from the most objective and quantitative, to the most subjective and fuzzy data (Davidson, 1999).

Computer based patient data which are represented in coded form have a variety of uses, including direct patient care, statistical reporting, decision support, and clinical research. The typical approach is to encode the information using some standard terms taken from a controlled vocabulary (Brrett, 2000).

Although many coding schemes have been developed and used in CPR, none of those schemes support all the desired functions. The lack of standards for coding patient data is one of the greatest impediments of medical computing today. This has forced application developers to create their own coding schemes for systems (Shortliffe, 1999).

1.7.6 Related research works.

A project entitled "information systems development for healthcare in Africa: the INDEHELA- methods project" has been held by the Obafemi Awolow University, Nigeria and University of Kuopio, Finland (1998-2000) to develop such a 'Made in Nigeria' ISD methodology.

Its general objective is to develop a 'Made in Nigeria' ISD methodology for Nigerian systems practitioners with special emphasis on the requirements of the healthcare sector. The research design has three inputs: 1) Literature review of relevant ISD methodologies, 2) Theoretical analysis of the special requirements in Africa and Nigeria, 3) A survey about the existing practice and problems.

The research reaches at a conclusion of: appropriate software packages for African hospitals and health centers can not be found off the shelf; they must be developed locally; which becomes a strong ground for the student researcher, to held an in-house ISD for Butajira Rural Hospital. To justify the conclusion, it states that: the requirements are too different for an African or European hospital application without major adjustment, and appropriate information system for African healthcare must thus be developed locally.

Sean Ressler (1998) has done another work for a master's thesis from Oregon Health Sciences University. The title is Development of a system linking the nursing interventions classification to the nursing outcomes classification. The

aim was to incorporate the use of contextual software design methodology in the development of a nursing information system.

The purpose of the study is to develop a prototype computerized system linking the nursing intervention classification to the nursing outcome classification.

A quantitative interviewing strategy to extract knowledge from nurses is used. Developing a system prototype and using interview for collecting necessary information are points that make this work related to the current research work that has been held at Butajira hospital.

Building a database for Peking Union Medical College Hospital outpatients with rheumatic diseases is a master's thesis by Xinping Tian (2003). Goal of the project is to build a database that can collect and organize visit- related medical information of patients with rheumatic diseases from Peking Union Medical College Hospital.

Database design methodology used is a Relational Database Management System that is also a selected method in developing a database for Butajira Rural Hospital.

Also another work entitled "A prototype information support system for All African Leprosy & Rehabilitation Training Center" has been done by Mohammed-sied (1995).

The objective of this study is to demonstrate that data about leprosy patient can be stored in microcomputer database, which would be readily accessible for a variety of administrative, clinical, educational, and research related activities.

A fact finding method used in the study is interviewing selected physicians or users of the system, that make it similar with the technique used in the study held at Butajira Hospital.

Yamazaki and Satomura (2000) in their work 'Standard methods for describing an Electronic Patient Record ' have developed a template definition language to share knowledge about how to construct a Computer-based Patient Record template.

In doing so, the authors favor capturing data in coded form rather than as narrative text to reach the desired beneficial effects of CPRs. They claim that structured data entry is more promising approach than natural language. They state the advantage of structured data entry over natural language as the data capturing process can be influenced by implemented knowledge.

The structured data entry issue relates the work of Yamazaki and Satomura with this study. Although, the application of structured data entry in CPR is of great value, in this study, the combination of both natural language i.e., free text data entry and structured, i.e., coded data entry have been implemented. Free text with text narratives data entry is adopted due to the nature of some clinical

records being expressed well and communicated easily by free text and taking into consideration the need of clinicians to have the freedom of expression that comes with free text data entry where applicable.

CHAPTER TWO

2. BACKGROUND

2.1 HEALTH INFORMATION SYSTEM IN ETHIOPIA

The Health Information System (HIS) of the country is structured hierarchically from the health facilities to the Federal Ministry level. Apart from the routine and basic HIS at country level, there is independent epidemiological surveillance system functioning at Federal and Regional level that created to support prompt decision-making in case of emergencies.

Routine disease related data has been collected manually from the health facilities according to their formulated working standard. Those data aggregated initially at the health facility are then transferred to Woreda Health Office, Zonal Health Department and Regional Health Bureau before it has reached the Federal Ministry. Except on some of the Regional Health Bureau's (RHB) level, data is processed on a computer. However, due to construction of new health facilities and increase in per capita of outpatient visits observed in the health facility level, the currently functioning computers are either replacement or memory upgrade to enable them communicate fully.

Concerning information dissemination, from the Federal Ministry, Office of Health Management Information System, the publication entitled "Health and health related indicators of Ethiopia" has been published in annual bases and

distributed for all stakeholders freely. The publication is mainly used for the purpose of monitoring & evaluation, and as a means of feedback for those collaborators especially the RHB.

Largely, information dissemination for the public has been conducted through the Office of Public Relation of the Ministry, in collaboration with the Ministry of Information. Periodical publication on health information is disseminated with low coverage even in urban areas. Quarterly newsletter has been started to publish recently covering news on the progress of diseases under eradication.

As such, there is nothing to say the information dissemination in the form of publication from the RHBs level. Several types of information have been submitted as a means of reports for their entire council and Federal Ministry of Health (FMoH). For processing and disseminating of information, however, the personnel working at regional levels are overburdened by report compilation due to the existing technical and administrative structures.

There is currently increasing demand for information utilization throughout the country. The States Council on one hand and the Health Sector on the other are looking ahead for information from the RHB for routine management, budget allocation and long-term planning.

2.2 CHALLENGES IN THE HEALTH INFORMATION SYSTEM

Effective utilization of health information depends very much on the timeliness, coverage and accuracy of the data and management skills of the users, which can, mentioned as great challenges of the country's Health Information System.

The cause of delay is a long way reporting mechanism on using a manual practice applied in compiling the data. Hardcopy mailing through the Post Office in the country with poor infrastructure aggravates the delay. The issue of completeness of reports is also a great problem. It is common to use the 6-month or 9-month report to estimate for annual report. Among all, drug-related data and financial information are badly affected in relation to coverage. Concerning the coverage of health providers, the private sectors are not fully captured, which is currently growing in all over the regional states.

In relation to data integration, the struggle blocks have been the absence of any agreed upon standards for interconnection or intercommunication. There is no comprehensive national standard like minimum data sets at various levels or data dictionaries for data elements and indicators, for collecting, analyzing, and reporting health data or information.

Most managers and decision-makers for daily management, budget allocation, and long term planning traditionally do utilization of data to a very limited extent.

Currently, the health system has been functioning with the decentralized management structure, which might change the picture.

The human resource necessary to implement and maintain the information and communication technology (ICT) in the health sector is very scarce. At all levels, from policy makers to users, the pool of expertise on idea or knowledge in ICT is so small. Regional states are of particular disadvantage with extremely limited availability of expertise to handle hardware and software troubleshooting.

2.3 THE BUTAJIRA RURAL HEALTH PROGRAM

Established in 1987, The Butajira Rural Health Program (BRHP) is devoted to continuous population based studies in rural Ethiopia. The BRHP is located in Meskan and Mareko district, Gurage zone, in Southern Nations Nationalities and People Regional State (SNNPRS) in Ethiopia (Yemane et al, 1999).

Butajira town is located 130 km south of Addis Ababa and 50 km to the west of Zway town in the Rift Valley. The town's population has estimated about 25,000 in 1999 while the population of the district on the basis of the 1999 census is estimated 257,000.

The objectives of BRHP, when initiated in 1986, were to generate health- related information, to establish and maintain an epidemiological research laboratory, to build and strengthen research capability and to develop local capacity in the

prevention and control of disease. In general, its overall objective were to develop and evaluate a system for continuous registration of births and deaths, to generate valid data on fertility and morbidity and to provide a study base for essential health research and intervention in the area (Yemane et al, 1999).

Butajira Rural Health Program has maintained a 'field population laboratory' in ten villages since 1987 by registering of vital events. Data is collected monthly by visiting each household. Each household is identified by a unique number within its village, and each individual within their household.

The BRHP is a national asset that can provide scientifically sound information for use in public health planning, policymaking and evaluation. Additionally, with the availability of patients' clinical data of the district, its information content can be sufficient and complete in satisfying the needs of researchers in the area.

2.4 BUTAJIRA HOSPITAL

The Butajira Hospital is one of the district hospitals found in Southern Nations Nationalities & People Regional State (SNNPRS) under Gurage Zone Butajira district in the town of Butajira, which is 130 km far away from Addis Ababa. It is a relatively new hospital of the region that starts its function or operation recently in 2000. The hospital is estimated to serve for more than 148,000 people from the district and its surroundings like Oromia Regional State, Hadiya and Silte Zones.

The Butajira Hospital is situated in the area of 160,000 square care meters. It has ten buildings of a ground floor connected with attractive and convenient corridors. Two of the buildings are serving as wards of which, one for medical and pediatric ward and the other for surgical and gynecology- obstetrics ward. Outpatient and pharmacy are in the same building while X-ray and laboratory occupied another one. The rest buildings are used as administrative offices, stores, archives and the like.

The objectives of the Butajira Hospital can be stated as primarily to provide the visiting patients with curative services and next with preventive services. For its proper functioning and fulfilling the stated objectives of which it is established for, the hospital has employed 55 clinical staff excluding the administrative workers. Of these employees, two are specialist doctors, seven general practitioners, thirty senior and junior clinical, public, and midwife nurses, six laboratory technicians and six pharmacy technicians in different levels, one sanitarian, two x-ray technicians and two health assistants.

The hospital is composed of nine clinical departments broadly classified as Outpatient Department and Inpatient Department. Specific departments can be mentioned as Surgical, Medical, Pediatrics, Gynecology and Obstetrics, Major Operation room, Minor Operation room, Mother and child Health, and Delivery. Additionally, there are ancillary departments like Pharmacy, Laboratory, X-ray Environmental Health and the like. Under Administrative and Finance Services,

departments are Finance and Budget, Personnel, Property Control, Archives, Laundry, Guard and others.

On average, about 150 patients can be seen per each working day of the hospital. The current four wards are equipped with a total of 110 beds. This figure tells us the capacity of the Inpatient department.

Currently, The Butajira Rural Health Program (BRHP) and Butajira Hospital are agreed upon cooperation on a number of points. To mention some, the BRHP can provide the hospital with patient charts and additional forms incorporating additional attributes (variables) not found in the previous Federal Ministry of Health's chart. These additional fields hold an important data for demographic and other clinical and financial information of patients who are from the BRHP's project area. This can be seen as a step towards integrating the available epidemiological and clinical data. The hospital is so cooperative in filling these additional fields by its staff. Also there is a plan on the side of the BRHP in the near future, to make a local area network (LAN) entire the hospital. It will provide all the necessary hardware and software in addition to its previously contributed desktop computer, which is available at the Registrar office of the hospital.

CHAPTER THREE

3 SYSTEMS ANALYSIS

3.1 INTRODUCTION

System analysis is the study of a current business and information system, and the definition of user requirements and priorities for the new information system (Whitten, 1994). The analyst studies the current system by collecting facts from different documents and from system users. From this information, the analyst seeks to understand the systems problems and limitations.

In the requirement analysis, the analyst approaches the user to find out what they want out of the new system. The purpose of requirement analysis is to identify the data and process requirements for the users of the new system. It is to specify these requirements without expressing computer alternatives and technology details (Whitten, 1994).

This chapter starts on discussing the existing system. It is a detailed observation and analysis of the current system. Next, problems with the existing system can be identified and listed out. Requirements analysis is the next step, which includes business requirements and system reengineering steps, i.e. data and user requirements. As a method of clarifying ideas, models of systems can be created presenting conceptual view of the system's working environment.

3.2 EXISTING SYSTEM DESCRIPTION

The description of the existing system can be used to understand the process of the system, to identify the problems with the system, and to limit the scope of the study. This section describes patient care in the Butajira Hospital using paper medical records, problems with it and business practices to automate the patient medical record.

People involve in the process of providing care to patents and receiving care can be classified into two broad categories.

I People who receive care called patients.

- Inpatient: a patient who receive care in the hospital,
- Outpatient: a patient who receives care outside the hospital.

II. People who provide care called caregivers.

- Specialist doctor: a physician who has advanced education and training in a specialty area such as medicine, surgery, pediatrics, etc.
- General practitioner: a medical doctor who has completed a doctorate degree in medicine.
- Nurse: This can include nurses in different levels and categories like senior clinical, public, midwife nurses and junior clinical, public, midwife nurses.

- Ancillary department personnel: Personnel in a department providing services for patients or providing services for departments providing direct medical care including laboratory, Radiology and pharmacy.
- Registration clerk: a person who can register and schedule patients in the chart room.
- Manager: This can include the top management of the hospital like medical director and matron.

3.2.1 Workflow processes in providing patient care

In order to make a detailed description of the existing system, the ideal way is to model the system. A model is a graphic representation of reality. For the purpose of this study, first a process model known as Data Flow Diagram (DFD), and then a data model called Entity Relationship Diagram (ERD) have been used.

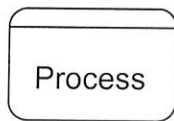
3.2.1.1 Data Flow Diagram

A data flow diagram (DFD) is a process-modeling tool that depicts the flow of data through a system and the work or processing performed by that system (Whitten et al, 1994).

Data flow diagram is one of the most important tools in a structured system analysis. It presents a method of creating relationship between functions or processes of the system with information it uses. DFD is a key component of requirement specification, because it determines what information is needed for

the process. Hence, in this study DFD is used to analyze the process and determine the different requirements of the proposed system. Figure 3.1 is a process model (DFD) that illustrates the workflows and functions of the current system.

The following symbols are used in our DFD.



A process is the main symbol on a DFD. It is a work or action performed on incoming data flows to process outgoing data flows.



a data flow represents the input of data to a process or the output of data from the process.



a data store is an inventory of data like file or database.



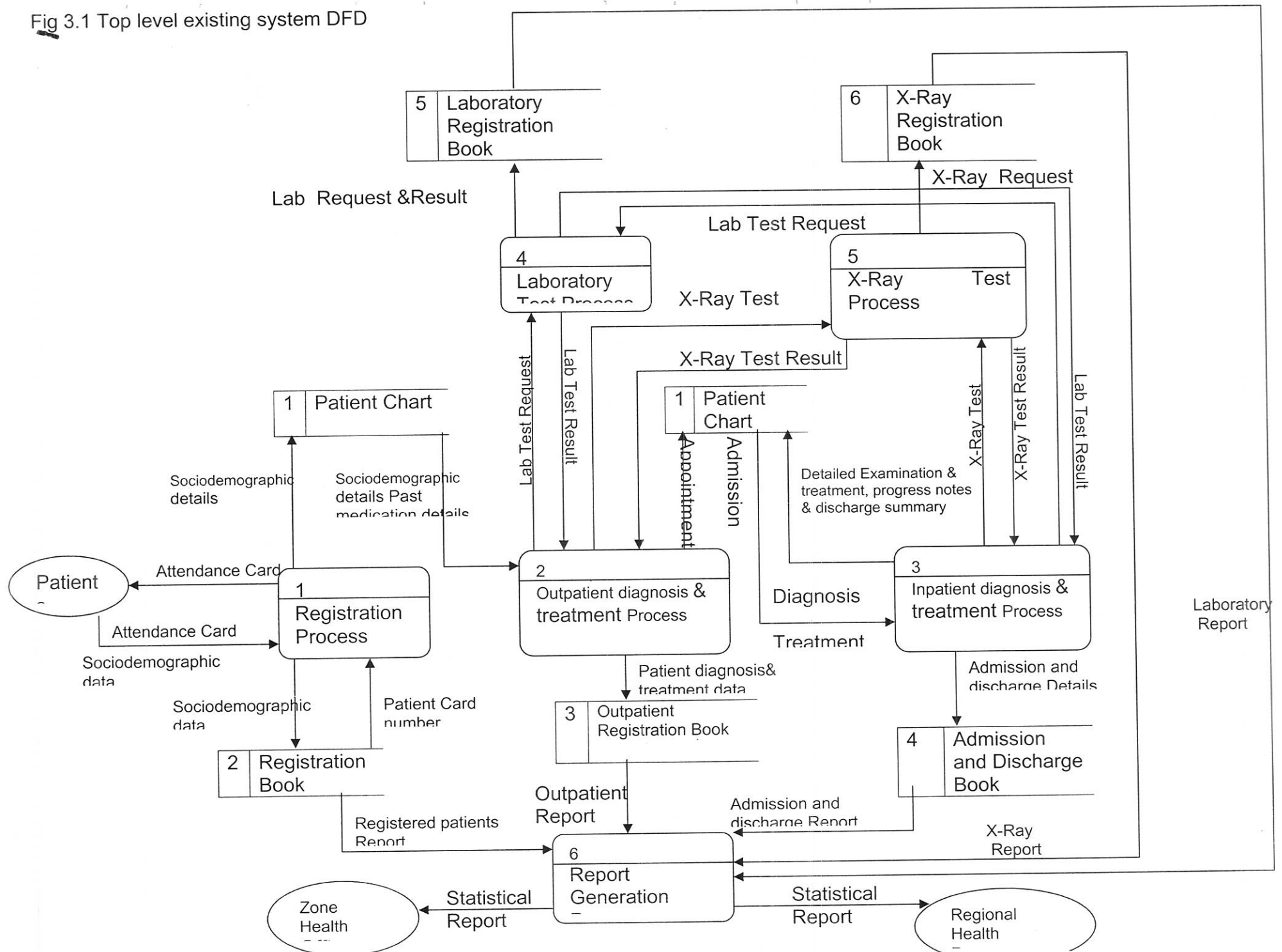
Internal and external agents define a system's boundaries. They provide net inputs into a system, and net outputs from a system.

3.2.1.2 Registration process

When patients became sick or have a medical problem, the first place they have to go is the hospitals chart room. Patients have an opportunity to go to the chart room early in the morning or late in the afternoon at 1.00 PM to get the registration services. In case of emergency patients, there is no time limitation and can get the registration services any time they arrive to the hospital. If the

patient is a new patient, or it is her/his initial visit to the hospital, a new chart will be assigned to her/him with all the sociodemographic data of the patient being filled in the chart. All information that has been filled in the chart is then recorded on the chart room's Registration Book to be used for reporting purpose. All patients are subject to pay for registration and other services they can earn like

Fig 3.1 Top level existing system DFD



laboratory and radiology tests. But, if a patient comes with an official letter attesting his financial status as being poor, he can be classified as a free serviced patient.

②
In completing the registration process, the patient is given an attendance card filled with some of the information on his chart. This includes his chart number, name, and date of registration, which can be used for future retrieval of the chart in case of other visits.

For patients with second or repeated visits, the situation is a little bit different. This time, they need to come with their attendance card so that their chart could be easily retrieved. The routine is that the chart room clerk checks their chart number from the attendance card and search for the chart from the shelves that contain patient charts arranged in ascending order by patient's chart number. If patients lost their attendance card, search is done by their name and visiting date, if they remember their first visiting date, which is used to trace their chart number from the Registration Book. If it is not possible to get patients' chart number, they will be assigned a new chart.

The charts can then be distributed and forwarded to caregivers in the outpatient department (OPD) by the chart room clerks. In case of patients with an appointment, their charts could be preserved in a separate shelf labeled 'appointment' and on their appointment date they have to come with appointment

card given to them previously by the appointing caregiver, that can be used for crosscheck and for chart retrieval. Then the chart can be distributed to appointing caregiver, especially for physicians in special departmental clinics.

At the end of the day, the chart room clerks collect charts from examination rooms and reshelv them according patient's chart number.

In general, the registration process can be summarized as:

- Assigning charts and filling sociodemographic details of new patients,
- Issuing attendance card for a new patient,
- Registering or recording new patient details on Registration Book,
- Searching and retrieving charts from shelves for revisiting and appointed patients.
- Distributing patient charts for caregivers.
- Collecting and shelving patient charts.

3.2.1.3 Outpatient clinical process

Although it is not quite the same, the processes of diagnosis and treatment (patient care) in both Outpatient and Inpatient have more common activities. While the case of Inpatient process is more detail, its additional activities will be mentioned after describing the Outpatient process.

After receiving patient charts from chart-room clerks, caregivers begin to diagnose (evaluate) patients in the Outpatient department's examination room. Usually, the general practitioners and some times nurses are assigned in the examination rooms. The Caregiver can refer to patient's past medical history and demographic detail from patient chart if the patient is a revisiting patient. Otherwise, only patient's demographic data can be referred.

Upon visiting the patient, the physician or nurse can ask the patient different information. Information given by the patient can be recorded as subjective which include his chief complaint, history of present illness including the symptoms that are troubling the patient, when the symptoms first occurred, his opinion to the cause of the illness, medication treatment the patient has tried. From this information the caregiver forms some initial hypothesis on the diagnosis, which is referred to as the differential diagnosis (a set of possible diagnosis).

The caregiver asks further questions including information about past medical history, past illness and treatment administered, past operations and allergies, and family history. The caregiver then reviews each body system of the patient and records it on the chart.

In order to refine the hypothesis on the diagnosis, the caregiver exams the patient and may order diagnostic tests. The caregiver's examination of the patient is recorded as an objective finding. Vital signs and results of examination

are recorded as physical examination, with findings usually separated out by each body area; the physical exam may later include laboratory, X-ray and other diagnostic results.

From the subjective and objective findings, including diagnostic test results, the caregiver makes a best determination of diagnosis, the name of the condition from which the patient was suffering, which is recorded as an assessment.

On the plan or treatment, the caregiver makes a treatment for the patient that include, medications and dosages, instructions given to the patient, any recommendations for hospitalization or surgery, and any special tests that need to be performed.

During all these processes, the general practitioner or the nurse could add information to the patient chart or produce information that is later added to the chart. This patient information should also be recorded on a registration book, which is available at each examination room.

It has to be noted that currently there are only two specialists in Butajira Hospital; a surgeon and a gynecologist. These specialists also can do the processes of asking chief complaints, history, physical examination, assessment and plan to patients referred to them. They can order laboratory and/or X-ray tests; they can admit patients to wards and also they can give appointments for their patients

especially for patients with chronic illness follow up. All the generated records have also to be recorded on the patient chart and on respective departmental registration books.

3.2.1.4 Inpatient clinical process

The inpatient care process involves admitting and caring for the patient and can include the Registrar's department personnel, physicians, and nurses. Admission to the hospital could be a result of outpatient visit or a planned one for appointed patients for admission.

After making the outpatient clinical processes, physicians or nurses can decide to admit the patient. If they decide to admit the patient, the patient goes through the admission process, which starts by asking the hospital registrar about the availability of vacant bed. If so, an admission card can be assigned to the patient that holds patient's demographic, diagnostic and financial information. The patient obliged to deposit some amount of money in advance before his admission. Additional information available on admission card is, patient's ward number, bed number, date of admission, admitting and discharging physician and price of all treatments given to the patient. This information uses to control the occupied and released beds, and to control the financial status of the patient.

The patient goes through the admission process for the inpatient stay. After the patient is moved to a bed in a room in a unit of the hospital, the patient is added to the admission and discharge book. The patient chart can also be moved to the inpatient ward with the patient.

Once the patient is in the hospital, the physician re-examines the patient and may order diagnostic tests (x-ray, laboratory tests, etc) receiving back diagnostic findings, possibly revising the diagnosis as a result. A treatment plan is also determined, which may include order for medications. Results of the treatment plan and patient care are observed, with further revisions of diagnosis or treatment. This information is recorded on physician's progress notes. Physician's progress notes include physician's observations, notes on the patient's progress and treatment data.

Detailed clinical examination is done in the inpatient stay that is recorded on clinical examination form, and physician's medication order is recorded on medication order sheet. Vital signs are also taken on intervals and recorded on vital sign sheets, all of which are attached to the patient's chart. Discharge summary and status of the patient on discharge are points that are recorded on a chart and on admission and discharge book.

Planning for discharge begins at the time of initial assessment and continues up to the time of discharge. Information is put on a discharge summary document.

The discharge summary is usually completed immediately after discharge and may include all relevant diagnosis, all operative procedures, instructions specifying medications, and diet.

As a summary, processes dealt in an Outpatient and Inpatient can be stated as:

- Asking problems, chief complaints and history of patients,
- Making physical examination, laboratory and X-ray tests orders, assessment and plan or treatment for the patient,
- Ordering laboratory and x-ray tests,
- Receiving results of orders,
- Treating and then return to home or giving appointment for patients,
- Admitting patients,
- Make detailed clinical examination, medication order and vital signs,
- Record all the processes on patient's chart and registration books,
- Filling all forms like progress notes, clinical examination forms, discharge summaries and the like and then paste it in patient's chart,
- Discharge patients.

3.2.1.5 Laboratory order and test process

Orders can be filled by requesting physicians on order forms and send to the laboratory department. Order tests can be urine test, hematology, stool, or blood chemistry. All these tests have their own forms, which uses for request and also for response of the tests filled on the same form. In the case of outpatient order, order request forms are taken to the laboratory and order responses are returned to the ordering physician by the patients themselves or their relatives whereas, for inpatient case this process is done by inpatient nurses.

After receiving the request forms, tests can be done and results are recorded on the same form to be sent for the requesting physician. All the performed tests need to be recorded on a registration book of each type of test.

3.2.1.6 X-ray order and test process

All the processes are similar with that of the laboratory. The difference is that, the forms are different and the time taken to make the test may differ. Here order tests can be X-ray of different body parts or organs. Order requests and results are done on the same form and orders are taken to the X-ray and returned to the physician by the patients or their relatives in the case of outpatient stay. This process is also different for the inpatient case since it is done through inpatient nurses.

3.2.1.7 Report generation process

All the activities performed in registration, outpatient, inpatient, laboratory, X-ray, special clinic and the likes have to be recorded on the registration books of each department. These records are aimed to be used for reporting purpose that can be compiled as monthly reports, quarterly reports, half a year and annual reports.

Point to mention here is, there is no statistics office, assigned statistician or any professional with statistical training or background in the hospital. For this reason, each department heads completes the reporting process. The heads compile reports from their registration books and send to the matron's office where aggregated and recompiled reports are produced. All the report compilation and generation processes are done manually.

The generated or recompiled reports in the matron's office are then sent to the Medical Director's office where final checks are done and distributed to Regional and Zone Health Offices and other health organizations or institutions.

3.2.2 Data elements in paper medical record

The paper medical record (chart) includes patient demographics information, patient clinical data, and patient financial data. Here the non-financial part of the chart is described.

3.2.2.1 Patient demographics information

Patient demographics information is information that identifies or describes a patient. The following are typical patient demographics information in Butajira Hospital.

Chart number

Name

Age

Sex

Address

Marital status

Occupation

Ethnicity

Education

Religion

Date registered

Payment status

BRHP household representative name

Household identification number

Reason for selecting to be treated in this hospital

Treated hospital other than this

Distance of home from the hospital

Amount paid for the transportation

Payment made by whom

3.2.2.2 Patient clinical information

Patient clinical information in the paper chart consists of documents of varying types, which could be:

Medical history and physical examination; this includes:

- Chief complaint

- History of present illness

- Past medical history

- Family history

- Social history

- Marital history

- Allergies

- Immunizations

- Vital signs

- Physical examination

- Assessment

- Diagnosis

- Plan

Medication, treatment

Progress notes for follow up visit and observations, i.e. notes on patients' progress and treatment data.

Physician's orders; a record of physician's medical orders.

Diagnostic findings; diagnostic and laboratory data like X-ray, urine, stool, hematology, blood chemistry, VDRL, etc.

Admission and discharge data for inpatients.

Clinical examination and investigation.

Discharge plan and summary.

In the process of recording patient's clinical information, patient's demographics data is recorded in many forms that are part of the patient chart.

3.2.3 Problems of the existing system

The purposes of the patient medical record are to:

- Record information from the patient,
- Record the caregivers' findings and treatment,
- Communicate information to latter caregivers who see the patient,
- Coordinate caregivers and organize their activities in the care to the patient,
- Serve as a formal and legal report of care,
- Provide information for public health, epidemiological study and clinical research.

Base on the collected data, observed documents, and description of the existing system, several drawbacks has been identified in the existing system. In general, on serving for the purpose they are created to, paper patient medical records at Butajira Hospital are found to be subject to the following defects.

- Patient charts are usually misplaced hence; patients fail to get their proper charts on subsequent visits. Also, it is not uncommon to come across patients with a return visit who lost their attendance cards. In such cases, the chart-room clerk finds it difficult and sometimes practically impossible to retrieve their charts. Therefore, reissuing a new chart with patient's demographic information becomes a normal process. As a consequence, past medical information, which could have helped the caregiver in his evaluation of the patient, becomes unreachable.
- The consequence of the above mentioned problem has multitude impacts; for instance, re-issuing of new charts, increased staff time spent looking for missing charts, increased laboratory test redundancy, general decrease in staff productivity etc. In worst cases, failing to retrieve previous charts could have grave implication. Patients with a recorded history of allergy to a certain drug could be wrongly medicated putting his/her life at risk. This is a possible risk on patients of emergency case who are unconscious on arriving to the hospital.

- The patient may be seen by many caregivers in different departments of the hospital like antenatal, chronic illness, or maternity. This results the patient to have more charts with different chart numbers. As a consequence, it becomes impossible for the caregiver to have general and detailed information on his patient.
- Due to the absence of a statistics department in the hospital, the process of collecting and compiling of reports from register books of each department is done by department heads. In addition, since all these processes are done manually by a method of tallying from the register books, it is subject to creating several errors in the reports. Most of the time, what have been done and what is reported are not corresponding to each other. Usually, the figure stated on the report is smaller than the actual performance. Besides, writing all their performed duties both on patient chart and register book becomes boring and time consuming for caregivers.
- Since the patient can be seen by several caregivers in different times through his lifetime, and caregivers have to record all the information they come across of patient's clinical data manually, their handwritings can not be the same and clear to be read by other caregivers. Usually, when caregivers refer for past medical history of their patients from charts, they found it difficult and time consuming to get the general picture and idea of what they need from the chart. This is due to the common features of disorganized, inconsistent,

illegible and incomplete nature of the information in the patient chart. This problem is also common for researchers in the area to get organized and complete data.

- The patient charts are available only at one location or department at a time. If other caregivers in other departments need it, waiting for the completing of duty at the first department and physically transporting the chart to other departments latter, causes inconveniency and workload to caregivers.
- The paper chart consists of many individual pages or forms organized in a chronological order with considerable redundant data. Especially, patient demographic data like chart number, name, age and sex are recorded in different forms attached in the chart. The effect is duplication of efforts and consumption of considerable time of caregivers. Also pages or forms could be easily misfiled and misplaced. Sometimes, as the size of the chart is growing significantly, forms for tests and procedures are not easily located in a chart. Thus, tests and procedures can simply repeated. Such actions led to redundant information being filed in the patient's chart.
- Within its four years of service, the Butajira Hospital has accumulated more than 40,000 patient charts in the chartroom. According this pace, it is obvious that the number of charts will increase dramatically, and cause a storage space problem in the chartroom.

In general, the paper chart in Butajira Hospital has the following defects:

- Potential misplacing or destruction of the chart,
- Illegibility, inconsistency and incompleteness of information on the chart,
- Disorganization of information with caregiver difficulty in finding information in the chart,
- Difficulty for researchers in finding information in the chart,
- Available at only one location at a time, and required physical transport of the chart from one location to another,
- Availability of redundant orders and demographics and clinical data on several forms in the chart, which are causes of duplication of efforts and data inconsistency,
- Potential storage space consumption in the chartroom.

3.3 REQUIREMENTS ANALYSIS

In section 3.2 detailed current system descriptions has been stated, which describes the business processes, data elements and problems of the existing system. Hereafter, a detailed examination and description is given concerning the business and data requirements for the proposed information system.

In different methodologies the requirements analysis phase might be called the definition phase or logical design phase. This phase is critical to the success of any new information system. The purpose of requirement analysis is to identify what the new system is to do without the consideration of technology; in other words, to define the business requirements for a new system (Whitten, 1994).

Best current practice suggests that requirements be expressed in terms of system models. System models can be verified by users and analyzed by Computer Aided Systems Engineering (CASE) tools and systems analysts.

For our case, a Data Flow Diagram (DFD) is used to model the process requirements, and Entity Relationship Diagram (ERD) is used to model the data requirements for the proposed system.

3.3.1 Business requirements

Business requirements for the proposed system have been derived from upper management and workers' suggested list of improvements and ideas for change, from vision of the future and from list of problems of the existing system.

For Butajira Hospital patient information system, the following requirements are stated as being necessary:

- The system registers patients with initial visit by assigning them unique identifier (Chart number).
- For patients who already lost their attendance cards, the system has to be able to search, find and make available patient chart by searching through other variables than the chart number, like patient name, sex, and visited date,
- Provide patient appointment and daily scheduling system for caregivers,
- Creates and maintain a complete, integrated, and always available patient medical record,
- Minimize redundant entrance of information in clinical systems, and eliminate possible contradictory information by making relationships among the several documents of the automated patient medical record database. It uses to gather information on demographics, encounters, and order and results.
- Where possible, validate as correct all information input by the caregiver,
- Enable caregivers to quickly find relevant information in patient medical record by methods such as providing summarization information,

organization, information retrieval and tailoring of information related to type of caregiver. These process can be done by electronically organize the patient medical record for various types of caregivers, provide a summary of the patient's health history, and enable searching for relevant information.

- Support simultaneous access to the same patient records by multiple caregivers,
- Enable useful access to clinical information, for medical research purpose,
- Offer flexibility for future improvement, if necessary. The data held in the database can easily be exported into future advanced electronic systems.
- Provide security checks to control users access to patient information, through assigning a hierarchy of privileges,
- Provide sufficient backup and recovery features to assure minimal data lose due to system or power failure.

The product of business requirements in the hospital has found to be the implementation of an automated patient medical record system. This decision was made on the basis of fulfilling the stated requirements. The conceptual view of this product can be described as a data flow diagram and entity relationship diagram latter. The basic parts or components of an automated patient medical record system are: a part to display appointments and daily schedules of paints for caregivers; a part to display the patient medical record; a part to enable caregivers to document all aspects of patient care; and a part to enable

caregivers to order medications, clinical laboratory and X-ray tests and to receive results back.

The proposed automated patient medical record system would provide the following capabilities:

- Documents patient care that makes patient chart,
- Record actions dealing with the patient's care: this covers all activities to schedule or record care including ordering clinical laboratory and X-ray tests, medications and receiving back results; documenting patient care, producing documents in the chart; and making patient appointments.
- Display the clinical information that makes up the patient medical record,
- Quick overview of clinical information for a patient i.e., a summary of patient medical record to the caregiver (e.g. current medications, past encounters, allergy, immunization, etc),
- Select clinical information and search for clinical information for display,
- Identify patients of interest to caregivers,
- Enable clinical research.

3.3.2 Process requirements

In order to solve the problems and meet the stated requirements on implementing the improved system changes and modifications are vital in the processes, data flows, and other methods of the existing system.

On describing the existing system in section 3.2, it has been tried to use a data flow of the system as a top-level data flow diagram. Although, it is a top-level diagram, which indicates the process in a broader sense, a detailed description of the workflow processes of the current system has been stated. Now, again, it becomes important to look through those processes and the DFD in order to discuss about and create a vision of the new improved system.

On the data flow diagram of Figure 3.1, it can be simply observed that there are so many duplicate and redundant data kept and stored in several data stores. For instance, on the process of registering the patient, patient's demographics information is recorded on a patient chart and also the same information is registered on the Registration Book, aiming to be used for report generation purpose. These demographics information are also redundantly recorded on several forms, which are normally parts of patient's chart that can be attached with it. Besides, all the register books available at different departments and processes contain similar information regarding patient clinical data that has been previously recorded on patient's chart, in addition to the already acquired redundant demographics information.

Having to continue with these redundant data causes the proposed system to live with duplicate, inconsistent and erroneous data. On top of that, since, one of the requirements of the proposed information system is to eliminate or minimize redundant entrance of information from the patient medical record, it becomes

advantageous to make the new information system rid of such duplicate entries. Therefore, the top-level data flow diagram of the proposed system (Figure 3.2) has been depicted without those register books of Figure 3.1. This results all the demographics and clinical data of the patient can be kept within the chart without duplication. The same data can be accessed and retrieved from patient chart to be used for report generation purpose.

Another area, which needs more observation and modification, is patient's chart itself. In the above paragraphs, it was tried to see how to minimize, if not to eliminate, recording redundant data on several register books by deciding not to use those register books at all. Although it is a nice decision to do so, our patient chart is not in a condition to become completely free of holding duplicate data. Parts that constitute patient medical record being held in the chart contain redundant data, especially concerning the demographics information.

The patient chart, as a single data store, accommodates all the patient's medical record including patient demographics, epidemiological data, test order request and result data, diagnosis and treatment data, admission and discharge data and appointment data. Most of these data are recorded on the patient chart itself, and some on special forms designed for a specific process like laboratory or X-ray test order request and result. These and some additional forms like admission and discharge, clinical examination, order and vital sign forms filled and filed or attached in the chart in a chronological order.

The process of accumulating and attaching all the medical record in a single repository data store, i.e., a patient chart is not simply functioning without its grave implications. It is not uncommon for the physicians to come across with the difficulties of obtaining organized, summarized, and complete information of their patients on their patient care process. Since every data is written on and/or paste in the chart, the volume of the chart increases significantly. Searching and identifying individual pages and forms from the chart becomes cumbersome and sometimes impossible, incases when those forms are misfiled or lost.

To overcome the above and other problems like reordering tests and procedures, significant modifications and additions have been made to the improved automated patient medical record system. As it is clearly observed from the data flow diagram (Figure 3.2) of the proposed system, the patient chart has been partitioned or divided into several individual data stores with each data store holding specific information on patient's required data.

This process creates simplicity on the system to integrate the available data stores through their unique identifiers, and to produce and retrieve summarized organized and consistent information according to the specified needs of caregivers. Accordingly, since keeping redundant data has been minimized, unnecessary consumption of storage space is also avoided considerably. As what have to be recorded under each data store is clearly specified by the

attributes of the data stores, recording and obtaining complete patient information becomes easily practical.

Additional data stores that are not part of Figure 3.1 are daily schedule, Epidemiology, Caregiver, Appointment, Encounter, and SOAP.

Daily schedule stores data on physician-patient schedule for each day. It is created in sub process called Scheduling under Registration Process. The chart-room clerk can register newly arrived patients on patient registration. By checking for the patients with a repeated visit and newly registered patients from Patient Registration, and looking through the appointment data store to check if there exist patients appointed for a given day, the chart-room clerk creates physicians-patient daily schedule through scheduling process. In performing this process, the chart-room clerk also uses a data store called caregiver that holds list of every caregiver in the hospital.

Fig 3.2 Top-level DFD for the Proposed System

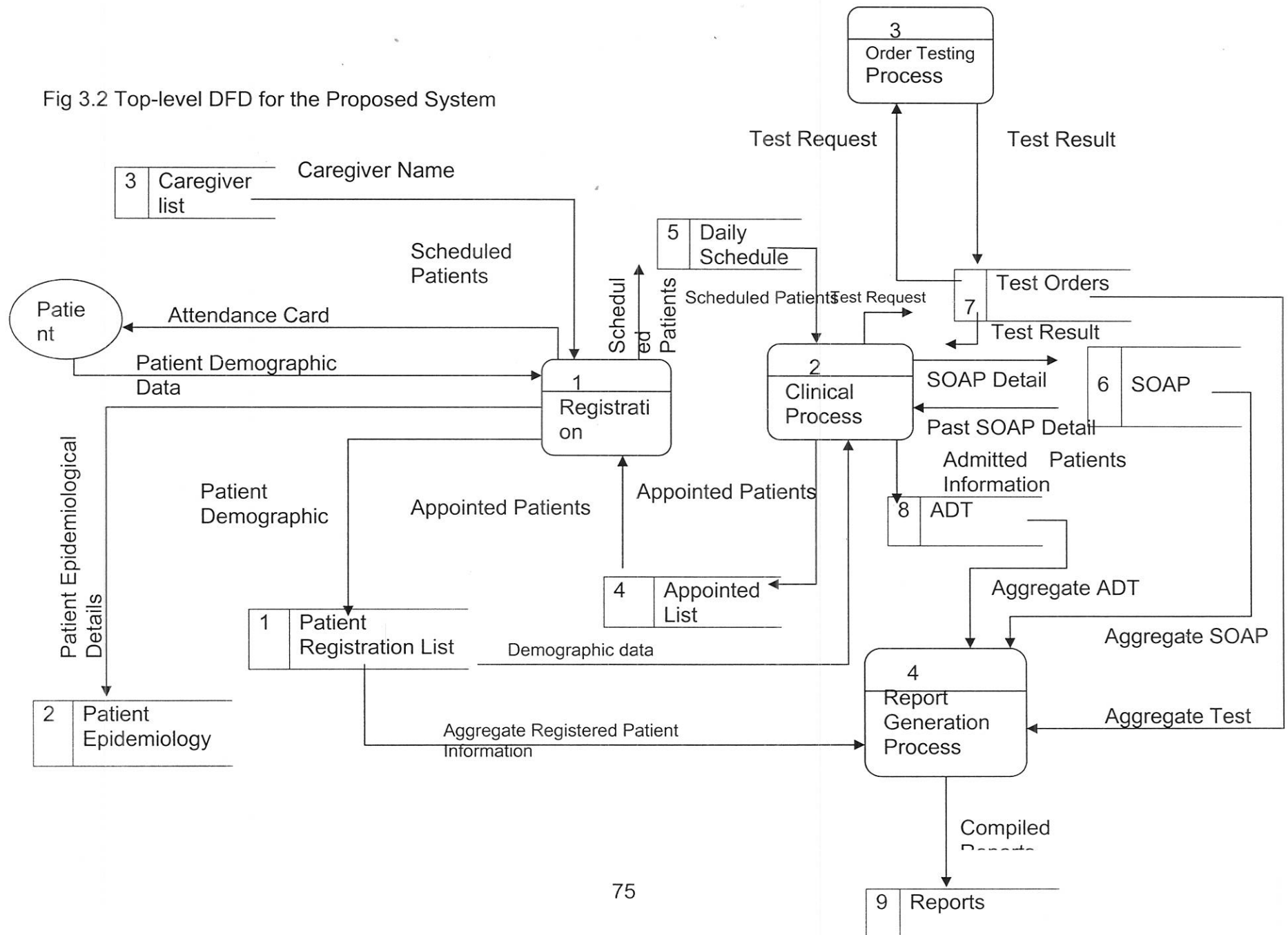


Fig 3.3 Registration Process

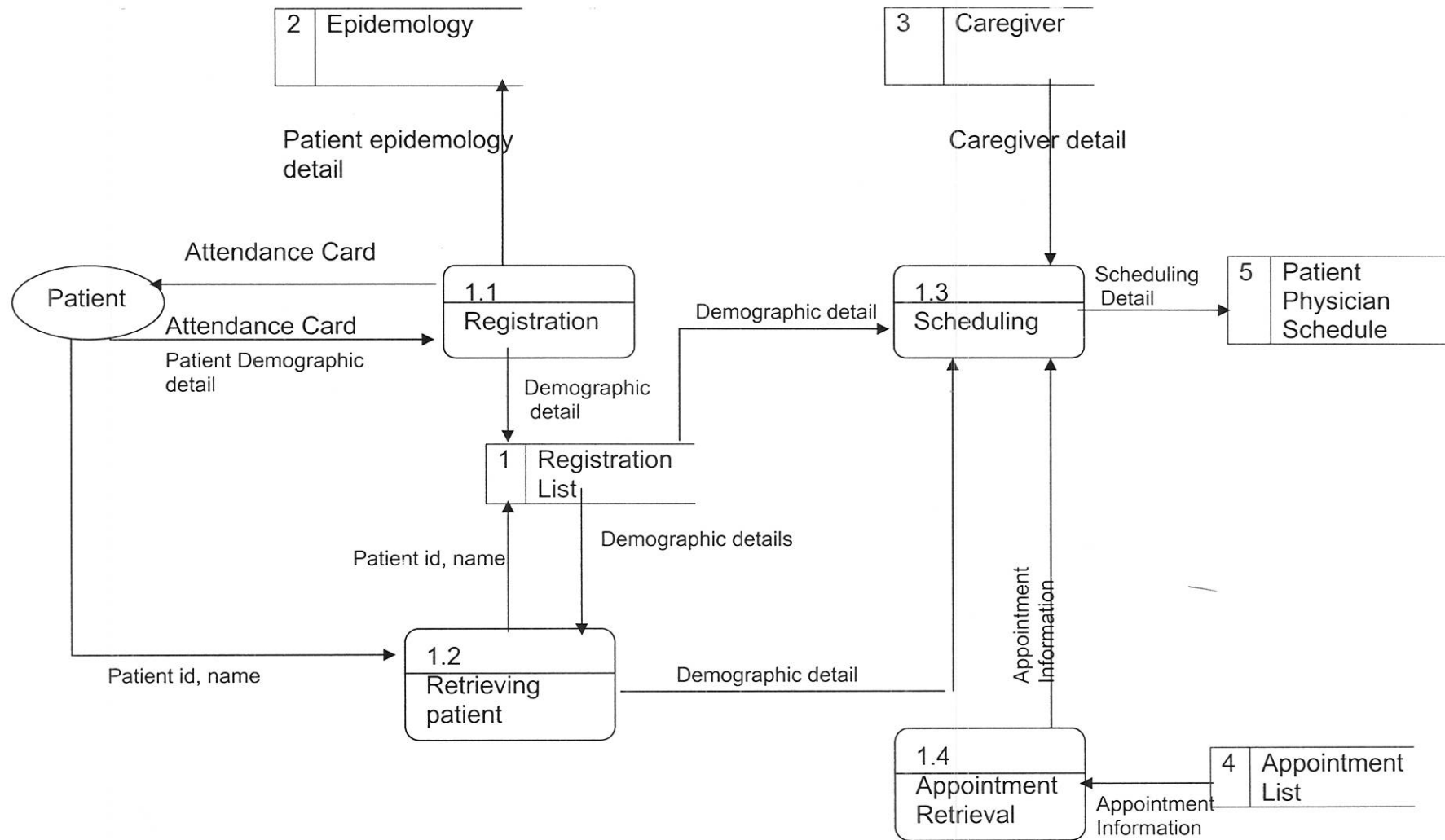


Fig 3.4 Clinical
Process

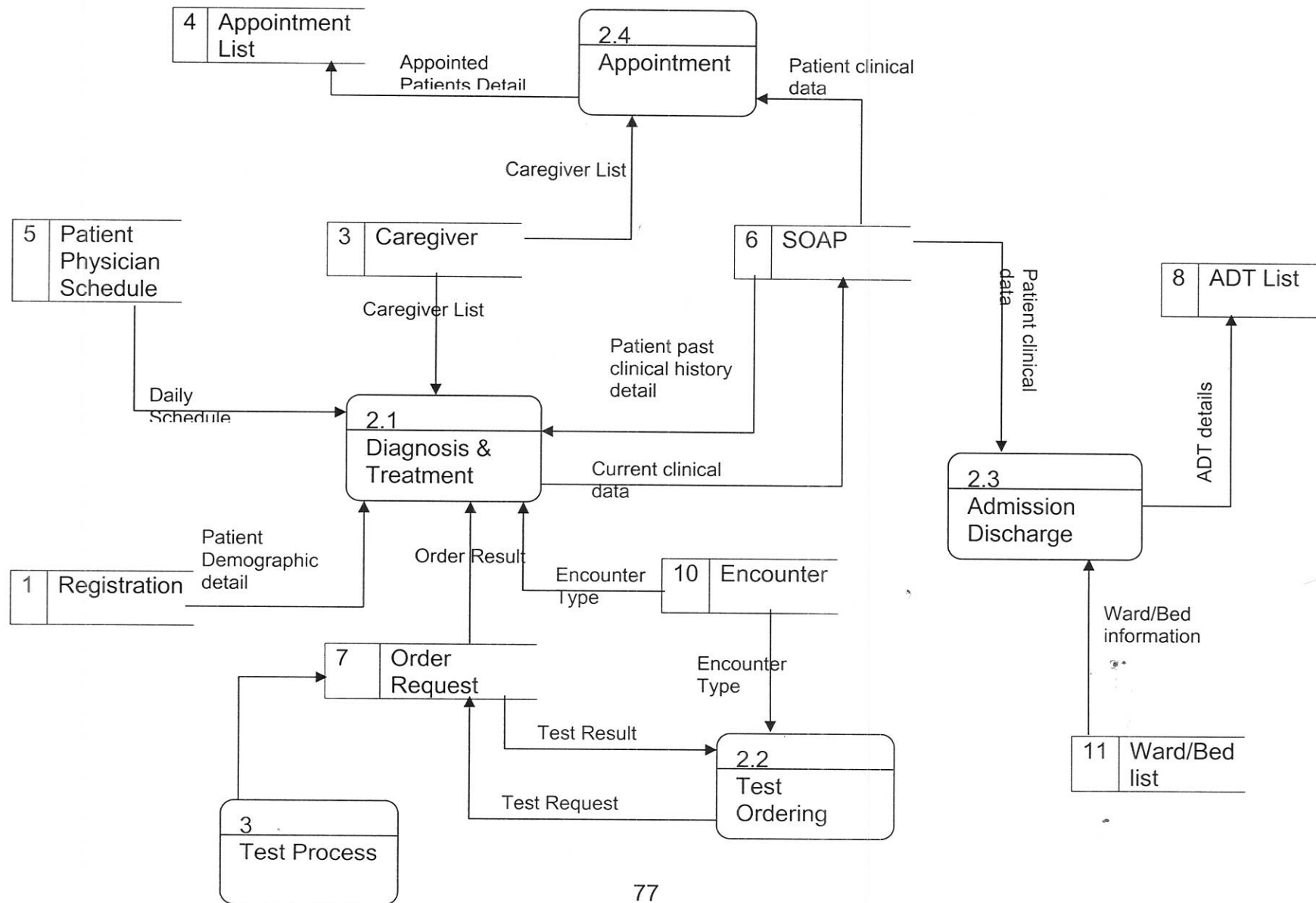


Fig 3.5 Testing Process DFD

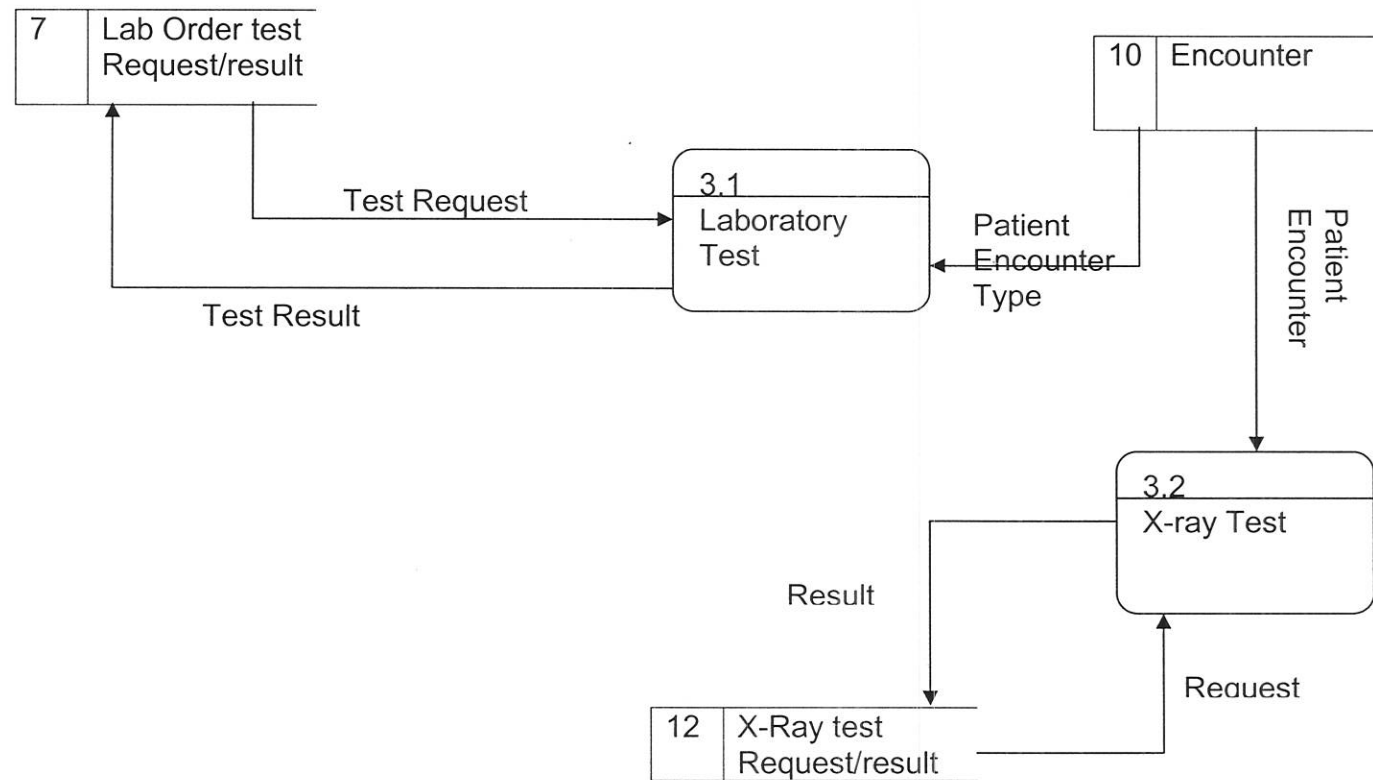
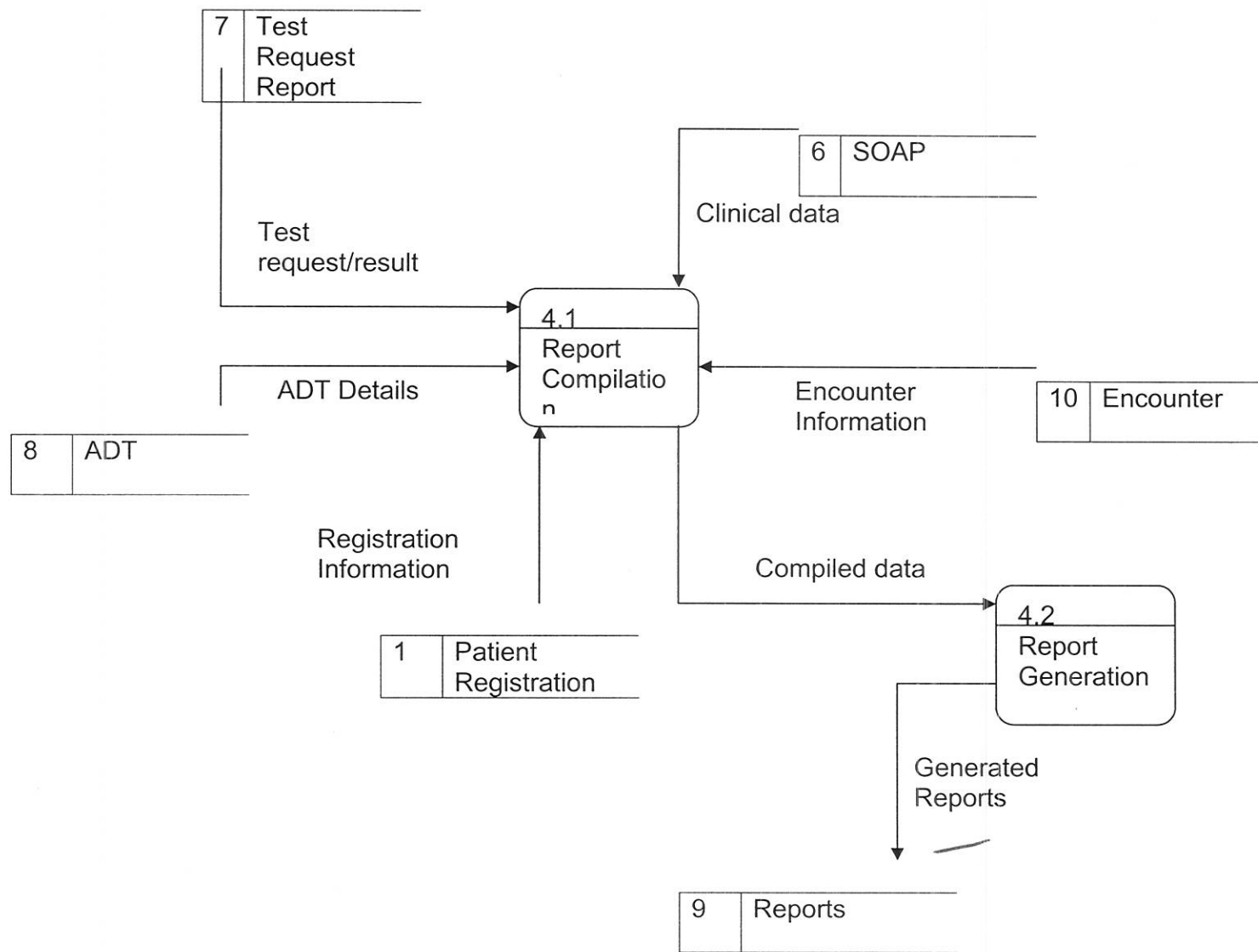


Fig 3.6 Report Generation process
DSD



Epidemiology data store stores some demographics and epidemiological data of patients who are from the BRHP study district and are members of the study project. This data is collected due to the need of BRHP that is aimed on integrating the clinical data collected here with the already available BRHP's epidemiological data. As clearly stated under section 2.3 of this study, one of the objectives of BRHP is to provide a study base for essential health research and intervention in the area. The availability and integration of the clinical data of its study population with its epidemiological data has invaluable contribution for the researchers in the area and on accomplishing the stated objective of BRHP.

Caregiver data store holds caregivers of the hospital with attributes that describe each caregiver uniquely from the other. It uses to make a daily schedule, to identify by whom the patient is appointed, and by whom the patient is seen in each encounter.

Appointment stores each appointed patient with the date of appointment and appointing caregiver. Chart-room clerks use it to make a schedule for patients who have an appointment with a specific caregiver in a specific date. Also a caregiver can check for his appointed patients for a given day from appointment data store.

A natural and straightforward way of organizing documents making up the patient chart is to categorize patient clinical information as to whether they apply to inpatient stay, outpatient visit or surgery known as encounter. Associating each clinical document with an encounter would enable a caregiver to select all patient clinical information associated with a particular encounter. Therefore, an encounter data store is added in the DFD of the new system.

The process of providing care for both inpatient and outpatient is the same and stated precisely as follows: The patient is identified and the problem referred to as the 'chief complaint' is recorded through various means, and the caregiver hypothesizes on the diagnosis. Based upon a selected diagnosis, a caregiver develops a treatment plan for the patient, or observes the results and may refine his or her hypothesis and diagnosis. After the caregiver observes the results, the diagnosis or treatment may be changed. If patient's case needs a follow up treatment, the caregiver can give an appointment for his patient to be returned on a specified date. On the patient's subsequent visits, the caregiver can examine the progress if any, or may change the treatment, or appoint the patient again. All the appointments made for each patient, with the caregiver who makes the appointment and current and appointed date are recorded on the Appointment data store. This process is often occurs over many encounters.

There is additional admission and discharge process in the case of inpatient care. Since the whole process is the same for the inpatient and outpatient care, except for the admission and discharge, which is applied only for inpatient case, these processes can be combined and called clinical process and another process known as admission and discharge can be added as a clinical sub process. The product of this process is ADT data store.

The process of admitting a patient can be an output of immediate outpatient service or a preplanned and appointed one. When a caregiver admits a patient, the encounter of the patient is changed as an inpatient. If a bed is available in a specific ward related to patient's case, admission process starts by registering patient chart number, admission date, admitting physician, ward and bed number and the like on the ADT. The process is completed when the patient is discharged after making a record of discharge date and discharge summary. Other than discharge summary, all clinical information of the patient is recorded in SOAP with the encounter being inpatient.

In order to accurately record the care process in the patient chart when there are many encounters for the same treatment, it is supposed to use the SOAP approach with some additions. SOAP stands for Subjective, Objective, Assessment and Plan. By incorporating some additional variables like allergies and immunization, patient clinical data can be handled properly and completely through SOAP data store.

Testing orders process has no significant change, except for the movement of order request/result forms. In the case of the existing system, the movement is accomplished by patients themselves or their relatives, and by nurses in case of admitted patients. The proposed system is aimed to send and also to receive the order forms electronically through a local area network. The requests and results of laboratory test and X-ray test processes are not identical both in their content and structure. The laboratory may use standardized data with some exceptions, while in most of the X-ray cases, plain text is used. Therefore, it requires a separate data store for both order test processes.

Report generation process can perform compilation and reporting processes. In the existing system, the data stores used for generating reports are used to be each department's register books and the compilation process is completely manual. In the proposed system, any available data store can be used for report generation and, the compilation and reporting processes are performed electronically.

3.3.3 Data requirements

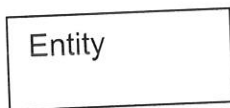
Data analysis is a method to define basic information units useful for the system, and identify the internal relationships or the cross identifier between them. Thus, data analysis means, to base on ideal point of view of data to consider an archive method for it in a perfect way. The data analysis technique lies in the way to put which information into which table. Data model displays the expanding of table

structure and the relationships between them and the entity relationship model support.

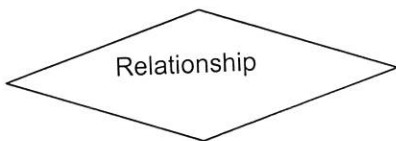
3.3.3.1 Entity relationship diagram

An entity relationship diagram (ERD) is a data-modeling tool that depicts the association among different categories of data within a business or information system. It does not imply how data is implemented, created, modified, used or deleted (Whitten et al 1994). ERD is one of the most useful models forming tools that describe stored data of a system at a high level of abstraction. Here, ERD is selected to be used as a modeling tool in our system study.

The following symbols are used for depicting entity relationship diagram on the data modeling process.



A data entity is anything real or abstract, about which we want to store data. The rectangle represents all occurrences of the named entity.



A data relationship is a natural association that exists between two or more entities. A diamond connecting the entities expresses it.

For the proposed information system of Butajira Hospital, the following entities and the relationships between them are identified and under each entity its data attributes are listed.

Patient: the patient entity has attributes Chart number, Full name, Sex, Date of birth, Age, Address, Religion, Marital status, Occupation, date registered, Payment status, Education, Ethnicity, allergies, immunization.

Caregiver: Identification number, Full name, Department, occupation, Qualification.

Department: department number, department name.

Bed: Ward number, ward name, bed number, bed status.

Encounter: Encounter type, encounter number.

Laboratory Order: lab order number, chart number, encounter type, Lab order, lab result, ordering caregiver, testing caregiver, date ordered, date of report.

X-ray Order: X-ray order number, chart number, encounter type, X-ray order, X-ray result, ordering caregiver, testing caregiver, date ordered, date of report.

Epidemiology: Household number, household representative name, chart number, reason for selecting Butajira hospital, other treated hospital, home distance from the hospital, amount paid for transportation, payment made by.

SOAP: chart number, encounter type, caregiver, Subjective (chief complaint, history of present illness, past medical history, family history, social history, marital history), Vital signs (height, weight, temperature, Heart rate, blood pressure), objective (physical examination, diagnostic test findings), assessment, diagnosis (ICD code), Plan (medications, procedures, clinical orders), date seen, status.

Appointment: chart number, date seen, Appointment date, reason, and appointing caregiver.

Schedule: chart number, date, scheduled to, department.

Admission: chart number, ward name, bed number, admitting caregiver, date admitted, date discharged, status in discharge, discharge summary, discharging caregiver.

3.3.3.2 Relationships connecting the different entities:

Patient – SOAP ✓

Patient – Epidemiology

Patient – Appointment

Patient - Schedule

Patient – Ward/bed ✓

Caregiver – Department ✓

SOAP – Encounter

SOAP – Caregiver ✓

SOAP – Lab test ✓

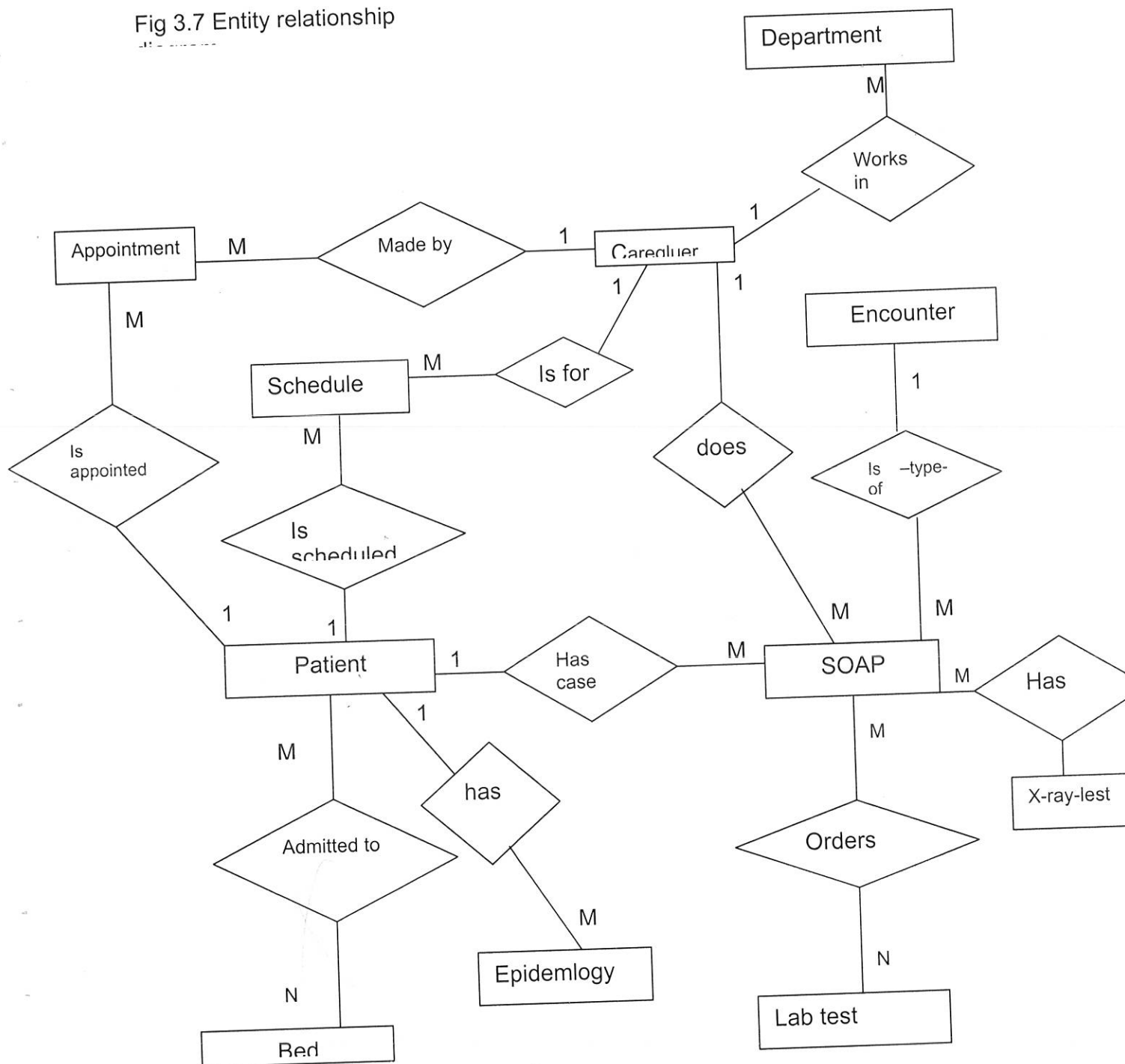
SOAP – X-ray test ✓

Appointment – Caregiver

Schedule – Caregiver

A detailed description of the whole entities, relationships and their attributes can be discussed in the next chapter.

Fig 3.7 Entity relationship



3.3.4 Transaction requirements

Frequently performed transactions of the proposed system are the following:

- The system should register newly arrived patients or patients with initial visit into patient table. Here, patient's demographics data is recorded. Every patient has to be assigned a unique identifier, i. e. chart number.
- It should be able to display list of appointed patients matching a particular date, caregiver, or department.
- It also has to list out scheduled patients for a specific caregiver on a given day.
- Should accept updates and additional insertions of patient medical information entered by authorized users.
- Accept and retrieve patient's epidemiological data with any additional clinical information as needed.
- The system should be able to retrieve data on a single patient, specified through his chart number. The data can be patient's demographics information, retrospective medical history, or a combination of two.
- Also it should be able to retrieve data by identifying a set of patients, who happen to match a particular attribute or set of attributes. This can be done, for instance, for patients having similar encounter, identified with the same disease, having got the same treatment, seen by a particular caregiver, of the same sex group, or within the same age group.
- Accept and display laboratory and X-ray request orders and also results.
- Display the status of beds in each ward as being occupied or vacant.

- Generate information on admitted patients, their status on discharge, calculate total number of days on admission, and display their discharge summary.
- Produce number of admitted, cured, or died patients in the hospital within a given time period.
- Provide disease distribution across the community patterned by age, sex, occupation etc.
- Generate up-to-date and aggregate data for the upper management or decision-makers according to specified time limit or gap. It also should provide summary data on works performed in departments, number of patients seen as an inpatient, outpatient, or emergency patient in a limited period of time. All these are necessary for report generation purpose.
- Provide researchers with the necessary data according to their need based on the approval by the hospital management.

3.3.5 User interface requirements

Especially for on-line systems, the development of user interface (the dialogue between the end-user and the computer), and its design requirements are critical activities. The idea behind user interface design is to build an easy-to-learn and easy-to-use dialogue around the input and output screens. It is trying to make it easy for the end-user to understand what the screen is displaying at any given time.

The user interface may be defined in terms of screens, written requirements for the interface or both. When user interfaces are defined in terms of screens without any underlying functioning code or database, this is referred to as prototyping.

The user interface of the proposed system must be easy to use, i.e. user-friendly interface and hide the complexities of whatever storage system is chosen for patient medical record. A graphical user interface strategy can be used on developing the interface. Every part of the user interface shall have a common look and feel. This makes the interface to be learned by the users easily and in a short period of time. It is not to bother users in learning different formats and functions of the interface.

One basic principle of quality software design is to have a consistent and useable set of screen display and input standards as this decreases the complexity of the system and makes the system more intuitive and useable for the user. Therefore, the following important points have been considered in designing the user interface for the new proposed system.

- It should never get in the way of the caregiver doing his/her job. It has to be transparent so a user can forget it, use it intuitively, and concentrate on his job.
- Make the most used part of the system very simple to use, while hiding the most complex parts. Make the fundamental functions obvious and easy to find

and use. It is also nice to have powerful complex functions, but they should be hidden from users who do not need them.

- Consistency: have absolute consistency of everything, so users know exactly what to expect of the system at all times (e.g., have scroll bars, list selections, etc., all work the same).

3.3.6 Security and backup requirements

A software system is secure if you can depend upon it to behave as you expect, and security can be defined as safeguards applied to an automated system to ensure that it behaves as expected.

Security of electronic medical record system requires various technical, physical and administrative security measures be combined to protect the privacy, integrity, and availability of patients' medical records. Thus, security measures would:

- Govern the transmission and accessibility of patient medical record information to individuals, organizations and to Medicare, disallowing access to those not authorized to view it,
- Protect against destruction of medical records,
- Protect against the unavailability of a system providing access to medical record information.

Implementation of security measures in Butajira Hospital automated patient medical record system considers the following points:

- Person authentication: the system has to know a person seeking a service through a predefined password.
- Authorization: it has to permit or allow the user access to the available information by applying access control on the information and determining how this information can be accessed (e.g., a user can read, add, and replace information and another user can only read). Authentication and authorization for a person happens when the user logs on.
- Confidentiality is also another concern of the new system. It has to ensure that the patient medical records have to be only seen by the people authorized to see it.

Another aspect of security in the system is the availability of the service. The system does not go down, and complete functioning of the system is available and required at all times, for 24 hours, 7 days of the week. Unavailability of the system occurs by hardware failure, through virus attacks or power failure. Subscribing and updating anti-virus software, and using uninterrupted power supply (UPS), and power generator are methods to overcome the problem.

Disaster recovery is also an important issue of security. It is off-site duplication of medical record information for backup purpose or to use backup computer systems for access to the medical record. Disaster recovery is making a back up of information, in our case, the patient medical record and makes the information

available after an occurrence of a disaster. The disaster can include fire, earthquake, major criminal act and other disasters that destroy the computer system.

3.3.7 Alternative solutions

In this section, the focus is on essential network modeling, that is the modeling of business network requirements independent of their implementation. There are many network designs for the automated patient medical record. Here, three network designs can be discussed and one possible design is selected for our proposed system.

3.3.7.1 Centralized system.

Centralized computing is an application architecture that uses a single computer, usually located in a central data processing center. The computer is usually a mainframe or mini-computer that provides access to multiple simultaneous users. Users communicate with the computer through terminals.

A centralized system simplifies databases by centralizing them and is the least risky because it uses technology that has been around many years. This system simplifies the protection of privacy, since certain individuals may have access to secured information. Both material and human resources are concentrated in a specific central area. Therefore, such a system supports tight managerial control.

Its disadvantages are that it is difficult to make full use of graphical user interface (GUI), it requires a very expensive computer and networks, a very expensive support staff, and it has potential bad response time due to the processing power being concentrated to a single computer.

3.3.7.2 Distributed system

Distributed processing allows allocating data processing, input/output, and storage to multiple computers and to exchange data and information among those computers. A key result of distributed processing is distributed data storage. Data can be located closer to departments or users while preserving the ability to share some central data and exchange any data between locations.

The advantages of this system are: it is relatively flexible for change, it also provides quicker access and results, and its structure is relatively less exposed to a single point failure.

Obvious disadvantages of distributed system are problems on network security, data integrity, and duplication of efforts.

3.3.7.3 Client/Server system

In client/server computing, an applications processing is distributed among multiple computers. Server computers will provide shared or common services to the application or system. An example is a database server whose job is to

process reading and writing to a database. The client computers perform local processing to the end-users. Clients and servers interact through cooperative processing to form a complete application.

Processing for shared databases should be done on servers and the user interface, input and editing should be performed in client workstations.

There are several reasons for the growing interest in client/server computing:

Clients are increasingly powerful and cheaper than mainframes and mini-computers; server computers are becoming powerful enough to handle the workload of many clients, again at a lower cost than mainframe and mini-computers. In addition graphical user interfaces are said to make applications easier to learn and use, and client/server architecture is said to be cheaper and easier to construct and maintain.

3.3.7.4 Selected alternative solution

Despite the functional and flexibility problems of choice 1, it is not the right choice for Butajira Hospital due to the cost it incurs for both the expensive computers and supporting staff. Besides, the difficulty to make full use of GUI makes it inappropriate system.

Choice 2 seems ideal system. But, since it is a distributed system with central and local systems, it needs to construct local databases for several departments.

This system is preferable for businesses that operate in multiple locations. In our case, the Butajira Hospital is located in a single campus, and there is no need of designing multiple databases for each department. Therefore, this choice is not our preference.

The last choice, i.e. choice 3 becomes the right one for the proposed new system. It is due to the concerned hospital is situated in a campus suitable and appropriate for making a single local area network, in addition of all the advantages of the client/server architecture. A single server with workstations in some selected departments is enough in the present situation. One central patient medical database can be stored on the server and other clients can use the database through the network.

In order to use the client/server architecture, it is necessary to have a network connection throughout the hospital campus. A local area network with a continuous Ethernet connection is vital. Personal computers have to be available in clinical departments, registrar office and in the wards and these computers have to be connected to the server through the local area network.

A point that should be mentioned here is the problem of entering all the patient medical records. From the conducted interview with the users, it was observed that the idea of entering the clinical data by doctors is not accepted due to the workload they have and the required additional time to enter the data. Most users

suggest entering the data to the computer by nurses, some users indicate to use the registrar department staff and others suggest hiring a staff with basic computer skills for this purpose.

The ideal and temporary solution for the problem is to assign nurses responsible to enter the data in clinical departments. One laboratory technician and one X-ray technician also have to be assigned in their departments' computers for performing the data entry process. Also a clerk from the hospital registrar can enter the data on the registration and scheduling data of the patient. The doctors use the system to retrieve information on a single or group of patients, and on the process, they can start to enter clinical information. Soon they will become familiar to the system's features and observe how the system is easy to use and fast to record patient's information. Since the system reduces entering redundant data and its GUI becomes attractive and entering data by selection from drop-down list rather than keyboard typing make the doctors to prefer using the system in near future.

3.4 System constraints

There are several issues that have constrained the effort to build and utilize effective electronic patient medical record system. In our case, the following points can be mentioned being the main constraints.

3.4.1 The need for standardized clinical terminology.

The richness and variety of medical concepts are currently major barriers to formulating a widely accepted and standardized clinical vocabulary that is suitable for encoding patient-specific information in electronic medical record. Evolving standards like ICD10 and Read Codes are not yet sufficiently accepted or comprehensive to meet the full needs of the medical record.

This is a problem that happens in this study on creating the electronic medical record. Only a limited part of ICD9 is used to record patients' disease.

3.4.2 Data entry problem

Integrating computer use with the workflow of busy clinicians is inherently challenging. This problem can be seen as technological challenge. Healthcare presents a somewhat difficult environment for computing compared to other industries. For example, most healthcare services are not desk oriented. Instead they can take place at bedside, in operating rooms, or in examination rooms. Computers that can be used comfortably in these environment have been slow to

arrive and costly. This is also a challenge faced in our system on entering data by clinicians in relation to their work place.

3.4.3 Data capturing format

The capturing format of clinical data is an important problem in the design and development of CPR. Clinical data can be captured as free text, coded and combination of both.

In relation to CPR, free text has the flexibility and the richness of expression, while coded data capturing has the advantages of acquiring classified and standardized data, thus it is easy to retrieve data and query the database for specific information.

For our proposed information system, the combination of both free text and coded data can be used to represent patient clinical data, by looking when and where it is necessary to exploit the advantages of each representation.

For the sake of consistency and ease, some of patients' data can be entered by selecting from the available options of combo boxes or drop-down lists associated with those attributes such as occupation, religion, encounter type, department, disease and status of the patient. For other fields like subjective, objective, treatment, plan and discharge summary, lengthy free text with varying length up to 255 characters can be allowed to be entered by caregivers.

This time, appropriate medical narratives can be used for recording, for instance, PE for Physical examination, ROS for review of systems under the attribute objective. This recording system is useful for standardizing free text entry, and making the record easily understandable for caregivers.

3.4.4 Physician acceptance of the automated patient medical record system.

Automation of the patient medical record will not be successful unless physicians and other caregivers use the system. Physician usage is particularly important. Studies have shown that physician even more so than other caregivers, are reluctant to use automated clinical information systems. A major effort must be made by the hospital's management to convince physicians and other caregivers to use the automated patient medical record system properly and effectively.

To overcome this bottleneck, additional design features have found to be necessary such as making the data entry process so easy for caregivers and creating an attractive, simple to learn, and easy to use user interfaces. This point is also the concern of this study that has got considerable attention.

3.4.5 Continuity of the paper chart

Another obstacle in automation of the patient medical record is that the paper patient chart cannot be gotten rid of, at least for some period of time. Until the patient chart and all clinical processes are completely automated in the hospital, and until some part of the patient chart are converted to electronic format, the

patient chart must continue to be maintained. Therefore, it can be considered as a constraint in automation of patient record, since patient information is recorded both on paper chart and electronic database that causes duplication of efforts and consumption of a great deal of time of caregivers.

3.4.6 Technical obsolescence

Because technology needed for automation of the patient medical record is changing so rapidly, and because standards for patient health record have not been agreed upon as of yet, any system to automate the patient medical record has the potential of becoming quickly obsolete with upcoming technical changes and changes in standards. This is another potential obstacle to the automation of the patient medical record.

3.4.7 Security and confidentiality

Another obstacle to the automation of the patient medical record is that patient medical record information would potentially become available to more people, and there is a greater potential problem with the security and confidentiality of patient medical information. For example, the patient must be protected against the fear of being discriminated against because he is tested HIV positive, and the fear of being harassed due to having an abortion, which is mainly caused by releasing patient medical record information to an unauthorized person.

A system that allow access to the patient medical record by password must be established, and also there must be hierarchy of privileges, i.e., a method of controlling what information a user is allowed to access, change, or modify.

The automated patient medical record system may become unavailable at any time. If the system came down, all the patient information that the clinical staff was using might suddenly disappear.

Possible solutions can be to periodically print very important medical records, or making a periodic backup of the patient records to be used by other local computers. At systems down time, paper records can be used to enter the data latter when the system comes back. Methods of assuring the automated system do not go down for very long time often a power failure are to provide emergency power to the server via generator, and UPS (uninterrupted power supply) for workstations.

Backing-up the patient record on constant interval in daily, weekly or monthly manner is also a solution for disaster recovery purpose.

CHAPTER FOUR

4 PROTOTYPE SYSTEM DESIGN

4.1 INTRODUCTION

Prototyping refers to the activity of developing a prototype and the use of a prototype, a part of a deliberate effort to simplify, speedup, and reduce the costs of development. The essential concept is that it is a working model. A prototype is a simplified model of a system or part of a system. It is possible to simplify function, performance, appearance, or quality as long as the basic behavior remains the same. It should be seen as a tool for simplifying and clarifying the communication between the designer and the user.

The purpose of prototyping is to shorten development time and reduce the cost of development. There are several advantages associated with prototyping. Chiefs among them are speed, flexibility, simplicity, ease, and lower cost of development.

The work of development and evaluation of prototype is an iterative process, and the future users of the system test it. System analysts can quickly build prototypes using modern forth generation languages and application generators.

The prototyping process can be described as follows.

- A prototype database would be designed, using the 4GL underlying database impose. The prototype database would be loaded with the sufficient collection of test data.
- Prototype outputs can be created using the report generator of the 4GL.
- Prototype inputs can be created and generated using the screen or report generation of the 4GL.

Prototyping does consolidate portions of the definition, physical design and construction phases of the traditional life cycle. Therefore, in designing the proposed new information system, prototype system design strategy has been used in order to exploit the above listed advantages of prototyping.

4.2 DATABASE DESIGN

A concept of data organization, a database approach, is today replacing file systems in many organizations. Database systems have a single data pool that is shared by many users and applications. There is only one representation of each data item within this shared data pool. This avoids redundancy of storage and data inconsistencies since the value of each data element is generated, validated, and stored just once.

A specialized set of programs, called a Database Management System (DBMS) is generally acquired to help computer users access and manipulate the data in a database system. Most DBMSs include a special query language that allows users to access the database, and retrieve information from a database without having to write a program.

For the proposed new information system, a prototype database design method can be used. Under this section, it was tried to see the conceptual database design, then the chosen DBMS, logical database design, database normalization and integrity constraints comes accordingly.

4.2.1 Conceptual database design

The goal of this phase is to produce a conceptual schema for the database that is independent of specific DBMS. The intent of conceptual design is to keep it as free as possible from the implementation details.

4.2.1.1 Entity types

Patient: General term given to patients coming to Butajira Hospital to get medical services.

Appointment: List of patients appointed by caregivers for a specified date.

Schedule:	Daily list of patients allocated for or scheduled to each caregiver on a given day to get a service.
Epidemiology:	Term used to describe patients from BRHP who come to get a service in Butajira Hospital.
Bed:	Ward names and bed number of beds available in the hospital where the patient is admitted.
Caregiver:	List of employees of the hospital who have participation on the process of patient care.
Department:	Describes available departments in the hospital.
Encounter:	Type of encounter for each visit of a patient served in the hospital.
SOAP:	General term use to describe detailed patient's medical case for every visit.
LabTest:	Considers laboratory test requests and results of patients.
X-rayTest:	X-ray test requests and results of patients.

4.2.1.2 Relationship types and their cardinalities.

Table 4.1: Entity relationships and cardinality

Entity type	Relationship type	Entity type	Cardinality
Patient	is-appointed	Appointment	1:M
Patient	is-scheduled	Schedule	1:M
Patient	has	Epidemiology	1:M
Patient	has-case	SOAP	1:M
Patient	admitted-to	Bed	M:N
Appointment	made-by	Caregiver	1:M
Schedule	is-for	caregiver	1:M
Caregiver	works-in	Department	1:M
SOAP	is-type-of	Encounter	1:M
Patient	orders is	LabTest	M:N
Patient	has order	X-rayTest	M:N

According to the relationship types and their cardinality of table 4.1

Patient/Appointment relationship is a one-to-many relationship. This means that a patient may have one or many appointments in different times. But a single appointment is done for only a single patient. No single appointment is given for two or more patients.

Patient/Schedule relationship is also one-to many. It is possible for a patient to have several schedules, but a particular schedule is done for one patient.

Patient/Epidemiology relationship is one-to-many relationship. A single epidemiological record belongs to a single patient, but a patient may have more than one epidemiological record on different visits.

Patient/SOAP relationship is also one-to-many relationship. Patient can have several SOAP records through his lifetime, while a single SOAP data is about a patient.

Patient/Bed relationship is many-to-many relationship. A patient may admitted to several beds in different wards and a bed can be used by many patients in different times.

Appointment/Caregiver relationship is a one-to-many relationship. Since a caregiver can make many appointments but a single appointment is made by a single caregiver. It is 1:M relationship.

Schedule/Caregiver relationship is one-to-many relationship. A particular schedule can be scheduled for only a single caregiver, but a caregiver may have several schedules in a given day.

Caregiver/Department relationship is also one-to-many relationship. A caregiver belongs to one department; however several caregivers can work in a single department.

SOAP/Encounter relationship is one-to-many relationship. An encounter can be assigned for many SOAPS, while a single SOAP has only one type of encounter

Patient/Lab Test relationship is a many-to-many relationship. It is due to a patient may have more than one lab test and a single lab test type can be done for many patients.

Patient/X-ray Test relationship is also many-to-many relationship. One patient can possibly have many X-ray tests, and an X-ray test may be done for several patients.

From the above description, one can observe the existence of three many-to-many (M:N) relationships. These are Patient/Bed, Patient/LabTest and Patient/X-ray Test relationships.

In relational database design, ER-to-Relational mapping, when we face to many-to-many relationships, we have to create a new relation to make the M:N to two 1:M relationships. Accordingly, for Patient/Bed relationship, the Admission relation or table is created. This time we have two relationships, i. e. Patient Admission that is 1:M, and Bed/Admission, which is also 1:M.

Appointment

chno
dateSeen
dateAppo
appoReason
cldno
department

Schedule

chno
dateSche
cldno
department

Epidemiology

chno
houseHoNum
houseHoRepName
reasonSelectHospital
otherTreatedHospital
homeDist
amPayTrans
payBy
dateSeen

Bed

wardName
bedNum
bedStatus

Caregiver

idno
cName
department
occupation
qualification

Department

deptNum
deptName

Encounter

eNum
eType

SOAP

chno
eType
cldno
subjective
vitalSigns
objective
assessment
diagnosis
plan
status
dateSeen

LabOrder

labNum
chno
eType
labRequest
labResult
orderCidno
testCidno
dateOrder
dateReport

X-rayOrder

xNum
chno
eType
xRequest
xResult
orderCidno
testCidno
dateOrder
dateReport

Admission

chno
wardName
bedNum
dateAdmit
admitCidno
dateDisch
dischStatus
dischSummary
dischCidno

Lab Test

labNum
labTestName

X-ray Test

xNum
xTestName

Disease

diseaseCode
DiseaseName

4.2.1.4 Attribute domains

<i>chno:</i>	Any combination of alphanumerical values adopted by the hospital to uniquely identify each patient.
<i>patientName</i>	Series of character strings representing patient's name and father name.
<i>sex</i>	Single character entry describing patient's gender which is either "M" or "F".
<i>dob</i>	A valid date format for birth date of the patient.
<i>age</i>	A derived attribute (present date deducted from date of birth) which tells us patient's age.
<i>address</i>	patient's present address, which is a combination of patient's Zone, District, Kebele or peasant association and house number accordingly separated by comma.
<i>religion</i>	Patient's religion which is one of the following; Muslim, Orthodox christen, Catholic Christen, Protestant Christen, Wakifecha, Pagan, Other.

marStatus Patient's marital status, one of these; Single, married, divorced, widowed, Child.

occupation A field that contains one of the following patient's occupation; peasant, merchant, unemployed, teacher, student, prostitute, bar lady, soldier, daily laborer, civil servant, house wife, other.

dateReg a valid date format for patient's first registration date in the hospital.

payStatus payment status of the patient; one of the three options; paying, free or sponsored.

education educational status of the patient with several options.

ethnicity Patient's ethnic origin.

dateSeen a valid date format for patient visit date.

DateAppo a valid date format for patient appointment.

appoReason Character string states reason for appointment.

<i>cldno</i>	caregivers identification number that uniquely identify each caregiver in the hospital.
<i>dateSche</i>	a valid date format for scheduled patient in a specific date.
<i>department</i>	name of a department in the hospital.
<i>houseHoNum</i>	Unique number assigned for each household under Butajira Rural Health Program.
<i>houseHoRepName</i>	full name of a household representative for patients from Butajira Rural Health Program.
<i>reasonSelectHospital</i>	Reason given by patient for selecting Butajira Hospital to get a service.
<i>otherTreatedHospital</i>	Name of a hospital other than Butajira Hospital where the patient has got a service.
<i>homeDist</i>	Distance of patient's home from the hospital usually in KMs.

<i>amPayTrans</i>	Amount of money paid for transportation to arrive to the hospital.
<i>payBy</i>	describes by whom payment for transportation is covered.
<i>wardName</i>	one of Surgery, pediatrics, medicine, or gynecology and obstetrics wards of the hospital.
<i>bedNum</i>	a numeric value assigned for each bed in the hospital.
<i>bedStatus</i>	a character tells us the current status of a bed; i.e. occupied or vacant.
<i>cName</i>	This field holds caregiver's full name.
<i>occupation</i>	Different from patient's occupation, and it describes caregiver's occupation like doctor, nurse, lab-technician, health officer, health assistant, etc.
<i>qualification</i>	describe a specific caregiver's qualification.

deptNum numeric value assigned for departments to uniquely identify them.

deptName name of departments of the hospital.

eNum encounter number assigned for each encounter type.

eType type of patient's encounter, holds one of the following; outpatient visit, inpatient stay, or emergency.

subjective This field contains patient's subjective history that the caregiver obtains from asking his patient. The following are parts of this attribute, which are recorded for every patient separated by comma (CC For chief complaint, HPI for history of present illness, PMH for past medical history, FM for family history, SH for social history, MH for marital history, and ROS for review of systems).

allergies Contains list of allergy drugs for a patient.

immunization This also contain patient's list of immunity.

vitalSigns

These are vital signs of a patient recorded as follows separated by comma. (T for temperature, RR for respiratory rate, BP for blood pressure, and PR for pulse Rate).

objective

physician's objective findings are stated here as physical examination, and diagnostic test findings separated by comma (PE for physical examination and DD_x for differential diagnosis with several body parts represented by additional narratives).

assessment

it is for assessment of patient problems, and diseases (D_x for diagnosis).

diagnosis

This field holds patient's identified disease according to ICD9 code.

plan

clinical orders and medication procedures are under this field, stated separated by comma (I_x for investigation and R_x for treatment).

status

for patient current condition having values like same condition, worsen, died, improved.

<i>labNum</i>	number assigned for each lab test types.
<i>labRequest</i>	type of ordered lab request selected from options.
<i>labResult</i>	a result for each ordered lab requests.
<i>orderCidno</i>	id number of caregiver who makes a lab order.
<i>testCidno</i>	id number of caregiver who make a lab test.
<i>dateOrder</i>	an order date for lab test.
<i>dateReport</i>	lab result reported date.
<i>xNum</i>	a consecutive number assigned for each x-ray test type.
<i>xRequest</i>	type of x-ray request selected from options.
<i>xResult</i>	result of x-ray order request.
<i>admitCidno</i>	id number of caregiver who has admitted a patient.

<i>dateAdmit</i>	patient's admission date.
<i>dateDisch</i>	discharging date of a patient from the hospital.
<i>dischStatus</i>	Patient's status on discharge, which can be; worsen, same condition, died, or improved.
<i>dischCidno</i>	id number of caregiver discharged the patient.
<i>DischSummary</i>	Patient's summary note on his/her discharge completed by discharging caregiver (H _x for history, PE for physical examination, I _x for investigation, D _x for diagnosis, R _x for treatment, Course, and DD for discharge diagnosis).
<i>labTestName</i>	Name for a laboratory test.
<i>xTestName</i>	Name for x-ray test.

4.2.1.5 Entities and their primary and alternate keys.

Table 4.2: Entities with primary and alternate keys

Entity	Primary key	Alternate key
Patient	chno	
Appointment	chno, dateSeen	chno, dateAppo
Schedule	chno, dateSche	
Epidemiology	chno, dateSeen	houseHoNum, dateSeen
Bed	wardName, bedNum	
Caregiver	idno	
Department	deptName	deptNum
Encounter	eType	eNum
SOAP	chno, disease, eType, dateSeen	
LabTest	labTestNum	
X-rayTest	xTestNum	
Admission	chno, dateAdmit	chno, dateDisch
LabOrder	labNum	
X-rayOrder	xNum	

4.2.2 Choice of a DBMS

In chapter one, on the review of related literature section, a detailed discussion has been made on the issue of developing health information system in developing countries. Standardized digital form of storing patients' medical information system does not yet exist in the market, and the available ones are not applicable or compatible to the real situations like economic, information technology, and healthcare infrastructure of developing countries like Ethiopia.

Appropriate software packages for African hospitals and health centers cannot be found off the shelf. The requirements are too different for the African hospital to be able to benefit from an American or European hospitals application without major adjustment, and the situation is even more problematic in primary health care. Therefore, appropriate information system for African healthcare must be developed locally (Soriyan, 1999).

On the basis of the points discussed in section 1.8.5 and 1.8.8, and the above paragraphs, it was recognized that the unavailability of a readymade off-the-shelf software applied for the purpose of this study. Therefore, developing the system in-house using one of off-the-shelf DBMS application software becomes the appropriate choice. Hence, it was decided to develop the CPR information system for Butajira Hospital in-house by using the structured systems analysis and prototype database design methodologies.

The idea and practice of developing the application software or database locally through an in-depth analysis of the real economic, social, cultural, and educational situations of the intended organization is one of the major issues that have been given great emphasis on this study.

The selected data model to be used in our database is a relational data model. In this data model related tables will be used to store information about patients' medical and demographic history.

The database created in this study uses one of the off-the-shelf database software. The selected DBMS is a relational database management system (RDBMS).

Microsoft Access 2000 application is selected in order to create the necessary database in-house. MS-Access is selected to perform the required system functions with cost-effective and easy to use manner. Since this software is relatively cheap, easy to learn through its GUI features, and familiar to users of the system, it was determined that Access is the best solution for the intended purpose. MS Access is a GUI application built on standard MS Windows-based equipment. This architecture was chosen because the GUI aspect would be more familiar to most users of computer systems, and window-based computer hardware could be reused for other purposes. For our Client/Server architecture, it is possible to convert or export the Access database to SQL database to be

used as a back-end and the Access database can be used as a front-end, so that we can exploit its rich graphical user interface features. Additionally, MS-Access is the popular database application, even countrywide than other types of Relational Database Management Systems. This by itself can shortened and makes simple the user training process.

4.2.3 Logical database design

Logical database design consists of two parts: (1) the identification of business objects whose information is to be stored on the database, and the identification of the relationships between this objects, and (2) the identification of sets of data (tables or records) making up the database and the format of data elements making up each set of data. The objects and relationships can be described by the entity relationship diagram (ERD).

On building the prototype database, a total of seventeen relations or tables have been used and also seven lookup tables are created to be used as options to be selected as attribute values for those tables. This lookup tables can be referenced by more than one attribute of different tables where necessary. The tables are described logically as follows.

Patient (chno, patientName, sex, dob, age, address, occupation, education,
religion, ethnicity, marStatus, payStatus, allergies, immunization, dateReg)
primary key: chno

Department (deptNum, deptName)

Primary key: deptName

Encounter (eType, eNum)

Primary key: eType

SOAP (chno, eType, cldno, subjective, vitalSigns, objective, assessment,

diagnosis, plan, status, dateSeen)

Primary key: chno, eType, diagnosis, dateSeen

Foreign key: eType REFERENCES Encounter (eType)

Foreign key cldno REFERENCES Caregiver (idno)

Foreign key: chno REFERENCES Patient (chno)

Foreign key: diagnosis REFERENCES Disease (diseaseCode)

LabOrder (labNum, chno, eType, labRequest, labResult, orderCidno, testCidno, dateOrder, dateReport).

Primary key: labNum

Foreign key: chno REFERENCES Patient (chno)

Foreign key: labRequest REFERENCES Lab Test (labNum)

Foreign key: eType REFERENCES Encounter (eType)

X-rayOrder (xNum, chno, eType, xRequest, xResult, orderCidno, testCidno, dateOrder, dateReport).

Primary key: xNum

Foreign key: chno REFERENCES Patient (chno)

Foreign key: xRequest REFERENCES X-ray Test (xNum)

Foreign key: eType REFERENCES Encounter (eType)

Admission (chno, wardName, bedNum, dateAdmit, admitCidno, dateDisch, dischStatus, dischSummary, dischCidno).

Primary key: chno, dateAdmit

Foreign key: chno REFERENCES Patient (chno)

Foreign key: bedNum REFERENCES Bed (bedNum)

Lab Test (labNum, labTestName)

Primary key: labNum

X-ray Test (xNum, xTestName)

Primary key: xNum

Disease (diseaseCode, diseaseName)

Primary key: diseaseCode

Table 4.3: Logical database definition

Entity	Attribute name	Description	Data type & length	Null
Patient	chno	A unique chart number for patients	Variable character (10)	No
	patientName	Name of a patient	Variable character (30)	No
	sex	Patient's sex	One field character	No
	dob	Date of birth of a patient	Date/time	No
	age	Patient's age, derived attribute	Numeric (3)	No
	address	Patient's present address	Variable character (50)	Yes
	occupation	Patient's present occupation	Variable character (20)	Yes
	education	Patient's educational status	Variable character (20)	Yes
	religion	Patient's religion	Variable character (20)	Yes
	ethnicity	Patient's ethnic origin	Variable character (10)	Yes
	marStatus	Marital status of the patient	Variable character (10)	No
	payStatus	Payment status of the patient	Variable character (4)	No
	allergies	Drugs allergic to the patient	Variable character (15)	Yes
	immunizations	Patient's immunity	Variable character (15)	Yes
	dateReg	Patient's first registration date	Date/time	No
Appointment	chno	Patient's chart number	Variable character (10)	No
	cldno	Caregiver's identification number	Numeric (10)	No
	appoReason	Reason for appointment	Variable character (15)	Yes
	dateSeen	date patient seen by caregiver	Date/time	No
	dateAppo	Date patient appointed	Date/time	No
Schedule	chno	Patient's chart number	Variable character (10)	No
	cldno	Caregiver's identification number	Numeric (10)	No
	department	Department where patient seen	Variable character (15)	Yes
	dateSche	Patient's schedule date	Date/time	No
Epidemiology	chno	Patient's chart number	Variable character (10)	No
	houseHoNum	Household number for BRHP	Fixed character (10)	No
	houseHoRepName	Household representative name	Variable character (30)	No
	reasonSelectHospital	Reason for selecting BJ hospital	Variable character (30)	Yes
	otherTreatedHospital	Treated hospital other than BJ	Variable character (20)	Yes
	homeDist	Home distance from the hospital	Numeric (3)	Yes
	amPayTrans	Amount paid for transportation	Currency	Yes
	paydBy	Payment made by	Variable character (20)	Yes
	DateSeen	Date patient seen	Date/time	No
	WardName	Name of a ward in the hospital	Variable character (15)	No
Bed	BedNum	Number of a bed in a ward	Numeric (3)	No
	BedStatus	Current status of the bed	Variable character (8)	No
	Idno	Caregiver's identification number	Numeric (10)	No
Caregiver	Department	Caregivers department	Variable character (15)	Yes
	Occupation	Caregiver's occupation	Variable character (20)	Yes
	Qualification	Caregiver's qualification	Variable character (20)	Yes
	DeptNum	Number assigned for a department	Numeric (2)	No
Department	DeptName	Name of a department	Variable character (15)	No
	EType	Type of patient's encounter	Variable character (16)	No
Encounter	ENum	Number for each encounter type	Numeric (1)	No
	Chno	Patient's chart number	Variable character (10)	No
SOAP	EType	Type of patient's encounter	Variable character (16)	No
	Cldno	Caregiver's identification number	Numeric (10)	No
	Subjective	Patient's subjective medical history	Variable character(255)	Yes
	VitalSigns	Patient's vital sign records	Variable character(100)	Yes

Entity	Attribute name	Description	Data type & length	Null
		Patient's objective medical findings	Variable character(255)	No
	Objective	Patient's objective medical findings	Variable character (80)	No
	Assessment	Assessment for a patient	Character	Yes
	Diagnosis	Diagnosis of a patient	Variable character (80)	No
	Plan	Caregiver's plan for his patient	Variable character (15)	No
	Status	Patient's present status	Date/time	No
	DateSeen	Date patient seen	Numeric (10)	No
LabOrder	LabNum	Consecutive number for lab order	Variable character (10)	No
	Chno	Patient's chart number	Variable character (16)	No
	Etype	Type of encounter	Variable character (30)	No
	LabRequest	Laboratory request for patient	Variable character (30)	No
	LabResult	Result for laboratory request	Numeric	No
	OrderCidno	Ordering caregiver id number	Numeric	No
	TestCidno	Testing caregiver id number	Date/time	No
	DateOrder	Laboratory test order date	Date/time	No
	DateReport	Laboratory test report date	Numeric (10)	No
	Xnum	Consecutive number for Xray order	Variable character (10)	No
X-rayOrder	Chno	Patient's chart number	Variable character (16)	No
	Etype	Type of encounter	Variable character (30)	No
	Xrequest	X-ray request for patient	Variable character (30)	No
	Xresult	Result for X-ray request	Numeric (10)	No
	OrderCidno	Ordering caregiver id number	Numeric (10)	No
	TestCidno	Testing caregiver id number	Date/time	No
	DateOrder	X-ray test order date	Date/time	No
	DateReport	X-ray test report date	Variable character (10)	No
	Chno	Patient's chart number	Variable character (15)	No
	WardName	Ward name	Numeric (3)	No
Admission	BedNum	Number for a bed in a ward	Date/time	No
	DateAdmit	Date patient admitted	Numeric (10)	No
	AdmitCidno	Admitting caregiver id number	Date/time	Yes
	DateDisch	Date patient discharged	Variable character (15)	Yes
	DischStatus	Patient's discharge status	Variable character(100)	Yes
	DischSummary	Patient's discharge summary	Numeric (10)	No
	DischCidno	Discharging caregiver id number	Variable character (50)	No
	TestType	Type of the laboratory test	Numeric (2)	No
	TestNum	Laboratory Test number	Variable character	No
	TestType	Type of the X-ray test	Numeric (2)	No
X-ray Test	TestNum	X- ray Test number	Variable character (5)	No
	DiseaseCode	ICD code for represent disease	Variable character (50)	No
Disease	diseaseName	Name of each coded disease		

4.2.4 Database Normalization

Normalization is the process of organizing data in a database. This includes creating tables and establishing relationships between those tables according to the rules designed both to protect the data and to make the database more flexible by eliminating redundancy and inconsistent dependency. In other words, normalization is a data analysis method that organizes data attributes such that they are grouped together to form stable, flexible, and adaptive entities.

The normalization process involves getting three progressive normal forms, which are, First Normal Form (1NF), Second Normal Form (2NF), and Third Normal Form (3NF). A highest form of normalization cannot be achieved until the previous levels have been achieved.

The first normal form dictates that every attribute must have a single value for any occurrence of its entity. A relation is in 1NF if and only if: it contains no repeating groups. For second normal form, every attribute must depend on the entire identifier of its entity for its value. 2NF only apply to composite primary keys. A relation is in 2NF if, and only if: it is in 1NF and every non-key attribute is dependent on all parts of the primary key. A relation is in 3NF if, and only if: it is in 2NF and no non-key attribute is functionally dependent on another non-key attribute. This means that, every attribute must not depend on anything except the unique identifier of its entity for a value.

According to the previously stated normalization rules, it was tried to look through and analyze the database relations and their attributes. When describing the relationship type, and their cardinality in section 4.2.1.2, it has been tried to see ER-to-relational mapping and what to do when facing to many-to-many relationships. That is where all many-to-many relationships have been reduced to one- to-many relationships by creating additional entities to those many-to-many relationships. At that point, most of the normalization processes are almost completed. This has been done due to the intention of simplifying the future normalization process.

Now, we can analyze each table by listing all its attributes and applying the rules of normalization.

Patient relation/ table

(chno, patientName, sex, dob, age, address, occupation, education, religion, ethnicity, marStatus, allergies, immunization, dateReg)

Primary key: chno.

This relation is in 1NF. There is no multi-valued attribute or composite attribute value in the relation.

It is also automatically be in 2NF, since it has only a single primary key, or there is no composite primary key.

FD: (chno) $\rightarrow$ (patientName, sex, dob, age, address, occupation, education, religion, ethnicity, marStatus, allergies, immunization, datereg)

To be in the 3NF, the relation must have to be in 2NF and no transitive dependency exists. But, in patient relation, an attribute 'age' is functionally dependent on a non-key attribute 'dob', i.e. date of birth of the patient. Age is a derived attribute of 'dob', that can be derived by deducting present date from date of birth. Therefore, it is not necessary to build another relation for age, since we can get it through a query when it is needed. This makes the Patient relation in 3NF.

Appointment relation/ table

(chno, dateSeen, dateAppo, appoReason, cldno)

Primary key: chno, dateSeen

This relation is created based on the idea of separating the Patient and Caregiver relations by taking their primary key and creating a new relation, i.e. Appointment relation.

It is in 1NF. No multi-valued attribute is available.

FD: (chno, dateSeen) $\rightarrow$ (dateAppo, appoReason, cldno)

No attribute is partially dependent. Therefore, it is in 2NF.

No non-key attribute is functionally dependent on another non-key attribute.

Hence, it is in 3NF.

Schedule relation/ table

(chno, dateSche, cldno, department)

Primary key: chno, dateSche

There is no composite or multi-valued attribute. This relation is in 1NF.

FD: (chno, dateSche) $\rightarrow$ (cldno, department)

No partial dependency exists, so it is in 2NF.

Also there is no transitive dependency. Hence, It is in 3NF.

Epidemiology relation/ table

(chno, houseHoNum, houseHoRepName, reasonSelecthospital,
otherTreatedHospital, homeDist, amPayTrans, payBy, dateSeen)

Primary key: chno, houseHoNum, dateSeen

This relation is in 1NF. There is no multi-valued/ composite attribute.

FD: (chno, houseHoNum, dateSeen) $\rightarrow$ (houseHoRepName,
reasonSelecthospital, otherTreatedHospital, homeDist, amPayTrans, payBy)

Every non-key attribute is dependent on all parts of the primary key attributes.

This makes the relation a 2NF.

No non-primary key attribute is dependent on other non-primary key attribute.

Hence, it is in 3NF.

Bed relation/ table

(wardName, bedNum, bedStatus)

Primary key: wardName, bedNum

There is no composite/ multi-valued attribute. The relation is in 1NF.

FD: (wardName, bedNum) $\rightarrow$ (bedStatus)

The non-key attribute is dependent on both primary key attributes, which makes the relation to 2NF.

No transitive dependency exists. Hence, the relation is in 3NF.

Caregiver relation/ table

(idno, cName, department, occupation, qualification,)

Primary key: idno

The relation is in 1NF, since there is no composite attribute.

Having a single primary key attribute qualifies the relation to 2NF.

FD (idno) $\rightarrow$ (cName, department, occupation, qualification).

No non-primary key attribute depends on other non-primary key attribute.

Therefore, the relation is in 3NF.

Department relation/ table

(deptNum, deptName)

Primary key: deptName

It is in 1NF. There is no composite/ multi-valued attribute.

Also it is in 2NF, since it has only one primary key.

FD (deptName) $\rightarrow$ (deptNum)

The relation is in 3NF. No transitive dependency exists.

Encounter relation/ table

(eType, eNum)

The relation is in 1NF. No composite/ multi-valued attribute exists.

It is also in 2NF, since it has only a single primary key attribute.

FD: (eType) $\rightarrow$ (eNum)

No transitive dependency exists. So it is qualified as a 3NF.

SOAP relation/ table

(chno, eType, cldno, subjective, vitalSigns, objective, assessment, diagnosis, plan, status, dateSeen)

Primary key: chno, eType, diagnosis, dateSeen)

No composite/ multi-valued attribute is there. Hence, it is in the 1NF.

FD (chno, eType, diagnosis, dateSeen) $\rightarrow$ (cldno, subjective, vitalSigns, objective, assessment, plan, status)

No partial dependency exists. It is in 2NF.

The relation is in 3NF. No non-primary key attribute is dependent on other non-primary key attribute.

LabOrder relation/ table

(labNum, chno, labRequest, labResult, orderCidno, testCidno, dateOrder, datereport)

Primary key: labNum, chno, dateOrder,

The relation is in 1NF. There is no multi-valued/ composite attribute.

FD: (labNum, chno, dateOrder) $\rightarrow$ (labRequest, labResult, orderCidno, testCidno, dateReport)

It is also in 2NF. No partial dependency exists.

This relation is also in 3NF. No non- primary key attribute is dependent on other non- primary key attribute.

X-rayOrder relation/ table

(xNum, chno, xRequest, xResult, orderCidno, testCidno, dateOrder, dateReport)

Primary key: xNum, chno, dateOrder

Since there is no multi-valued attribute, the relation is in 1NF.

FD; (xNum, chno, dateOrder) $\rightarrow$ (xRequest, xResult, orderCidno, testCidno, dateReport).

There is no partial dependency. So it is in 2NF.

Also there is no transitive dependency. So it is in 3NF.

Admission relation/ table

(chno, wardName, bedNum, dateAdmit, admitCidno, dateDisch, dischStatus, dischSummary, dischCidno)

Primary key: chno, dateAdmit

No multi-valued/ composite attribute is available. It is in 1NF.

FD (chno, dateAdmit) $\rightarrow$ (wardName, bedNum, admitCidno, dateDisch, dischStatus, dischSummary, dischCidno)

No partial dependency exists. Therefore, the relation is in 2NF.

A non-primary key attribute is not dependent on other non-primary key attribute in the relation. Hence, it is in 3NF.

Lab Test relation/ table

(labNum, labTestName)

Primary key: labNum

The relation is in 1NF. There is no multi-valued attribute here.

Since it has a single primary key, it can automatically qualified as being in 2NF.

FD (labNum) $\rightarrow$ (labTestName)

Also there is no transitive dependency. Hence, it is in third normal form.

X-ray Test relation/ table

(xNum, xTestName)

Primary key: xNum

There is no multi-valued/ composite attribute in the relation. Thus, the relation is in 1NF.

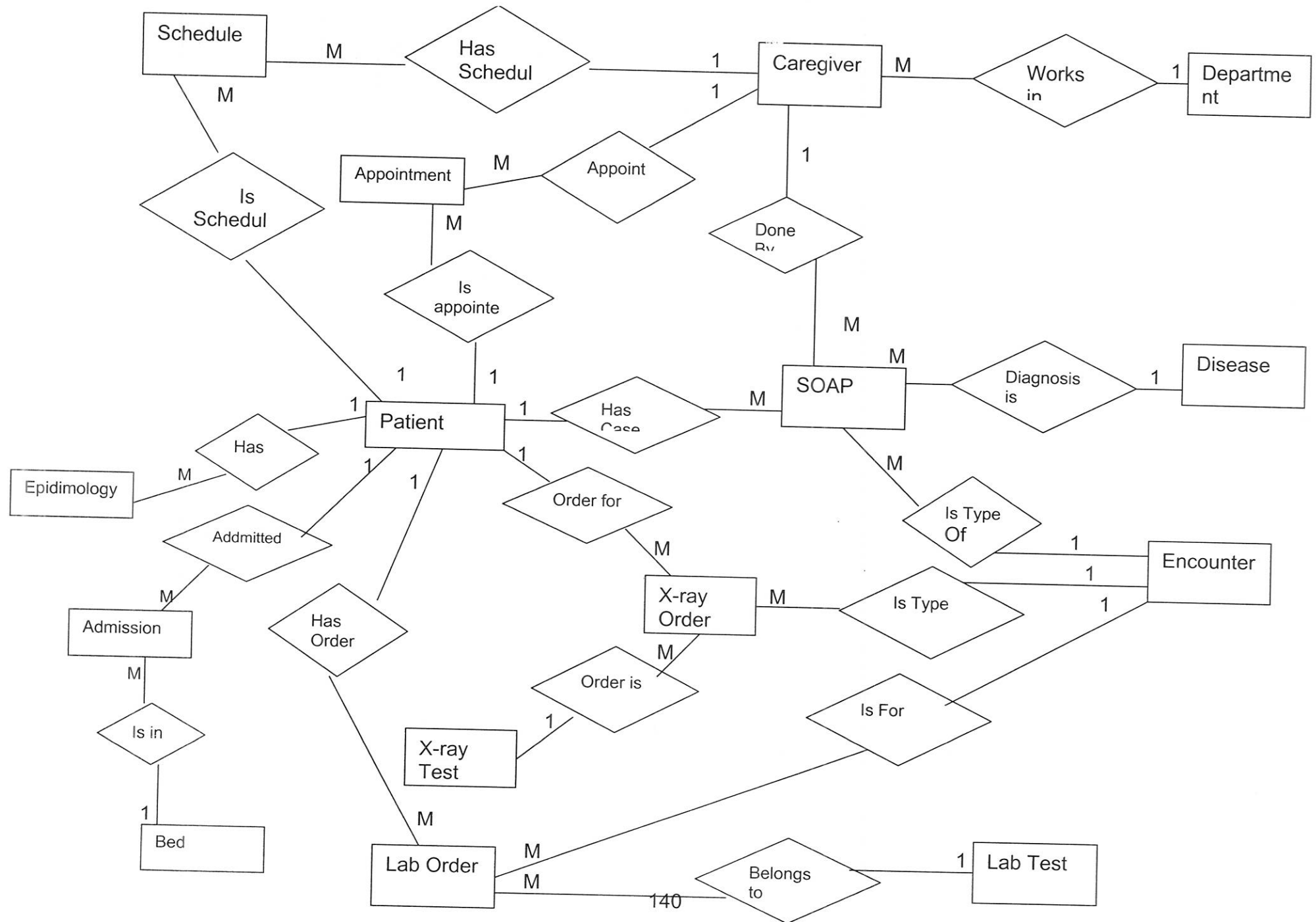
It is also in 2NF, since it has a single primary key.

FD: (xNum) $\rightarrow$ (xTestName)

No non-primary key attribute is dependent on other non-primary key attribute.

Therefore, the relation is in 3NF.

Fig 4.1 Logical entity relationship diagram



4.2.5 Data capturing formats design

One of the obstacles to automation of the patient medical record is sometimes the lack of standards for the patient medical record and clinical information, and sometimes, the multiplicity of different standards. The capturing format of clinical data is a considerable problem in the design and development of CPR. The data can be captured as free text, coded data and a combination of the two.

As stated in sections 1.1 and 1.7.8, free text has the flexibility and richness of expression. However when used in CPR it has some disadvantages. First, with the current state of computer technology, free text cannot be utilized in an efficient manner for other CPR applications, although the evolution of natural language processing may ameliorate this problem. Second, free text fields can change the meaning of coded data. Free text entry made by clinicians during the recording of medication data changed the meaning and lowered the accuracy of coded data.

Coded data capturing has the advantages of acquiring classified and standardized data, thus it is easy to retrieve data and query from the database for very specific information and reports, in addition to making the information readily available for other applications in the CPR especially epidemiological research.

Coded data has some disadvantages. It limits the user to predefined vocabulary, which might not meet the goal, and coding can be time-consuming and tedious.

In this study, both free text and coded data capturing formats have been used to represent patients' demographic and clinical information. A standard developed by World Health Organization (WHO) and adopted by Ministry of Health known as International Classification of Diseases (ICD9) has been used to represent disease type of a patient. Ministry of Health modifies this standard by reducing its disease types to 229 from lists of a huge volume. The list follows the WHO international list of 150 causes. However due to the conditions prevailing in Ethiopia, certain diseases not specified in the WHO list were found to be of such important and has specified. Additional local standards have also been developed in-house to be used for laboratory and X-ray orders. These standards are developed with tight communication and discussion with system users in order to get the advantages of using coded data in CPR.

Short and lengthy free texts are also used for recording patient information, which are not convenient to be coded. Data on patient's subjective and objective history, discharge summary, vital signs, treatment plan and the like, are designed to be captured as a lengthy free text data up to 255 characters due to their nature of difficulty to be captured in coded format. But with the free text formats, medical narratives have been used in order to make the medical record more standardized and easily understandable by caregivers. The narratives can be

listed as CC for chief complaint, HPI for history of present illness, PMH for past medical history under subjective attribute, ROS for review of systems, PE for physical examination and R/O for rule out under objective attribute, and P_x for prognosis, R_x for medication. List of medical narration is available at the appendices.

The process of applying both free text and coded data capturing formats in locally developed CPR is the unique feature of this study that makes the system adaptable to the local situations and acceptable by the users. It was tried to make the system more simple to learn and use, and considerable effort have been made to develop own vocabularies and codes, which also contribute a lot for simple entry of data and utilizing the available captured data for statistical analysis and reporting purposes.

Huge proportions of the data have been designed to be entered through selecting a value from drop down lists (combo boxes). It was believed that using these drop down lists have a significant contribution in making the system acceptable, attractive, simple to use and learn by caregivers with its additional GUI features, which will be discussed in detail in the next section.

For the developed and utilized coding systems, for medical narratives, and for drop down lists a "code manual" containing the full description of codes and

narratives should be developed. The printed manual could be distributed to system users to serve as a reference manual in the data entry process.

From what was stated in previous studies and discussion, it is obvious that clinicians would prefer to continue with the traditional method of capturing clinical data as free text. By applying the above-mentioned techniques, this study tries to change the attitude and preference of physicians to use both coded and free text methods. Although it is out of the scope of the study to evaluate the degree of acceptance on the application of these techniques, definitely it paves the way for further research and indicates the necessity of another study in the acceptance and utilization areas.

4.2.6

Integrity constraints

Every Date/time data type has to be according to Gregorian calendar.

Table names have to begin with upper cases.

Every attribute name has to begin with lower cases, and if the name is a combination of two or more words, the first letter of every additional word would start with upper case letters.

4.2.6.1 Domain constraints

The value of each attribute must be atomic.

The data types associated with domains typically include standard data types like Numeric (short integer, long integer), Character (fixed length, variable length), specific Date/time, and Currency formats. For some attributes, enumerated data types and all possible values are explicitly listed. All these constraints are practical in our database by specifying a data type for each data item.

4.2.6.2 Key constraints

All tuples in a relation must be distinct. To uniquely identify tuples in the relation, there must be a primary key (consists of one or more attributes) for each relation or table.

4.2.6.3 Null values

For every attribute, constraints on whether Null values are permitted or allowed or not has been stated clearly.

4.2.6.4 Entity integrity and referential integrity constraints

No primary key value can be null for every table, and this has been ascertained.

A tuple in one relation or table that refers to another relation must refer to an existing tuple in that relation. For a tuple to exist as a foreign key, there must be a primary key tuple in another related table. For this constraint, appropriate primary and foreign keys are clearly indicated.

4.3 User interface design

A graphical user interface (GUI) model is selected to develop the user interface. GUI is the proper interface for many parts of the automated patient medical record. GUI is a user interface that makes use of detailed visual symbols for the user navigation, characters, pictures and lines. Using keyboard and mouse does input through the GUI to the database system.

Dozens of forms have been used in the interface part of the database. From these forms seven are switchboards. The main switchboard uses to direct us to two data entry, three information retrieval, and one report generating switchboards and a button to exit the program.

Data entry I contain seven buttons, of which six are used to access data entry forms and one to go back to the main page. The same is true for Data entry II. The first one directed us to Patient, Schedule, Caregiver, Bed, and Epidemiology data entry forms while the second connect us to SOAP, Appointment, Lab order, X-ray order and admission data entry forms.

Information retrieval I, II, and III switchboards are designed to retrieve information from the database based on pre-defined queries. The queries are designed and saved and a form for each query is created that becomes visible through buttons on the switchboards. For majority of queries, parametric query is developed in order to enhance the retrieval process according to specific patient, sex, date etc.

In developing some of the queries, a combination of main form and sub form is used when it becomes necessary to retrieve information from two or more tables or queries.

Report generation switchboard is designed to make a link to forms of aggregated queries designed to use for report generating purpose. The queries are based on one or more attributes using aggregate functions like count, group by and where functions.

All the switchboards are made of a button that returns the user to the main page and the main page to exit the program. On the design of the forms it was tried to apply similar format, color and appearance intentionally. This is to make the forms so simple to learn and easy to use by the system users.

Fig 4.4 Data entry II switchboard

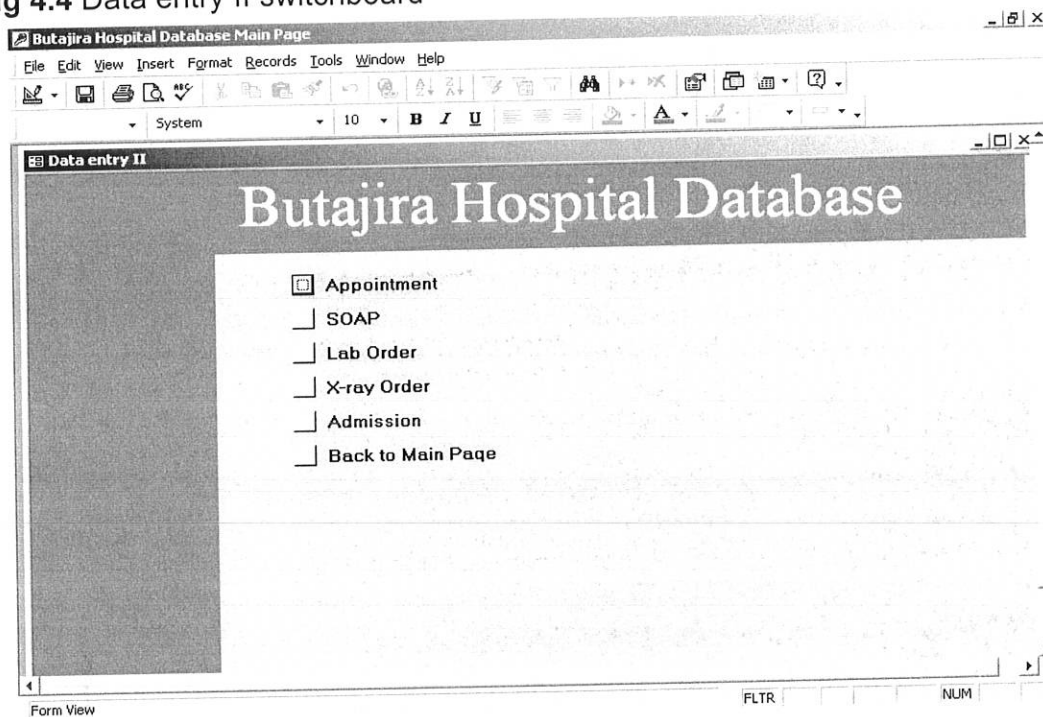


Fig 4.5 Information retrieval I switchboard

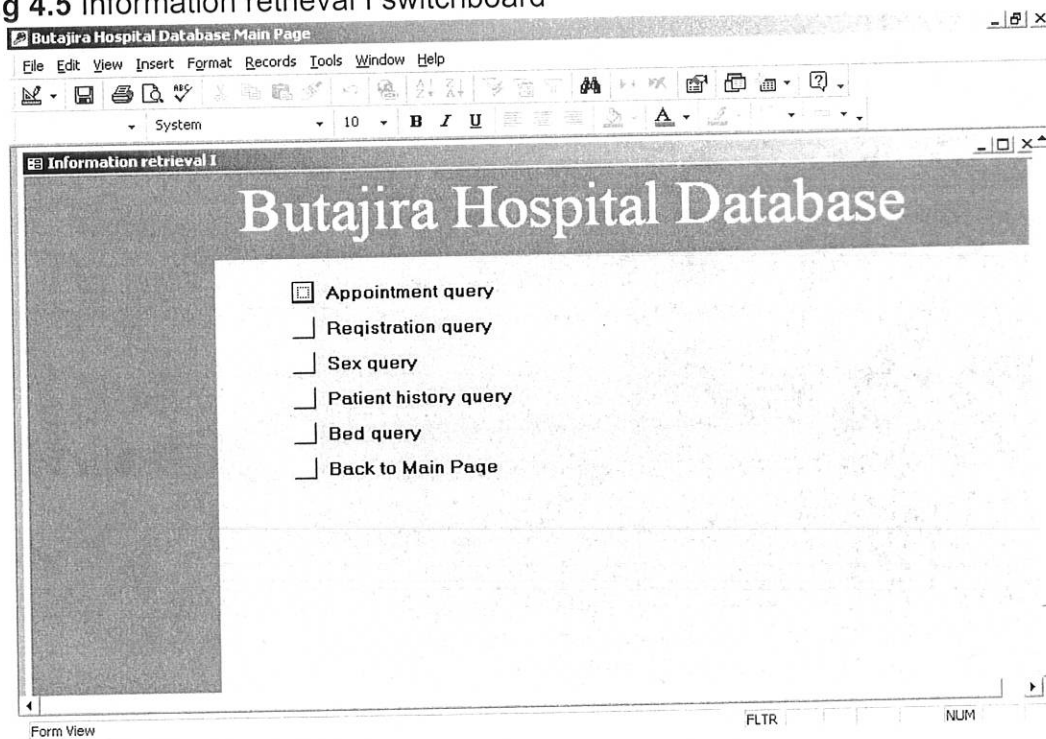


Fig 4.6 Data entry form for Patient table

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

MS Sans Serif 8 B I U

Patient form

Patient data entry form

Chart number: 1126/94 Date registered (dd/mm/yy): 8/26/2002

Patient name: Yirgu Bireda Visit status: Initial

Sex: M

Date of Birth (dd/mm/yy): 8/26/1984

Address (Zone, District, Kebele (Peasant Asso.), House No): Gurage, Meskan, 01

Occupation: Student

Education: Secondary school com

Religion: Muslim

Ethnicity: Gurage

Marital Status: Single

Paying status: Paying

Record: 1 of 5

A unique chart number for patients

NUM

Fig 4.7 Data entry form for Bed table

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

MS Sans Serif 8 B I U

Data entry I

Butajira Hospital Database

Bed form

Bed data entry form

Bed number: 51

Ward name: Gyn-Obs ward

Bed Status: Occupied

Record: 1 of 99

Number of a bed in a ward

NUM

Fig 4.8 Data entry form for SOAP table

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

MS Sans Serif 8 B I U

SOAP data entry form

Chart number: 11126/94 Disease: 001

Encounter type: Outpatient Plan: Ix=cxr,sputum exam

Caregiver idno: 48 Status after visit: Died

Allergies: lat Date seen (dd/mm/yy): 8/26/2002

Immunization: fully immunized

Subjective: HPI=cough, night sweating, fever, chest pain, night loss

Vital signs: T=37, RR=18, PR=76, BP=110/90

Objective: HEENT=pale conj, RS=bbs over the right

Assessment: Dx=tuberculosis

Record: 1 of 6

Patient's chart number NUM

Fig 4.9 Data entry form for Lab order table

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

Lab order data entry form

Lab number: 11243/94

Chart number: 11243/94

Lab Request code: 37

Lab Result: p.f

Ordering caregiver idno: 81

Testing caregiver idno: 56

Date order (dd/mm/yy): 1/8/2001

Date report (dd/mm/yy): 1/8/2001

Record: 1 of 3

Consecutive number for laboratory order NUM

Fig 4.10 Data entry form for Admission table

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

Data entry II

Admission form

Admission data entry form

Chart number: 11126/94

Ward name: Medical ward

Bed number: M10

Date admitted (dd/mm/yy): 8/27/2002

Admitting caregiver idno: 48

Date discharged (dd/mm/yy): 8/28/2002

Discharge Status: Died

Discharge summary: Hx=A 20 years old male patient admitted with a diagnosis of pul tb after being investigated with CXR and sputum

Discharging caregiver idno: 86

Record: 1 of 2

patient's chart number

NUM

Fig 4.11 Data entry form for Appointment table

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

Data entry II

Appointment form

Appointment data entry form

Chart number: 11273/94

Caregiver idno: 48

Reason for appointment: Follow up

Date seen (dd/mm/yy): 1/9/2002

Date appointed (dd/mm/yy): 2/11/2002

Record: 1 of 1

Patient's chart number

NUM

Fig 4.12 Registration query form

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

MS Sans Serif 8 B I U

Information retrieval I

Registration query

Registration query form

Chart number: 11243/94 Date registered: 1/12/2001

Patient name: Rdlat Legese

Sex: F

Date of birth: 1/8/2001

Address: Gurage,Meskan,03

Education: Child

Religion: Orthodox Christen

Ethnicity: Amara

Marital status: Child

paying status: Paying

Record: 1 of 1

NUM

A unique chart number for patients

Fig 4.13 Patient history query by chart number form

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

MS Sans Serif 8 B I U

Information retrieval I

Patient history query form

Patient history query form by chart number

Chart number: 11243/94 Date Seen: 1/12/2001

Visit Status: Initial Date admitted: 2/11/2002

Encounter type: Outpatient

Allergies: bez pen

Immunization: polio

Subjective: CC= cough/three days duration, HPI= has productive cough ,fever,weight loss,runny nose, ht

Objective: RS=has flaring of alarasea, course creps on the right lbasal lung, GIT=hepatomegaly.

Assessment: Dx=broncho pneumonia

Plan: lx=b/f

Record: 1 of 2

NUM

A unique chart number for patients

Fig 4.14 Patient history query by sex form

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

Information retrieval I

Sex query form

Patient history query form by sex

chno	11243/94	labRequest	37
patientName	Rdiat Legese	labResult	p.f
sex	F	orderCidno	81
eType	Inpatient	testCidno	56
subjective	HPI=fever, headache, vomiting	payStatus	Paying
vitalSigns	T=38, RR=28, PR=120		
objective	GA=conscious, HEENT=pale conj., GIT=hepatomegaly		
assessment	Dx=severe malaria		
plan	Rx=iv quinine		

Record: 1 2 of 2

NUM

A unique chart number for patients

Fig 4.15 Patient and SOAP query form and sub form

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

chno

Patient + SOAP form

Patient SOAP query form and subform

chno	11243/94	patientName	Rdiat Legese
sex	F		
Age	3.45		
Marital Status	Child		
Occupation	Other		

SOAP

subjective	vitalSigns	objective
HPI=fever, headache, vomiting	T=38, RR=28, PR=120	GA=conscious, HEENT
CC= cough/three days duration, HPI= has produ	T=36, RR=23, PR=100,	RS=has flaring of alana

Record: 1 of 2

Record: 1 of 1

NUM

Patient's chart number

Fig 4.16 Patient and SOAP query2 form and sub form

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

MS Sans Serif 8 B I U

Information retrieval II

Patient SOAP Form2

Patient SOAP query2 form and subform

Chart number: 11243/94 Age: 3.42

Patient Name: Rdial Legese

Sex: F

Occupation: Other

Marital Status: Child

SOAP

Encounter type	Allergies	Immunization	Subjective
Inpatient		Measles	fever, head
Outpatient	bez.pen	polio	cc cough/th cough, fever

Record: 1 of 2

Record: 1 of 1

Type of patient's encounter

NUM

Fig 4.17 Lab order query by chart number form

Butajira Hospital Database Main Page

File Edit View Insert Format Records Tools Window Help

MS Sans Serif 8 B I U

Information retrieval II

Lab order query form

Lab order query form by chart number

chno: 11243/94

patientName: Rdial Legese

sex: F

visitStatus: Initial

labRequest: 37

labResult: p.f

orderCidno: 81

testCidno: 56

dateOrder: 1/8/2001

dateReport: 1/8/2001

Record: 1 of 1

A unique chart number for patients

NUM

Fig 4.18 Report of medical doctors

Butajira Hospital Database Main Page

File Edit View Tools Window Help

100% Close W

Reports

Medical doctor caregiver Report

Medical doctor caregiver Report

<i>idno</i>	<i>Name</i>	<i>occupation</i>	<i>qualification</i>
48	Kifle Tilahun	Medical doctor	General Practitioner
50	Solomon Worku	Medical doctor	Specialist
72	Workabeba Abebe	Medical doctor	General Practitioner
73	Solomon Teferra	Medical doctor	General Practitioner
80	Getnet Gizaw	Medical doctor	Specialist
81	Fekadu Lemma	Medical doctor	General Practitioner
85	Mulugeta Wordwosen	Medical doctor	General Practitioner
86	Loza H/ Mariam	Medical doctor	General Practitioner

Page: 1

Ready NUM

Fig 4.19 Encounter type report

Butajira Hospital Database Main Page

File Edit View Tools Window Help

100% Close W

Reports

Report on encounter type

Report on encounter type

CountOfchno

eType

CountOfchno

eType

Page: 1

Ready NUM

CHAPTER FIVE

5 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The current global situation concerning patient medical record keeping system confirms that CPR systems are increasingly becoming a necessary tool in healthcare for improving the quality and effectiveness of care.

This study aims at the construction of CPR system for Butajira Hospital. On the process, the study has investigated the current paper-based patient record system in order to understand and identify the drawbacks of the system. After identifying the problems with the existing system, alternative solutions have been proposed and implemented. On proposing alternative solutions, it was observed that the implementation of Computer-based record keeping system is essential and beneficial on alleviating the existing problems. Developing and implementing a database to handle the patient data is also practiced. And finally, recommendations are stated for better exercising and further strengthening of the proposed system.

On the study of the existing system, document analysis and semi-structured interview methods were conducted for collecting the necessary data. In general, the study reveals that the existing paper-based patient record keeping system has several defects listed as follows.

- Potential misplacing and destruction of the paper chart,
- Illegibility, inconsistency, and incompleteness of information on the chart,
- Difficulty of finding information for caregivers resulted from disorganization of information,
- Difficulty for researchers in finding information in the chart,
- Limitation on the availability of a chart only at one location at a time, and the need for physical transportation of it from one location to another when needed by other caregivers,
- Availability of redundant orders, demographics and clinical data on several forms in the chart,
- Potential storage space consumption of the chart in the chart room,
- Prone to errors on generating aggregate statistical data for reporting purpose.

Based on users' and upper management's suggestions for change and improvement, vision of the future, and existing system problems, requirements for the proposed system are analyzed in detail concerning process, data and transaction requirements. To alleviate the mentioned problems, the study decided that implementing a CPR system is found to be a mere solution. All the system analysis exercise and practice have been done using structured system analysis methodology.

For the realization of the proposed new information system, in-house development of a centralized database for the patient medical record becomes

vital. The database is constructed by using one of a RDBMS, which is Microsoft Access. A prototype database design methodology was used on developing the database. On the process of database development, attempts were made on the participation of system users in the design process. Also additional attempts were made on the constraints of data capturing formats of medical records. To alleviate the data capturing format difficulties, the study reveals the utilization of both structured and coded, and free text and medical narrative words when necessary. In addition, international and homemade standards have been implemented in the proposed system database creation.

By exploiting the rich GUI features of Microsoft Access, it was tried to develop an easy and simple to learn and use interfaces like switchboards, forms and reports. More emphasis also given for simplifying the system by providing the user with options to select from drop-down lists of combo boxes.

In general, on the process of undertaking this study, considerable amount of literature in the area of CPR, developing CPR in developing countries, and data capturing formats in CPR keeping system have been consulted.

To sum, for better implementation of the proposed system, valuable recommendations have been stated on the next section.

5.2 RECOMMENDATIONS

- As the system is not comprehensive in its scope, it is recommended to expand the system to contain other sub systems like administrative, financial, legal agreement, and pharmacy prescription and inventory systems,
- It is also nice to undertake a survey on the degree of acceptance of a CPR in Butajira Hospital by system users. The acceptance of implementation of data capturing formats in medical records is also an area of research which have to get great attention and emphasis,
- Integration of the clinical epidemiological data to community based epidemiological data available at BRHP is also an area in need of further work,
- Local area network through entire the hospital with client/server architecture is vital for the implementation of the proposed CPR system. A server has to be installed in an office at the center of the campus. Personal computers at the Chart-room, in each outpatient examination rooms, in special clinics, in each ward, and in laboratory and X-ray are necessary to perform the recording, retrieving and reporting processes.
- Training on basic computer skills, RDBMS, and specifically on the utilization of the developed software for system users is recommended,
- Technical staff on computer troubleshooting and report compilation is also necessary,
- As the concerned hospital is relatively new and small, it is also fine to enter some of the retrospective charts data to the CPR,

- The involvement and support of the hospital's management is quite necessary and recommended for the implementation of the CPR system,
- Updating the home-made codes according to situational needs, and adoption of national and international standards for capturing patient data is also important and recommended for system's improvement,
- Providing security checks to control users access to patient information through assigning hierarchy of privileges has to be a point of concern,
- Providing sufficient backup and recovery features to assure minimal data lose due to system or power failure is also vital. Backing-up the patient record on a constant interval in daily, weekly, or monthly manner is recommended as a solution for disaster recovery purpose.

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Appendix A

List of International Classification of Diseases (ICD9), adopted by Ministry of Health of Ethiopia and used in the database to capture coded data.

Code	Disease
1	Tuberculosis of respiratory system
2	Tuberculosis of meninges and central nervous system
3	Tuberculosis of intestines, peritoneum, and mesenteric glands
4	Tuberculosis of bone and joints
5	Tuberculosis, all other forms
6	Congenital syphilis
7	Early syphilis (I and II)
8	Tabes dorsalis
9	General paralysis of insane
10.1	Cardio-vascular syphilis
10.2	All other syphilis
11.1	Gonococcal infections genito-urinary
11.2	Gonococcal infections of eye
11.3	Gonococcal infections other forms
11.4	Lymphogranuloma venereum (viral)
11.5	Granuloma inguinale venereum
11.6	Chancroid
11.7	Other unspecified venereal disease
12	Typhoid fever
13	Paratyphoid fever and other salmonella infections
14	Cholera
15	Brucellosis (undulant fever)
16.1	Bacillary dysentery
16.2	Amoebiasis (excluding symptomless carries)
16.3	Amoebic abscess
16.4	Food poisoning (excluding salmonella infections 013)
16.5	Other unspecified dysentery
17	Scarlet fever
18	Streptococcal sore throat
19	Erysipelas
20	Septicaemia and pyaemia
21	Diphtheria
22	Whooping cough
23	Meningococcal infections
24	Plague

- 25 Leprosy
- 26 Tetanus
- 27 Anthrax
- 28 Acute polimyelitis
- 29 Acute infectious encephalitis
- 30 Late effects of acute poliomyelitis and acute infectious encephalitis
- 31.1 Smallpox variol major
- 31.2 Smallpox variol minor
- 31.3 Chicken-pox
- 32.1 Measles
- 32.2 Rubella
- 33.1 Yellow fever
- 33.2 Dengue fever
- 33.3 Other arbor virus diseases
- 34 Infectious hepatitis
- 35 Rabies (with hydrophobia)
- 36.1 Louse-borne epidemic typhus
- 36.2 Flea-borne endemic typhus
- 36.3 Tick-borne typhus
- 36.4 Q. fever
- 36.5 Unspecified typhus
- 36.6 Other rickettsial diseases
- 37.1 Vivax malaria (S.T.)
- 37.2 Malarial malaria (Q.T.)
- 37.3 Falciparum malaria (S.T.)
- 37.4 Other unspecified malaria
- 37.5 Blackwater fever
- 38.1 Schistosomiasis vesical (Bilharziasis)
- 38.2 Schistosomiasis intestinal (Bilharziasis)
- 38.3 Other and unspecified schistosomiasis (Belharziasis)
- 39 Hydatid disease
- 40.1 Onchocerciasis (Rever blindness)
- 40.2 Filariasis bancrofti
- 40.3 Elephantiasis of filarial origin
- 40.4 Other filariasis
- 41 Ankylostomiasis (hook worm)
- 42.1 Tapeworm
- 42.2 Ascariasis
- 42.3 Guinea-worm
- 42.4 Strongyloidiasis
- 42.5 Trichuriasis
- 42.6 Other helminths
- 43.1 Relapsing fever
- 43.2 Leptospirosis (Wiel's disease)

- 43.3 Yaws
- 43.4 Herpes Zoster
- 43.5 Mumps
- 43.6 Trachoma
- 43.7 Leishmaniasis
- 43.8 Trypanosomiasis (sleeping sickness)
- 43.9 All other infective and parasitic diseases
- 44 Malignant neoplasms of buccal cavity and pharynx
- 45 Malignant neoplasms of oesophagus
- 46 Malignant neoplasms of stomach
- 47 Malignant neoplasm of intestine, except rectum
- 48 Malignant neoplasm of rectum
- 49 Malignant neoplasm of larynx
- 50 Malignant neoplasm of trachea, bronchus and lung, (not specified as secondary)
- 51 Malignant neoplasm of breast
- 52 malignant neoplasm of cervix uteri
- 53 Malignant neoplasm of other and unspecified parts of uterus
- 54 Malignant neoplasm of prostate
- 55.1 Malignant neoplasm of skin of leg
- 55.2 Malignant neoplasm of skin of other than leg
- 56.1 Malignant neoplasm of jaw
- 56.2 Malignant neoplasm of other bone and connective tissues
- 57.1 Malignant neoplasm of liver (primary)
- 57.2 Malignant neoplasm of ovary
- 57.3 Malignant neoplasm of penis
- 57.4 Malignant neoplasm of other unspecified sites
- 58 Leukaemia and aleukemia
- 59 Lymphosarcoma and other neoplasms of lymphatic and (hematopoietic system)
- 60.1 Benign neoplasm of breast
- 60.2 Uterine fibromyoma
- 60.3 Benign neoplasm of ovary
- 60.4 Other benign and unspecified neoplasm
- 61 Non-toxic goiter
- 62 Thyrotoxicosis with or without goiter
- 63.1 Diabetes mellitus
- 63.2 Diabetes insipidus
- 64.1 Beriberi
- 64.2 Scurvy
- 64.3 Kwashiorkor
- 64.4 Marasmus
- 64.5 Vitamin D deficiency
- 64.6 Vitamin A deficiency

- 64.7 Other states of malnutrition
- 65.1 Pernicious anaemia
- 65.2 Iron deficiency anaemias (hypochromic anaemias)
- 65.3 Sickle cell anaemia
- 65.4 Other unspecified anaemias
- 66.1 Bronchial asthma
- 66.2 Purpura and other hemorrhagic conditions
- 66.3 Infective mono-nucleosis
- 66.4 Other allergic endocrine, metabolic and blood diseases
- 67 Phychosis
- 68 Psychoneurosis
- 69 Mental deficiency
- 70 Vascular lesions affecting central nervous system
- 71.1 Meningitis due to H. influenza
- 71.2 Meningitis due to pneumococcus
- 71.3 Other meningitis (except meningococcal)
- 72 Multiple sclerosis
- 73 Epilepsy
- 74 Inflammatory diseases of eye (except trachoma 43.6)
- 75 Cataract
- 76 Glaucoma
- 77 Otitis media and mastoiditis
- 78.1 Otitis external
- 78.2 Other diseases and conditions of the ear
- 78.3 Other diseases and conditions of the eye
- 78.4 All other diseases of the nervous system
- 79 Rheumatic fever
- 80 Chronic rheumatic heart disease
- 81 Arteriosclerotic and degenerative heart disease
- 82.1 Acute and sub-acute bacterial endocarditis
- 82.2 Endomyocardial fibrosis
- 83 Hypertension with heart disease
- 84 hypertension without mention of heart
- 85 Diseases of arteries
- 86 Other diseases of circulatory system
- 87 acute upper respiratory infections
- 88 Influenza
- 89 Lobar pneumonia
- 90 Bronchopneumonia
- 91 Primary atypical, other, and unspecified pneumonia
- 92 Acute bronchitis
- 93 Bronchitis, chronic and unqualified
- 94 Hypertrophy of tonsils and adenoids
- 95 Empyema and abscess of lung

- 96.1 Pleurisy without effusion
- 96.2 Pleurisy with effusion without mention of T.B.
- 97.1 Pneumoconiosis
- 97.2 All other respiratory diseases
- 98.1 Dental caries
- 98.2 All other diseases of tooth and gums
- 99 Ulcer of stomach
- 100 ulcer of duodenum
- 101 Gastritis and duodenitis
- 102 Appendicitis
- 103.1 Hernia of abdominal cavity with obstruction
- 103.2 Hernia of abdominal cavity without obstruction
- 103.3 Intussusception
- 103.4 Volvulus
- 103.5 Intestinal obstruction without hernis
- 104.1 Gastro-enteritis and colitis (age 4 week to two years)
- 104.2 Gastro-enteritis and colitis (age 2 years and over)
- 104.3 Chronic enteritis and ulcerative colitis
- 105.1 Cirrhosis of liver
- 105.2 Chronic hepatitis
- 106.1 Cholelithiasis and cholecystitis
- 107.1 Necrosis of liver
- 107.2 Other diseases of digestive system
- 108 Acute nephritis
- 109 Chronic, other and unspecified nephritis
- 110 Infections of kidney (except T.B.005)
- 111 Calculi of urinary system
- 112 Hyperplasis of prostate
- 113 Diseases of breast
- 114.1 Structure of urethra
- 114.2 Hydrocele
- 114.3 Disorders of menstruation
- 114.4 Sterility of female
- 114.5 Vaginal fistula
- 114.6 All other diseases of genito-urinary system
- 115 Sepsis of pregnancy, childbirth, and the puerperium
- 116.1 Pre-eclamptic toxæmia
- 116.2 Eclamptic toxæmia
- 116.3 Other toxæmia of pregnancy and childbirth (ante-natal)
- 117.1 Hemorrhage of pregnancy and childbirth (post-natal)
- 118 Abortion without mention of sepsis or toxæmia
- 119 Abortion with sepsis
- 120.1 Ectopic pregnancy
- 120.2 Abnormal labour due to disproportion

- 120.3 Abnormal labour due to malposition
- 120.4 Ruptured uterus
- 120.5 Other complication of pregnancy, childbirth and puerperium
- 120.6 Deliveries without mention of complication
- 121 Infections of skin and subcutaneous tissue
- 122 Arthritis and spondylitis
- 123 Muscular rheumatism and rheumatism unspecified
- 124 Osteomyelitis and periostitis
- 125 Ankylosis and acquired musculo-skeletal deformities (except 030)
- 126.1 Ulcer of leg
- 126.2 All other diseases of skin
- 126.3 Pyomyositis
- 126.4 all other diseases of musculo-skeletal system
- 127 Spina bifida and meningocele
- 128 Congenital malformation of circulatory system
- 129 All other congenital malformations
- 147.3 All other accidental causes
- 148 Suicide and self-inflicted injury
- 149 Homicide and injury purposely inflicted by other persons (not in war)
- 150 Injury resulting from operations of war

Appendix B

List of homemade codes for laboratory test type

Lab Code	Lab test type
1	Blood chemistry & serology alkaline phosphatase
2	Blood chemistry & serology bilirubin (direct)
3	Blood chemistry & serology bilirubin (indirect)
4	Blood chemistry & serology bilirubin D
5	Blood chemistry & serology bilirubin T
6	Blood chemistry & serology brucella antigen
7	Blood chemistry & serology cholesterol (esters)
8	Blood chemistry & serology cholesterol (total)
9	Blood chemistry & serology glucose
10	Blood chemistry & serology RBS
11	Blood chemistry & serology SGOT
12	Blood chemistry & serology SGPT
13	Blood chemistry & serology total protein
14	Blood chemistry & serology urea nitrogen
15	Blood chemistry & serology VDRL
16	Blood chemistry & serology WVF
17	Hematology blastic
18	Hematology bleeding time
19	Hematology blood morphology
20	Hematology bonds
21	Hematology basophiles
22	Hematology diff. Count
23	Hematology eosinophiles
24	Hematology ESR
25	Hematology haematocrit
26	Hematology haemoglobin
27	Hematology haemoparasites
28	Hematology lymphocytes
29	Hematology monocytes
30	Hematology myelocytes
31	Hematology neutrophils
32	Hematology platelets
33	Hematology RBC
34	Hematology reticulocytes
35	Hematology WBC
36	Stool appearance

Lab Code	Lab test type
37	Stool bile
38	Stool concentration
39	Stool consistency blood gross
40	Stool mucus
41	Stool occult
42	Stool OUA and parasites
43	Stool pus
44	Urine 17-ketostroles
45	Urine acetone
46	Urine albumen qualitative
47	Urine albumine quantitative
48	Urine bilirubin
49	Urine glucose
50	Urine microscopy
51	Urine quantity
52	Urine reaction
53	Urine S.Gr
54	Urine urobilin

Appendix C

List of homemade X-ray test codes

X-ray Code	X-ray test type
1	Skull postero-anterior
2	Skull lateral
3	Sellar view (conned view)
4	Sinus
5	Vertebral postero-anterior
6	Vertebral lateral
7	Chest postero-anterior
8	Chest antero-posterior
9	Chest lateral
10	Chest spine vs erect
11	Long bone postero-anterior
12	Long bone lateral
13	Short bone postero-anterior
14	Short bone lateral
15	Pelvic postero-anterior
16	Pelvic lateral
17	Soft tissue
18	Interavenous pyelography (IVP)
19	Myelography
20	Uretherography
21	Barium enema
22	Barium swallow
23	Ultrasound

Appendix D

Medical narratives used in the database

Attributes	Narration	description
Subjective	CC	Chief complaint
	HPI	History of present illness
	PMH	Past medical history
	FH	Family history
	SH	Social history
	ROS	Review of systems
Vital Signs	T	Temperature
	RR	Respiratory rate
	BP	Blood pressure
	PR	Pulse rate
Objective	PE	Physical examination
	GA	General appearance
	HEENT	Head, eye, ear, nose and throat
	LGS	Lympho pandular system
	RS	Respiratory system
	CVS	Cardiovascular system
	GIT	Gastrointestinal track
	GUS	Genetourinary system
	IS	Integumentary system
	MSS	Masculoskeletal system
	CNS	Central nerves system
	DDx	Differential diagnosis
Assessment	Dx	Diagnosis
Plan	Ix	Investigation
	Rx	Treatment
Discharge summary	Hx	History
	PE	Physical exam
	Ix	Investigation
	Dx	Diagnosis
	Rx	Treatment
	C	Course
	DD	Discharge diagnosis

Appendix E

Other options used in dropdown lists

Discharge Status
Against medical advise
Died
Improved
Referred
Same condition
Transferred
Worsen

Marital Status
Child
Divorced
Married
Single
Widowed

Patient's Occupation
Bar Lady
Daily laborer
Farmer
Government employee
House wife
Merchant
Other
Prostitute
Retired
Self worker
Solder
Student
Unemployed

Caregiver's occupation
Clerk
Health assistant
Health officer
Laboratory technician
Medical doctor
Nurse
Pharmacist
X-ray technician

Caregiver's qualification
BSc. Lab technician
BSc. Nurse
BSc. Pharmacist
BSc. Sanitarian
BSc. X-ray technician
General Practitioner
Health assistant
Health officer
Junior clinical nurse
Junior lab. Technician
Junior midwife nurse
Junior pharmacy technician
Junior public nurse
Junior sanitarian
Junior x-ray technician
Ophthalmic nurse
Others
Psychiatric nurse
Senior clinical nurse
Senior lab. Technician
Senior midwife nurse
Senior pharmacy technician
Senior public nurse
Senior sanitarian
Senior x-ray technician
Specialist

Religion
Catholic Christen
Jehovah
Muslim
Orthodox Christen
Other
Protestant Christen
Wakifecha

Appendix F

Interview guide questions

1. Could you describe for me the functions you perform?

Business functions

Information processing functions

2. What are the sources of information and from where do you require those information for your functions?

3. For what purpose do you need the information?

4. How do you process your information processing functions?

5. What are the data elements you work with? Ex. Patient = id, name, disease, treatment, etc.

6. Where do you send your processed information?

7. What are the problems (defects) of the existing system?

8. What are the strong points to be preserved in the current (existing) system?

9. What is your opinion or suggestion to improve the existing system?

10. How and what kinds of information do you require from the improved system? (Arrangement, format etc.).

11. Do you need a computer-based information system?

12. If 'yes' are you willing to involve in the development of such information system?

13. How is your exposure to basic computer skills?

14. Is there any point or issue you think to be mentioned or discussed?

15. Do you have any questions about my study?

Thank you!