Emergency Medical Services Management Information System

A Thesis Presented

By

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in

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ACCEPTANCE

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July 2020

DECLARATION

I, the undersigned, declare that this thesis work is my original work, has not been presented for a degree in this or any other universities, and all sources of materials used for the thesis work have been duly acknowledged.

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List of Acronyms

BLS	Basic Life Support
EC	Emergency Center
ER	Emergency ROOM
GOB	Gynecology and Obstetrics
LCP	Liaison Command Post
LO	Liaison Office
OR	Operation ROOM
TT	Triage Team
OPD	Outpatient department
AD	Activity Diagram
SD	Sequence Diagram
UC	Use case
SR	System Requirement
OOAD	Object Oriented Analysis and Design

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Abstract

One cause of for high mortality in emergency patients is the inefficient communication between hospitals providing the emergency services. Hospitals that are not designed to manage causality may be out of their depth when a man made or natural disaster occurs .The problem of managing emergency patient increases daily in Addis Ababa as the number of patient in need of emergency medical service increases .

An Emergency medical Service focuses on providing timely care to victims of sudden and life-threatening injuries or emergencies in order to prevent needless mortality or long-term morbidity. The complexity and demand for the management of beds with in Addis Ababa hospitals is increasing day by day for patients coming for an emergency service. One of the functionalities of Emergency Medical Service is a systematic bed provisions and ambulance services across network of governmental hospitals

This proposal project proposes the development of a web-based application that facilitates registration of an emergency patient's information, emergency patient bed management, and ambulance usage until the patient is hospitalized. The System will be used across number of governmental hospital wards within Addis Ababa City. The project is also designed to solve the problem managing provision to disaster survivors.

Object oriented analysis and design methodology will be used for the development of the project.

Future research work need to be done on web based emergency service at national level service.

Keywords: Emergency Medical Service, Emergency Patient, Governmental Hospitals.

Chapter One

Introduction

1.1 Background

Emergency Medical Services, more commonly known as EMS, is a system that provides emergency medical care. Improving the emergency care provided to patients is the key priority for the emergency medical services that are provided by hospitals. Ambulance services and emergency departments have a common goal to meet the emergency health care of the community. To meet the need for emergency medical services in Ethiopia, a referral system was established in 1983 with a main objective of establishing the referral system to use governmental hospitals effectively.

The first Ethiopian emergency medicine specialists, who have graduated in Oct 2013, improved the EMS in Addis Ababa and paved the way to its current status. Currently the EMS that is established in Addis Ababa has small team of specialized emergency medical teams at each governmental hospital.

One of the parties that play the leading role in EMS is Liaison Command Post, which is the focus of this project. Liaison Command Post (LCP) directly report to Ministry of Health. It has branches across 10 Governmental Hospital in Addis Ababa with the exception of Army and police Hospitals.

At each of these hospitals there is a Liaison office (LO) with 3 to 4 health professionals stationed at a time. And each hospital has at least 1 Ambulance dedicated for this service. The main objective of the command post is to give an immediate service to emergency patients, distribution of emergency patients to different wards (Patient Admission and Discharge) and referral to other hospitals. These emergency patients can be from referral hospitals, Health center or a walk in. The emergency can be of an accident, laboring mother, surgical emergency, bleeding and others.

A call to an emergency medical service can be initiated from different location. Once it is activated by an incident that causes serious illness or injury, the focus of EMS is to provide an emergency medical care for the patient. In Addis Ababa, there are lists of Emergency Medical Service responders that gives EMS related pre hospital services with no or minimum cost like: Red Cross, Ambulance at each hospital, Ambulances shared by Governmental health Center and the City fire Department.

A Liaison office in each hospital has a list of available beds in each ward. Patient admittance (bed assignment), discharge from hospital and transfer across wards is managed by this office.

The aim of Liaison command post is to provide immediate medical service to emergency patients. Currently there are problems which hinder the command post from achieving fully its objectives. The problems in the existing system will be discussed in detail in Chapter 3.

1.2 Statement of the Problem

For every Emergency Medical system, a highly coordinated delivery of service in an organized and efficient way is of paramount importance for the successful delivery of its objectives. These objects can be listed as [1]:

- To provide a prompt, accurate and definitive emergency medicine and trauma care service.
- To provide an integrated and comprehensive care which is seamless and continuous from the pre hospital care setting through the hospital service.
- To provide an efficient and effective resuscitation and stabilization together with an accurate diagnostic service and critical saving interventions

While advanced EMS systems in high-resource settings have been shown to save lives that previously had a high risk of dying at the scene or on the way to the hospital, there is still a high burden of preventable morbidity and mortality in Addis Ababa that lacks a responsive and time-sensitive EMS system.

There are many problems facing the EMS system like:

- The lack of a coordinated EMS system.
- The lack of designated well-developed emergency center (EC).
- The lack of human and material resources to care for injury or acutely ill patients.
- The lack of medical training on principles of triage and emergency management.
- The lack of systematic contingency plan to care of the needy in case of natural or manmade disaster.

The project will focus one on of the problems and tries to provide a solution for it.

Summarizing the above mentioned problems facing the manual system, the project focuses on the lack of a coordinated EMS. This lack of coordination is manifested in the communication between health centers and Hospitals, Hospitals to Hospitals and hospitals to command center. The project will describe the flow of communication starting from a call made by a patient to the final admittance of the patient to a hospital.

1.3 Objectives

1.31 General Objectives

- To design and develop Web Based Emergency Medical Service.

1.32 Specific Objectives

- To design Web Based Emergency Medical Service.

- To develop Web Based Emergency Medical Service.

- To minimize the time between emergency patient bed requesting to admittance.

- To deploy the Web Based Emergency Medical Service.

1.4 Scope and Limitation

The scope of the project is to analyze, design and develop a Web Based Emergency Medical Service system.

The proposed system will have a central web server and database from which authorized users will be allowed access to retrieve and insert information. All hospitals under Liaison Command Center will be able to use the system.

The proposed system will have basic functionalities which are detailed in functional and non-functional requirement in section 4.3 and 4.4.

Deliverables at the end of the end of the project will include:

- Final report of the project which includes requirement document, system analysis and design.
- A web-based Emergency Medical Services Management Information System

Constraints:

- The system will not include other than emergency cases like billing, appointment, patient history and laboratory which are not included in the functionality requirement.

-The system to be developed will not have an interface to include users at health centers.

- The only system users considered are those that operate at the hospitals with in the network and those at the command post.

1.5 Significance of the Project

The development of the system serves multipurpose. For every stake holder that is going to be involved with the project it serve different role.

For The patient: Satisfaction from first emergency call until the final treatment at hospitals.

For The Emergency Medical Staff at Hospitals:

- Satisfaction in the easy and systematic way emergency patients are managed.

For the Command Post:

- The management of emergency patients to hospitals beds.
- The management of disaster management (massive) patients at temporary hospitals, like in a hall or auditorium.

For Policy Makers:

- Organized data available to make future decision (plan) on emergency service provided.

1.6 Organization of the rest of the report

In Chapter Two (Literature Review) the report defines what EMS (emergency Medical Service) is. It points out that a well-organized EMS is vital in handling different types of emergency requiring medical responsiveness. Then Different types of EMS models are discussed:

1. Anglo-American and Franco-German model.
2. Basic Life Support and Advanced Life Support

Ambulance services and triage are mentioned as Type of services in EMS. The effectiveness of EMS as a Crisis/Disaster Management is as a determinant factor is mentioned. In related works, comparison of EMS in different parts of the world is discussed.

In Chapter three (methodology) tools used in data collection and construction of the system with their specific purposed is discussed.

Chapter Four (Requirements Analysis)

Importance of determining the right users' requirement is a paramount importance which is discussed here. In the importance of selecting system requirement, **Interviews** are

compared against **Questionnaires**. Detailed analysis of existing system business process is extracted from the interviews and represented as use-cases. Furthermore, problems of the existing manual system are covered. The functionality and non-functionality for the system to be developed is listed and discussed in detail. Use-cases describing each functionality in graphically UML (use-case, Activity Diagram, Sequence Diagram and in descriptive statements have been described.

Chapter Five (Proposed System Design)

Class diagram which represent the static view of the system is represented with its object-oriented feature in graphical representation. Likewise, in the database model which includes databases objects the structure of these objects are defined. The database objects described are: Auditor Tables, Lookup Tables, Transactional Tables, Views and Triggers. The entity relationship diagram (ERD) between the above mentioned-tables in the database is also described.

Chapter Two

Literature Review

2.1 Introduction

An Emergency Medical Service (EMS) can be defined as a comprehensive system which provides the arrangements of personnel, facilities and equipment for the effective, coordinated and timely delivery of health and safety services to victims of sudden illness or injury [2].

Countries will face major challenges to protect their population from an increasing number of potential health threats in the future. Preparedness and prevention will play a significant role in ensuring an efficient response to national and international crises. EMS systems form an integral part of any public health care system as their primary function is to deliver emergency medical care in all emergencies, including disasters [3].

It is widely recognized that an effective disaster response is more dependent on the pre-existing local system than on external assistances. In the early stages of a health crisis, the ability to respond depends on the level of preparedness of the local community and health services.an efficient and well–structured EMS system insures the achievement and maintenance of the skill necessary to deal with disasters, while disaster preparedness helps to identify organizational gaps [3].

2.2 Models of EMS

EMS can be defined as a comprehensive system which provides the arrangements of personnel, facilities and equipment for the effective, coordinated and timely delivery of health and safety services to victims of sudden illness or injuries. The aim of EMS focuses on providing timely care to victims of sudden and life-threatening injuries or emergencies in order to prevent needless mortality or long-term morbidity. The function of EMS can be simplified into four main Components:

1. Accessing emergency care
2. Care in the community
3. Care en route
4. Care upon arrival to receiving care at the health care facility.

Since 1970s, the manner in which emergency health care delivery in pre-hospital environment has grown into two main models of EMS with distinct features. These are the Anglo-American and Franco-German model. These categorical distinctions were obvious during the 1970s until the end of the 20th century. Today, most EMS systems around the world have varied compositions from each model [4].

Another method of EMS classification is according to the level of care provided into Basic Life Support and Advanced Life Support according to the level of care provided.

The Franco-German model of EMS delivery is based on the "stay and stabilized "philosophy. The motive of this model is to bring the hospital to patients. It is usually run by physicians and they have extensive scope of practice with very advanced technology. This philosophy is widely implemented in Europe in which emergency medicine is relatively a young field [4]. Consequently in Europe, pre-hospital emergency care is virtually provided by emergency physicians. The attending emergency doctors in the field have the authority to make complex clinical judgment and treat patients in their homes or at the scene. This results in many EMS users being treated at the site of the incident and less being transported to hospitals. The very few transported patients are usually directly admitted to hospital wards by the attending field emergency medicine physician bypassing the emergency department. Hence this system has the advantage of minimizing the overcrowdings that will occur by patients needing emergency service at hospitals.

Countries such as Germany, France, Greece, Malta and Austria have well-developed Franco-German EMS [4].

In divergence from the Franco-German model, the Anglo-American model is based around the "scoop and run "philosophy. The aim of this model is to speedily bring patients to the hospital with less pre-hospital interventions. It usually works in

cooperation with public services such as police or fire departments. It greatly relies on land ambulance and less so on aero-medical evacuation or coastal ambulance. In countries following this model, emergency medicine is well-developed and generally recognized as a separate medical field. Almost all patients in the Anglo-American model are transported by EMS personnel to developed Emergency Departments rather than hospitals wards. Countries which use this model of EMS delivery include the United States, Canada, New Zealand, Sultanate of Oman and Australia.

Comparison between Franco-German model and Anglo-American model

While both systems have the same principal mission when delivering emergency care for trauma and life-threating illness, they differ when delivering non-life threating care and scheduled transports of stable cases. The conventional European style uses primary care options rather than transporting patients to Emergency departments in comparison to the Anglo-American system.

Many studies have attempted to compare the two systems in terms of outcome or cost-effectiveness. However, it seems that they are not really comparable because they tend to operate in different contexts with different types of demands to meet. Also, the lack of unified standards between the two models makes comparison an unjustifiable exercise. Thus, there is currently no evidence that one model is better than the other and studies continue to show conflicting conclusions. Other than the issue of which model is best, there is the question of which organization in the community should provide EMS [4].

2.3 Types of Services Provided in EMS

Ambulance services

According to the EU standards, road ambulances can be categorized into three types:

Ambulance type A (patient transport ambulance): Road ambulance designed and equipped for the transport of patients who are not expected to become emergency patients.

Ambulance type B (emergency ambulance): Road ambulance designed and equipped for the transport, basic treatment and monitoring of patients.

Ambulance type C (mobile intensive care unit): Road ambulance designed and equipped for the transport, advanced treatment and monitoring of patients [3].

The ambulance service that is used in the EMS in Ethiopia is mainly used for the transportation purpose of transporting emergency patients or Ambulance type B.

Triage

One of main indicators used to evaluate EMS are process indicators. One of these process indicators is response time for ambulances and waiting times for patients in Emergency Departments. To minimize the waiting time for emergency patients, the usage of triage is imperative.

According to Wikipedia, Triage is the process of determining the priority of patients based on the severity of their condition. An effective triage system aims to ensure that all patients seeking emergency care 'receive appropriate attention, in a suitable location, with the necessary degree of urgency'. In another word, Triage is a continuous process for classification of the patients according to priority. It is reported that employment of triage scales in Emergency Departments has led to significant reduction in waiting times and improved patients' satisfaction [5].

The most important cause of bottleneck in the ED seems to be a growing population with non-urgent complaints. Non-urgent patients' use of EDs, rather than primary care settings, allows them to be treated without an appointment in a setting with modern and high-quality technologies [5].

People who do not want to wait in lines in polyclinics prefer to use EDs and ED physicians are forced to give healthcare to everyone entering ED whether urgent or not. The use of Triage in an ED can be of great use in facilitating the treatments of patients according to the severity of their case.

As a result, diagnosis and appropriate treatment is made earlier. Admission is made appropriately which leads to timely care, less complication and earlier discharge from the emergency center.

2.4 Crisis/Disaster Management

Crisis is in EMS sense defined as any situation where the health services receive such a rush of new patients that it strains available resources to the limit. A “critical situation” can be described as the equilibrium between the demand and the supply of medical care. This occurs when the health care service receives an unusually large number of new patients in a relatively short period of time (casualty), a rush that overwhelms the capacity to meet needs if exceptional measures are not implemented [3].

The term crisis is alternatively used in the literature with other expressions of similar meaning such as: “mass casualty incident”.

It implies a high number of patients requiring medical assistance at once. However, it disregards the ratio between supply and demand, which is a two-dimensional relationship. The chief components of emergency services include the fields of security medical care, shelter, logistics, rescue, telecommunication, public information etc. Major incidents may require most, if not all, emergency services available and, depending on their size, they may involve the services at a national scale.

Problems and suggestions in Bed Managements Bottleneck

A variety of less sophisticated strategies are also promising for reducing Emergency department(ED) output bottlenecks. These include the following:

1. Minimize discharge waiting times by rescheduling physicians’ discharge rounds when occupancy rates increase,
2. Use housekeeping SWAT teams to clean and prepare beds as soon as patients are discharged instead of cleaning all empty beds in an entire unit on a pre-set schedule.
3. Use discharge lounges where patients can complete paperwork, receive follow-up instructions, and wait for transportation without occupying an inpatient bed [6].

Given the difficulties involved maintaining large amounts of excess capacity, a major patient surge will require hospitals to expand well beyond their normal capacity by creating additional patient treatment areas. This may involve placing beds or stretchers

into cafeterias and conference rooms or the use of specialized tents and mobile facilities that can be placed near the hospital building. During a major disaster, hospitals may create surge capacity by rearranging existing patterns of care. The quickest and easiest way of doing this would involve postponing elective procedures and redirecting patients seeking non-urgent care. A more difficult, but potentially important, action involves altering the standards of care that patients receive. Under ordinary circumstances, hospitals give priority to the most critical patients first. But when responding to a disaster, hospitals may need to change priorities [6].

2.5 Related Works

Africa:

Little is known about the existence, distribution, and characteristics of Emergency Medical Services (EMS) systems in Africa, or the corresponding epidemiology of pre-hospital illness and injury.

A survey was conducted between 2013 and 2014 by distributing a detailed EMS system questionnaire to experts in paper and electronic versions. The questionnaire ascertained EMS systems' jurisdiction, operations, finance, clinical care, resources, and regulatory environment. The discovery of respondents with requisite expertise occurred in multiple phases, including snowball sampling, a review of published scientific literature, and a rigorous search of the Internet.

The survey response rate was 46%, and data represented 49 of 54 (91%) African countries. Twenty-five EMS systems were identified and distributed among 16 countries (30% of African countries). There was no evidence of EMS systems in 33 (61%) countries. A total of 98,574,731 (8.7%) of the African population were serviced by at least one EMS system in 2012. The leading causes of EMS transport were (in order of decreasing frequency): injury, obstetric, respiratory, cardiovascular, and gastrointestinal complaints. Nineteen percent of African countries had government-financed EMS

systems and 26% had a toll-free public access telephone number. Basic emergency medical technicians (EMTs) and Basic Life Support (BLS)-equipped ambulances were the most common cadre of provider and ambulance level, respectively (84% each).

Emergency Medical Services systems exist in one-third of African countries. Injury and obstetric complaints are the leading African pre-hospital conditions. Only a minority (<9.0%) of Africans have coverage by an EMS system. Most systems were predominantly BLS, government operated, and fee-for-service [7].

Middle East: Saudi Arabia

The EMS in Saudi Arabia is a vital first point of contact for pre-hospital patients and the responsibility for providing pre-hospital care and transport falls on the Saudi Red Crescent Authority (SRCA).

The EMS service in Saudi Arabia is based mostly on an Anglo-American model, which aims for the rapid transport of patients to an emergency department by clinically competent paramedics. Other countries that adopt this model are the United Kingdom, the United States, New Zealand, Australia and the Sultanate of Oman [8].

The pre-hospital care system in Saudi Arabia is still developing in issues pertaining to community awareness, attitudes and the knowledge deficiencies of pre-hospital care providers.

A study found that out of the 2,928 patients transferred, only 109 (3.7%) used the Red Crescent EMS service, which the study described as a “disturbing finding ”.In addition, the study reported a significant lack of basic life support (BLS) and advanced cardiac life support (ACLS) certifications of the paramedics involved[8].

This deficiency in knowledge gives an indication of the lack of development in EMS education in Saudi Arabia.

European Union:

In response to changes in medical technologies and population health trends, most European EMS now have elements of both organizational models–load & go for complex trauma care, such as in the case of road traffic accidents, and stay &stabilize for medical emergencies, such as heart attack or stroke. Neither model, on its own, is superior.

2.6 The Role of IT in Emergency Medical System

The Role and effect of Information Technology (IT) in healthcare service is visible from the way the quality of healthcare services has changed during the last 20 years. One increase in the quality of service is in timeliness and precision [24].

The quality and timeliness of emergency medical service (EMS) care is receiving considerable public interest in developed countries. The emerging significance of time-sensitive medical interventions for conditions such as cardiac arrest, stroke, and acute myocardial infarction has led to growing utilization of EMS care prior to hospital arrival. In fact, demand for EMS care internationally is increasing by as much as 12.5% every year, and this is placing renewed pressure on EMS performance targets [26].

The increase in the quality of the EMS has been visible when seen through the change in different factors produced by the advancement of IT. One of these factors is accountability. Lack of accountability has contributed to the failure of the emergency care system to adopt needed changes in the past. Without accountability, participants in the system need not accept responsibility for failure and can avoid making changes necessary to avoid the same outcomes in the future [25].Accountability is difficult to established in emergency care because responsibility is dispersed across many different components of the system.

In conclusion use of IT in emergency care is a determinant factor for increasing the managing of responsibility, timeliness and precision across different sectors of the EMS.

Chapter Three

Methodology

In all types of projects, there is a 'lifecycle'. That means there a sequence of process from the inception of the project to its termination (completion).In software development it is called the software development lifecycle

A Software Development Life Cycle (SDLC) is a framework that defines the steps that need to be followed in software development. SDLC contains several phases that pertain to the progress of system under development. Every textbook author and information system development organization uses a slightly different life cycle model, with anywhere from three to almost twenty identifiable phases [3].

To list some of the most common types of process models in use: waterfall model, prototype model, spiral model, incremental model, rad model and agile model. Each model has its advantage and disadvantages depending on the type of software and environment the system is to be developed.

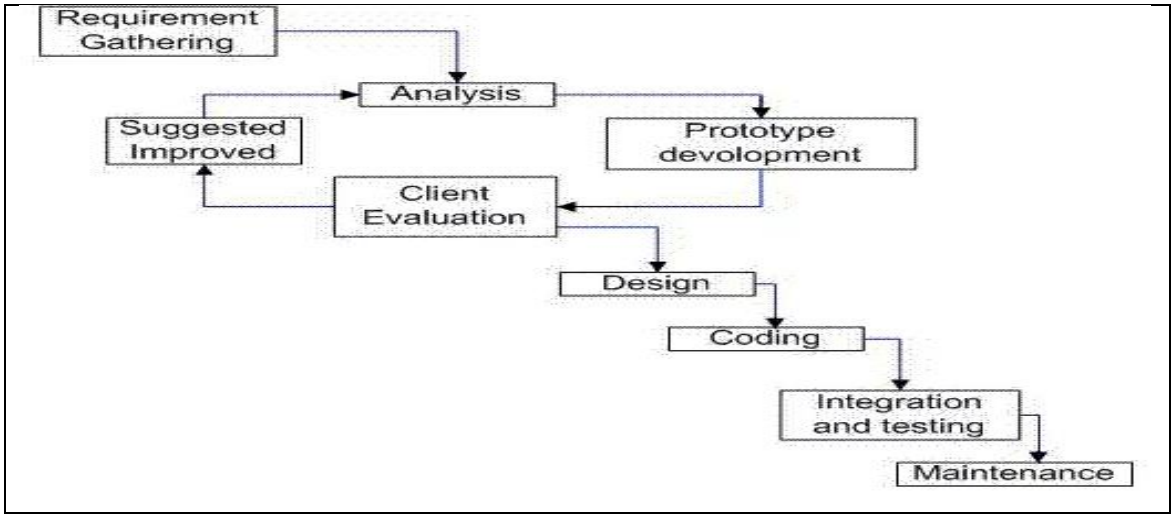


Fig 3.1: Evolutionary Prototyping Model

Of all the above mentioned design methods OOAD method of decomposing a problem is different .One difference is that it highlights modularity and re-usability. An object-

oriented system is composed of objects and the behavior of the system results from the communication of those objects.

The system being developed uses object oriented system analysis and design approach (OOAD) and also adapts features of waterfall model in an iterative manner. The project has followed a highly participatory methodology with reasonable levels of interest and motivation from the majority of participants (domain experts).

The system uses a highly user (experts in the field of EMS) interaction during the development phase: from user requirement gathering to the implementation.

3.1 Data Collection Tools and Techniques

What type of data collection is used and why?

To answer this question we need to consider the type of data source and size which will be considered for the system requirement .As the process of managing emergency medical service is identical across all 10 governmental referral hospital, it is sufficient to consider one of these hospital for data collection. For this purpose Menilik II hospital lesion team select, as they are the one directly related to the hospitals EMS.

The size of the sample considered are the team of lesion office, about 10 people, working in shifts .Though different types collection are used, the choice of selection for most of the data collection tool is interview .The reason of selecting interviews over questionnaires is that interviews are good tools for collecting rich, detailed information and that interviews allow exploration and follow-up. In addition, an interview is generally preferred for an expert analyst (lesion team) an in depth information about the current manual system.

In addition, the data collection method includes observation and relevant document review techniques to collect sufficient data needed for the system to be developed.

- **For Analysis and design** of the proposed system will be performed using the UML tools like the use case modeling and use case diagram.
- **For documentation** Microsoft word will be used.
- **For designing purpose** Visio will be used.

3.2 Software Construction Tools

- Ajax for transmitting data between client and the server without refreshing (reloading) the page.
- MYSQL for the database will be used.
- PHP will be used for server-side coding.
- JQuery, Bootstrap and HTML5 will be used for web page to be responsive to Mobile devices.

3.3 Data Sampling

As the data flow in the manual system is identical across all selected hospitals, only a single hospital (Minilik II Referral Hospital) is selected for requirement gathering. In the hospital, the manual EMS is managed by small number of specialists. As a result, intensive interviews are preferred over questionnaires (one of the reason for adopting agile).

3.4 Requirements Gathering

- Group and One-to-One Interviewing: The
- Prototyping (user interface).
- Observation: Observation as the Liaison personal handles emergency case.
- Documents: Documents used in the manual system.
- Interviewing the Liaison medical professional to go through different scenarios(Annex- I).

3.5 Testing techniques

Section 5.6 discusses in detail about functional and non-functional testing.

3.6 Documentations

Documents included in the paper are:

- SRS document
- Interview format
- Requirements Analysis which includes (system requirement, UML diagrams)
- Design document
- Testing document

- User graphical interface
- List of Tables and Figures
- References
- Source Code

Chapter Four

Requirements Analysis

4.1 Introduction

The objective of system analysis is to truly understand the requirements of a system. Most systems fail sort of this objective. The problem in most of this failed system is attributed to poor Requirement elicitation:

…accurately capturing system requirements is the major factor in the failure of 90% of large software projects" (Davis et al., 2006), Poor requirements management can be attributed to 71 percent of software projects that fail; greater than bad technology, missed deadlines, and change management issues[9].

To avoid system failure that comes from poor system requirements, the proposed system has tried to bridge the gap between requirements understood between domain experts and system developers. Of all the other tools mentioned for gathering requirement in chapter 3, the interviewing method is used repeatedly. The reason for selecting interview over questioners is described below in the Table 4.1 [10].

After the developer has introduced himself he explained the purpose for the interviews. It is explained that the interview is important in that it helps in pointing out the deficiency in the manual EMS and will help in alleviating the mentioned manual based EMS system in the new to be developed EMS system. The interviewees were informed that interview will based on list of interviews questioned which are prepared. The types of interviews followed are Open-Ended Questions and probing questions which are usually used in detail information extraction from domain experts. For reference the interviews used are added in the Annex-I.

Table 4.1 Comparison of Interviews and Questionnaires

Characteristics	**Interviews**	**Questionnaires**
Information Richness	High (Many Channels)	Medium to low (only responses)
Chance for Follow-up And probing	Good: probing and clarification questions can be asked by either interviewer or interviewee	Limited: probing and follow-up done after original data collection.
Confidentiality	Interviewee is known to the interviewer	Respondent can be unknown
Involvement of Subject	Interviewee is involved and committed	Respondent is passive
Potential Audience	Limited numbers, but complete responses from those interviewed	Can be quite large, but lack of responses from some can bias results

.

The question starts from describing the process of managing emergency patient coming to the hospitals. Formats that are used for the manual management of emergency patient is referred in the reference table.

4.2 Existing System

Description of the existing system is necessary to ensure that the old system functionality is correctly understood.

The existing Emergency Medical System has been established with the main object of saving life for an emergency case. The case could be injury or illness. To manage patient coming as emergency case, there is a Command Post established under Ministry of Health. Ten Governmental Hospital are assigned to manage emergency medical cases.

One of these Hospitals is Minilik II Referral Hospital. As the business process across all the other hospitals are the same, Minilik II Referral Hospital is taken as typical test case. A description of business process performed in Minilik II Hospital is described below.

4.2.1 Existing Business Process Model

In the existing manual system, a patient is referred from Health Center to the Hospital as described in table 4.2. Once the patient has been accepted by the emergency triage team an immediate medical assistance will be provided. Depending on the severity of the injury the patient might need to be admitted to the hospital as in Table 4.3 or will be referred to another hospital if there is no available bed in the hospital as in Table 4.4.

Table 4.2: Receive Patient

Use Case Title	Receive Patient
Brief Description:	Emergency patient is received at triage
Actors:	Doctors, Nurses, Receptionist
Basic Flow (BF) & Alternate Flow (AF)	
Line	Action
1	A phone call from Health Center requesting assistance is made to the triage team. The triage team sends an ambulance or the health center send the patient with an ambulance (BF1).
	An emergency patient brought from site of accident directly to the hospital (AF1).
	An emergency patient arrived at the hospital with an acute pain (AF2).
2	Emergency patient is brought to the triage ward. The triage team screens the patient and determined the severity of their condition by taking patient history, physical assessment and laboratory investigation. If the patient needs immediate medical treatment like bleeding, immediate medical treatment is provided.

Table 4.3: Send Patient to Ward

Use Case Title	Send patient to Ward
Brief Description:	A patient after triage is sent to a ward for further medical treatment.
Basic Flow (BF) & Alternate Flow (AF)	
Line	Action
1	After Determination of the type and severity of the emergency the triage Team sends the patient to related ward.
2	The ward recommends that the patient be admitted (BF1).
	Triage team admits the patient to a bed (BF2).
3	The patient after treatment is sent home (BF2).

Table 4.4: Refer Patient to Hospitals

Use Case Title	Refer Patient To Hospitals
Brief Description:	A patient is refereed to another hospital
Basic Flow (BF) & Alternate Flow (AF)	
Line	Action
1	The triage team makes a phone call to the other 9 hospitals until an empty ward is found to accept the patient.
2	A hospital with a vacant ward accepts the request to accept the patient.
3	The patient is sent to the hospital with an ambulance.
Post Condition:	Patient sent to another hospital.

4.2.2 Manual Forms Used in Triage

The Figure Fig 4.1 represents the format the Triage uses for admitting patient to a bed at Minilik II Referral Hospital. The total number of admission and discharge are marked

daily for each ward which is shown in Fig 4.2. The last manual form used by the Triage is used for making report total number of reference made to the hospital and out of the hospital in 24 hrs.

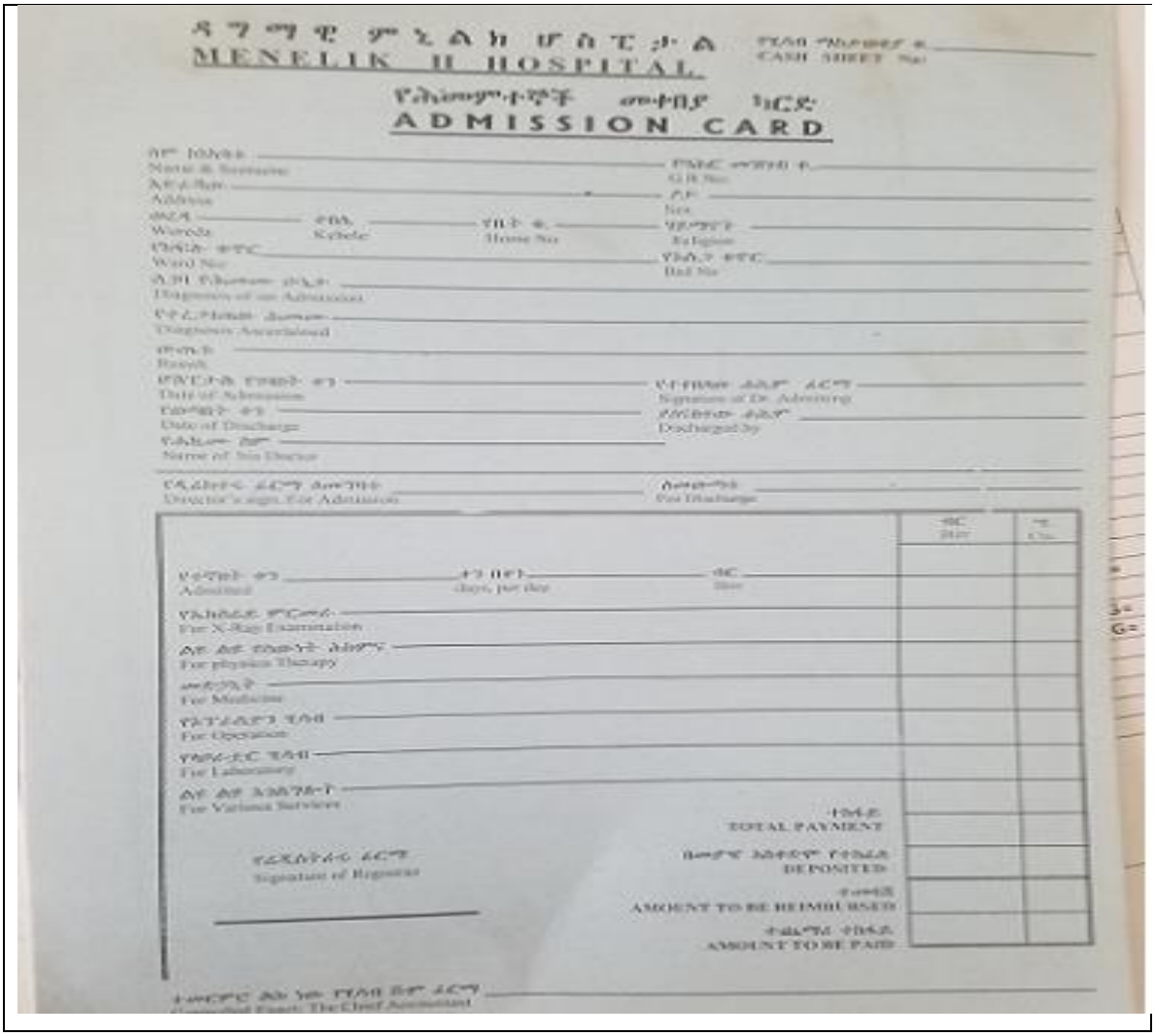


Fig 4.1: Patient Bed Admittance

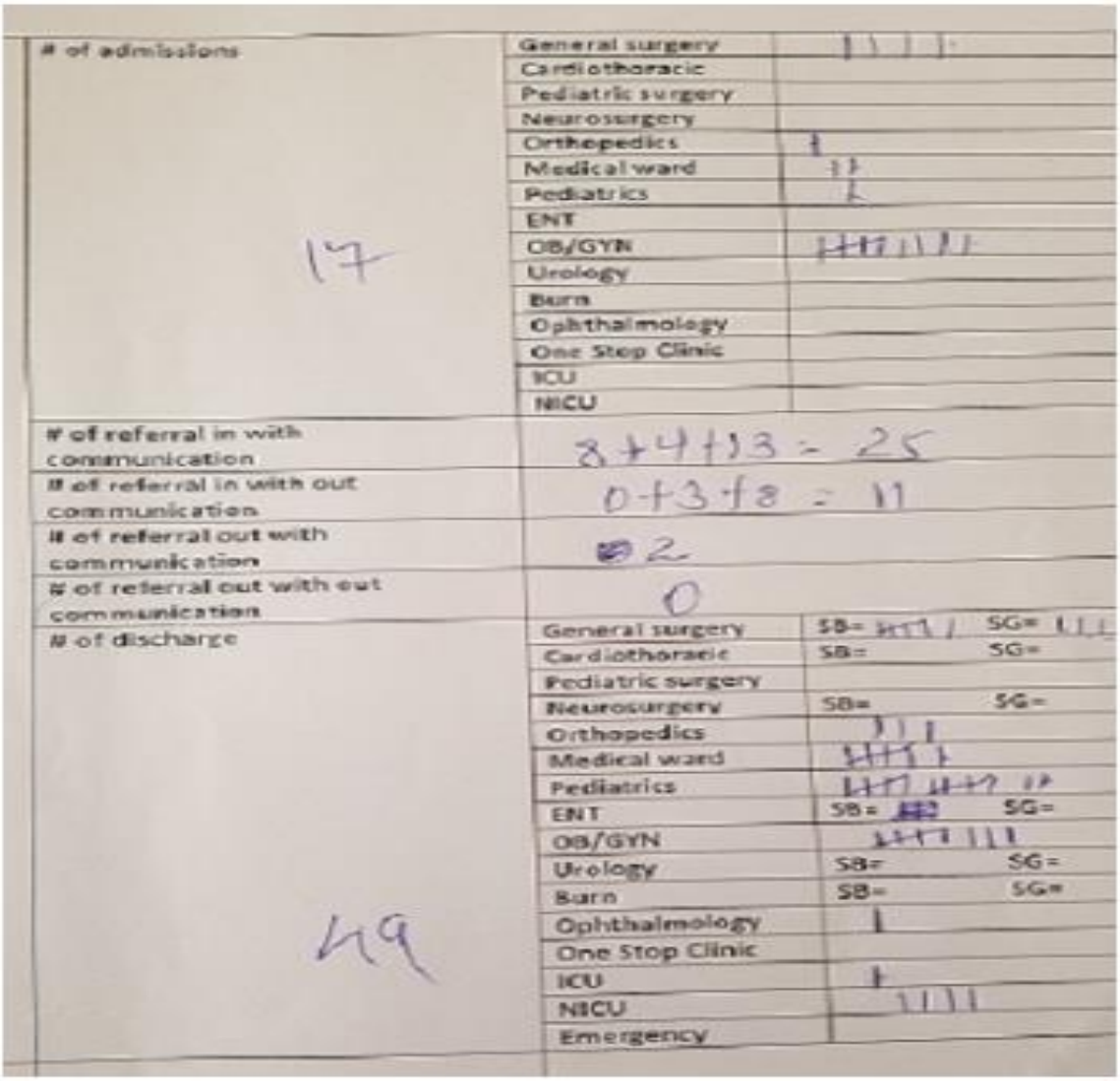
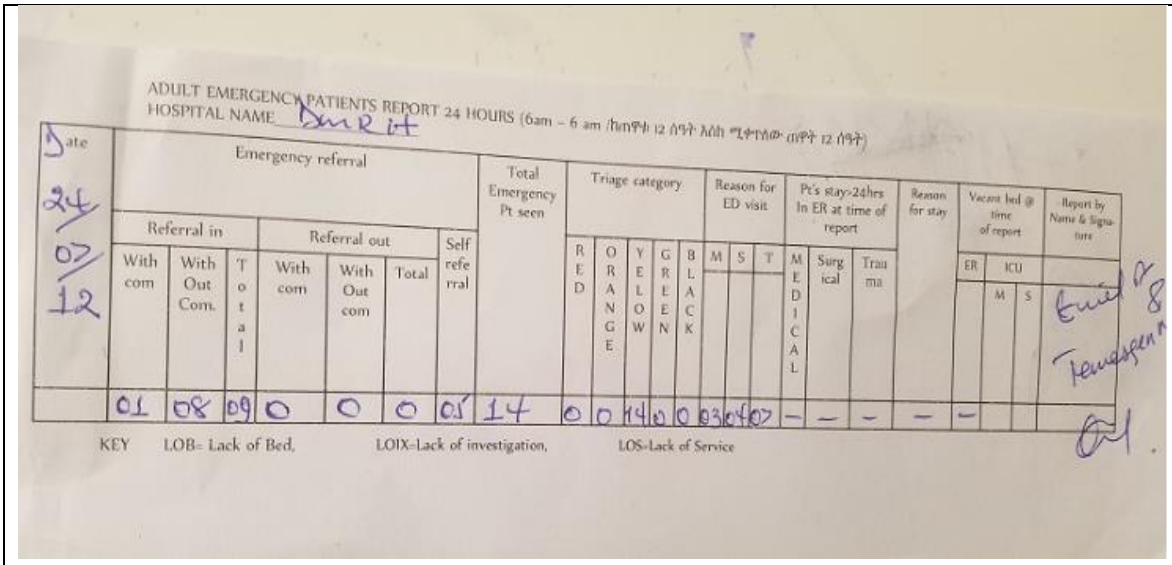


Fig 4.2: Emergency patient entry

Fig 4.3 below represents daily statistical report submitted by the triage on the number admitted, refereed and discharged patients to and out of the hospital.



ADULT EMERGENCY PATIENTS REPORT 24 HOURS (6am – 6 am ከጠዋት 12 ሰዓት እስከ ማታ 12 ሰዓት)

HOSPITAL NAME Amrit

Date	Emergency referral							Total Emergency Pt seen	Triage category					Reason for ED visit			Pt's stay>24hrs In ER at time of report			Reason for stay	Vacant bed @ time of report			Report by Name & Signature
	Referral in			Referral out			Self referral		RED	ORANGE	YELLOW	GREEN	BLACK	M	S	T	MEDICAL	Surgical	Trauma		ER	ICU		
	With com	With Out Com.	Total	With com	With Out com	Total																M	S	
24/07/12	01	08	09	0	0	0	05	14	0	0	14	0	0	03	04	07	–	–	–	–	–			Emil & Temesgen

KEY LOB= Lack of Bed, LOIX=Lack of investigation, LOS=Lack of Service

Fig 4.3: Emergency Patient Daily Report

4.2.3 Problems Identified on the existing manual System

1. Poor Communication between health center-hospital and hospital-hospital.

   When an emergency call received by a health care or a hospital, the hospital gives an immediate emergency treatment to the patient. The hospital available bed might be full or the patient needs special treatment in another hospital. Then the health officer at the hospital will start making phone call to Hospital A to receive the patient. Hospital A responds by saying that it has no available beds. So the Health officer continues making a call to another Hospital B, whose response might also be negative. If there is no available hospital to receive the patient, a call is made to the command post requesting assistance. The command post starts checking for available beds through the hospitals that have the medical specialty and equipment to treat the patient by going from hospital to hospital in person. Once the command post arranges for vacant hospital bed, it will inform the hospital with the patient to bring the patient to that particular hospital.

2. Time Consuming

   We can observe from the above scenario the number of minutes that will be lost while looking for available beds. As a result, critical minutes will be lost that could have served to save lives or minimized traumas.
3. Poor control of command post over the network of hospitals.

   Command post have no knowledge of available beds across hospitals at any time, which would be very essential in case of epidemic, mass accident or natural disaster.
4. Sometimes, the mobile or the phone on the receiver side does not work.
5. The caller does not have information on the type of bed available on each ward on other hospitals.
6. There is no formal and organized way of sending patient's vital signs and lab investigation results to the receiving end of a hospital.
7. There is no systematic way for the Command post to check on beds available across each hospital unless visited in person.
8. There is no systematic ways of keeping records of emergency service rendered on each hospital.
9. Performance depends on individual; depending on the individual respond to bed can be affirmative or negative.
10. There is no systematic ways of managing the logistic in Disaster Hospitals.

4.3 Functional Requirement

In software development process functional requirement specifies what the intended system should do. From listed functional requirement, we can determine if requirement analysis is missing or not. Listed below are the functional requirements for the intended EMS.

4.3.1 Manage Security (FR1)

Different system users have different privileges and have also different views of the system according to their profile.

- Only authenticated users should login to the system.
- A user shall have a role, which will have specific privileges.
- A user can change his password.
- Only active user should be able to login.
- The system will automatically disable a user after 4 wrong login tries.
- BCRYPT feature has been used for password verification.

4.3.2 Manage Lookup (FR2)

During data entry, numerous errors can be prevented if we can minimize data entered by typing by replacing it with a selection box. For this purpose the use of combo boxes that are populated from the database are repeatedly used in the system. The tables that are used for populating these combo boxes shall be referred as lookup tables. There will be an interface for populating these lookup tables. Note that the Lookup tables are not directly related to the main functional tables. The lookup tables used are:

- Category Lookup, Subcategory Lookup and Item Lookup
- Profession Category Lookup and Profession Lookup
- Facility Lookup – defines types of facility that will send patients.
- Ward Lookup – lists of wards with in Hospitals.
- Wereda Lookup
- Emergency Type Lookup
- Unit Lookup

4.3.3 Manage Privileges (FR3)

- All system users shall be assigned a role, which has list of privileges.
- According to their privilege users shall be able to open a page or not.
- According to their privilege users shall make an edit, insert, delete or not on a transactional data.

4.3.4 Registration of Facility (FR4)

- Though a facility can represent either a hospital or a health center, the system to be developed takes into account the basic features of a hospital

4.3.5 Registration of Staff (FR5)

- The system should be able to registered Staff with in a facility.
- .When the status of a staff changes (inactive), his/her user account is also changed (disabled) accordingly.

4.3.6 Registration of Vehicle (FR6)

- Vehicle belonging to hospital are registered.
- A vehicle that is registered under a Facility is also assigned a driver with a contact (tel) number.
- A Hospital emergency staff can check the availability of an ambulance from the system.

4.3.7 Registration of Patient (FR7)

- Emergency Patient shall be registered into the system.
- If the patient does not need a bed, the system concludes the transaction
- If the patient needs to be admitted, request for bed is initiated.

4.3.8 Management of Bed Request (FR8)

- Once emergency patient bed request has been initiated, the system timer shall starts counting .After a predefined time has elapsed with no positive acknowledgment(accepting the patient) to the request , the system makes a recording of all hospitals that have not responded to the request while they have vacant bed in their ward for that particular emergency.
- The command post can intervene and force the hospitals with ward available to take in the patient.

4.3.9 Manage Bed Assignment and Discharge (FR9)

It will register all beds across all hospitals under Liaison command post and updated list of available beds across all Hospitals.

- The system shall have the functionality of admitting a patient to a bed
- The system shall have the functionality of discharging patient.

4.3.10 Manage Disaster Hospital (FR10)

- The system shall have the facility of handling man-made and natural disaster by registering disaster type hospital.
- The system shall have the functionality of registering people coming to be sheltered at the disaster hospital.
- The disaster hospital shall have the facility searching for person registered in it.

4.3.11 Manage Logistics for Disaster Hospital (FR11)

- As a large number of different age group people may be sheltered with in, it is important to get the exact amount of logistic (food, water, cloth, medicine and others) under way.

  For this purpose the system has the functionality of recording item received and issued.

- The system shall register minimum stock level per person.
- The system shall generate report for items reaching minimum stock level.

4.3.12 Manage Message (FR12)

- The system shall have the functionality of sending message to a user.
- The system shall filer messages send to each user.
- The system shall categorized messages read and unread for usability.

Manage Report (FR13)

The system will generate report for functionalities listed.

- The system shall report different types of reports for the lookups.
- The system shall generate reports for staff with different criteria.
- The system shall generate report for patient registered within specific range of date for all or specific hospital for specific or all wards.
- The system shall generate report for patient admitted within specific range of date for all or specific hospital for specific or all wards.
- The system shall generate report for patient discharged within specific range of date for all or specific hospital for specific or all wards.
- The system shall generate reports on patient movement from registration to discharge.
- The system shall produce a report on hospitals response to patient bed request within a range of dates.
- The system shall produce a report on the number of available beds per hospital for specific or all wards.
- The system shall generate a report on available vehicles across one or all hospitals.
- The system shall generate medical man power available per profession across one or all hospitals.
- The system shall produce a report for patients registered within a given disaster hospital with different selection criteria.

- The system shall produce a report on items received for a disaster hospital within range of dates for a given item, item category or all items.
- The system shall produce report on items issued for a disaster hospital within range of dates for a given item, item category or all items.
- The system shall produce an inventory report for disaster hospital a given item category or all items.
- The system shall produce a report on items reaching minimum stock level.
- The system shall produce auditing report for patient registration, patient admittance, patient request acceptance, item received, item issued, staff and user registration.

Business Rule

- A given individual can be registered only under one facility as a staff.
- A system user has to be first registered as a staff under a hospital (facility).

4.4 Non-Functional Requirement

Is a requirement that the system should fulfill from quality aspect.

The system has:

Security

- Only authenticated user can log into the system.
- Each user is assigned a role which specifies what privilege the user can exercise.
- No direct access using URL, without creating a session.
- Number unsuccessful attempts to login will result in a lockout.

Audit Trail

- Transactions that are considered important has an auditing report.

Portability

- As the system is web based application it can be used from any device.
- It is responsive view port for different devices as it uses bootstrap.

Usability `

- The interface is easy to navigate and learn.

Performance

- The system should receive (refresh) new updated request for bed every 2 minutes.
- The system respond time should not be greater than 3 seconds.

Extensibility

- The system is highly modularized and uses MVC architecture which can used to accommodate future need.

Error Handling

- Error due data types or null values is reported to users by client side validation before being sent to the server.
- Error not handled at the client are controlled at the server (server side validation) and reported back to the user.

4.5 Requirements Modeling

4.5.1 Use Cases

In software and systems engineering, use case is a model representation of the software requirement that describe how the user interacts with a system .Use cases are used to gather the SR which is related to the functionality. Table 4.5 shows lists of uses cases identified from the user requirement for the system to be developed.

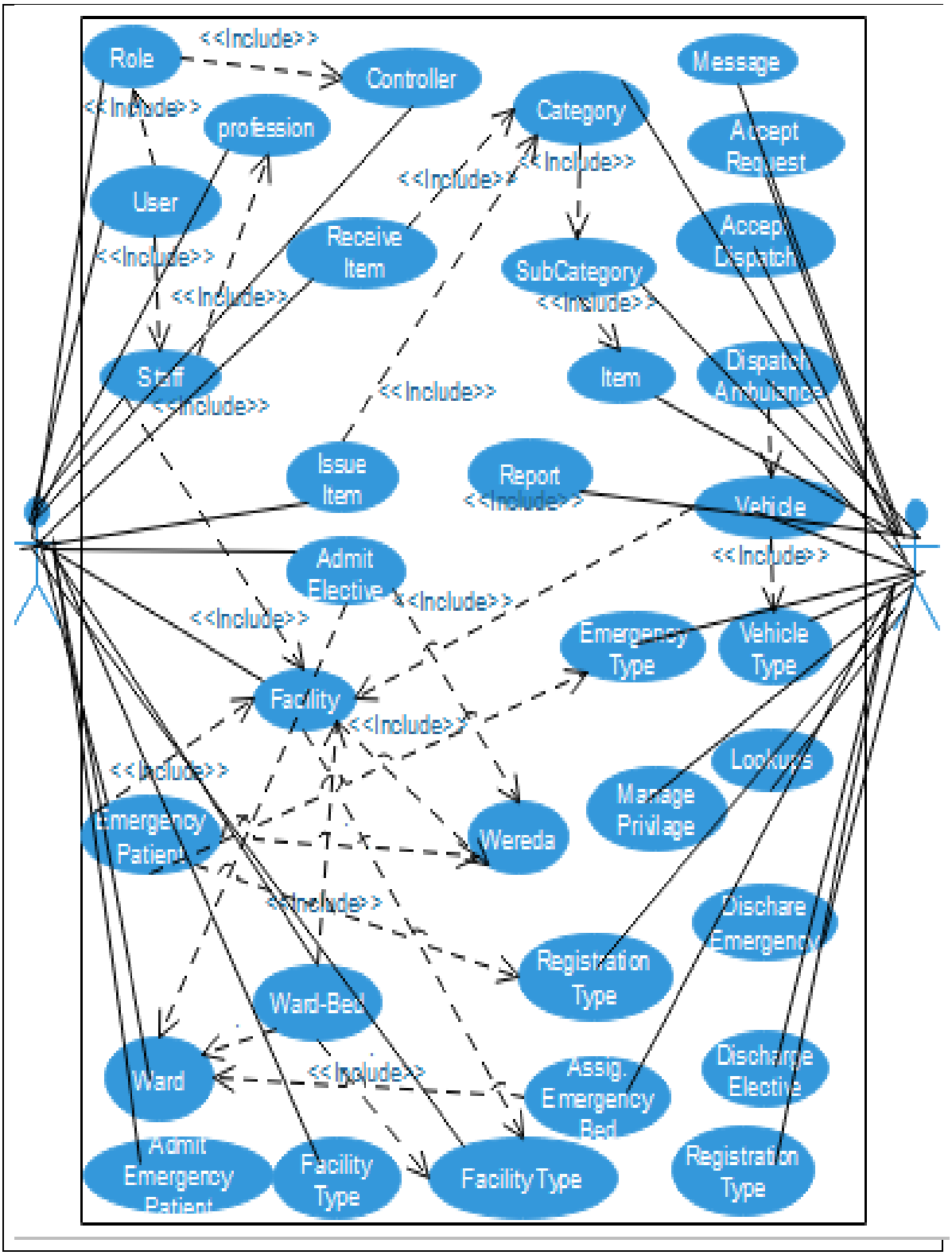


Fig 4.5.1 General use case

Table 4.5: List of System Use Case

Login Use Case	Admit Emergency Patient Use Case
Lookup Use Case	Admit Elective Patient Use Case
Register Staff Use	Discharge Patient Use Case
Register Facility Use Case	Manage Privilege Use Case
Register Vehicle Use Case	Manage User Use Case
Register Ward Use Case	Generate Reports Use case
Register Patient Use Case	Open Message Use Case
Accept Request Use case	Manage Disaster Hospital Use Case
Dispatch Ambulance Use Case	Logistics in Disaster Hospital Use Case
Receive Dispatched Use Case	Read Auditing Use Case

The Login UC in Table 4.6 defines who can login into the system. Login attempt will be successful only for authenticated username with a password. After a number of unsuccessful attempts the system will lock the user which can only be unlock by system administrator.

Table 4.6: Login Use Case

Use case ID	UC-1	
Use Case Name	Login	
Brief Description:	The use case begins when the actor types his/her name and password on the login form. The system validates the actor's password and logs him/her into the system. The system displays the Main Form and the use case ends.	
Business Trigger:	Actor need to execute something on the system	
Preconditions:	No precondition	
Actors:	Doctors, Nurses, Receptionist, and patient Registration	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The actor is a registered system user.		
Line	System Actor Action	System Response
1	The Actor insert correct username/password and pressed login (BF)	The system directs the actor to the main home page.
2	The Actor clicked a button to change password (AF1)	The system displays a page to enter username, new password and new password.
3	The Actor inserts the required data and clicked a button to change password.	The system responds with successful password updated message.
Post Condition:	Actor logged into the system or logged out from the system	
Business Rules:		
1. All Actors should have unique user name and password.		
Database Object Affected (Tables)		
tbl_user, tbl_request_response, tbl_patient_reg		

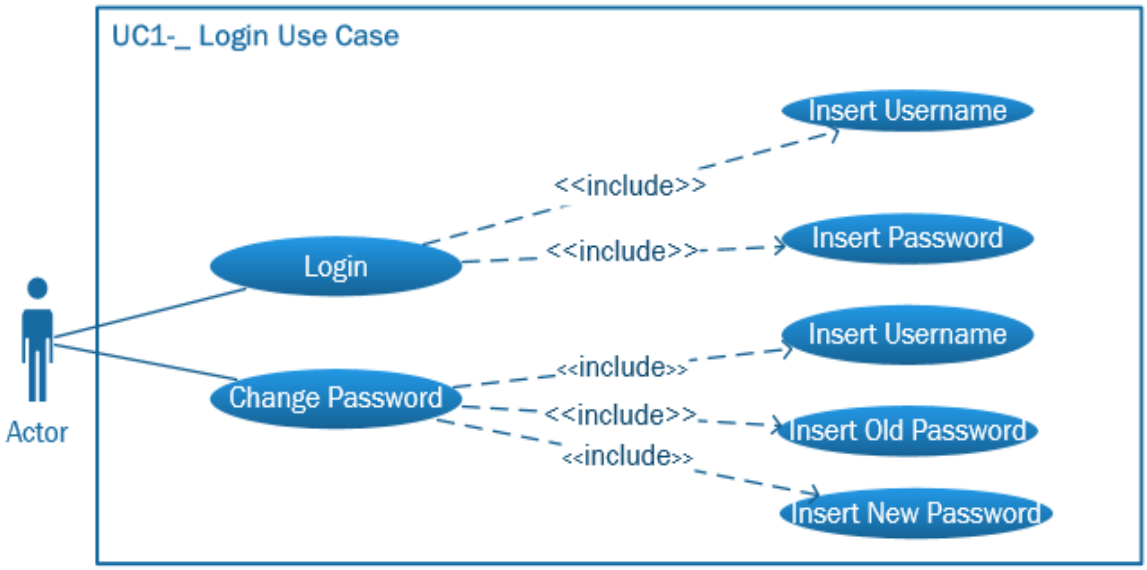


Fig 4.4: Login Use Case

The purpose of Lookup UC in Table 4.7 is to register data that are supportive to the main functionality of the system. Some of these use cases includes like Item Type, Unit Type and others.

Table 4.7: Lookup Use Case

Use case ID	UC-2	
Use Case Name	Lookup	
Brief Description:	Lookups are lists Items that are used as predefined data. Lists of data used in lookup are : Category Type, Emergency Type, Item Type, Profession Type, Facility Type, Unit Type, Ward Type, Wereda Type, User_Role Type	
Business Trigger:	A lookup item needs to be inserted	
Preconditions:	Actor has to log into the system.	
Actors:	Doctors, Nurses, Receptionist, and patient Registration	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The vehicle is property of federal police and has all necessary attributes for the data entry.		
Line	System Actor Action	System Response
1	Actor enters a new lookup item (**BF)**	Successful data entry message displayed
2	An already registered lookup data entered(**AF1**)	Message displayed informing that the item is already inserted.
3		
Post Condition:	Lookup item inserted.	
Business Rules: 1. Actor must have privilege to register (insert) lookup data.		
Database Object Affected (Tables) : - lu_category, lu_controller,lu_emergency_type,lu_facility,lu_healthcenter,lu_item, lu_profession, ,lu_profession_category, lu_role,lu_status,lu_subcategory, lu_unit,lu_ward,lu_wereda		

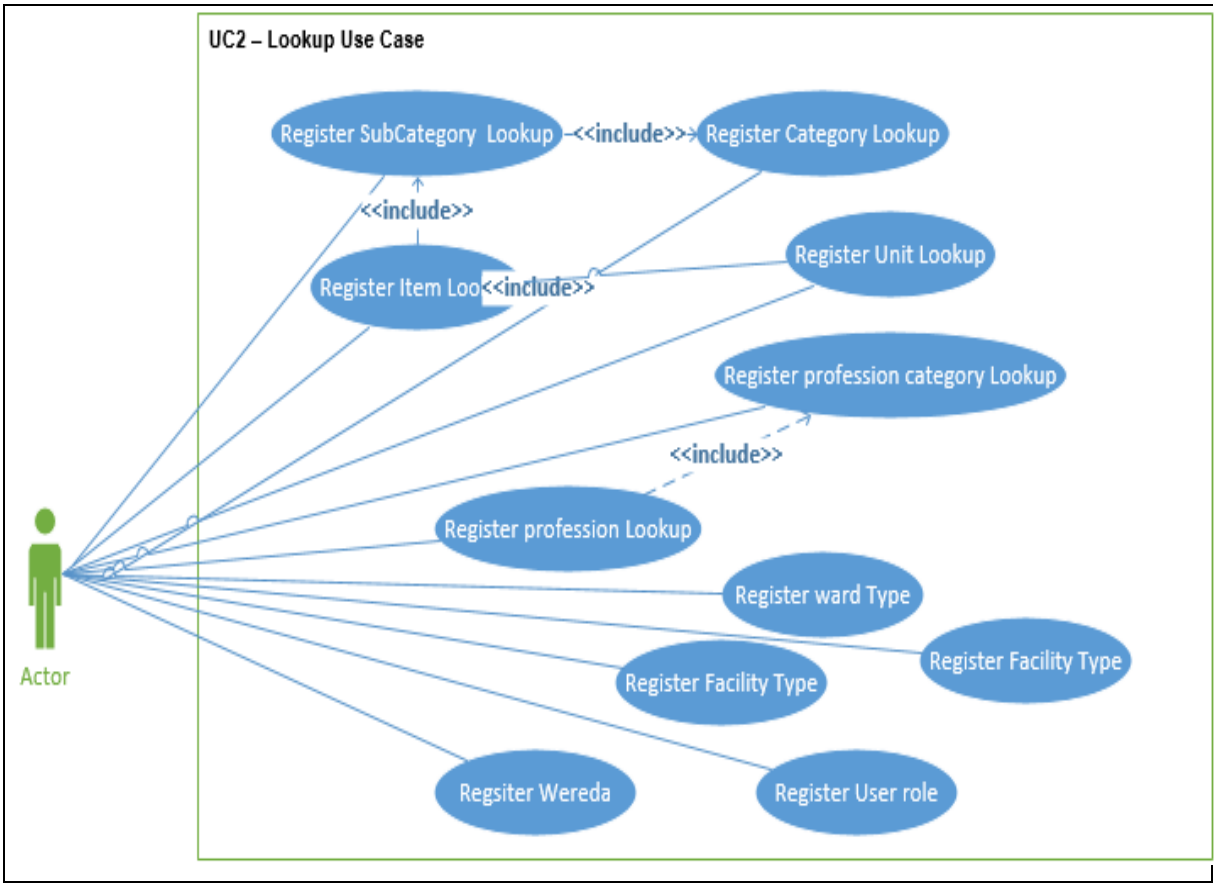


Fig 4.5: Lookup Use Case

Table 4.8 describes the staff registering UC. To be system user a first the use will insure that he/she has to be a staff. The registered staff can use the system with specific privilege.

Table 4.8: Register Staff Use Case

Use case ID	UC-3	
Use Case Name	Register Staff	
Brief Description:	Register of a staff includes register and edit of a staff. A staff includes personnel with in Hospital and Health Facility who are pertained to the system.	
Business Trigger:	New employee need to be registered or edit an existing employee	
Preconditions:	The Actor should have the privilege to register staff.	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: All data of the employee are provided		
Line	System Actor Action	System Response
1	The Actor search for the employee (**BF)**	The system display the user..
2	The Actor insert the correct data and necessary data and press save (**BF**)	If all data are properly entered, the system respond with data saved successfully message.
3	The Actor insert the correct data and some of the necessary data and press save (**AF1**)	The system informs that data has not been entered.
4	The Actor search the employee and update its data (AF2)	If all data are properly entered, the system responds with data saved successfully message.
5	The Actor search the employee and delete it (AF3)	If the employee is registered but has no transaction, it will be deleted and successful message be displayed.
Post Condition:	Employee registered or updated	
Business Rules:		
1 Actor must has privilege for employee registration 2 A Staff has a unique identifying		
Database Object Affected (Tables) : - lu_facility, tbl_facility,lu_profession,lu_profession_category, tbl_staff		

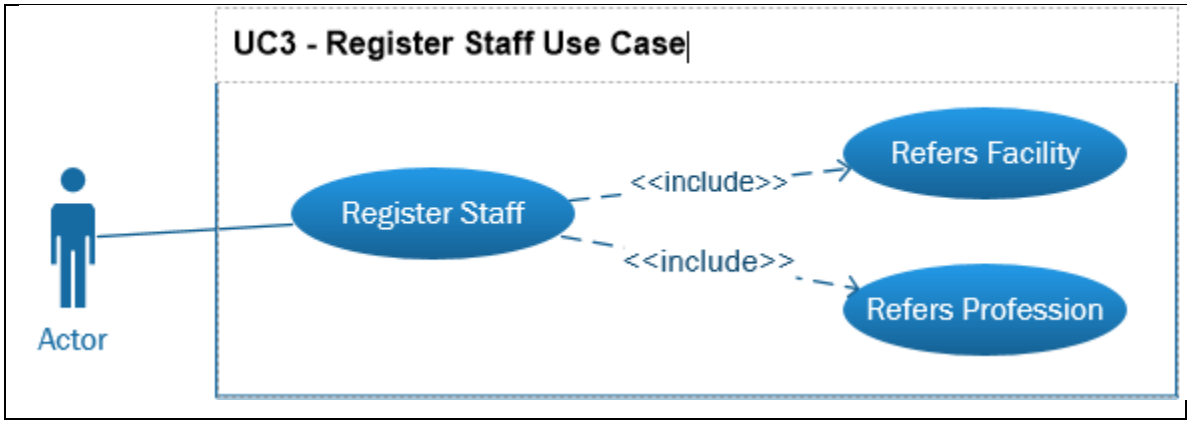


Fig 4.6: Register Staff Use Case

Table 4.9 represents a use case which is used for Registering Facility. A Facility could represent a hospital, health center or any other organization related to the EMS.

Table 4.9: Register Facility Use Case

Use case ID	UC-4	
Use Case Name	Register Facility	
Brief Description:	A Facility is an institution where patient emergency system communicates with. It could be a hospital, health center, fire brigade or others. The Facilities are located at Addis Ababa.	
Business Trigger:	New Facility need to registered or edited into the system	
Preconditions:	A user has to log in with privilege to create and edit a facility.	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The facility has not been registered into the system		
Line	System Actor Action	System Response
1	The Actor search for the facility (BF)	The system does not find the facility
2	The Actor insert the correct data and necessary data and press save (BF)	If all data are properly entered, the system respond with data saved successfully message.
3	The Actor insert the correct data and necessary data and press save (AF1)	The system displays error message if mandatory data are not inserted or wrong data type.
4	The Actor search the facility and update its data (AF2)	If all data are properly entered, the system would respond with data saved successfully message.
5	The Actor search the facility and delete it (AF3)	If the facility is registered but has no transaction, it will be deleted and successful message be displayed.
Post Condition:	Facility is registered	
Business Rules:		
1. Actor must has privilege for facility registration		
Database Object Affected (Tables)		
For facility Registration and update tables used : tbl_facility, lu_facility, lu_wereda		

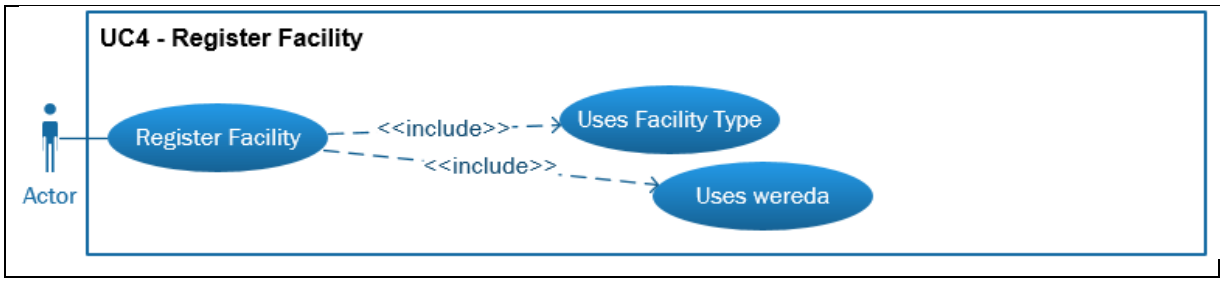


Fig 4.7: Register Facility Use Case

Table 4.10 represents Registration of Vehicles owned by a Facility. The purpose of registering hospitals' vehicles is for managing the availability of ambulances.

Table 4.10: Register Vehicle Use Case

Use case ID	UC-5	
Use Case Name	Register Vehicle	
Brief Description:	A vehicle could be an ambulance or any motor car that is used to transport patient.	
Business Trigger:	A vehicle owned by a facility needs to be registered	
Preconditions:	The Actor need to have the privilege to register vehicle.	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The vehicle has not been registered into the system.		
Line	System Actor Action	**System Response**
1	The Actor search for the vehicle (BF)	The system does not found the vehicle
2	The Actor insert the correct data and necessary data and press save(BF)	If all data are properly entered, the system responds with data saved successfully message.
3	The Actor insert the correct data and necessary data and press save(AF1)	The system displays error message if mandatory data are not inserted or wrong data type.
Post Condition:	Registered into the system	
Business Rules: A vehicle has uniquely identifying plate number.		
Database Object Affected (Tables) Tables involved are : tbl_vehicle, lu_vehicle		

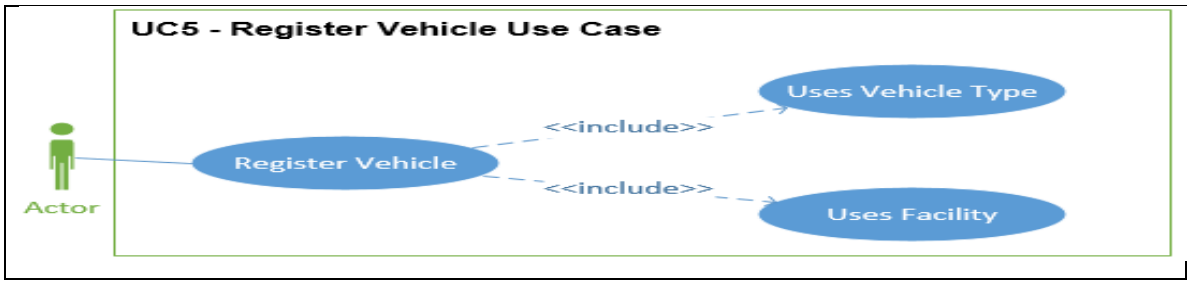


Fig 4.8: Register Vehicle Use Case

Table 4.11 below, represents Registration Ward and number of beds in each ward. During patient admittance or discharge from a ward, the number of available beds will be determined accordingly.

Table 4.11: Register Ward Use Case

Use case ID	UC-6	
Use Case Name	Register Ward	
Brief Description:	Wards are section of a building or rooms with number of beds which holds patients depending on the type of illness and sex.	
Business Trigger:	Ward need to be opened with in a facility.	
Preconditions:	The Actor must have the privilege to create wards.	
Actors:		
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: There is a hospital or health center.		
Line	System Actor Action	System Response
1	The Actor insert the correct data and necessary data and press save (BF)	If all data are properly entered, the system responds with data saved successfully message.
2	The Actor insert the correct data and necessary data and press save (AF1)	The system displays error message if mandatory data are not inserted or wrong data type.
Post Condition:	New ward with number of beds is added to a facility	
Business Rules: - A Facility (Hospital or health center) has wards with number of beds. - Ward's bed with in a facility can't be removed unless beds are released first.		
Database Object Affected (Tables) : lu_ward		

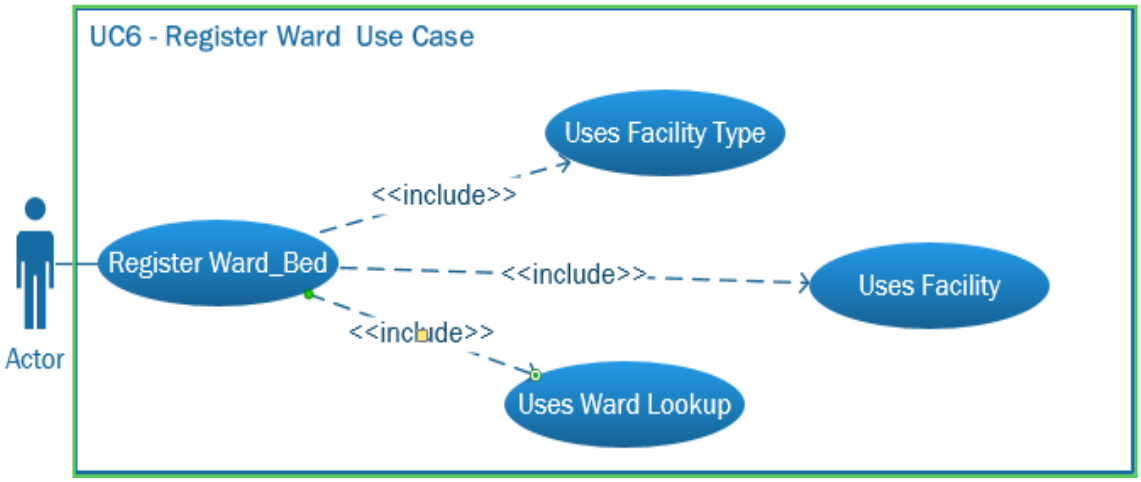


Fig 4.9: Register Ward Use Case

Table 4.12 refers to one of the main functionality of the system, registering emergency patient. The registered patient will go through the process of emergency patient management.

Table 4.12: Register Patient Use Case

Use case ID	UC-7	
Use Case Name	Register Patient	
Brief Description:	A patient arrived at Hospital or Health Center. If the patient considered as an emergency case, the patient is registered.	
Business Trigger:	An emergency patient arrived at hospital or health center.	
Preconditions:	Actor must have privilege to register a patient.	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The actor is a registered system user.		
Line	System Actor Action	System Response
1	The Actor insert the correct data and necessary data and press save (**BF**)	If all data are properly entered, the system responds with data saved successfully message.
2	The Actor insert the correct data and necessary data and press save (**AF1**)	The system displays error message if mandatory data are not inserted or wrong data type.
3	The Actor search the patient by patient-card or patient-name (AF2)	If all data are properly entered, the system responds with data saved successfully message.
Post Condition:	Patient is registered	
Business Rules: - Patient registered is those only considered as emergency. - Status of a patient is set (active). - When a patient is registered, bed (ward) request is automatically sent through the network. - Depending on emergency the patient is released or bed request is triggered. - A given type of emergency can be linked only to a specific type of ward. - After waiting for 24-hrs, waiting emergency list is automatically expired.		
Database Object Affected (Tables) Tbl_patient_reg, tbl_request_response		

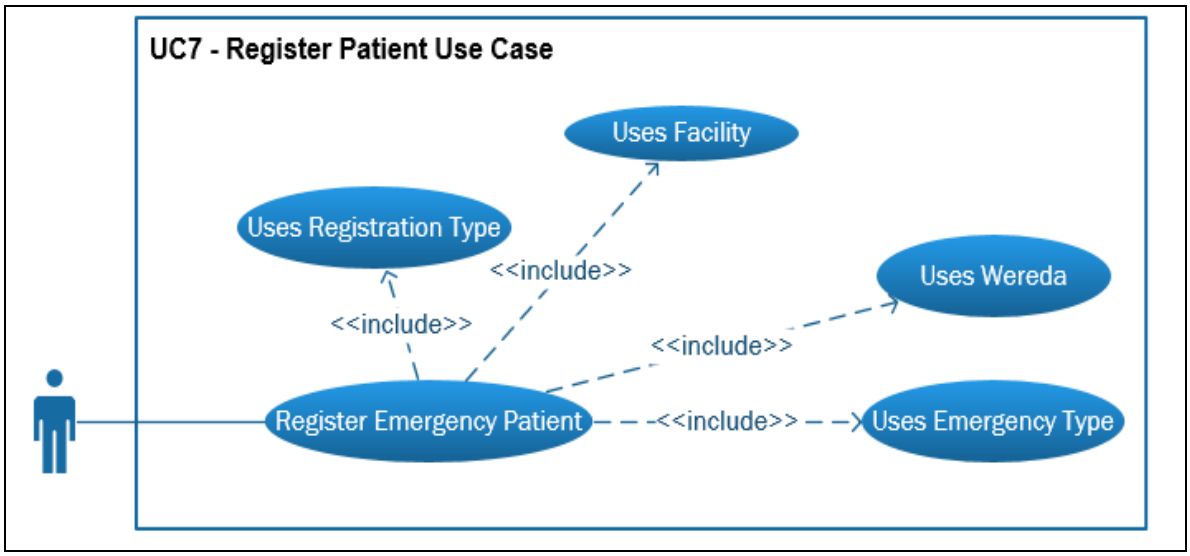


Fig 4.10: Register Patient Use Case

Table 4.13 use cases shows the processes of accepting emergency patient request for admittance. After a patient has been registered in the system, his/her condition is determined by the triage team. If the patient needs further emergency medication, the triage team will send a request for bed on where all hospitals could see the request on real time.

Table 4.13: Accept Request Use Case

Use case ID	UC-8	
Use Case Name	Accept Request	
Brief Description:	Patient bed request is displayed by this module. Any Hospital with available bed in the requested ward can accept the request .Once patient acceptance is confirmed, the patient is removed room the patient bed request list.	
Business Trigger:	Actor need to accept patient request on the system	
Preconditions:	Emergency patient registered who need bed accommodation.	
Actors:	Actor should have privilege to accept patient for bed accommodation	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The vehicle is still in WIP stage. Item request form has been filled		
Line	System Actor Action	System Response
1	Actor clicked update button (**BF)**	System display different options to change patient state
2	The clicked on accept patient button (**BF**)	System refresh window with new data.
Post Condition:	Patient removed from the waiting list.	
Business Rules: - Emergency Patient with bed request are sent to bed request waiting list. - A patient can be taken out of waiting list with update option.		
Database Object Affected (Tables) tbl_patient_reg, tbl_patient_accepted		

Table 4.14 shows Dispatch Ambulance use case. The ambulances which are registered in Table 4.10 are for the purpose of availability management.

Table 4.14: Dispatch Ambulance Use Case

Use case ID	UC-9	
Use Case Name	Dispatch Ambulance	
Brief Description:	Once patient bed request is accepted, patient accepter should send an ambulance to the location of the patient and logs him/her into the system. The system displays the Main Form and the use case ends.	
Business Trigger:	Patient requested for bed is accepted	
Preconditions:	Actor should have the privilege to send ambulance to a patient.	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: There are list of ambulance available for service.		
Line	System Actor Action	System Response
1	Actor select a patient from a list of patients.BF)	System displays details of the patient.
2	Actor selects ambulance and sends it the patient.	System removes the ambulance from availability. System removes the patient from ambulance waiting list.
3	Actor send private vehicle to the patient. (AF1)	System removes the patient from ambulance waiting list.
Post Condition:	Patient sent to a hospital.	
Business Rules: Actor can see available ambulances owned by hospitals.		
Database Object Affected (Tables) tbl_vehicle, tbl_patient_reg,tbl_patient_accepted		

The Receive Dispatch use case is shown in Table 4.15.After a hospital acknowledged a patient request for a bed from another hospital, the patient will be sent to it. When the

patient arrives at the hospital triage, it will be the responsibility of the hospital for processing the patient. And if the patient is brought by a registered government ambulance, the system will release the ambulance for another service.

Table 4.15: Receive Dispatched Use Case

Use case ID	UC-10	
Use Case Name	Received Dispatched	
Brief Description:	Dispatched patient are received at the Hospital .The Hospital must have sent an acknowledgment to receive the patient.	
Business Trigger:	Actor need to execute something on the system	
Preconditions:	Actor should have privilege to receive dispatched patient directed to the hospital.	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The hospital has agreed to receive the patient		
Line	System Actor Action	System Response
1	Actor select patient from a list.(**BF)**	System displays patient's details.
2	Actor saves selected patient.	System displays successful message.
Post Condition:	Patient received by reception now and is waiting for bed assignment.	
Business Rules: Actor can admit patient sent only to the hospital.		
Database Object Affected (Tables) Actor should have privilege to admit dispatched patient		

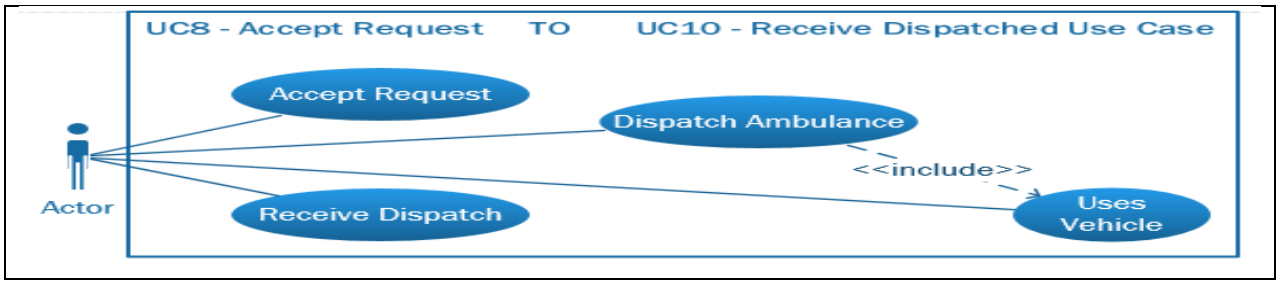


Fig 4.11: Accept Request Use Case

Table 4.16: Admit Emergency Patient 1

Use case ID	UC-11	
Use Case Name	Admit Emergency Patient	
Brief Description:	Bed can be assigned through two ways. One is through emergency dispatched patient. The other is through elective patient bed assignment. This use case describes the former.	
Business Trigger:	Emergency Patient already accepted by the system has been admitted at reception.	
Preconditions:	The Actor has privilege to assign bed.	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: Patient has been accepted from request list		
Line	System Actor Action	**System Response**
1	Actor selected patient from the list.(BF)	System response by displaying patient details.
2	Actor assigned bed to the patient	The system confirms successful bed assignment.
Post Condition:	Patient removed from bed waiting list. The number of beds available within the assigned ward in the facility decreases by one.	
Business Rules: A ward can assigned bed only if it has available beds.		
Database Object Affected (Tables) tbl_patient_reg, tbl_patient_accepted, tbl_bed_assigned		

After a patient has been received by triage team for bed admittance, the system will assign a bed to a patient in the assigned ward as in Table 4.16. Once a patient has been admitted, assigned a bed the total number of available beds in the ward will be decreased by 1.

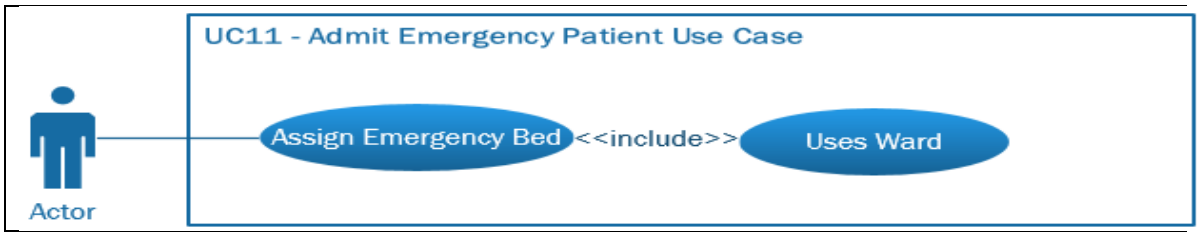


Fig 4.12: Admit Emergency Patient Use Case

In Table 4.17, elective patient admittance is shown. The bossiness flow for emergency and elective patient is identical during the admittance stage, where number of available beds in the respective ward is decreased by 1.

Table 4.17: Admit Elective Patient Use Case

Use case ID	UC-12	
Use Case Name	Admit Elective Patient	
Brief Description:	An elective patient is registered and assigned a bed directly.	
Business Trigger:	Elective Patient has been assigned a bed.	
Preconditions:	No Precondition	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The actor is a registered system user.		
Line	System Actor Action	System Response
1	Actor opens elective patient registration form.	System displays list of wards with available beds.
2	Actor types in patient's data and select ward and click save (**BF)**	The system confirms successful bed assignment.
Post Condition:	The number of beds available in the assigned ward in the facility decreases by one.	
Business Rules: A ward can assigned bed only if it has available beds.		
Database Object Affected (Tables) tbl_patient_reg, tbl_ward		

Discharging of admitted patient is the same for both elective and emergency patients which are represented in Table 4.18. During a discharge, the system simply increases the number of available bed by 1 for the respective ward within for a corresponding hospital.

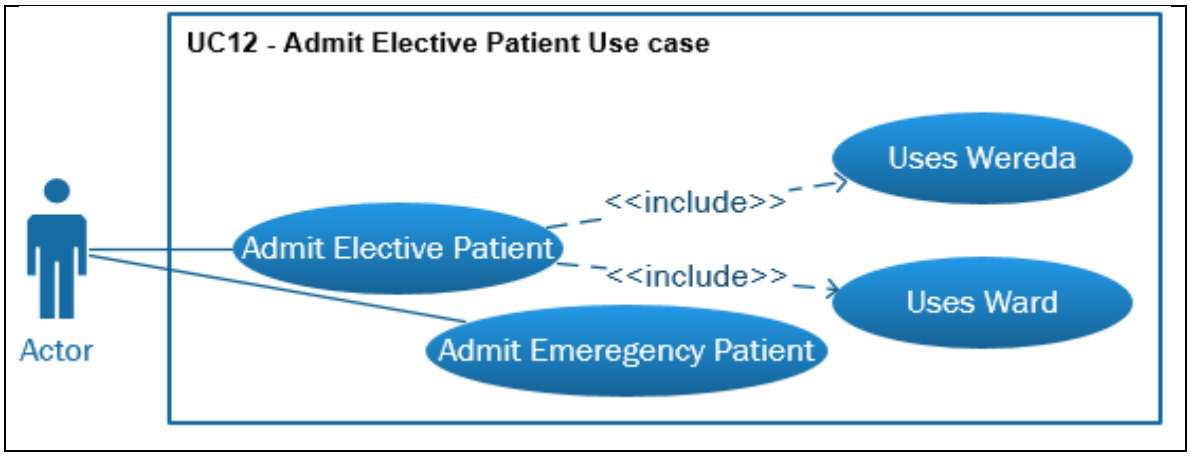


Fig 4.13: Admit Elective Patient Use Case

Table 4.18: Discharge Patient Use Case

Use case ID	UC-13	
Use Case Name	Discharge Patient	
Brief Description:	This use case is used to release admitted patient.	
Business Trigger:	An emergency or elective admitted patient needs to be discharged.	
Preconditions:	Actor has privilege to release patient's bed.	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The actor is a registered system user.		
Line	System Actor Action	System Response
1	Actor selects emergency or elective type of patients ward (BF)	System displays list of admitted emergency or elective patients.
2	Actor selects a patient from the list.	System displays description of the patient
3	Actor press discharge button.	System displays confirmation of successful discharge.
Post :	Patient is discharged. Patient status is changed. Available bed is increased by one with in the ward.	
Business Rules: Actor can see patient only in the hospital he/she is working		
Database Object Affected (Tables) tbl_patient_reg, tbl_ward,tbl_bed_assigned		

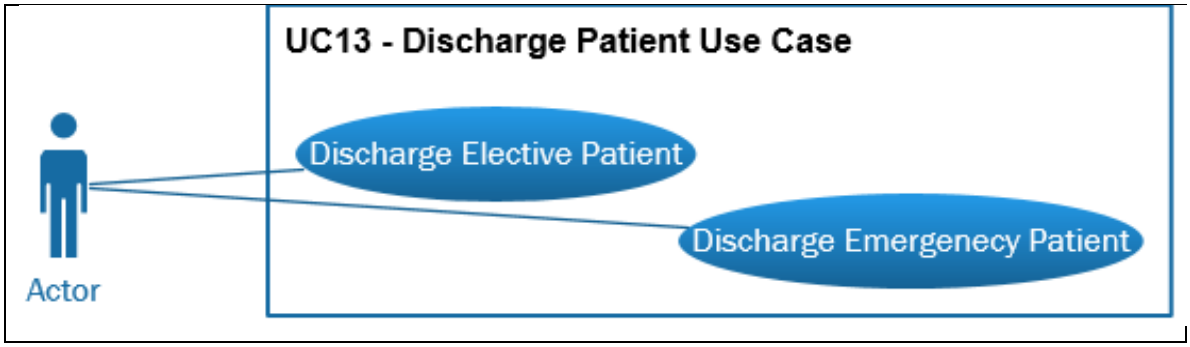


Fig 4.14: Discharge Patient Use Case

Table 4.19 represents a use case for managing system role. The system first defines different roles with in which number of privileges is contained.

Table 4.19: Manage Privilege Use Case

Use case ID	UC-14	
Use Case Name	Manage Privilege	
Brief Description:	Roles are given privileges	
Business Trigger:	An existing role's privilege need to be set.	
Preconditions:	Actor has privilege to manage roles.	
Actors:	System Administrator	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The actor is a registered system user.		
Line	System Actor Action	System Response
1	Actor opens role management page (BF)	System display list of roles with their privileges.
2	Actor writes select a role and assigns new privilege	System displays successful message.
3	Actor select a role and remove a privilege (BF)	System displays successful message.
4	Actor select a role and remove a privilege (AF)	System displays error message
5	Actor opens role management page (BF)	System display list of roles with their privileges.
Post	Role updated	
Business Rules: A Role can be deleted only if that privilege is not assigned to any user.		

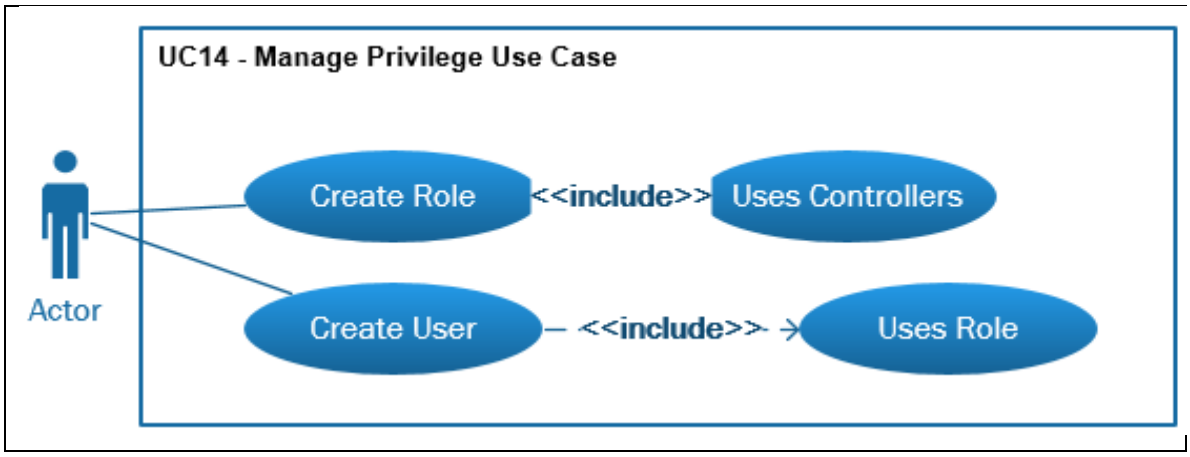


Fig 4.15: Manage Privilege Use Case

Table 4.20 use case is for management of user. A user is created in this use case and assigned a username and a role. A user can be assigned only one role.

Table 4.20: Manage User Use Case

Use case ID	UC-15	
Use Case Name	Manage User	
Brief Description:	A user is created with specific username and a password. The user is also assigned a role. A user password and role can be changed.	
Business Trigger:	Facility admin need to register or update system user.	
Preconditions:	Actor has privilege to create system user.	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The actor is a registered system user.		
Line	System Actor Action	System Response
1	Admin opens user management page.(BF)	System display list of users with within a facility
2	Admin selects a .user	System displays a user's profile
3	Admin edit user's password and role (BF)	System displays successful message.
Post	User's profile updated	
Business Rules: - Hospital Admin can create or edit users profile if they are within same facility - Admin at head office can create or edit user at any facility.		
Database Object Affected (Tables) - tbl_user		

The system generates two groups of reports shown as in Table 4.21.The first type of report represents business related reports while the second one represents auditing (security) reports which focus on activities performed by a user.

Table 4.21: Generate Reports Use case

Use case ID	UC-16	
Use Case Name	Generate Reports	
Brief Description:	A user generates reports. There are reports designed for each transaction.	
Business Trigger:	A user needs to generate report.	
Preconditions:	Actor has privilege to generate report.	
Actors:	Assigned User	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: The actor is a registered system user.		
Line	System Actor Action	System Response
1	Actor clicks report page.(BF)	System generates report.
2	Actor clicks report page.(AF)	System displays nothing.
Post Condition:	Report Generated.	
Business Rules: There are two types of reports depending on the privilege of the user (limited to a facility or to all facilities)		
Database Object Affected (Tables) tbl_privilage, tbl_user		

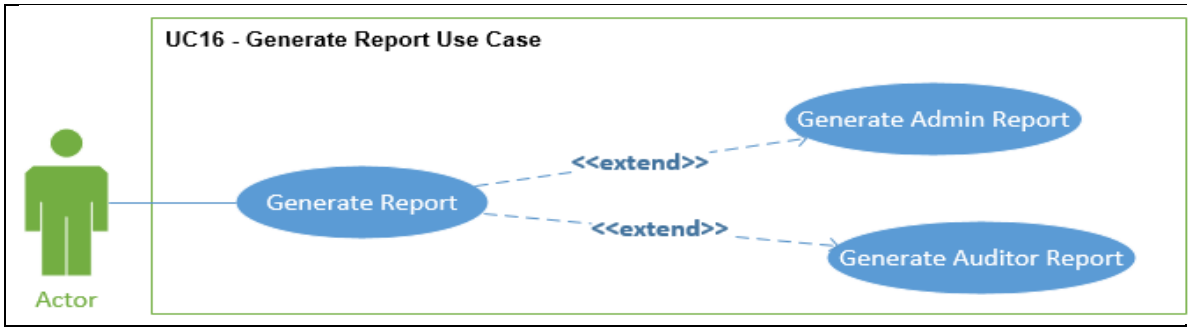


Fig 4.16: Generate Report Use Case

Table 4.22 use case is about messages or chats between users. A user sends a message to another system user. The system marks the message as unread, read, sent and received by a user. The system also manages replay to a message which will be stored in a single automated session number.

Table 4.22: Open Message Use Case

Use case ID	UC-17	
Use Case Name	Open Message	
Brief Description:	A user can send a message to hospital as a reminder for the bed request initiated from him/her.	
Business Trigger:	- A user needs to send a message to a user within a facility. - A user needs to read a message.	
Preconditions:	All user can read a message addressed to them.	
Actors:	Any User	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: none		
Line	System Actor Action	System Response
1	Actor composes and send a message.(BF)	System displays successful message
2	Actor clicks on message received (AF)	System displays message received.
Post Condition:	Message sent or message read.	
Business Rules: Any user can send a message		
Database Object Affected (Tables) - tbl_user, tbl_messages		

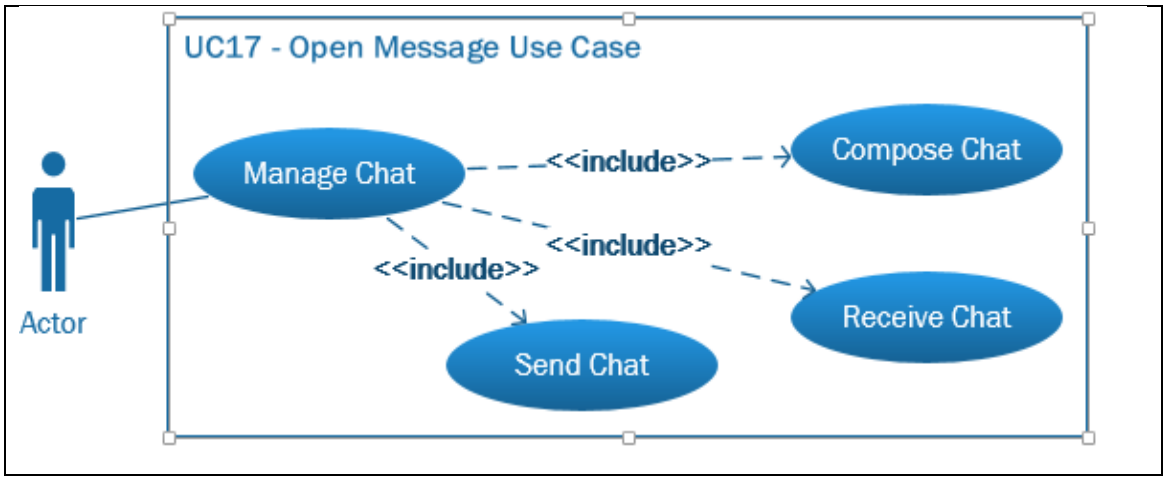


Fig 4.17: Open Message Use Case

In Table 4.23 the UC is about Disaster hospital. In Disaster hospital, the case of emergency for victims (patients) is similar. Detail of individual emergency is not needed here. Only the total number of patients with their name, sex, age, phone no and relationship is registered. Disaster hospital has also a feature for searching for individual relatives.

Table 4.23 Manage Disaster Hospital Use

Use case ID	UC-18	
Use Case Name	Register Disaster Affected Person	
Brief Description:	-Disaster Hospital Created -Person is registered at the hospital	
Business Trigger:	-A user need to register a person -A user need to search for a person	
Preconditions:	No condition	
Actors:	Privileged User	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: none		
Line	System Actor Action	System Response
1	Actor Creates a Hospital	System displays success.
	Actor need to register disaster victim	System displays success
	Actor need to search for a person(family)	System display data in a table.

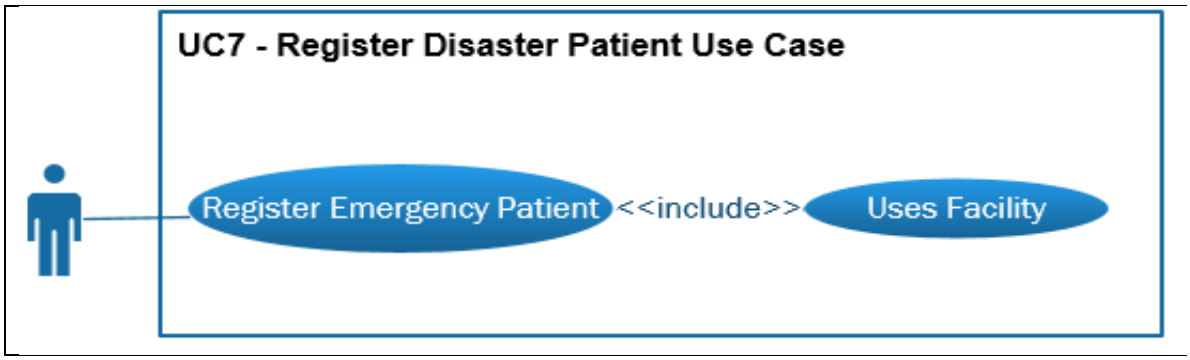


Fig 4.18: Register Disaster Patient Use Case

Additional functionality offered by Disaster Hospital is Logistic Management as presented in Table 4.24.The hospital includes item receive and item issue functionality which will be used as store management.

Table 4.24: Logistics in Disaster Hospital

Use case ID	UC-19	
Use Case Name	Manage Logistics in Disaster Hospital	
Brief Description:	A Disaster Hospital receives items from different source. A Disaster Hospital issues items.	
Business Trigger:	-Item is to be received or issued at disaster hospitals which need to be registered.	
Preconditions:	No condition	
Actors:	Privileged User	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: none		
Line	System Actor Action	System Response
1	Header for the list of items to be received is registered.	System displays success.
2	List of items received is inserted into the system (BF)	System displays success
3	Header for the list of items issued is registered.	System displays success
4	List of items issued is inserted into the system (AF)	System displays success
Post Condition:		
Business Rules:		
Database Object Affected (Tables) - tbl_itemissue_detail, tbl_itemreceive_detail, tbl_itemissue_header, tbl_itemrecieve_header		

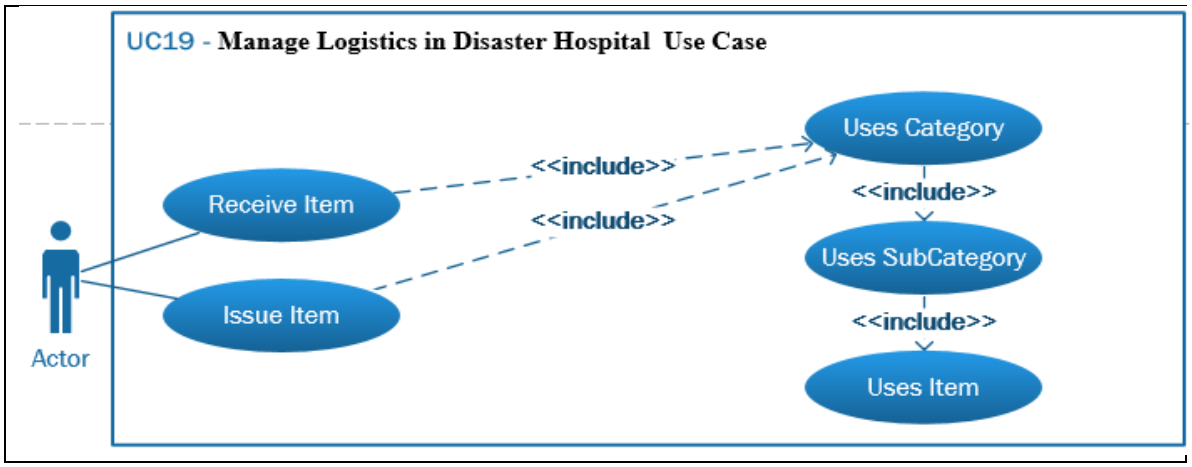


Fig 4.19: Manage Logistics Use Case

The table below shows a UC for Auditing user. An administrator or a user with privilege can see the users' activities for the tables shown in Table 4.25.

Table 4.25: Read Auditing Use Case

Use case ID	UC-8	
Use Case Name	Read Auditing	
Brief Description:	A user can read reading change made by users (deleting and updating) on transactional tables.	
Business Trigger:	- A user needs to read change made by a specific user on specific table.	
Preconditions:	No condition	
Actors:	Privileged User	
Basic Flow (BF) & Alternate Flow (AF)		
Assumptions: none		
Line	System Actor Action	System Response
1	Actor selects tables and clicks on view button	System displays reports
Post Condition:	Audit Report Displayed	
Business Rules: privileged user can see Audit Report		
Database Object Affected (Tables) audit_tbl_bed_assigned,audit_tbl_facility,audit_tbl_itemissue_detail,audit_tbl_itemreceive_detail,audit_tbl_patient_accepted,audit_tbl_patient_reg,audit_tbl_staff,audit_tbl_user		

Both Use case and Functional Requirement represent the same thing, user requirement. Usually the user requirement when represented as a use case has a feature of graphical feature while Functional Requirement is described in text.

Table 4.26: Mapping Functional requirement

Functional Requirement (FID)	**Use case (UC)**	**Description**
FR1	UC-1,UC-8	Manage Security
FR2	UC-2	Manage Lookup
FR3	UC-14,UC-15	Manage Privileges
FR4	UC-4	Registration of Facility
FR5	UC-3	Registration of a staff
FR6	UC-5	Registration of vehicle
FR7	UC-7	Registration of Patient
FR8	UC-8,UC-9,UC-10	Management of Bed Request
FR9	UC-11, UC-12, UC-13	Manage Bed Assignment and Discharge
FR10	UC-18	Manage Disaster Hospital
FR11	UC-19	Manage Logistics For Disaster Hospitals
FR12	UC-17	Manage Message
FR13	UC-16	Manage Report

4.5.2 Activity Diagrams

It describes the dynamic behavior of the system showing the flow of one activity to another. Activity diagrams flow from top to bottom. The initial state is represented by a closed circle. Activity proceeds through a series of activity states until it reaches its final state, which is represented by a closed circle inside an open circle.

Fig 4.20 below represents the activity diagram for user login .The activity shows two alternatives: to login into the system or edit password. In both scenarios the user is authenticated.

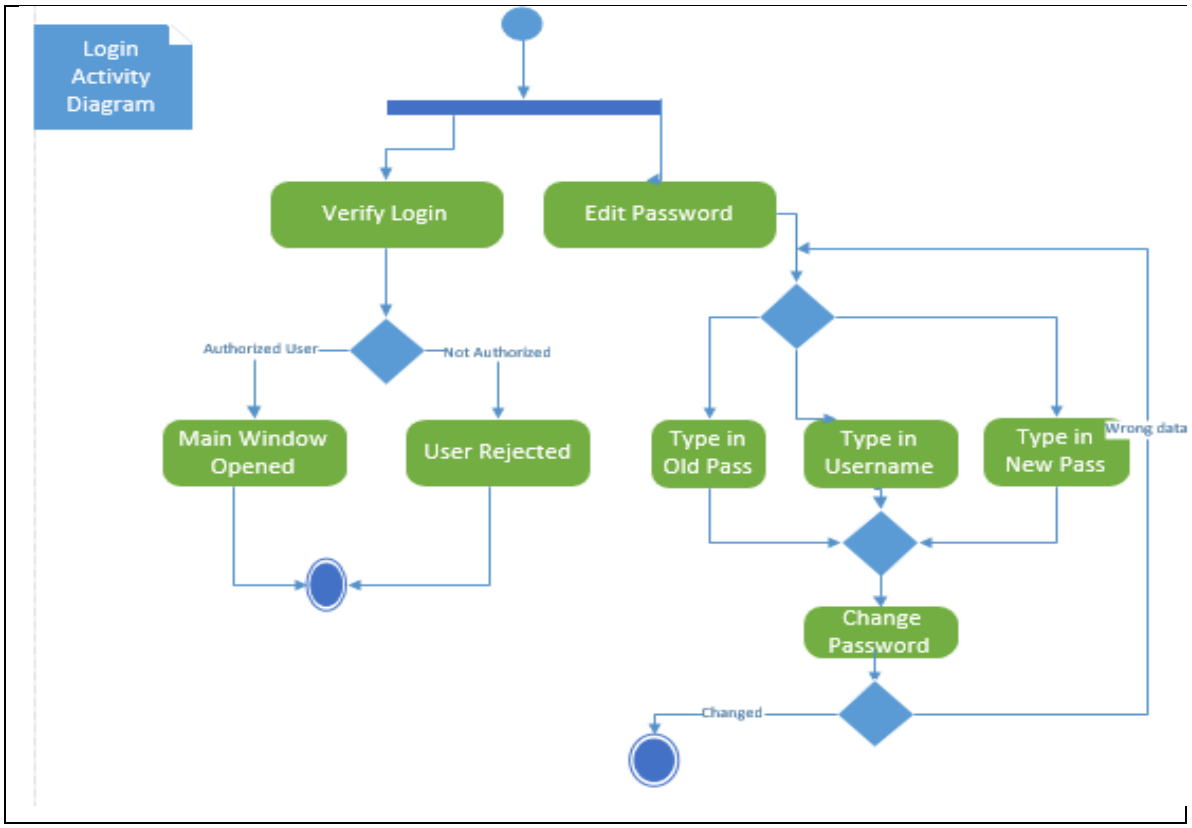


Fig 4.20: AC for Login

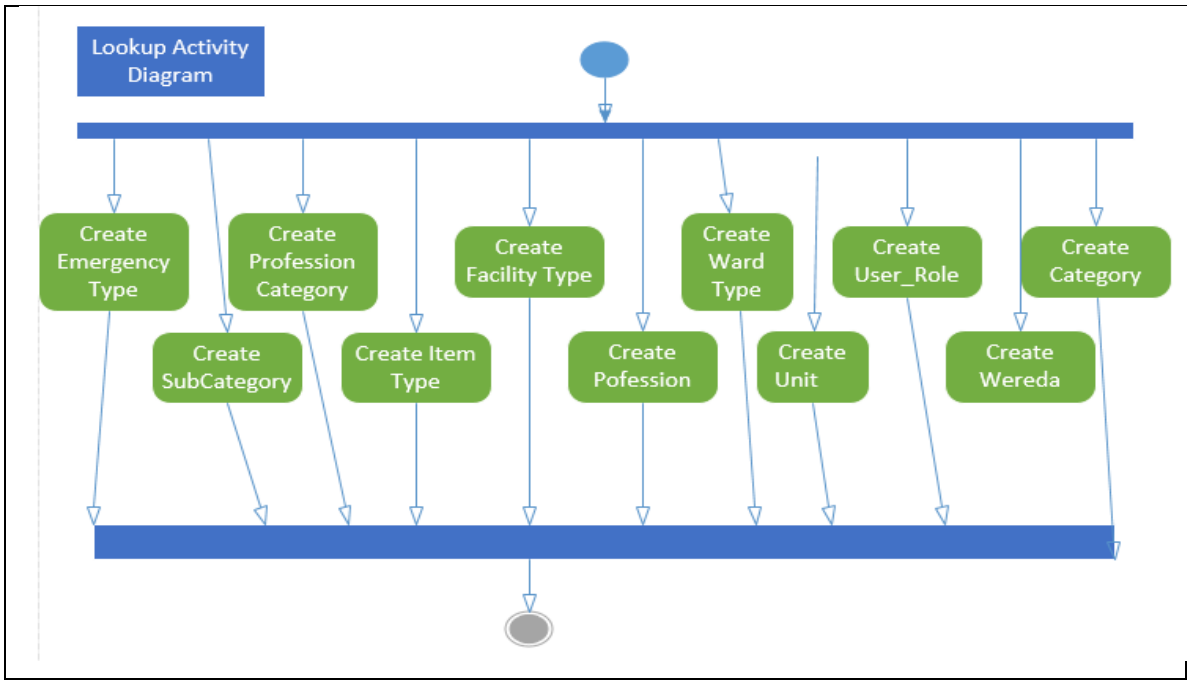


Fig 4.21: AD for Lookups

Fig 4.21 above represents activity diagram for the lookups. The activities performed (insertion, update or delete) are for those data that will be used during the patient management transaction. That transaction can be insertion of lists of emergency types, facility types list of profession Types like OR nurse, surgeon, internist and the likes which will later be used as a selection box within the system.

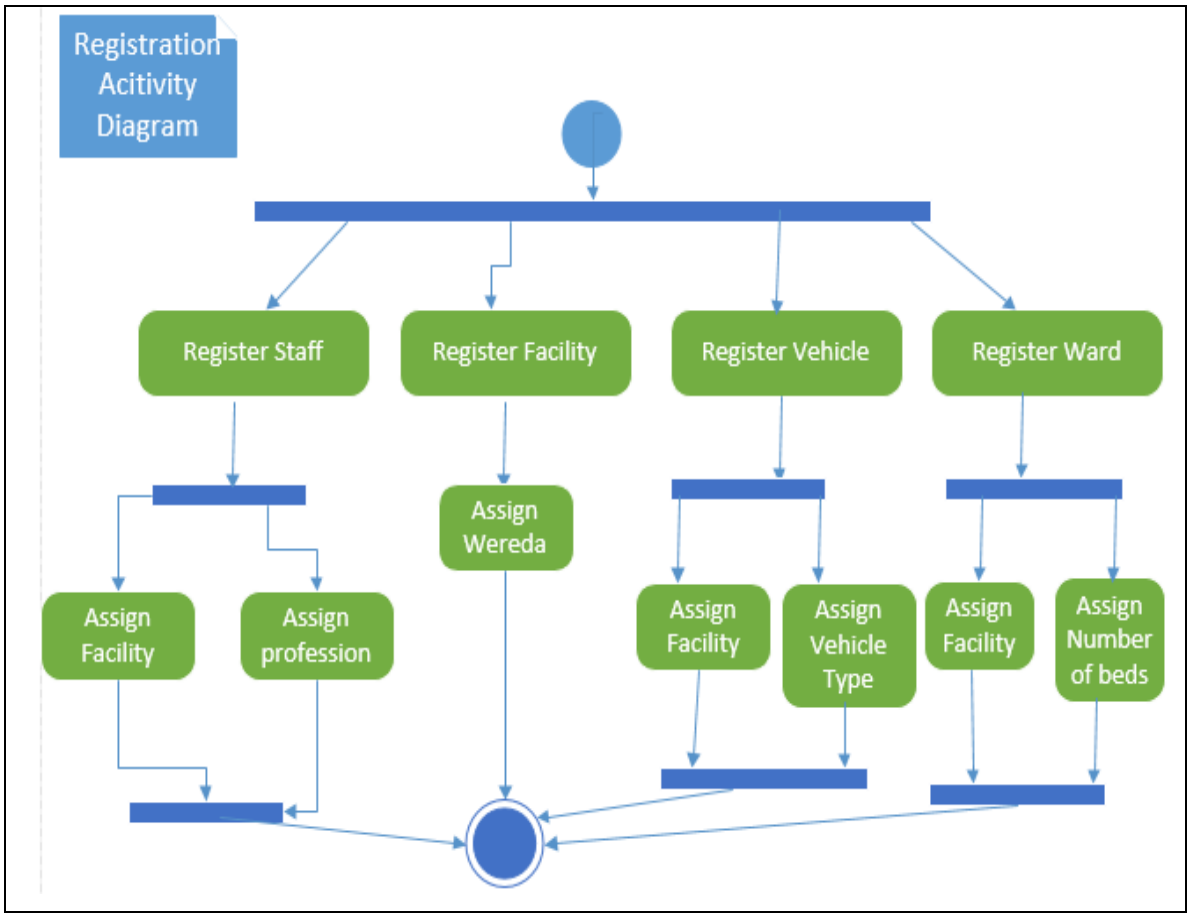


Fig 4.22: AD for Registration

Fig. 4.22 Represents Registration for Staff, Facility, Vehicle or Ward. In the registration of Staff, the transaction includes selection of Facility and Staff profession before completing the staff registration. In the registration of facility (usually a Hospital), first wereda is selected before registering the Facility. In the registration of a Vehicle, vehicle type and the facility into which the vehicle is to be assigned is selected. In the Registration of a ward, Facility and no of beds that the ward accommodates are selected.

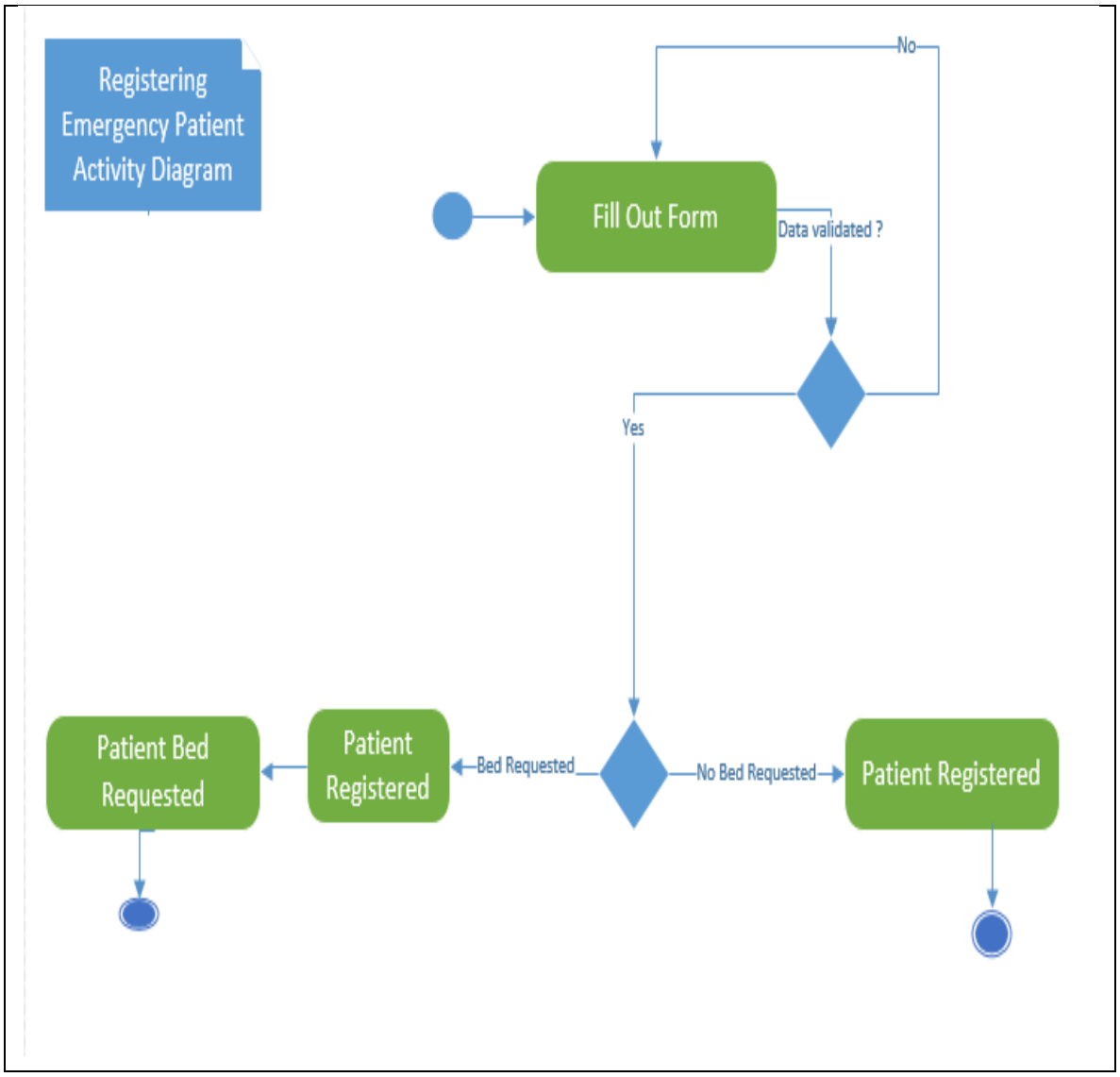


Fig 4.23: AD for Registration of Patient

Fig 4.23 shows the activity diagram for emergency patient registration. Emergency patient may come to a facility (Hospital) in different forms: referral, walk-in or ambulance. Once the patient is registered , the system checks if a bed is requested or not .If there is no bed request ,the activity is completed .But is bed is requested, the system will send the information to a bed request activity .

Fig 4.24 shown below represents activity diagram from Request acceptance to bed assignment. Once Bed requested has been accepted by a hospital, usually an ambulance

will be sent to the hospital that accepted the request. Once the ambulance has delivered to the patient to the hospital, the ambulance will be available for service, which will be shown in another activity diagram. Once the patient has been delivered to the hospital he/she will be assigned to bed.

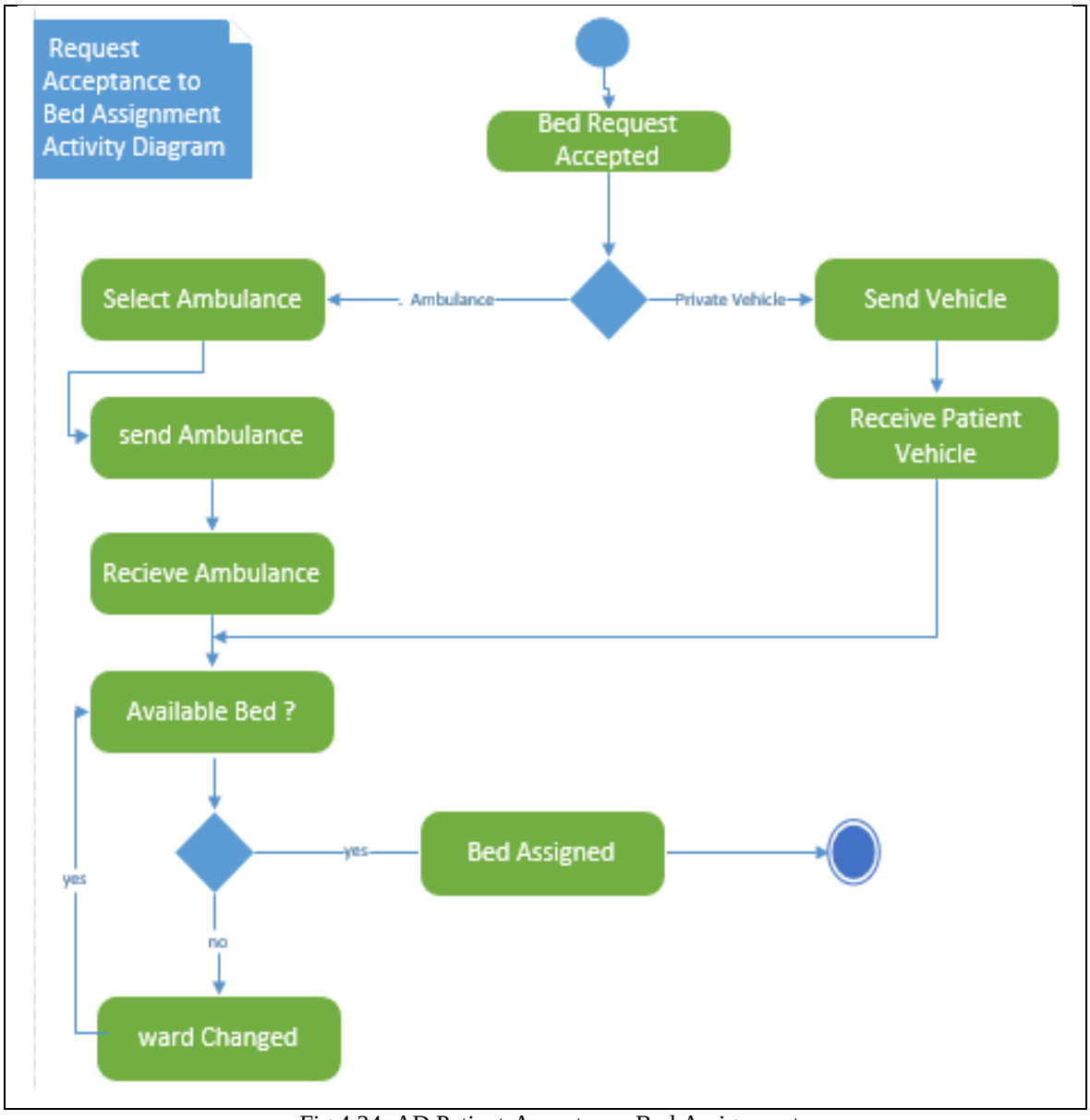


Fig 4.24: AD Patient-Acceptance-Bed Assignment

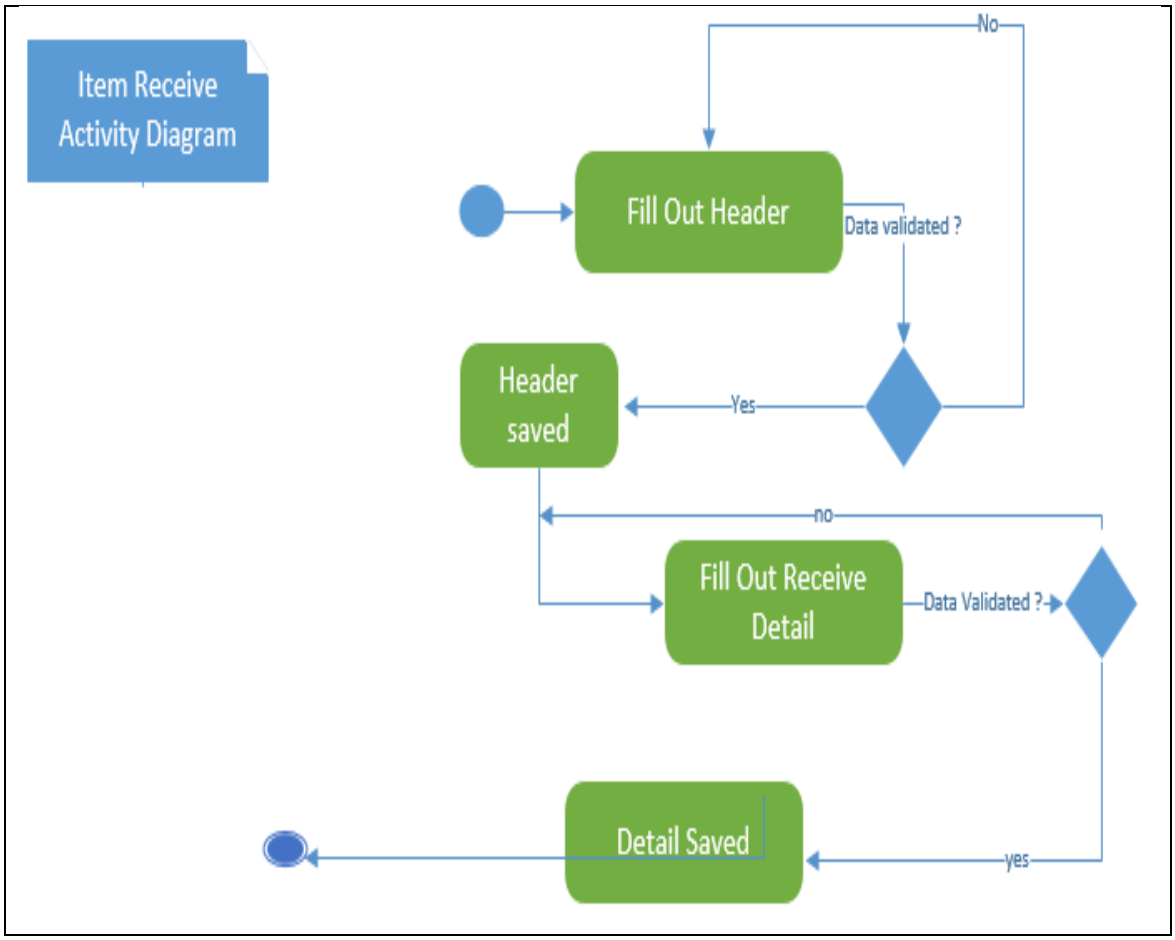


Fig 4.25: AD for Item Receive

The activity diagram for Item Receive (Fig 4.25) is shown above. Items are received and issued which are the bases for an inventory system is integrated in the system. The inventory subsystem is used for Emergency hospitals where the cause for an emergency is similar and maintaining systematic stock management is essential where large number of patients with similar aliments is to be confined within a compound. Here, first the header-form for item receive activity (date, reference No, donated by, remarks) are filled. Then detail of Items received for that reference header are filled (Item, quantity, price) and insert into the system.

The activity diagram for Item Issue (Fig 4.26) is shown Below .The activity here is similar to that of the one for Item Receive .There is header form and then detail of the item to be issued are listed in issue detail .Here, in the item issue , the system checked that the item quantity requested to be issued is available in the store .If item issue

requested quantity is greater that of item available in the store , the requested will not be completed .

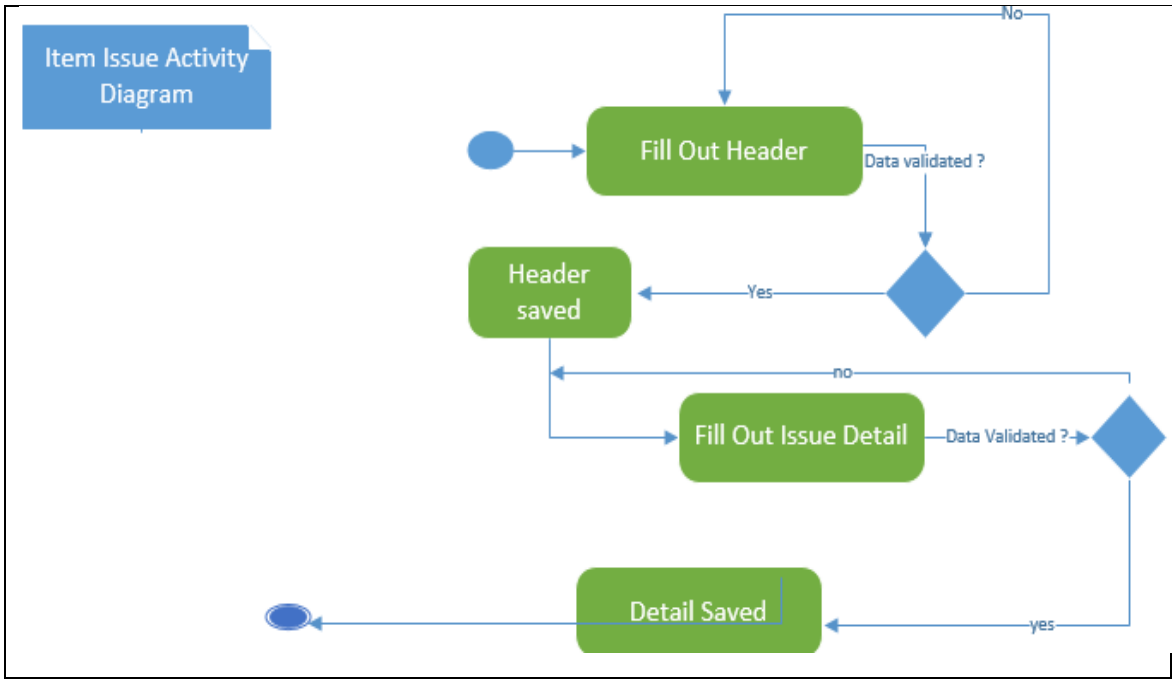


Fig 4.26: AD for Item Issue

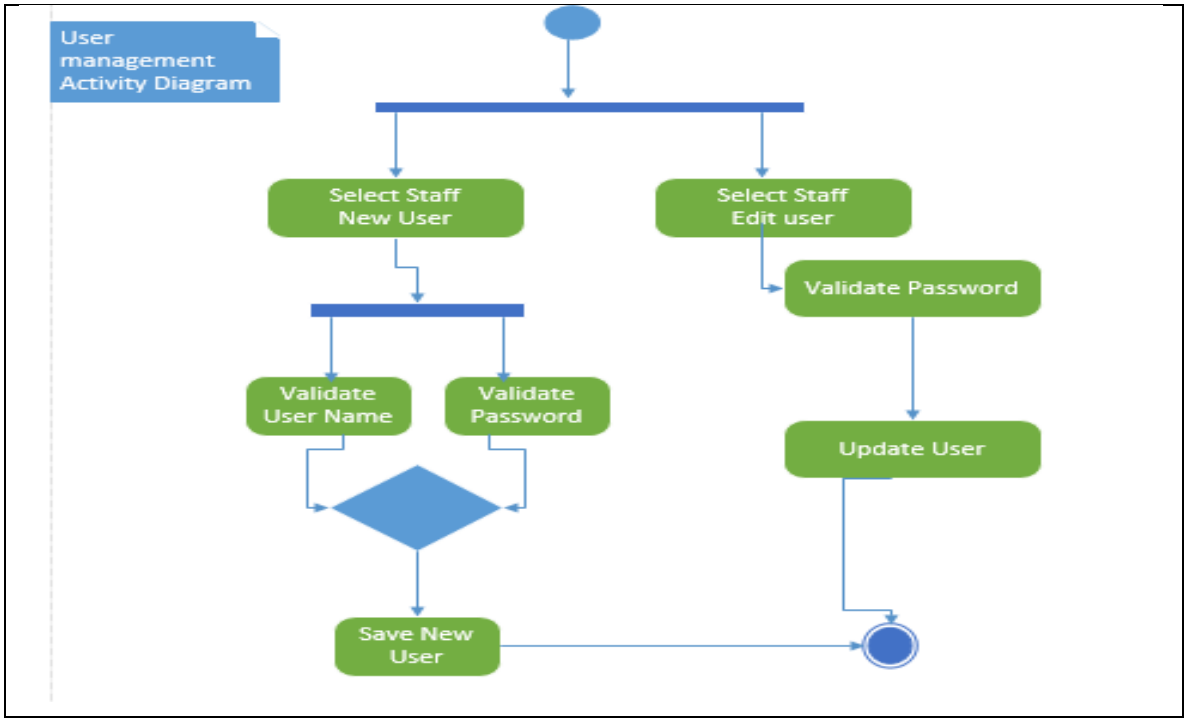


Fig 4.27: AD for User Management

4.5.3 Sequence Diagram

Sequence Diagram is another dynamic property describing the order in which system objects interacts. It shows time sequences that are not easily depicted in other diagrams. It is used during analysis and design to document and understand the logical flow of a system.

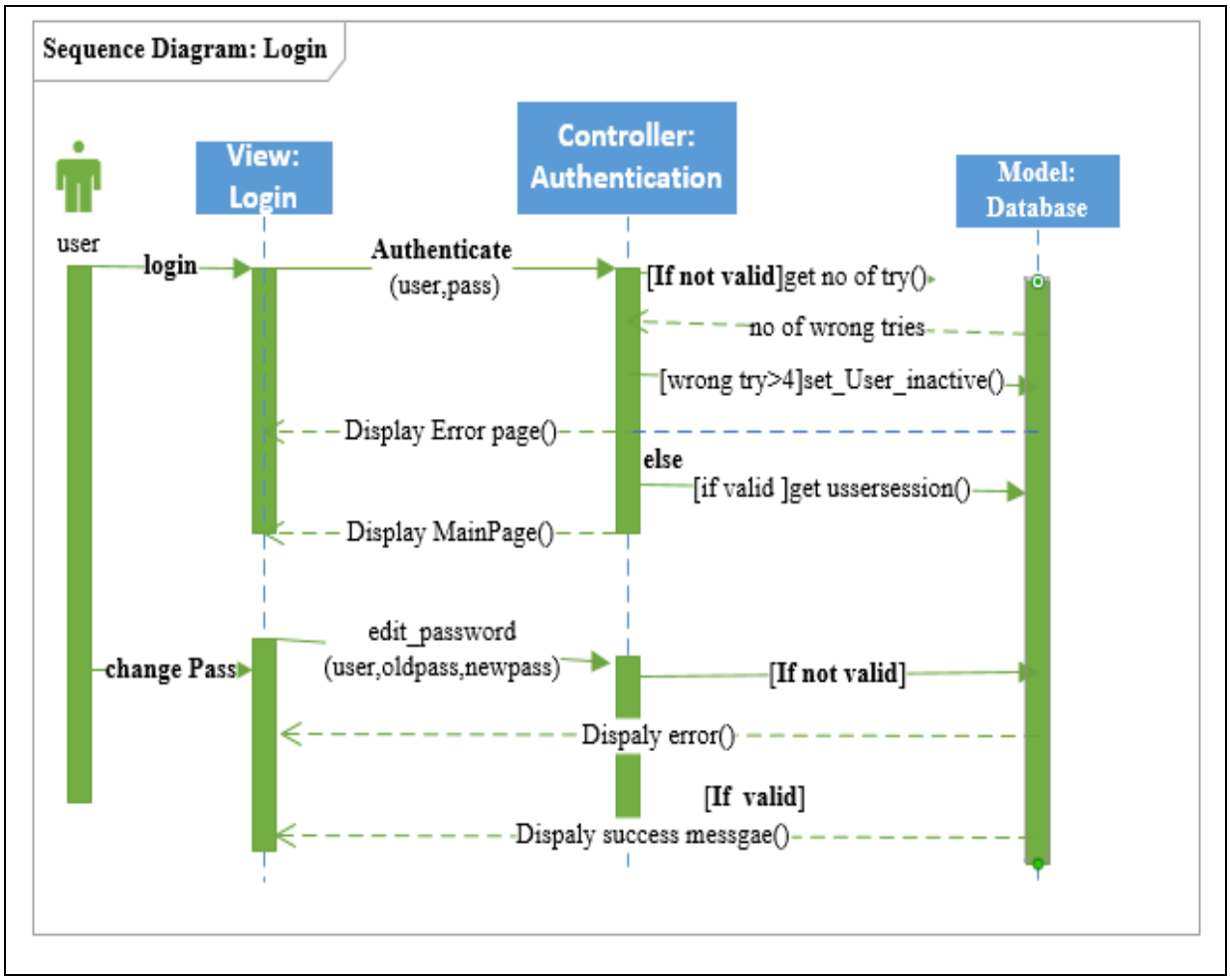


Fig 4.28: SD for Login

The Figure depicted above (Fig 4.28) represents Login Sequence diagram. It represents two distinctive sequence flows: login and change password. In the login sequence, the system accepts (user name, password) makes the authentication. If the authentication fails, the system increments no of wrong try and send current no of wrong tries. Until the no of wrong tries reach 4, the user is allowed to login. Once the no of wrong tries passes 4, the user is prevented from login into the system and the user account is locked. Then the user is required to contact system administrator for unlocking his/her account.

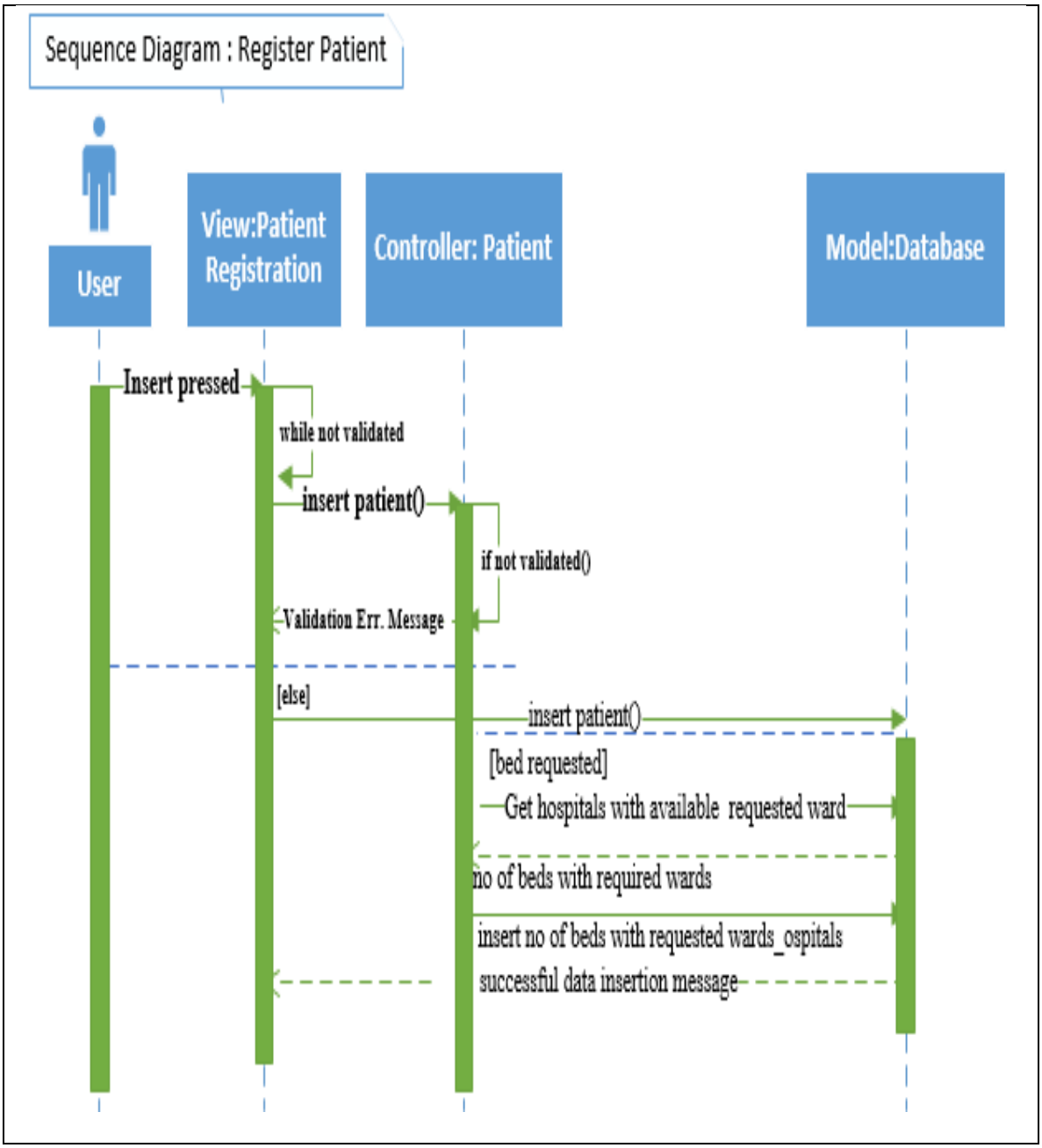


Fig 4.29: SD for Patient Registration

Fig 4.29 above shows sequence diagram for emergency patient registration. The user fills patient registration form and saves the data .The system validates the data before saving it into the system .For wrong data the system send error message to the user .For registered patient with bed request, the system search for available bed across all

hospitals with the wards that matches with patient registration. The system then registered the available beds with in each hospital for that particular patient request. This is for auditing the responses of hospitals to a bed request.

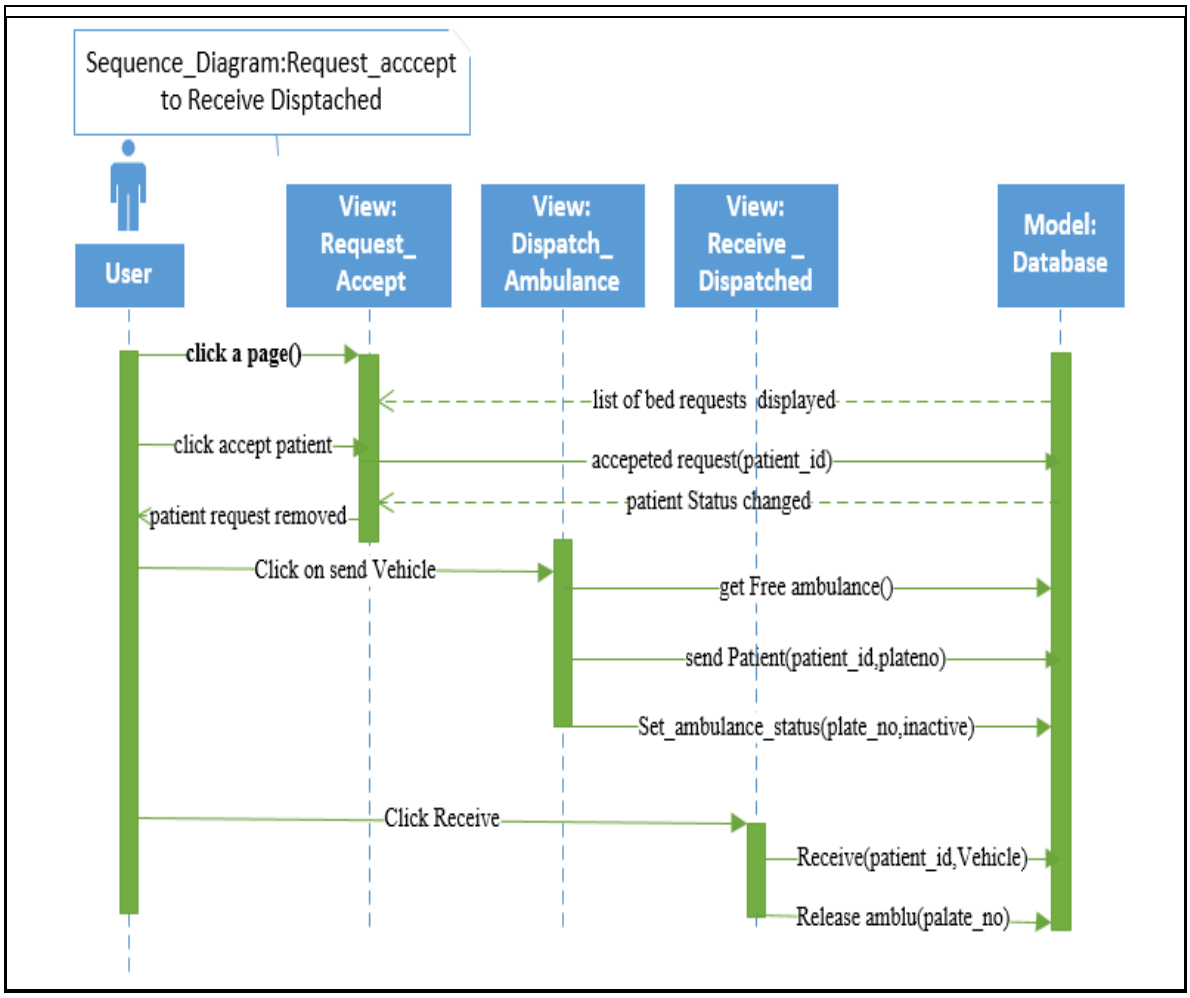


Fig 4.30: Sequence Diagram for Receive Dispatched

In Fig 4.30 above the sequence diagram shows the event from accepting a request to receiving dispatched patient. A hospital with available ward bed may accept bed request from list of bed request. Once a hospital accepts request for bed for a patient, the patient is removed from the patient request for bed list (patient status changed). Then the hospital will send the patient from available list of ambulances. Until the ambulance reaches its

destination, it will not be available on the system. Once the ambulance delivers it patient, its status automatically will be changed and it will be available for another patient.

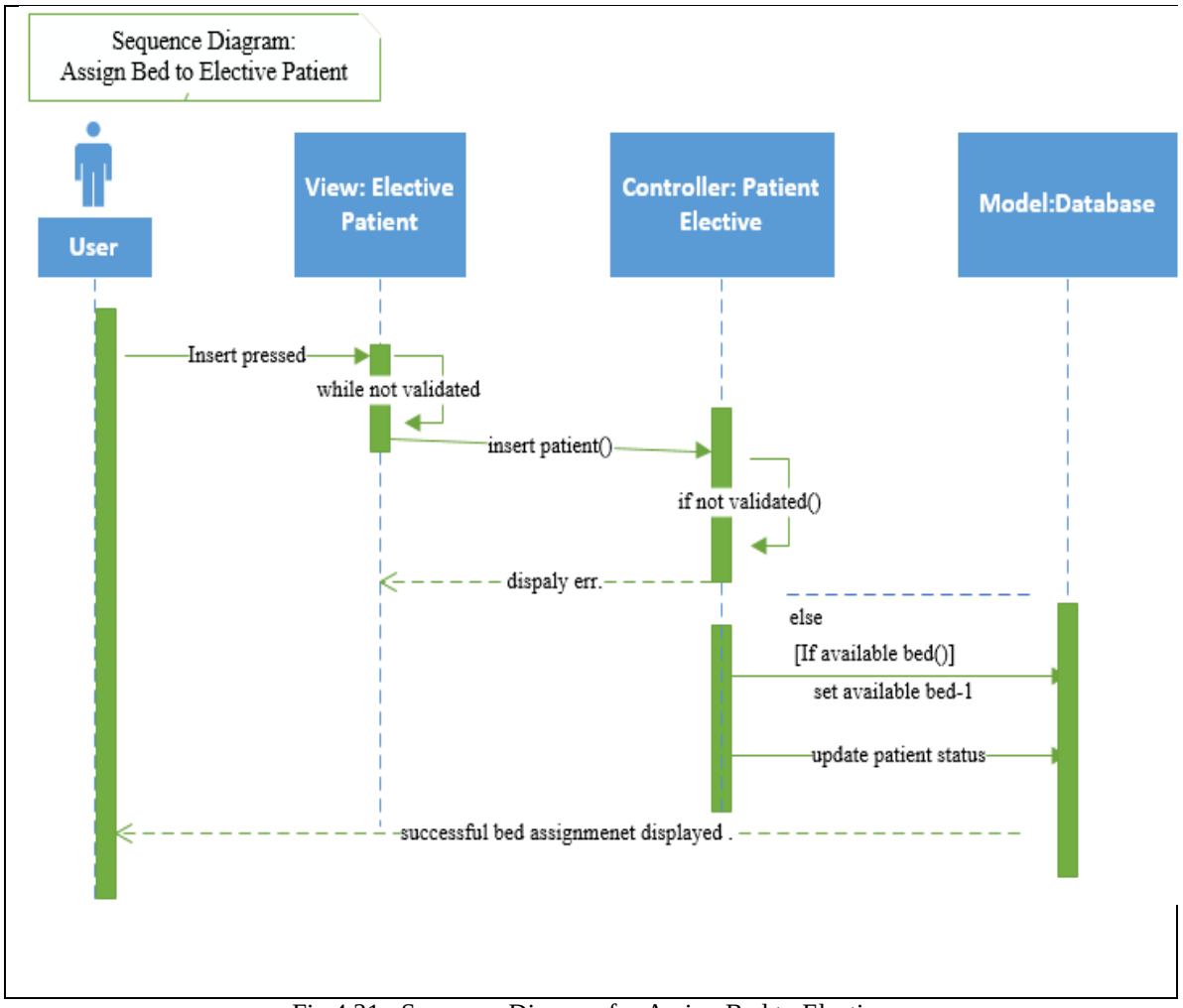


Fig 4.31: Sequence Diagram for Assign Bed to Elective

The sequence diagram for the above Fig 4.31 shows the sequence flow for registration and bed assignment of elective patient .Validation for data insertion is done at two steps: validation at client side and then at the server side . Elective patient is registered directly into the system and assigned a bed without bed request. When the patient is assigned a bed, the total no of available bed within that ward for a particular hospital is decreased by 1.

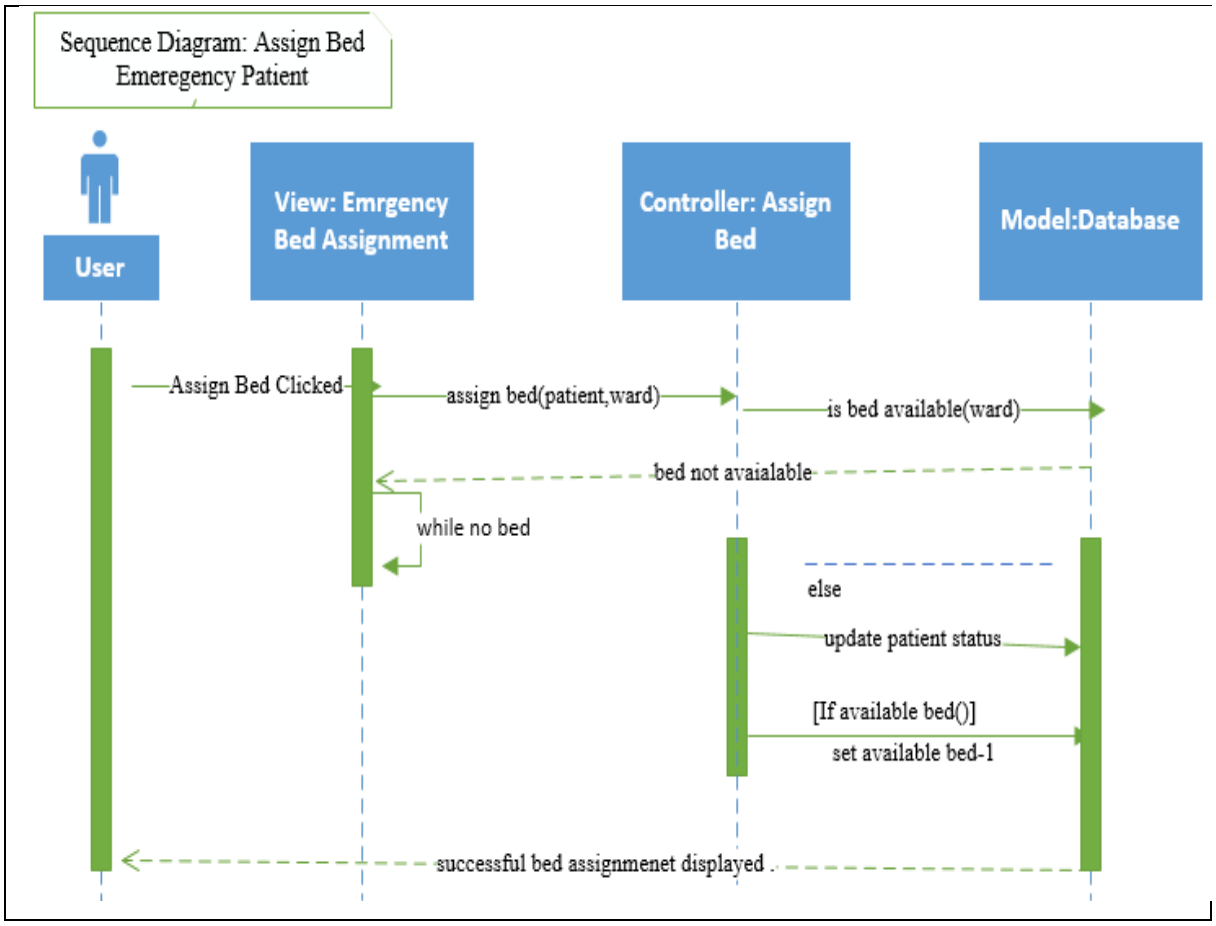


Fig 4.32: SD Bed Assignment to Emergency Patient

In Fig 4.32, sequence diagram for Bed assignment for an emergency patient is shown. In the assigning of a bed to an emergency bed request, if there is no free bed in that ward, the patient has to be admitted in another ward which has a free bed. Once the patient has been assigned to a bed (admitted), the available bed in that ward will decrease by 1.

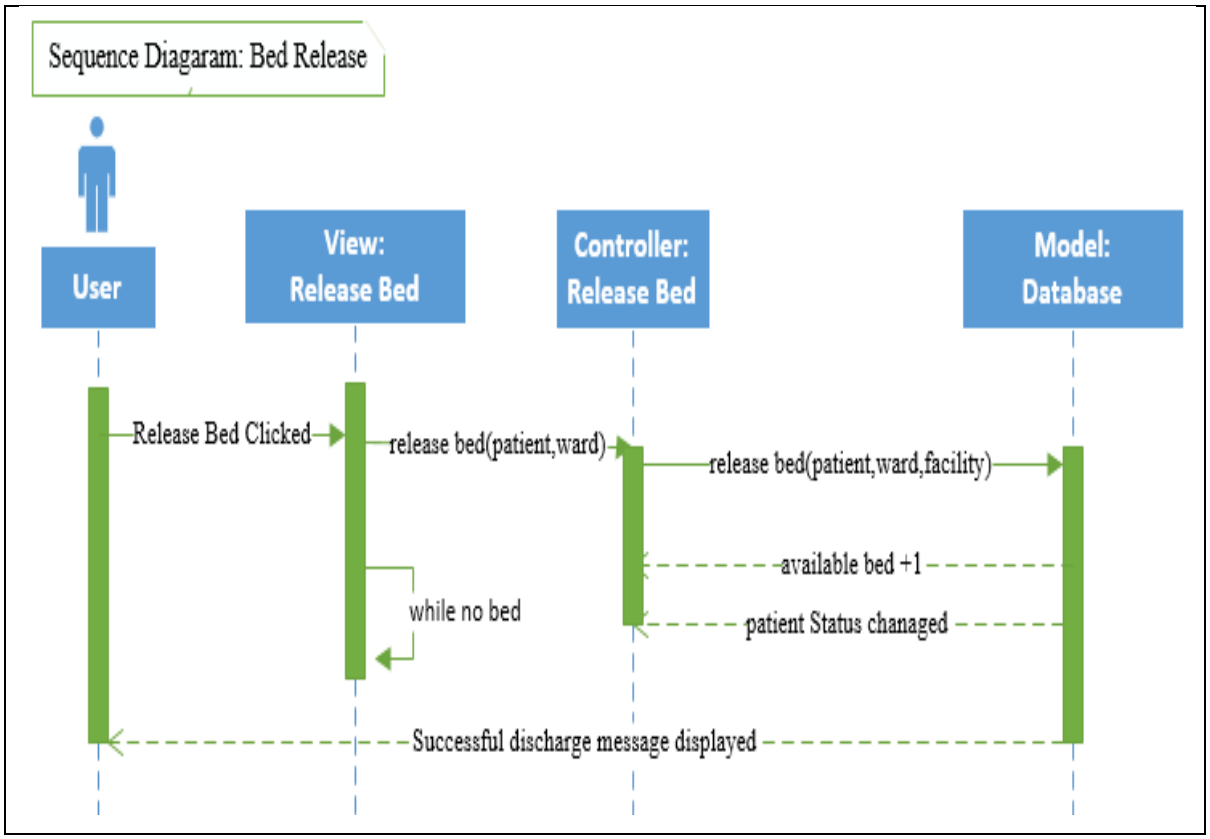


Fig 4.33: SD Bed Release

The sequence for Bed release is shown in Fig 4.33 above. Bed release is the same for both elective and emergency patient. In both cases, a patient that is admitted within a ward is selected and then discharged. Available number of bed within the ward is increased by 1 and patient status is changed to discharge.

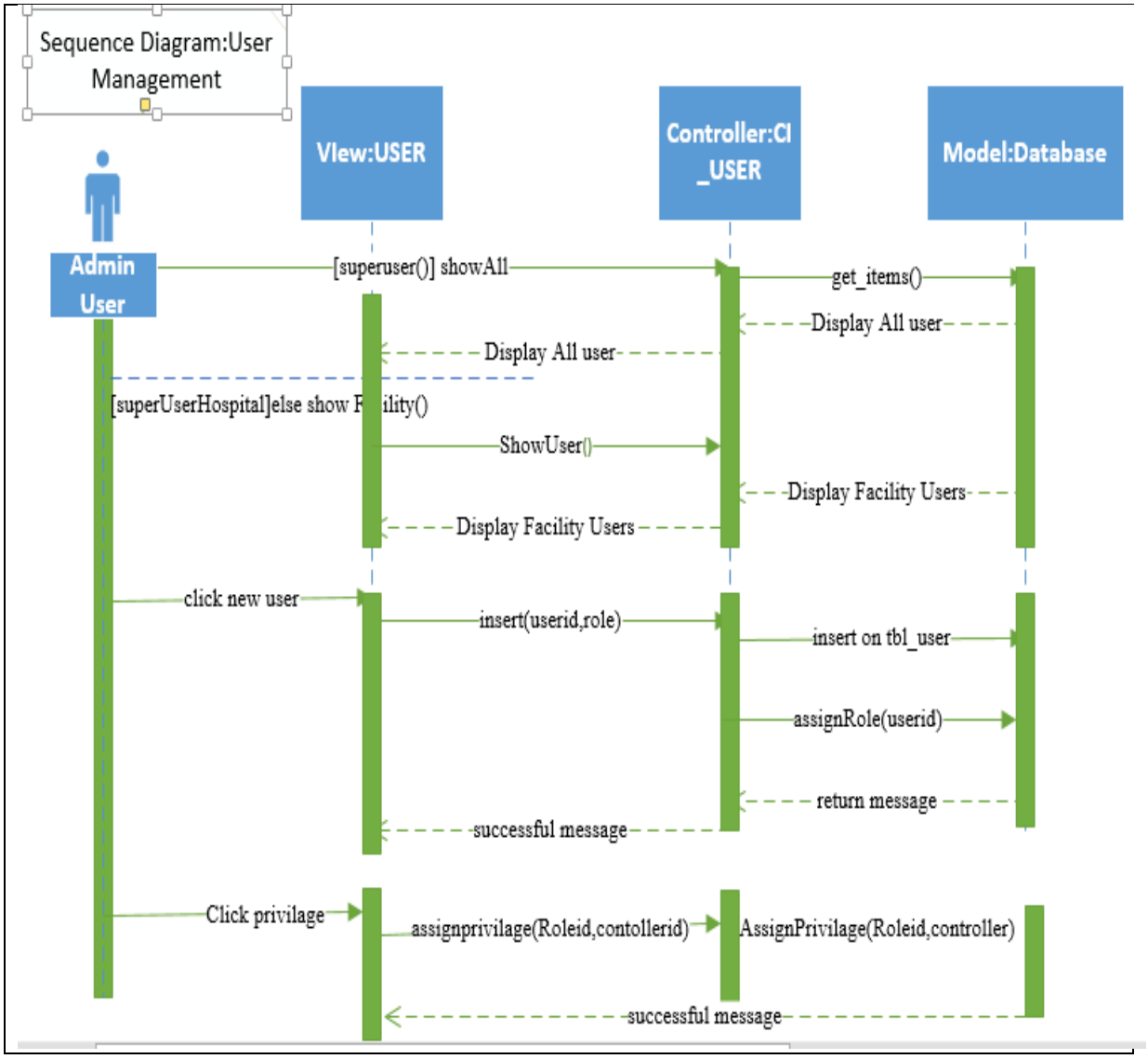


Fig 4.34: SD User Management

In the User Management Sequence diagram shown above in Fig 4.34, the user is a system admin. Two sequences of events can be started: edit user and create user. In create new user, the admin selects from lists of staff and create a new user. For editing an already existing system user, select user from lists of system users by clicking a button and make the necessary modification.

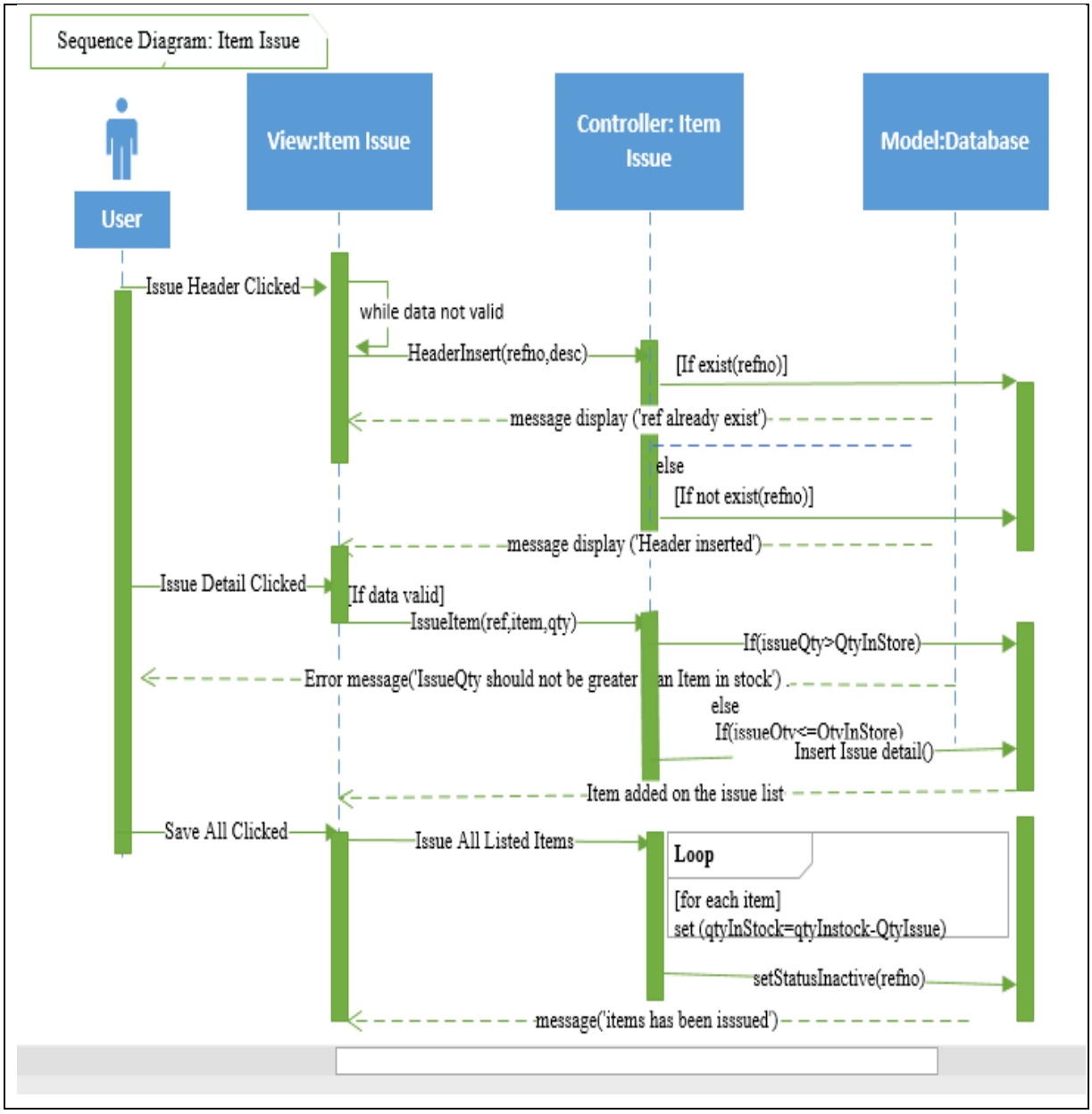


Fig 4.35: SD Item Issue

Chapter Five

Proposed System Design and Implementation

5.1 Class Diagram

A class diagram shows the static structure of an object-oriented model. The class diagram has two main goals:

1. To serve as a communication medium between the developers (analysts/ designers) and the users or their representatives. The diagram is created as a result of the interactions between the two parties, during which they discover and define the users' information needs; the diagram serves like a contract between these two sides which summarizes the users' needs.
2. To be the basis for further development of the information system (IS). Based on the diagram, it should be possible to design the database schema of the application, and (partially) the functions that it will have to perform [11].

A class diagram in UML model is represented by a rectangle divided into three parts. In the upper part, the class name is written, the attribute names in the middle, and the function names in the lower part.

5.1.1 Classes used in the System

Two types of classes are used in the system:

1. Lookup Classes: These classes are used in defining types of data, attributes used in the database (Fig 5.1)
2. Transactional Class: These are classes used directly related to the functionality of the system(Fig 5.2)

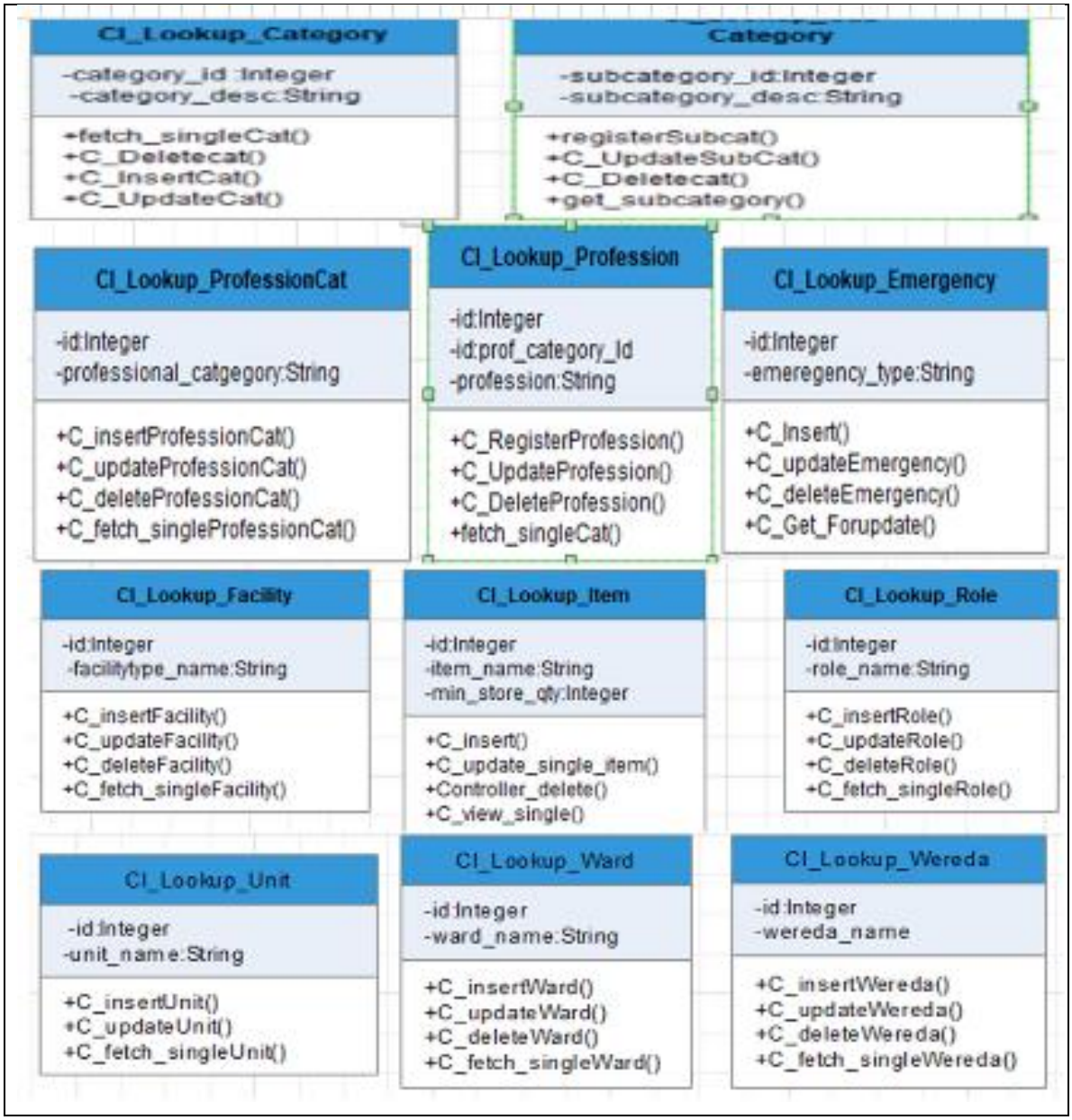


Fig 5.1: Lookup classes

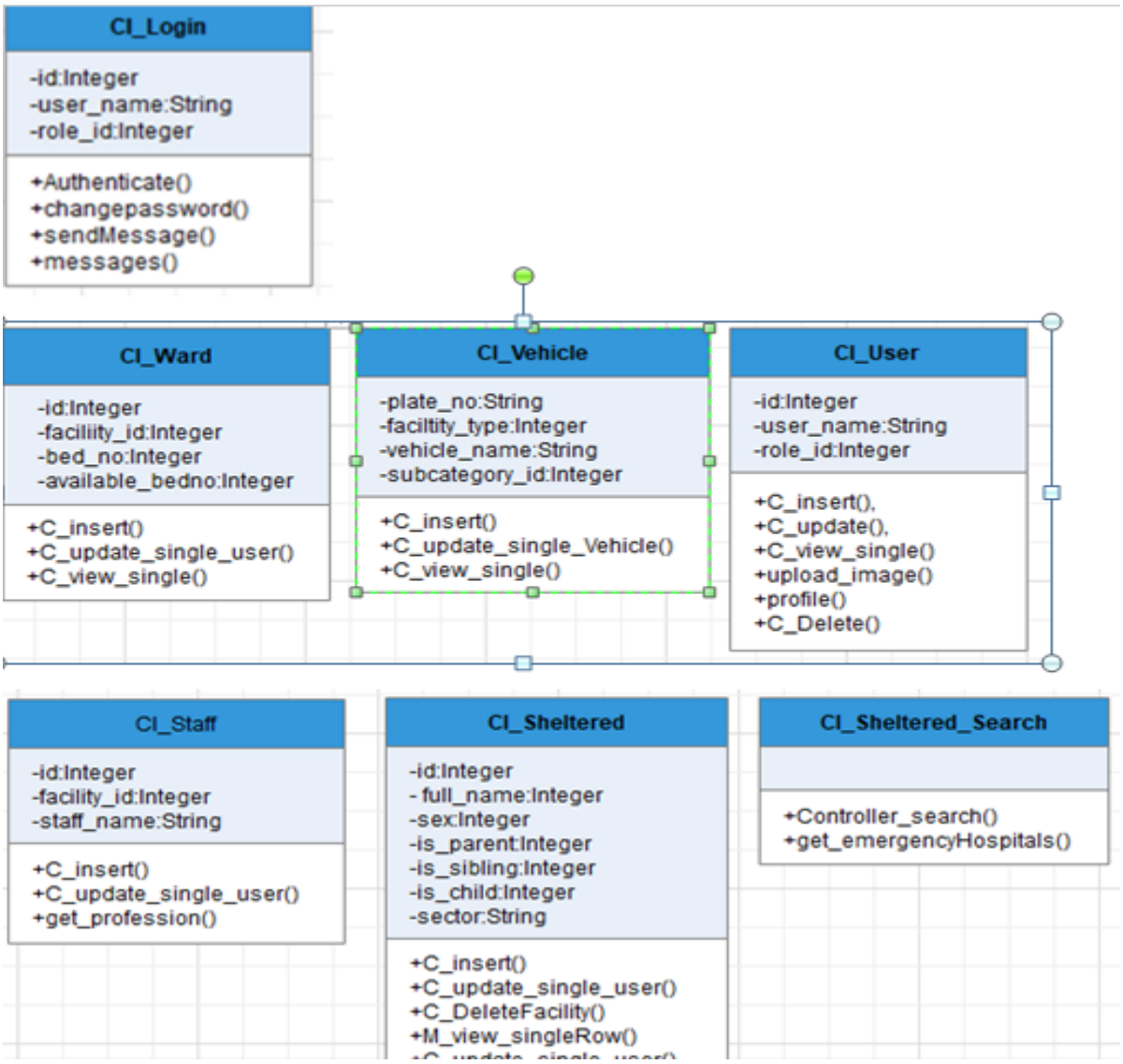

Cl_Login
-id:Integer
-user_name:String
-role_id:Integer
+Authenticate()
+changepassword()
+sendMessage()
+messages()
Cl_Ward
-id:Integer
-faciliity_id:Integer
-bed_no:Integer
-available_bedno:Integer
+C_insert()
+C_update_single_user()
+C_view_single()
Cl_Vehicle
-plate_no:String
-faciltity_type:Integer
-vehicle_name:String
-subcategory_id:Integer
+C_insert()
+C_update_single_Vehicle()
+C_view_single()
Cl_User
-id:Integer
-user_name:String
-role_id:Integer
+C_insert(),
+C_update(),
+C_view_single()
+upload_image()
+profile()
+C_Delete()
Cl_Staff
-id:Integer
-facility_id:Integer
-staff_name:String
+C_insert()
+C_update_single_user()
+get_profession()
Cl_Sheltered
-id:Integer
- full_name:Integer
-sex:Integer
-is_parent:Integer
-is_sibling:Integer
-is_child:Integer
-sector:String
+C_insert()
+C_update_single_user()
+C_DeleteFacility()
+M_view_singleRow()
Cl_Sheltered_Search
+Controller_search()
+get_emergencyHospitals()

Fig 5.2: Transactional Class Used

5.1.2 Class Diagram Relationship

Class diagram is part of UML that represents static view of a system. Class diagrams are widely used in the modeling of object oriented systems because they are the only UML diagrams which can be mapped directly with object oriented languages. It also shows the attributes, operations and relationships among objects.

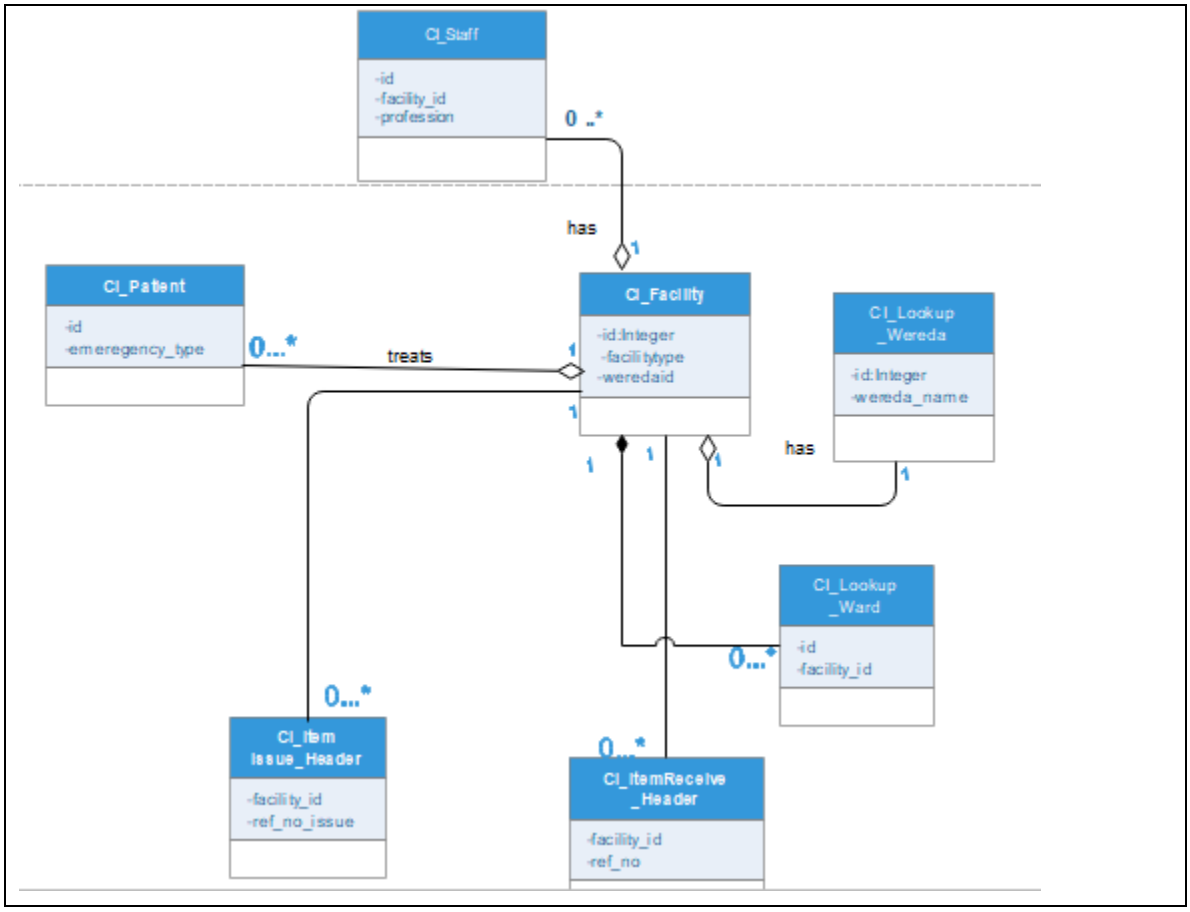


Fig 5.3.1.1: Class Diagram Relationships

The class diagram in Fig 5.3.1.1 shows the relationships a facility has with other objects. In the above relationship a staff for example can be assigned only to one facility while a facility can have many staff members .In the aggregate relation between facility and patients, a facility can have many patients but the patients can exist without a facility.In the composite relationship between facility and wards , wards can't exist without a facility.

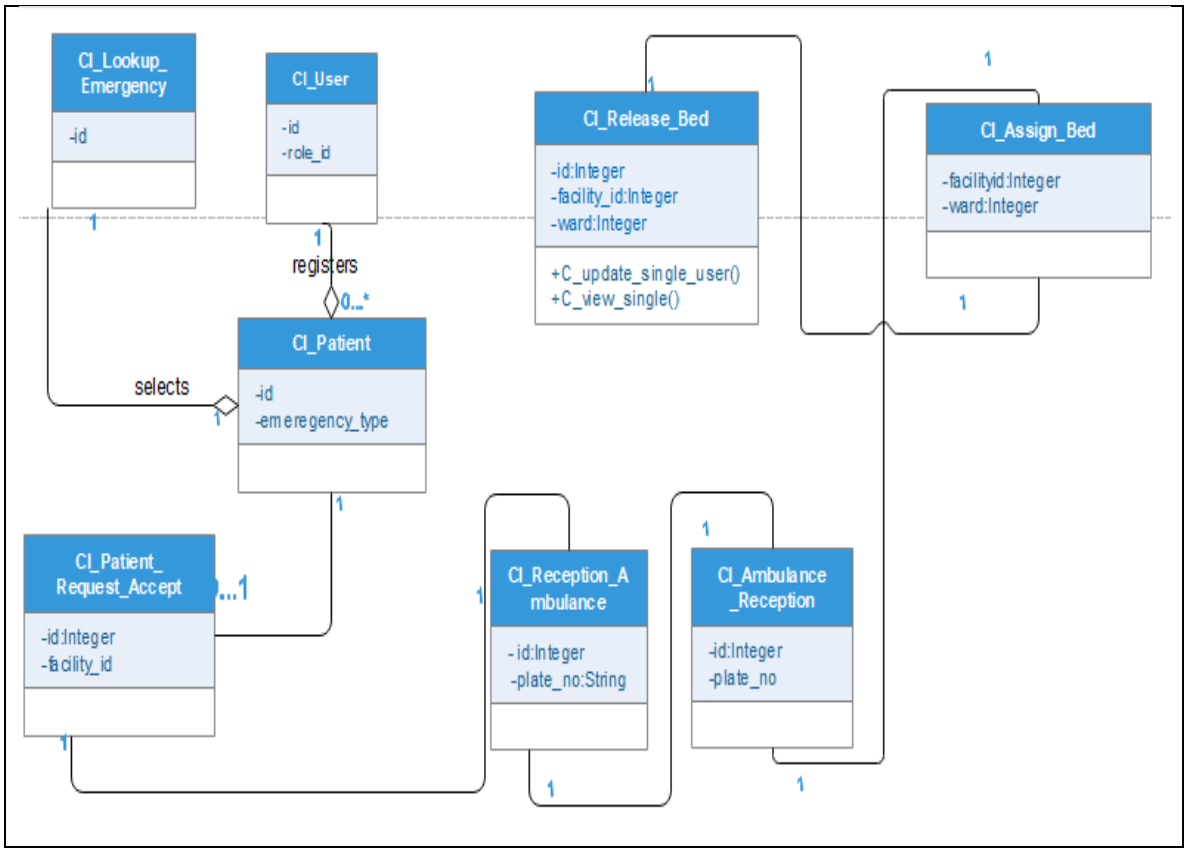


Fig 5.3.1.2: Class Diagram Relationships

In the above figure, the focus is given to the relationship that the different classes related as the patient passes from registration to the final discharge from a hospital. In the relationship between patient to a user , a single user can register many patients. A single registered patient can have one type of emergency type(eg. Pregenancy). For a single bed request there can be only one request acceptance. And for a unique acceptance only one ambulance can be assigned. For bed assignnment and finally for releasing patient(discharge) the relationship is one-one.

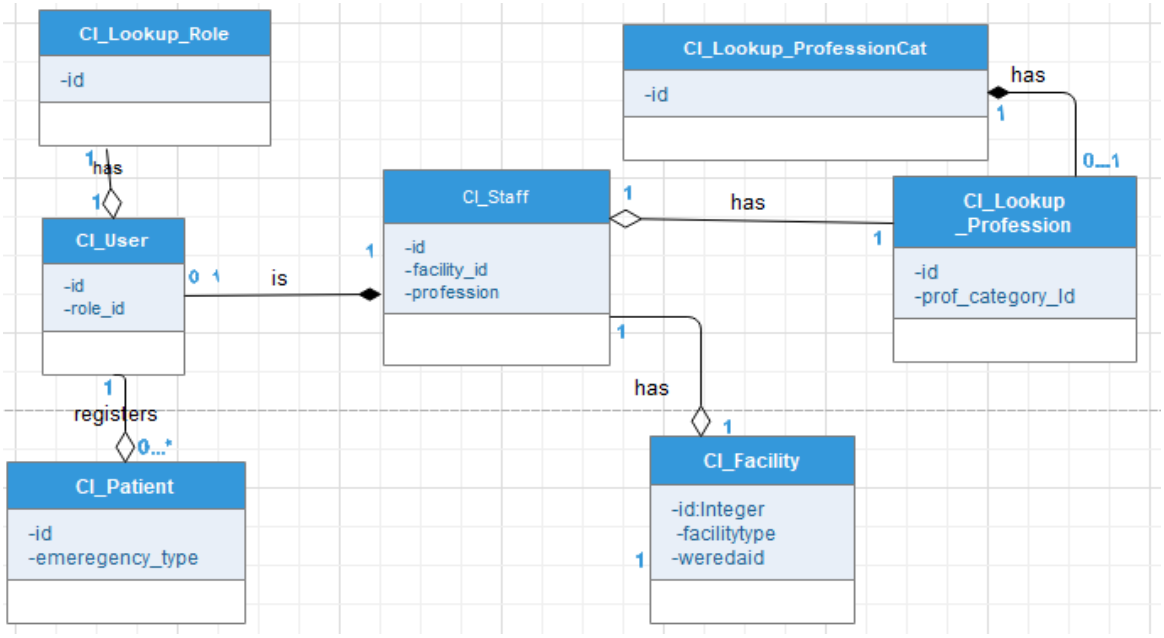


Fig 5.3.1.3: Class Diagram Relationships

The above Fig 5.3.1.3 shows the class diagram relation for the staff class (CI_Staff). A staff can only be assigned to one facility. A staff can be a user. A user can't exist without a staff. And a user has one role.

The figure shown below, Fig 5.3.1.4 shows class diagram related to the Inventory .Here the three classes directly related to inventory functionality are Item class(CI_Lookup_Item),Receive class(CI_ItemReceive_Header ,CI_ItemReceive_Detail) and Issue Class(CI_ItemIssue_Detail, CI_ItemIssue_Header).The relationship between (CI_ItemReceive_Header and CI_ItemReceive_Detail) and (CI_ItemIssue_Detail, CI_ItemIssue_Header) is one-many.

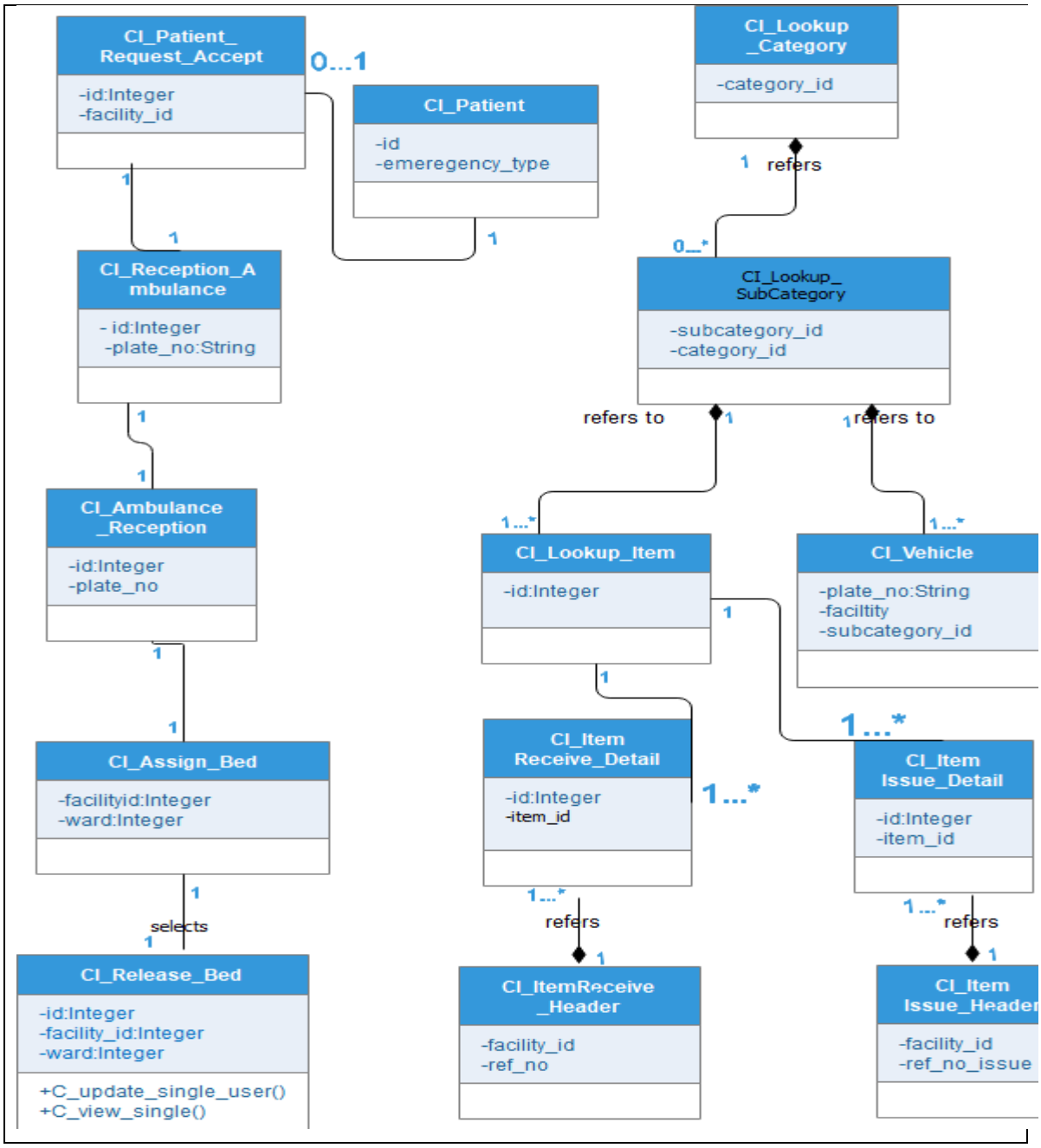


Fig 5.3.1.4: Class Diagram Relationships

5.2 Database Model

Data base schema represents a reference to the data assets. Many different database models are in use and are the basis for database technologies. Although hierarchical and network models have been popular in the past, these are not used often today for new information systems. Object oriented database models are emerging, but are still not

common. The vast majority of information systems today use the relational database model [10].

5.2.1 Database Objects

Listed below is Database objects used with in the database: Auditor Tables, Lookup Tables, Transactional Tables, Views and Triggers which are described separately.

Auditor Tables: - Database table to track down activities made on transactional tables. Fig 5.4 shows lists of auditing database tables used in the system.

audit_tbl_bed_assigned

Column	Type	Null	Default
ACCEPTED_ID *(Primary)*	int(11)	No	
PATIENT_CARD	varchar(11)	No	
FACILITY_ID	int(11)	No	
ENTERED_BY	varchar(15)	No	
WARD_ID	int(11)	No	
DATE_ASSIGNED	date	No	
DATE_RELEASED	date	No	
STATUS	varchar(2)	No	01
PATIENT_TYPE	varchar(20)	No	EMERGENCY
ACTIONS	varchar(10)	No	
ACTION_BY	varchar(20)	No	
ACTION_DATE	date	No	

audit_tbl_facility

Column	Type	Null	Default
FACILITYTYPE_ID	int(20)	No	
ID *(Primary)*	int(20)	No	
FACILITY_NAME	varchar(50)	No	
FACILITY_ADDRES	varchar(50)	No	
WEREDA_ID	int(20)	No	
INSERTED_BY	varchar(20)	No	
INSERTED_DATE	date	No	
TEL	varchar(20)	No	
CONTACT	varchar(20)	No	
STATUS	varchar(10)	No	ACTIVE
REMARK	varchar(200)	No	
ACTIONS	varchar(10)	No	
ACTION_BY	varchar(20)	No	
ACTION_DATE	date	No	

audit_tbl_itemissue_detail

Column	Type	Null	Default
ID *(Primary)*	int(20)	No	
REF_NO_ISSUE	varchar(11)	No	
QTY_ISSUED	int(11)	No	
ITEM_ID	int(20)	No	
ACTIONS	varchar(10)	No	
ACTION_DATE	date	No	
ACTION_BY	varchar(20)	No	

audit_tbl_itemreceive_detail

Column	Type	Null	Default
ID *(Primary)*	int(20)	No	
REF_NO	varchar(11)	No	
QTY_RECEIVED	int(11)	No	
QTY_REMAINING	int(11)	No	
ITEM_ID	int(20)	No	
UNIT_PRICE	float	No	
ACTIONS	varchar(10)	No	
ACTION_BY	varchar(20)	No	
ACTION_DATE	date	No	

audit_tbl_patient_accepted

Column	Type	Null	Default
ID	int(11)	No	
STATUS	varchar(10)	No	ready
ACCEPTED_BY	varchar(15)	No	
FACILITY_ID	int(11)	No	
ARRIVAL_TIME	timestamp	No	0000-00-00 00:00:00
PLATE_NO	varchar(12)	No	
VEHICLE_TYPE	varchar(10)	No	HOSPITAL
ACCEPTED_TIME	timestamp	No	0000-00-00 00:00:00
ACTIONS	varchar(10)	No	
ACTION_DATE	date	No	
ACTION_BY	varchar(20)	No	

audit_tbl_staff

Column	Type	Null	Default
ID *(Primary)*	varchar(20)	No	
PROFESSION_ID	int(11)	No	
FACILITY_ID	int(11)	No	
STAFF_NAME	varchar(50)	No	
TEL	varchar(20)	No	
EMAIL	varchar(20)	No	
INSERTED_BY	varchar(20)	No	
INSERTED_DATE	date	No	
SYSTEM_USER	varchar(7)	No	NO
SEX	varchar(6)	No	
STATUS	varchar(10)	No	ACTIVE
ACTIONS	varchar(10)	No	
ACTION_BY	varchar(20)	No	
ACTION_DATE	date	No	

audit_tbl_user

Column	Type	Null	Default
ID *(Primary)*	int(11)	No	
USER_NAME	varchar(20)	No	
PASSWORD	varchar(11)	No	
STATUS	varchar(11)	No	ACTIVE
ROLE_ID	int(11)	No	
IMAGE	longblob	No	
TRY	int(1)	No	0
ACTIONS	varchar(10)	No	
ACTION_BY	varchar(20)	No	
ACTION_DATE	date	No	

audit_tbl_patient_reg

Column	Type	Null	Default
ID *(Primary)*	int(11)	No	
PATIENT_CARD	varchar(20)	No	
PATIENT_NAME	varchar(50)	No	
SEX	varchar(10)	No	
AGE	int(11)	No	
BLOODTYPE	varchar(5)	No	
PHONE_NO	varchar(15)	No	
WEREDA_ID	int(50)	No	
REG_DATE	date	No	
TIME	timestamp	No	CURRENT_TIMESTAMP
FACILITY_ID	int(11)	No	
EMERGENCY_TYPE	int(20)	No	
PHYSICAL_ASSESMENT	varchar(100)	No	
VITAL_SIGN	varchar(100)	No	
EXAMINED_BY	varchar(20)	No	
INSERTED_BY	varchar(20)	No	
REGISTRATION_TYPE	varchar(20)	No	
REFER_FROM	int(11)	No	
REFER_TO	int(11)	No	
TREATMENT	varchar(100)	No	
STATUS	varchar(2)	No	01
TIME1	int(20)	No	
FINAL_TIME	datetime	No	
VARDATE	varchar(12)	No	
PATIENT_TYPE	varchar(10)	No	EMERGENCY
ACTIONS	varchar(10)	No	
ACTION_BY	varchar(20)	No	
ACTION_DATE	date	No	

Fig 5.4: Auditor Tables

Lookup Tables: - These tables are not the actual transactional tables directly related to user requirement. They are used to hold lookup data. Examples of lookup tables are those used to hold in formation like, list of Wereda, emergency types, list of nationality, list of languages and list of profession. Fig 5.5 shows lists of lookup database tables used in the system.

lu_category

Column	Type	Null	Default	Links to
CATEGORY_ID *(Primary)*	int(11)	No		
MAIN_CATEGORY	varchar(20)	No		

lu_subcategory

Column	Type	Null	Default	Links to
SUBCATEGORY_ID *(Primary)*	int(11)	No		
CATEGORY_ID	int(11)	No		lu_category -> CATEGORY_ID
SUBCATEGORY_NAME	varchar(20)	No		

lu_controller

Column	Type	Null	Default	Links to
CONTROLLER_NAME *(Primary)*	varchar(50)	No		

lu_emergency_type

Column	Type	Null	Default	Links to
ID *(Primary)*	int(11)	No		
EMERGENCY_TYPE	varchar(40)	No		
EMERGENCY_LEVEL	int(11)	No		
WARD_ID	int(10)	No		

lu_facility

Column	Type	Null	Default	Links to
ID *(Primary)*	int(11)	No		
FACILITYTYPE_NAME	varchar(40)	No		
TYPE_NO	varchar(1)	No		

lu_healthcenter

Column	Type	Null	Default	Links to
ID *(Primary)*	int(11)	No		
WEREDA_ID	int(11)	No		
CENTER_NAME	varchar(50)	No		
PHONE_NO	varchar(11)	No		

lu_item

Column	Type	Null	Default	Links to
ID *(Primary)*	int(11)	No		
SUBCATEGORY_ID	int(11)	No		
ITEM_NAME	varchar(40)	No		
ITEM_UNIT_ID	int(11)	No		
MIN_STORE_QTY	float	No		

lu_profession

Column	Type	Null	Default	
PROFESSION_NAME	varchar(20)	No		
ID *(Primary)*	int(11)	No		
PROFESSION_CATEGORY_ID	int(11)	No		lu_profession_category -> ID

lu_profession_category

Column	Type	Null	Default	Links to
ID *(Primary)*	int(11)	No		
PROFESSION_CATEGORY	varchar(20)	No		
MEDICAL	int(11)	No	1	

lu_role

Column	Type	Null	Default	Links to
ID *(Primary)*	int(11)	No		
ROLE_NAME	varchar(20)	No		

lu_status

Column	Type	Null	Default	Links to
ID *(Primary)*	varchar(2)	No		
STATUS	varchar(15)	No		

lu_unit

Column	Type	Null	Default	Links to
ID *(Primary)*	int(11)	No		
UNIT_NAME	varchar(10)	No		
INSERTED_BY	varchar(20)	No		

lu_ward

Column	Type	Null	Default	Links to
ID *(Primary)*	int(11)	No		
WARD_NAME	varchar(20)	No		

lu_wereda

Column	Type	Null	Default	Links to
ID *(Primary)*	int(11)	No		
WEREDA_NAME	varchar(20)	No		

Fig 5.5: Lookup Tables

Transactional Tables: - These database tables are those which are directly related to the functionality requirement and are used for storing transactional data. Fig 5.6 shows lists of transactional database tables used in the system.

tbl_bed_assigned

Column	Type	Null	Default	Links to
ACCEPTED_ID *(Primary)*	int(11)	No		
PATIENT_CARD	varchar(11)	No		
FACILITY_ID	int(11)	No		tbl_facility -> ID
ENTERED_BY	varchar(15)	No		tbl_user -> ID
WARD_ID	int(11)	No		lu_ward -> ID
DATE_ASSIGNED	date	No		
DATE_RELEASED	date	No		
STATUS	varchar(2)	No	01	
PATIENT_TYPE	varchar(20)	No	EMERGENCY	

tbl_facility

Column	Type	Null	Default	Links to
FACILITYTYPE_ID	int(20)	No		lu_facility -> ID
ID *(Primary)*	int(20)	No		
FACILITY_NAME	varchar(50)	No		
FACILITY_ADDRES	varchar(50)	No		
WEREDA_ID	int(20)	No		lu_wereda -> ID
INSERTED_BY	varchar(20)	No		
INSERTED_DATE	date	No		
TEL	varchar(20)	No		
CONTACT	varchar(20)	No		
STATUS	varchar(10)	No	ACTIVE	
REMARK	varchar(200)	No		

tbl_itemissue_detail

Column	Type	Null	Default	I
ID *(Primary)*	int(11)	No		
REF_NO_ISSUE	varchar(11)	No		tbl_itemissue_header -> REF_NO_ISSUE
QTY_ISSUED	int(11)	No		
ITEM_ID	int(20)	No		

tbl_itemissue_header

Column	Type	Null	Default	Links to
FACILITY_ID	int(20)	No		
INSERTED_DATE	date	No		
INSERTED_BY	varchar(11)	No		
REMARK	varchar(100)	No		
REF_NO_ISSUE *(Primary)*	varchar(11)	No		
STATUS	varchar(10)	No	ACTIVE	
ISSUED_TO	varchar(20)	No		

tbl_itemreceive_detail

Column	Type	Null	Default	
ID *(Primary)*	int(20)	No		
REF_NO	varchar(11)	No		tbl_itemreceive_header -> REF_NO
QTY_RECEIVED	int(11)	No		
QTY_REMAINING	int(11)	No		
ITEM_ID	int(20)	No		
UNIT_PRICE	float	No		

tbl_itemreceive_header

Column	Type	Null	Default	Links to
FACILITY_ID	int(20)	No		
INSERTED_DATE	date	No		
INSERTED_BY	varchar(20)	No		
REMARK	varchar(100)	No		
RECEIVED_FROM	varchar(50)	No		
REF_NO *(Primary)*	varchar(20)	No		
STATUS	varchar(10)	No	ACTIVE	

tbl_messages

Column	Type	Null	Default	Links to
CHAT_MESSAGE_ID *(Primary)*	int(11)	No		
SESSION_ID	int(11)	No		
USER_ID	varchar(20)	No		tbl_user -> ID
CHAT_MESSAGE_CONTENT	varchar(100)	No		
CREATE_DATE	timestamp	No	CURRENT_TIMESTAMP	
STAFF_NAME	varchar(20)	No		
RECEIVER_ID	int(11)	No		
STATUS	int(2)	No	0	
TOPIC	varchar(50)	No		

tbl_patient_accepted

Column	Type	Null	Default	Links to
STATUS	varchar(10)	No	ready	
ACCEPTED_BY	varchar(15)	No		tbl_user -> ID
FACILITY_ID	int(11)	No		tbl_facility -> ID
ARRIVAL_TIME	timestamp	No	0000-00-00 00:00:00	
PLATE_NO	varchar(12)	No		
VEHICLE_TYPE	varchar(10)	No	HOSPITAL	
ACCEPTED_TIME	timestamp	No	0000-00-00 00:00:00	
INSERTED_BY	varchar(20)	No		
ID *(Primary)*	int(11)	No		

tbl_sheltered

Column	Type	Null	Default	I
ID *(Primary)*	int(11)	No		
FACILITY_ID	int(11)	No		tbl_facility -> ID
FULL_NAME	varchar(30)	No		
MOTHER_NAME	varchar(20)	No		
SEX	varchar(10)	No		
IS_PARENT	varchar(10)	No	NO	
IS_SIBLING	varchar(10)	No	NO	
IS_CHILD	varchar(10)	No	NO	
AGE	int(11)	No		
HEIGHT	int(11)	No		
TEL	int(11)	No		
UNDERAGE	int(11)	No		
SECTOR	int(10)	No		
TENT	int(11)	No		
INSERTED_BY	varchar(20)	No		
DATE_INSERTED	date	No		
STATUS	varchar(10)	No	ACTIVE	

tbl_privilage

Column	Type	Null	Default	Links to
ID	int(110)	No		lu_role -> ID
ROLE_ID *(Primary)*	int(10)	No		
CONTROL_NAME *(Primary)*	varchar(50)	No		
FUNCT *(Primary)*	varchar(20)	No		

tbl_request_response

Column	Type	Null	Default	I
PATIENT_ID	int(11)	No		tbl_patient_reg -> ID
FACILITY_ID	int(11)	No		tbl_facility -> ID
REQUEST_STARTED	timestamp	No	0000-00-00 00:00:00	
REQUEST_TERMINATED	timestamp	No	0000-00-00 00:00:00	
WARD_ID	int(11)	No		lu_ward -> ID
AVAILABLE_BED_1	int(11)	No		
STATUS	varchar(12)	No	UNRESPONSIVE	

tbl_patient_reg

Column	Type	Null	Default	Links to
ID *(Primary)*	int(11)	No		
PATIENT_CARD	varchar(20)	No		
PATIENT_NAME	varchar(50)	No		
SEX	varchar(10)	No		
AGE	int(11)	No		
BLOODTYPE	varchar(5)	No		
PHONE_NO	varchar(15)	No		
WEREDA_ID	int(50)	No		lu_wereda -> ID
REG_DATE	date	No		
TIME	timestamp	No	CURRENT_TIMESTAMP	
FACILITY_ID	int(11)	No		tbl_facility -> ID
EMERGENCY_TYPE	int(20)	No		lu_emergency_type -> ID
PHYSICAL_ASSESMENT	varchar(100)	No		
VITAL_SIGN	varchar(100)	No		
EXAMINED_BY	varchar(20)	No		
INSERTED_BY	varchar(20)	No		
REGISTRATION_TYPE	varchar(20)	No		
REFER_FROM	int(11)	No		
REFER_TO	int(11)	No		
TREATMENT	varchar(100)	No		
STATUS	varchar(2)	No	01	
TIME1	int(20)	No		
FINAL_TIME	datetime	No		
VARDATE	varchar(12)	No		
PATIENT_TYPE	varchar(10)	No	EMERGENCY	

tbl_vehicle

Column	Type	Null	Default	Links to
PLATE_NO *(Primary)*	varchar(10)	No		
FACILITY_ID	int(20)	No		tbl_facility -> ID
DRIVER_NAME	varchar(30)	No		
PHONE_NO	int(12)	No		
STATUS	varchar(10)	No	01	
SUBCATEGORY_ID	int(10)	No		lu_subcategory -> SUBCATEGORY_ID
VEHICLE_NAME	varchar(30)	No		

tbl_staff

Column	Type	Null	Default	Links to
ID *(Primary)*	varchar(20)	No		
PROFESSION_ID	int(11)	No		lu_profession -> ID
FACILITY_ID	int(11)	No		tbl_facility -> ID
STAFF_NAME	varchar(50)	No		
TEL	varchar(20)	No		
EMAIL	varchar(20)	No		
INSERTED_BY	varchar(20)	No		tbl_user -> ID
INSERTED_DATE	date	No		
SYSTEM_USER	varchar(7)	No	NO	
SEX	varchar(6)	No		
STATUS	varchar(10)	No	ACTIVE	

tbl_user

Column	Type	Null	Default	Links to
USER_NAME	varchar(20)	No		
PASSWORD	varchar(200)	No		
STATUS	varchar(11)	No	ACTIVE	
ROLE_ID	int(11)	No		lu_role -> ID
IMAGE	longblob	No		
TRY	int(1)	No	0	
INSERTED_BY	varchar(20)	No		
ID	varchar(20)	No	0	tbl_staff -> ID

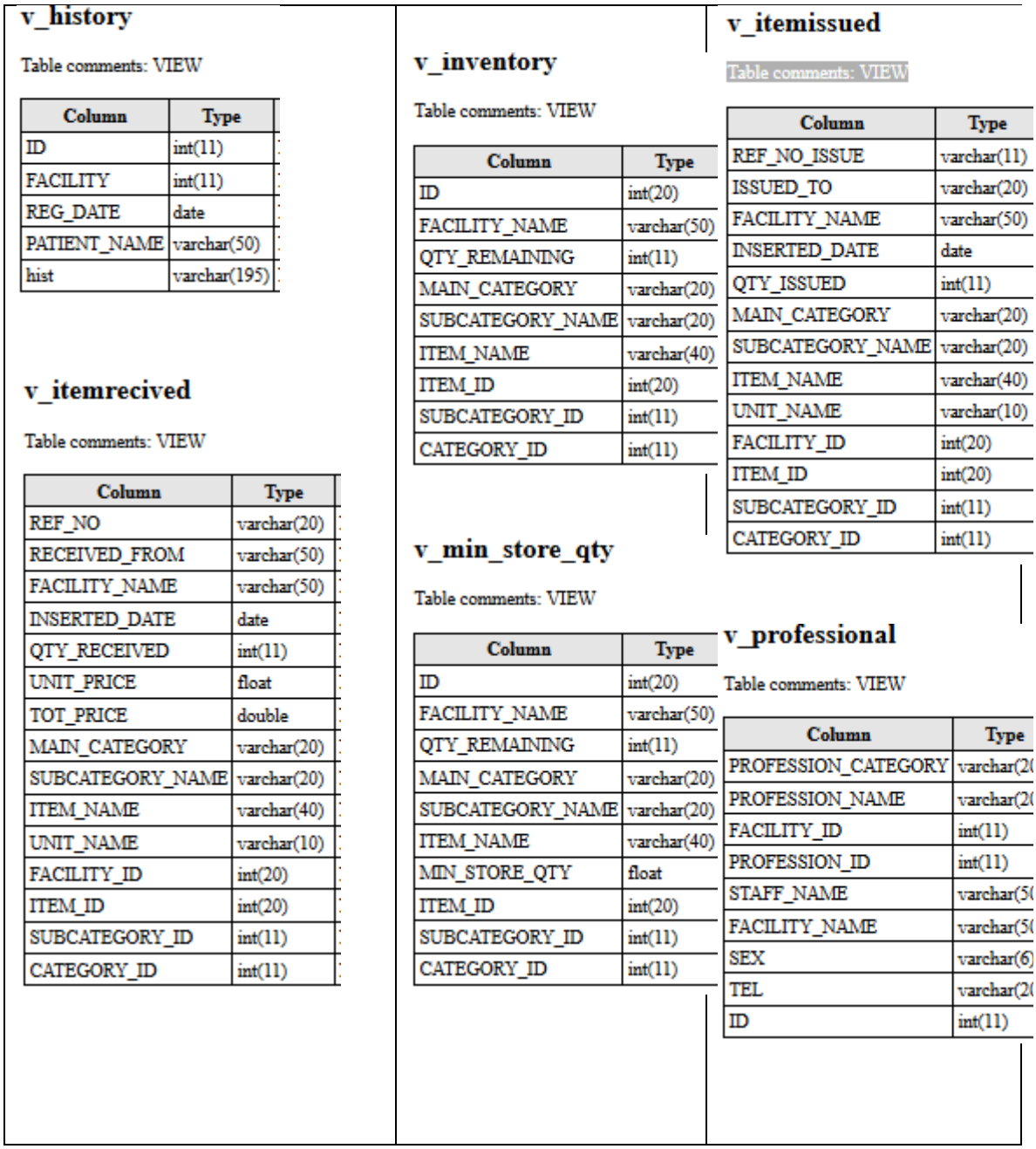
tbl_ward

Column	Type	Null	Default	Links to
FACILITY_ID	int(11)	No		tbl_facility -> ID
WARD_ID	int(11)	No		lu_ward -> ID
BED_NO	varchar(20)	No		
STATUS	varchar(20)	No	active	
AUTOID *(Primary)*	int(11)	No		
AVAILABLE_BED	int(11)	No		

Fig 5.6 Transactional Tables

Views: - The data structure of a database view is similar to a table. But, unlike a table when a view is created, only its SQL query statement is stored in the database schema. The data is presented only when the SQL statement is made to run. So views do not

occupies database space like database tables. Generally views are made by combining two or more tables. It is usually used for generating report and a query. List of views used in the database are shown in Fig 5.7.



v_history

Table comments: VIEW

Column	Type
ID	int(11)
FACILITY	int(11)
REG_DATE	date
PATIENT_NAME	varchar(50)
hist	varchar(195)

v_itemrecived

Table comments: VIEW

Column	Type
REF_NO	varchar(20)
RECEIVED_FROM	varchar(50)
FACILITY_NAME	varchar(50)
INSERTED_DATE	date
QTY_RECEIVED	int(11)
UNIT_PRICE	float
TOT_PRICE	double
MAIN_CATEGORY	varchar(20)
SUBCATEGORY_NAME	varchar(20)
ITEM_NAME	varchar(40)
UNIT_NAME	varchar(10)
FACILITY_ID	int(20)
ITEM_ID	int(20)
SUBCATEGORY_ID	int(11)
CATEGORY_ID	int(11)

v_inventory

Table comments: VIEW

Column	Type
ID	int(20)
FACILITY_NAME	varchar(50)
QTY_REMAINING	int(11)
MAIN_CATEGORY	varchar(20)
SUBCATEGORY_NAME	varchar(20)
ITEM_NAME	varchar(40)
ITEM_ID	int(20)
SUBCATEGORY_ID	int(11)
CATEGORY_ID	int(11)

v_min_store_qty

Table comments: VIEW

Column	Type
ID	int(20)
FACILITY_NAME	varchar(50)
QTY_REMAINING	int(11)
MAIN_CATEGORY	varchar(20)
SUBCATEGORY_NAME	varchar(20)
ITEM_NAME	varchar(40)
MIN_STORE_QTY	float
ITEM_ID	int(20)
SUBCATEGORY_ID	int(11)
CATEGORY_ID	int(11)

v_itemissued

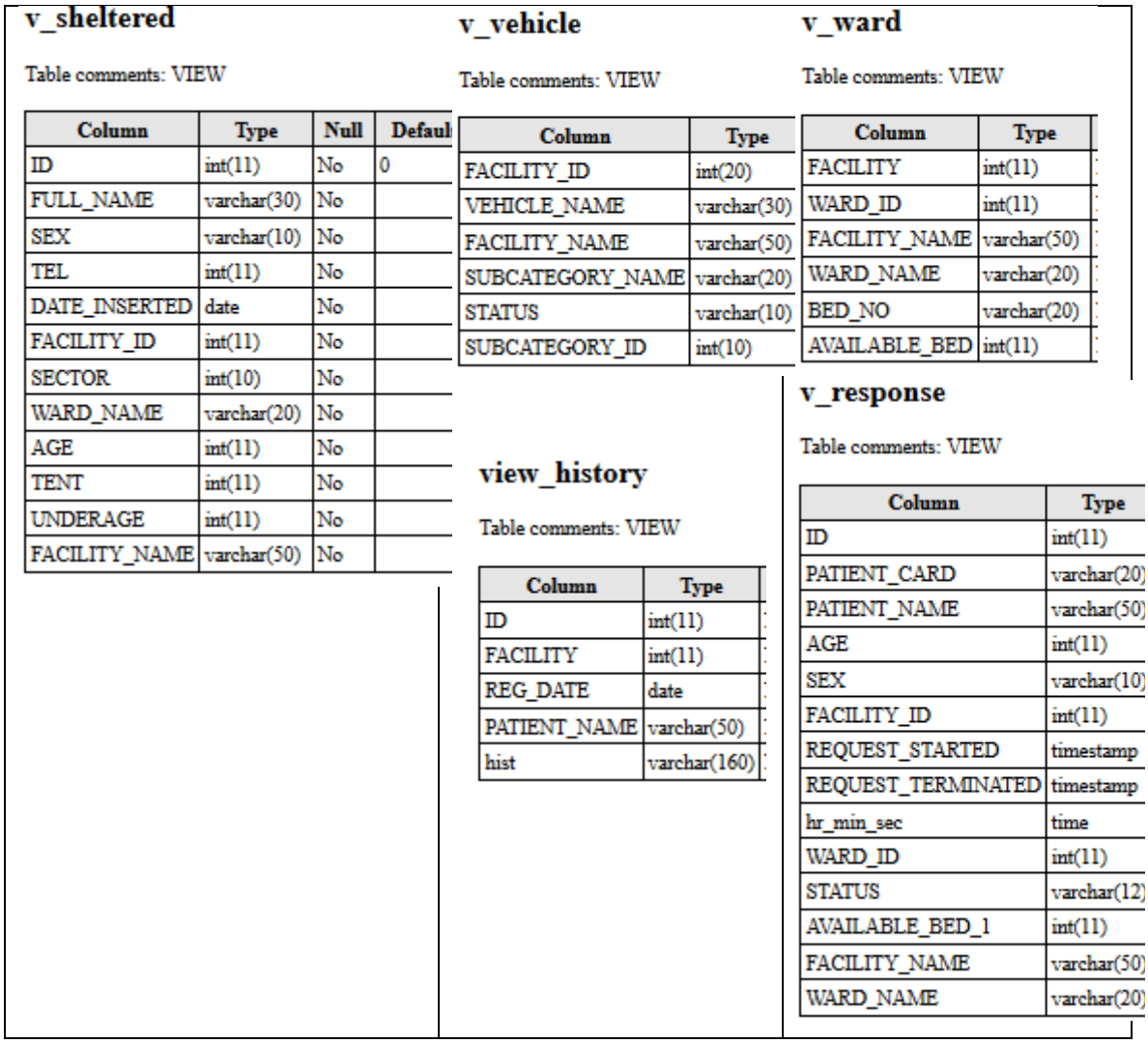
Table comments: VIEW

Column	Type
REF_NO_ISSUE	varchar(11)
ISSUED_TO	varchar(20)
FACILITY_NAME	varchar(50)
INSERTED_DATE	date
QTY_ISSUED	int(11)
MAIN_CATEGORY	varchar(20)
SUBCATEGORY_NAME	varchar(20)
ITEM_NAME	varchar(40)
UNIT_NAME	varchar(10)
FACILITY_ID	int(20)
ITEM_ID	int(20)
SUBCATEGORY_ID	int(11)
CATEGORY_ID	int(11)

v_professional

Table comments: VIEW

Column	Type
PROFESSION_CATEGORY	varchar(2
PROFESSION_NAME	varchar(2
FACILITY_ID	int(11)
PROFESSION_ID	int(11)
STAFF_NAME	varchar(5
FACILITY_NAME	varchar(5
SEX	varchar(6
TEL	varchar(2
ID	int(11)



v_sheltered

Table comments: VIEW

Column	Type	Null	Defaul
ID	int(11)	No	0
FULL_NAME	varchar(30)	No	
SEX	varchar(10)	No	
TEL	int(11)	No	
DATE_INSERTED	date	No	
FACILITY_ID	int(11)	No	
SECTOR	int(10)	No	
WARD_NAME	varchar(20)	No	
AGE	int(11)	No	
TENT	int(11)	No	
UNDERAGE	int(11)	No	
FACILITY_NAME	varchar(50)	No	

v_vehicle

Table comments: VIEW

Column	Type
FACILITY_ID	int(20)
VEHICLE_NAME	varchar(30)
FACILITY_NAME	varchar(50)
SUBCATEGORY_NAME	varchar(20)
STATUS	varchar(10)
SUBCATEGORY_ID	int(10)

v_ward

Table comments: VIEW

Column	Type
FACILITY	int(11)
WARD_ID	int(11)
FACILITY_NAME	varchar(50)
WARD_NAME	varchar(20)
BED_NO	varchar(20)
AVAILABLE_BED	int(11)

view_history

Table comments: VIEW

Column	Type
ID	int(11)
FACILITY	int(11)
REG_DATE	date
PATIENT_NAME	varchar(50)
hist	varchar(160)

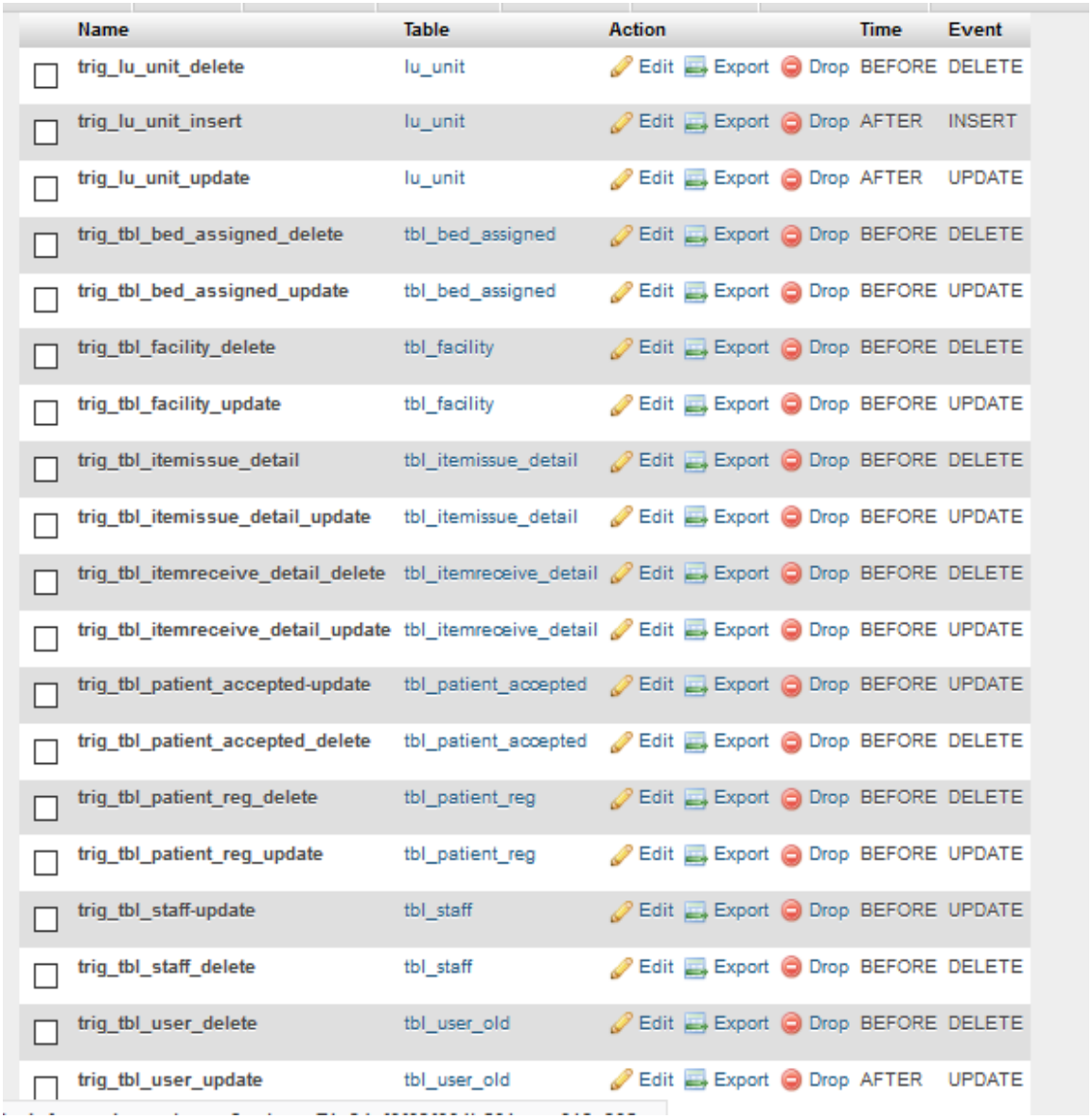
v_response

Table comments: VIEW

Column	Type
ID	int(11)
PATIENT_CARD	varchar(20)
PATIENT_NAME	varchar(50)
AGE	int(11)
SEX	varchar(10)
FACILITY_ID	int(11)
REQUEST_STARTED	timestamp
REQUEST_TERMINATED	timestamp
hr_min_sec	time
WARD_ID	int(11)
STATUS	varchar(12)
AVAILABLE_BED_1	int(11)
FACILITY_NAME	varchar(50)
WARD_NAME	varchar(20)

Fig 5.7: Views

Triggers: - Database trigger is SQL procedure that initiates an action when an event (insert/delete/update) occurs to a table that is linked to the trigger. To trigger an action (insert data on auditor tables) there has to be an action, update or delete transaction made on the target table. Fig 5.8 shows database triggers used in the system.



	Name	Table	Action	Time	Event
☐	trig_lu_unit_delete	lu_unit	Edit Export Drop	BEFORE	DELETE
☐	trig_lu_unit_insert	lu_unit	Edit Export Drop	AFTER	INSERT
☐	trig_lu_unit_update	lu_unit	Edit Export Drop	AFTER	UPDATE
☐	trig_tbl_bed_assigned_delete	tbl_bed_assigned	Edit Export Drop	BEFORE	DELETE
☐	trig_tbl_bed_assigned_update	tbl_bed_assigned	Edit Export Drop	BEFORE	UPDATE
☐	trig_tbl_facility_delete	tbl_facility	Edit Export Drop	BEFORE	DELETE
☐	trig_tbl_facility_update	tbl_facility	Edit Export Drop	BEFORE	UPDATE
☐	trig_tbl_itemissue_detail	tbl_itemissue_detail	Edit Export Drop	BEFORE	DELETE
☐	trig_tbl_itemissue_detail_update	tbl_itemissue_detail	Edit Export Drop	BEFORE	UPDATE
☐	trig_tbl_itemreceive_detail_delete	tbl_itemreceive_detail	Edit Export Drop	BEFORE	DELETE
☐	trig_tbl_itemreceive_detail_update	tbl_itemreceive_detail	Edit Export Drop	BEFORE	UPDATE
☐	trig_tbl_patient_accepted-update	tbl_patient_accepted	Edit Export Drop	BEFORE	UPDATE
☐	trig_tbl_patient_accepted_delete	tbl_patient_accepted	Edit Export Drop	BEFORE	DELETE
☐	trig_tbl_patient_reg_delete	tbl_patient_reg	Edit Export Drop	BEFORE	DELETE
☐	trig_tbl_patient_reg_update	tbl_patient_reg	Edit Export Drop	BEFORE	UPDATE
☐	trig_tbl_staff-update	tbl_staff	Edit Export Drop	BEFORE	UPDATE
☐	trig_tbl_staff_delete	tbl_staff	Edit Export Drop	BEFORE	DELETE
☐	trig_tbl_user_delete	tbl_user_old	Edit Export Drop	BEFORE	DELETE
☐	trig_tbl_user_update	tbl_user_old	Edit Export Drop	AFTER	UPDATE

Fig 5.8: Triggers Used

5.2.2 Database Diagram

A Database Diagram or an Entity Relationship Diagram (ERD) represents entities (tables) in a database and relationships between tables within a database. Relationship among tables is defined through referential integrity constraint which is part of schema design of database and ER diagram facilitates identifying association among entities belonging to system thereby facilitating schema design of database. Fig 5.9 shows the general ER diagram of the system.

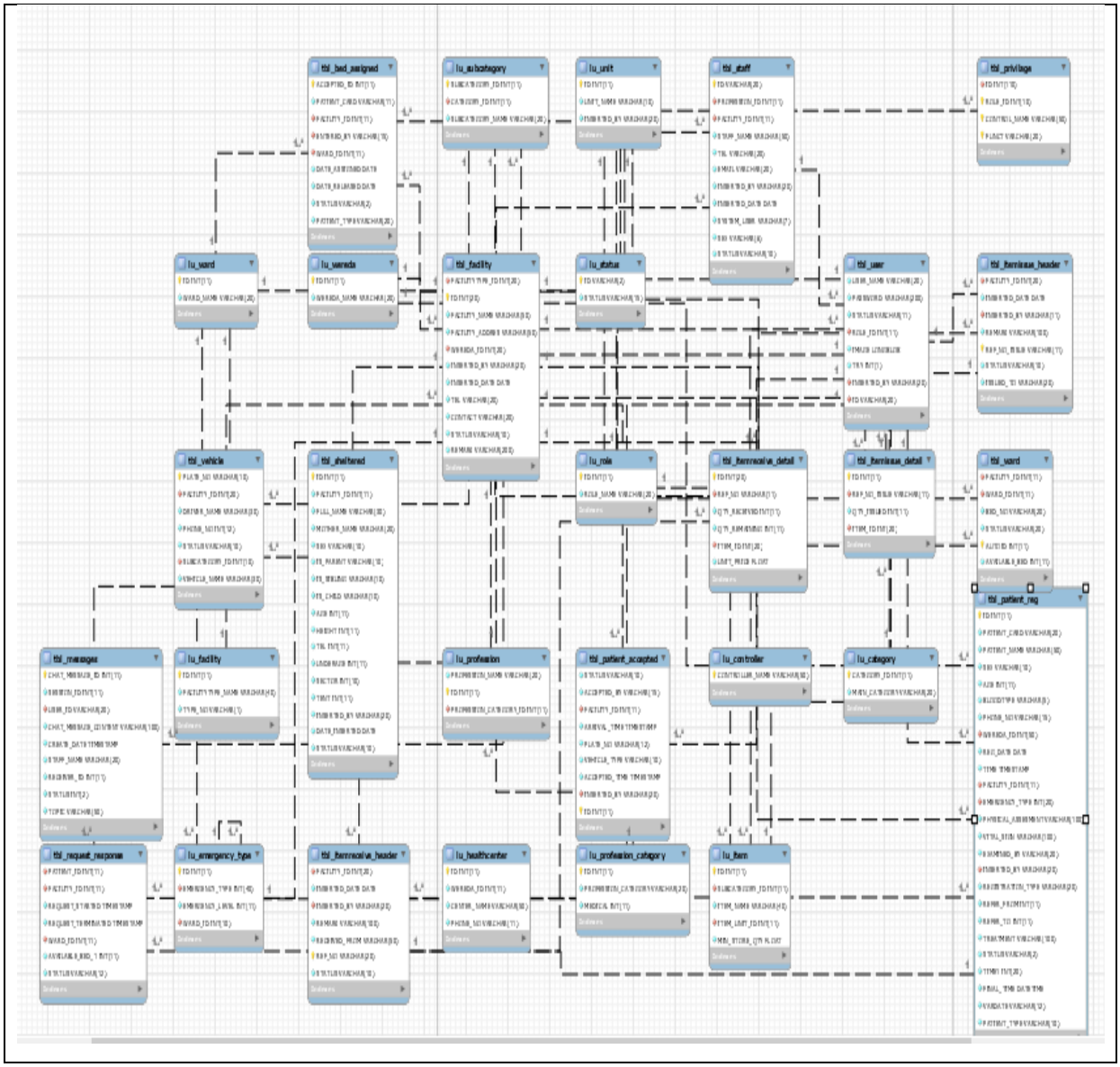


Fig 5.9: General Database Diagram

The figure below , Fig 5.10.1 represent a portion of the General ER diagram with high light on the relationship between system users ,the their profession and the facility under which they are registered. The tables in the relationship are tbl_user, tbl_staff ,lu_Profession and tbl_facility. These tables are used specially for user authentication.

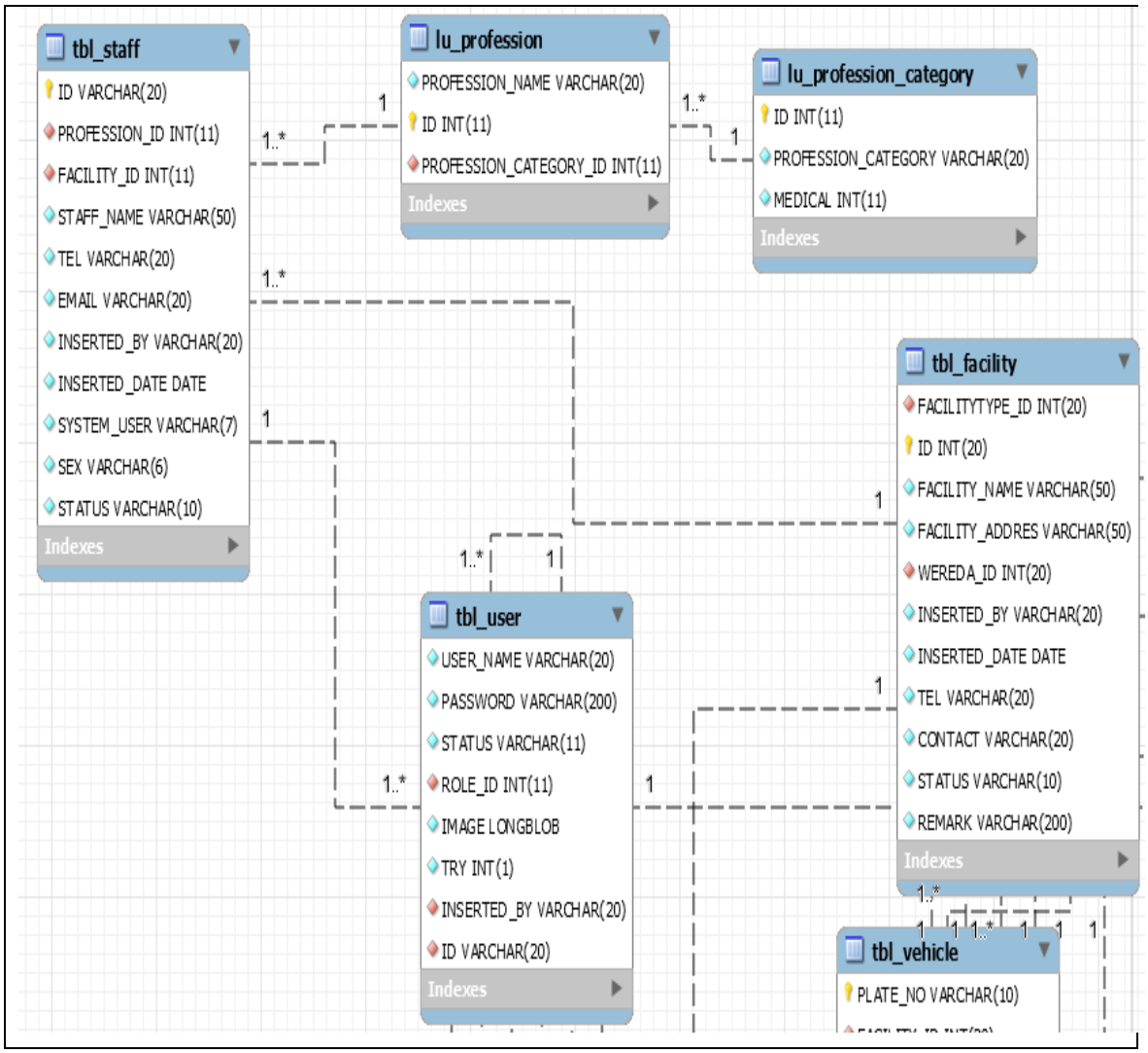


Fig 5.10.1: Detailed Database Diagram

Fig 5.10.2 represent part of the general ER diagram dedicated from the process of registering an emergency patient to bed assignment.

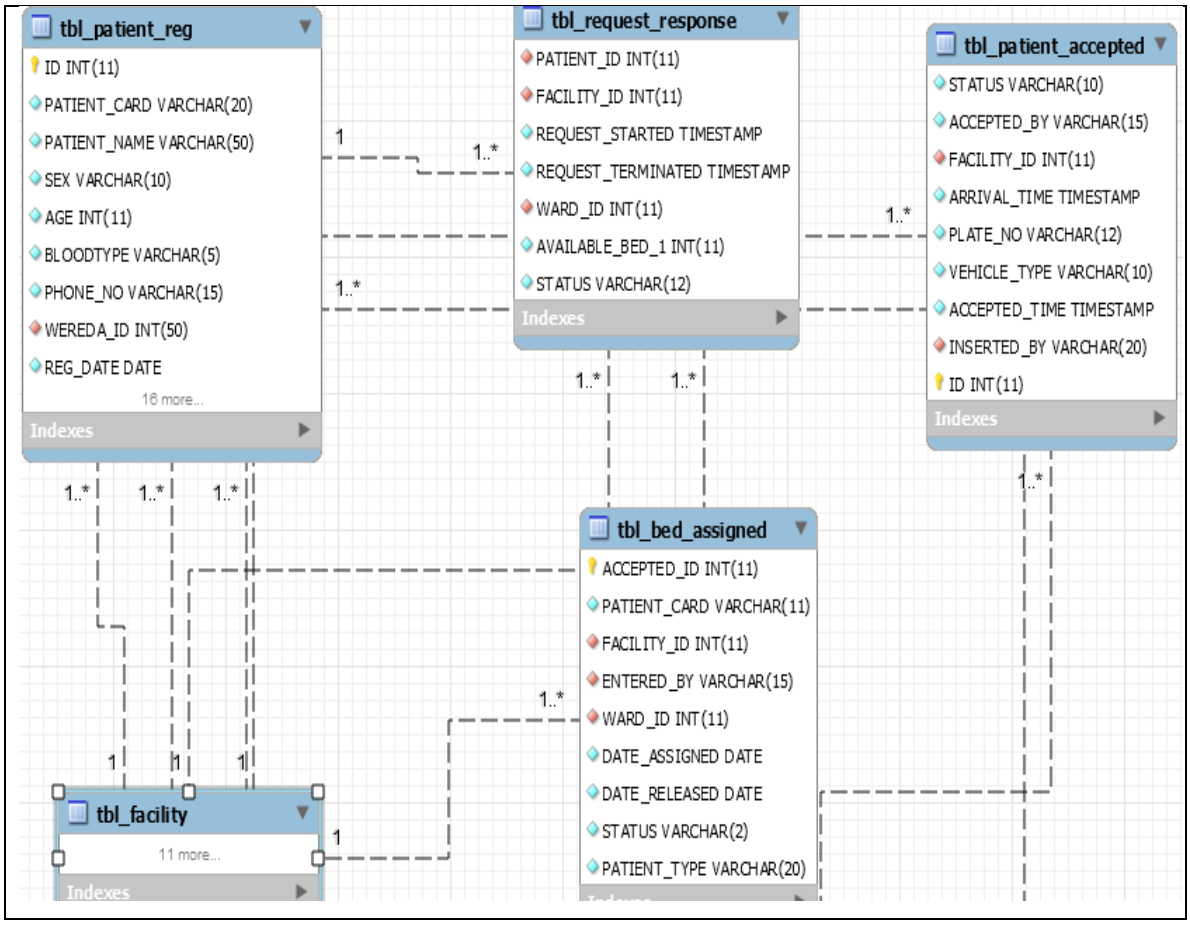


Fig 5.10.2: Detailed Database Diagram

Fig 5.10.3 which is shown below represents an example of a lookup tables defined in the database and their relationship with each other. The figure describes item lookup table that will be used in item receive and item issue tables.

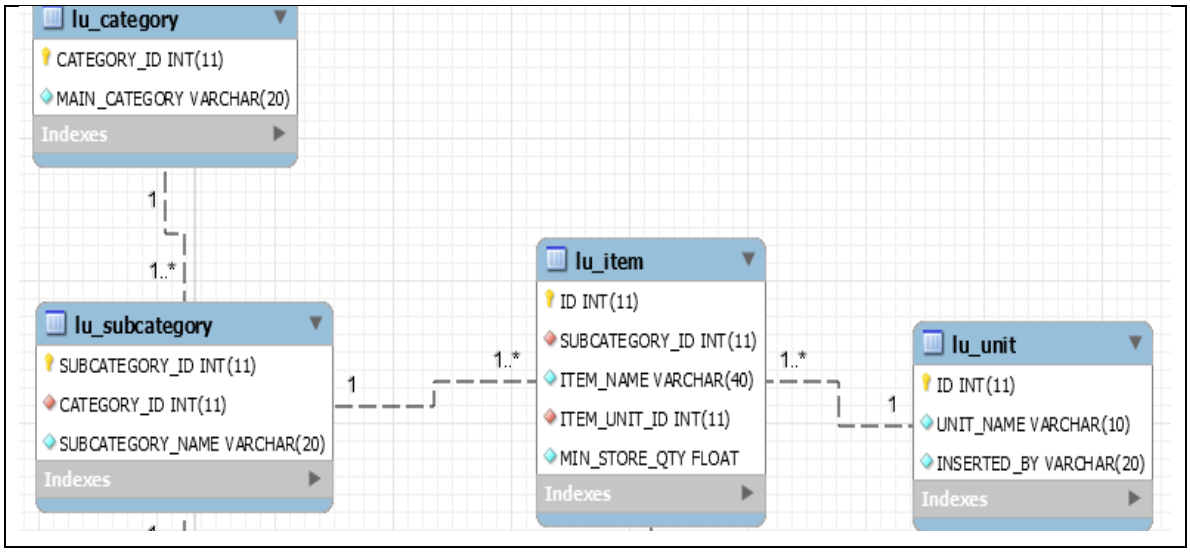


Fig 5.10.3: Detailed Database Diagram

The figure below, Fig 3.10.4 shows an ER diagram for item receive transaction which can be used in any facility(hospital).

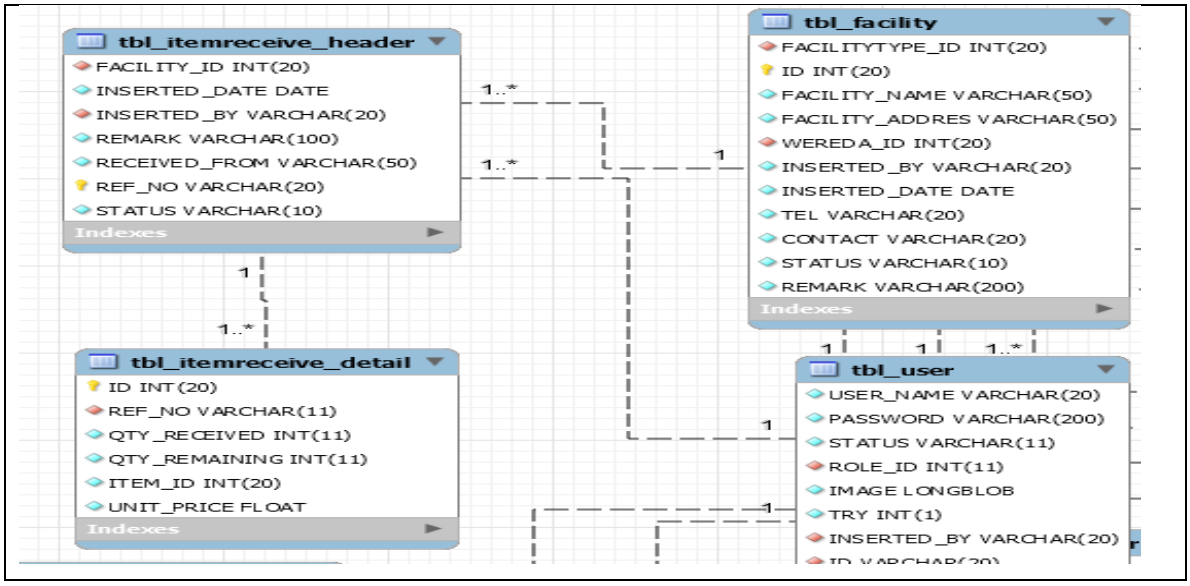


Fig 5.10.4: Detailed Database Diagram

Fig 5.10.5 diagram shows tables used for issuing items from a facility. Tables used for issuing purpose are used mostly in emergency hospitals where large number of needy people may be needed to manage.

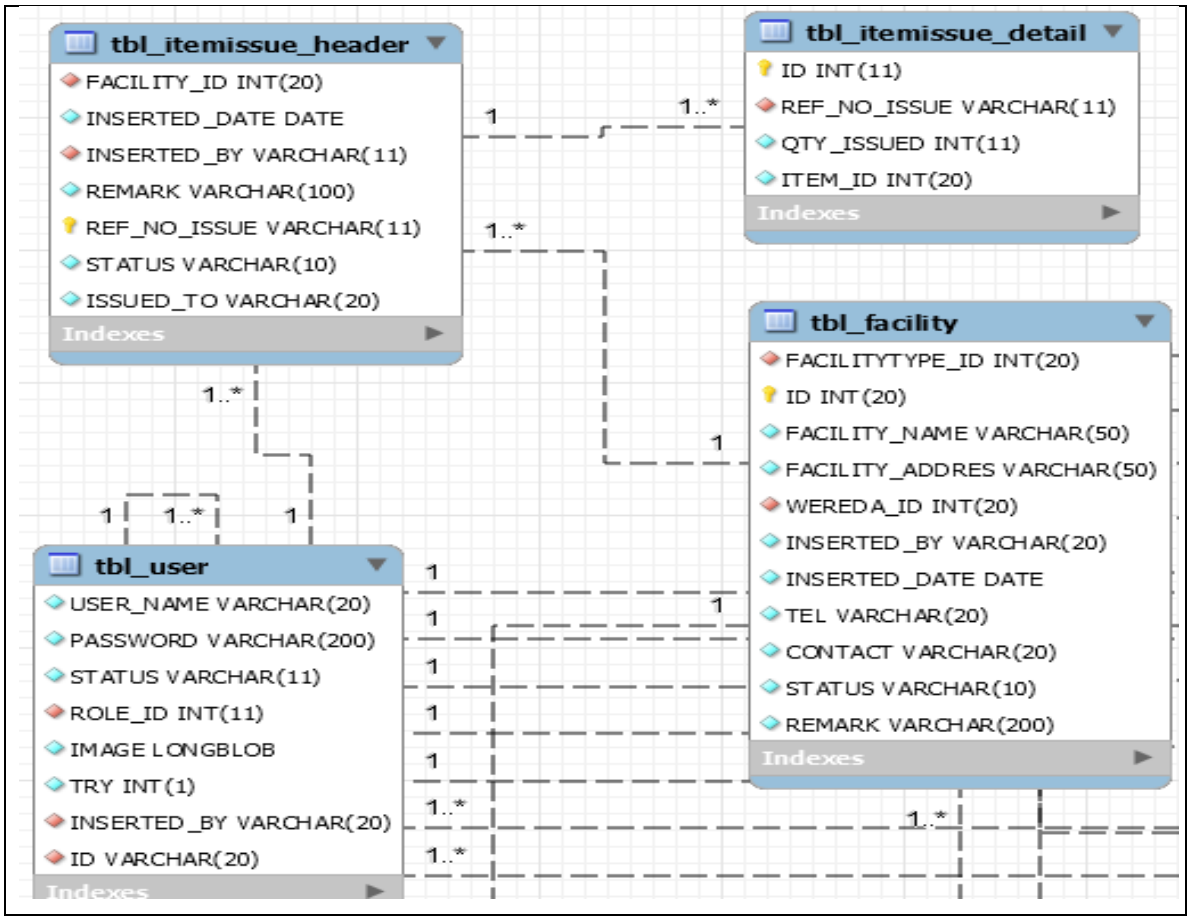


Fig 5.10.5: Detailed Database Diagram

Fig 5.10.6 shows tables used in exchange of messages (chat) between system users.

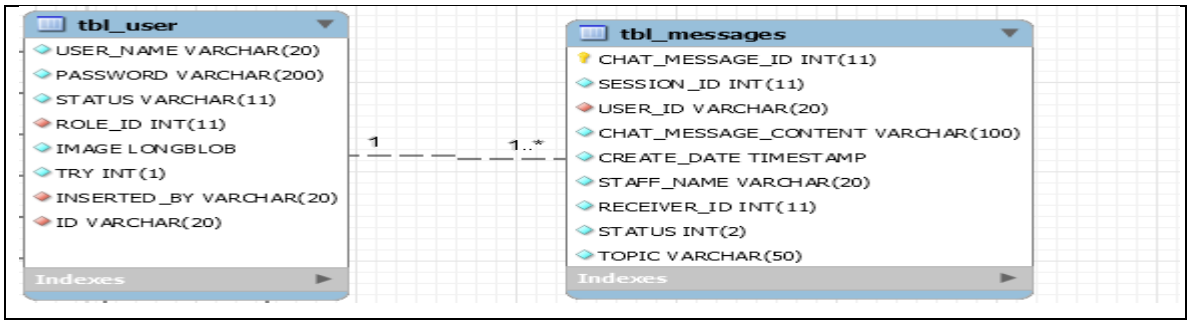


Fig 5.10.6: Detailed Database Diagram

5.3 System Architecture

The proposed system architecture is a three-tier-architecture. The rules of three-tier architecture are:

1) The presentation layer can only send requests to and receive responses from the business layer. It cannot have direct access to either the database or the data access layer.

2) The business layer can only receive requests from and return response to the presentation layer.

3) The business layer can only send requests to and receive responses from the data access layer. It cannot access the database directly.

4) The data Access layer can only receive requests from, and return responses to, the Business layer [12].

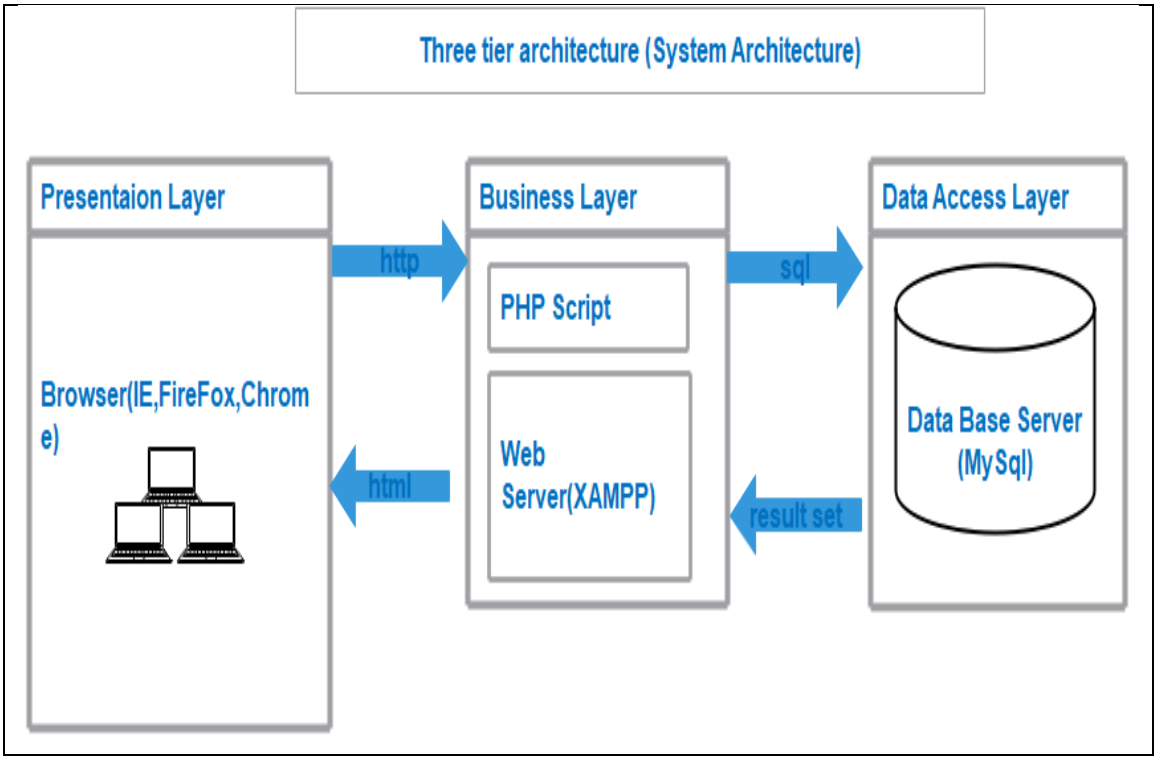


Fig 5.11: The System Architecture

The three-tier architecture is conceptual. In practice, there are different implementations of web database applications that fit this architecture. The most common implementation has the web server (which includes the scripting engine that processes the scripts and carries out the actions they specify) and the database management system installed on one machine: it's the simplest to manage and secure [22].

The advantage of 3-tier over 2-tier architecture is in that it provides great freedom to development teams who can independently update or replace only specific parts of the application without affecting the product as a whole .

The application can be scaled up by detaching the front-end application from the databases that are selected according to the individual needs of the customer.

A three-tier-architecture also provides a higher degree of flexibility to enterprises who may want to adopt a new technology as soon as it becomes available.

Critical components of the application can be encapsulated and retained while the whole system keeps evolving organically.

Development cycle or upgrade times are significantly improved ensuring minimal disruption in customer’s experience.

Different teams can work on different sections of the application rather than on the full stack according to their areas of expertise, improving their efficiency and speed [23].

According to techopedia: A two-tier architecture is a software architecture in which a presentation layer or interface runs on a client, and a data layer or data structure gets stored on a server . Both tier have their advantages and disadvantages. The reasons that Three-Tier is selected over Two-Tier in the project is : access from anywhere, Platform independent, makes bugs and update easier and no need to deploy in each client machine.

5.4 Sub System Decomposition

Using a Layering method of decomposition has the advantage in that it is:

- Clear representation of responsibility – each layer accountable only to itself
- The ability to replace one layer with another alternate layer with minimum effort(ex. Replacing of persistence database(Oracle database by Sqlserver database)
- The decomposition is grouped in 3 category :

  1. Graphical User Interface (Interface) layer

     Graphical User Interface Layer (GUI): is the one visible to the user and with which the user interacts. In our application it consists of: Web browser, Html, css, javascript, bootstrap and jquery components.

     Screen shot of user graphical interface is shown in the Annex-II

  2. Business (Application) layer
  3. Data access (persistence) layer

     Data base Schema is described in the folder 'data-dictionary' → index.html

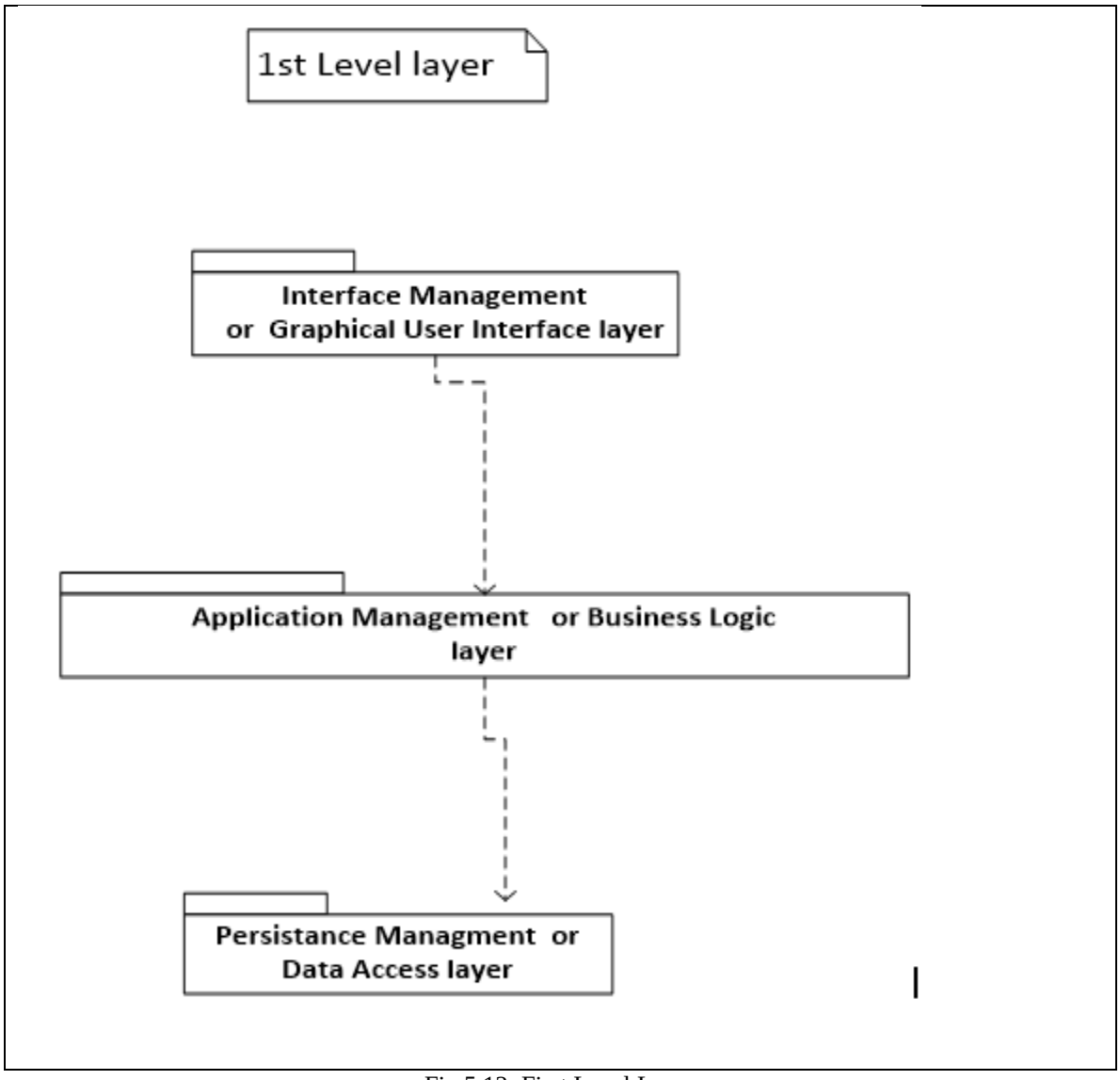


Fig 5.12: First Level Layer

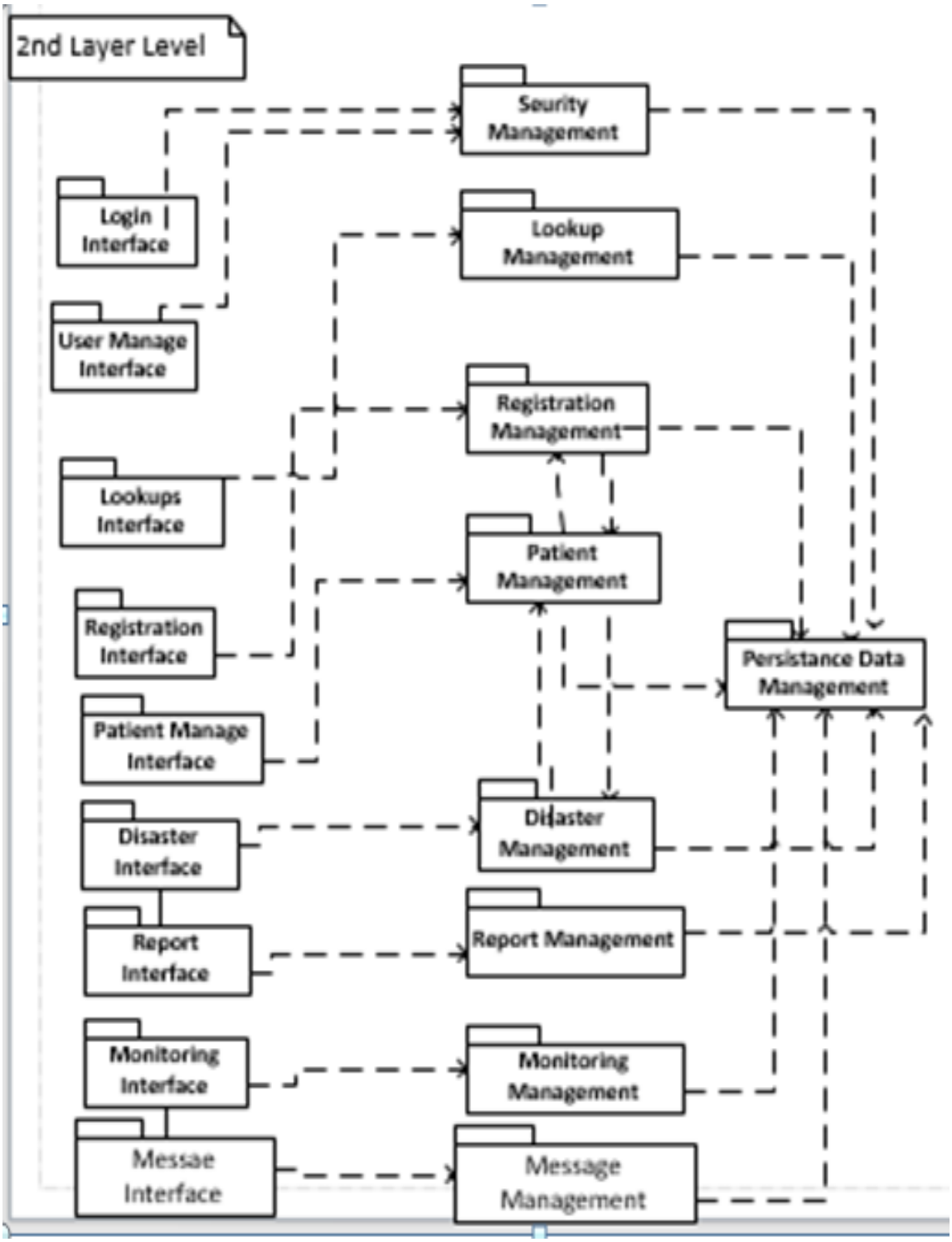


Fig 5.13: Second Level Layer

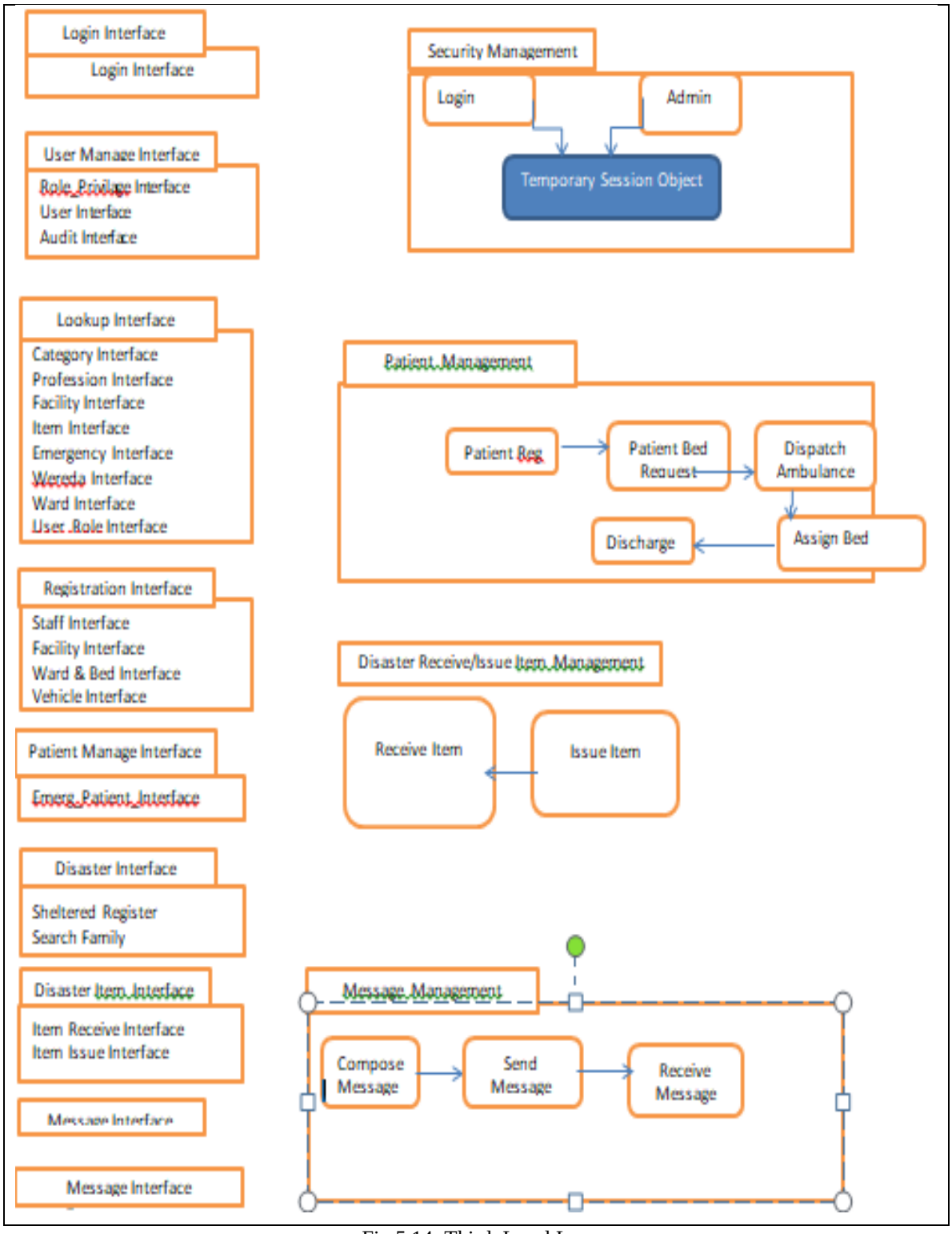


Fig 5.14: Third Level Layer

5.5 Component and Deployment Diagram

Component Diagram

Component diagrams are used to visualize the static implementation view of a system. Component diagrams also show the physical components of a system. It can to clarify it, one can say that component diagrams describe the organization of the components in a system.

Component diagrams are very important from implementation perspective. Thus, the implementation team of an application should have a proper knowledge of the component details. Component diagrams can be used to −

- Model the components of a system.
- Model the database schema.
- Model the executable of an application.
- Model the system's source code [27].

Shown below is the Component Diagram for the system.

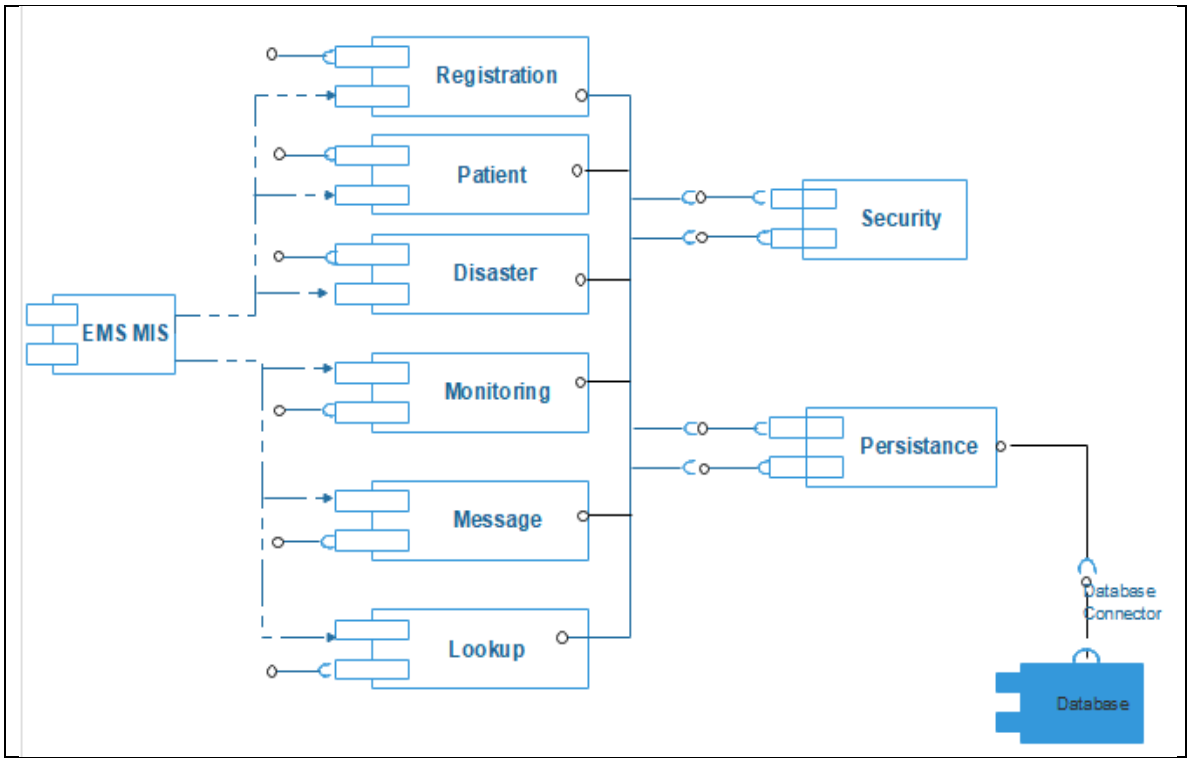


Fig 5.14b Component Diagram for the EMS MI

Deployment Diagram:

A UML deployment diagram depicts a static view of the runtime configuration of hardware nodes and the software components that run on those nodes**.** It maps the software architecture created in design to the physical system architecture that executes it. Generally deployment diagram visualizes the topological view of an entire system.

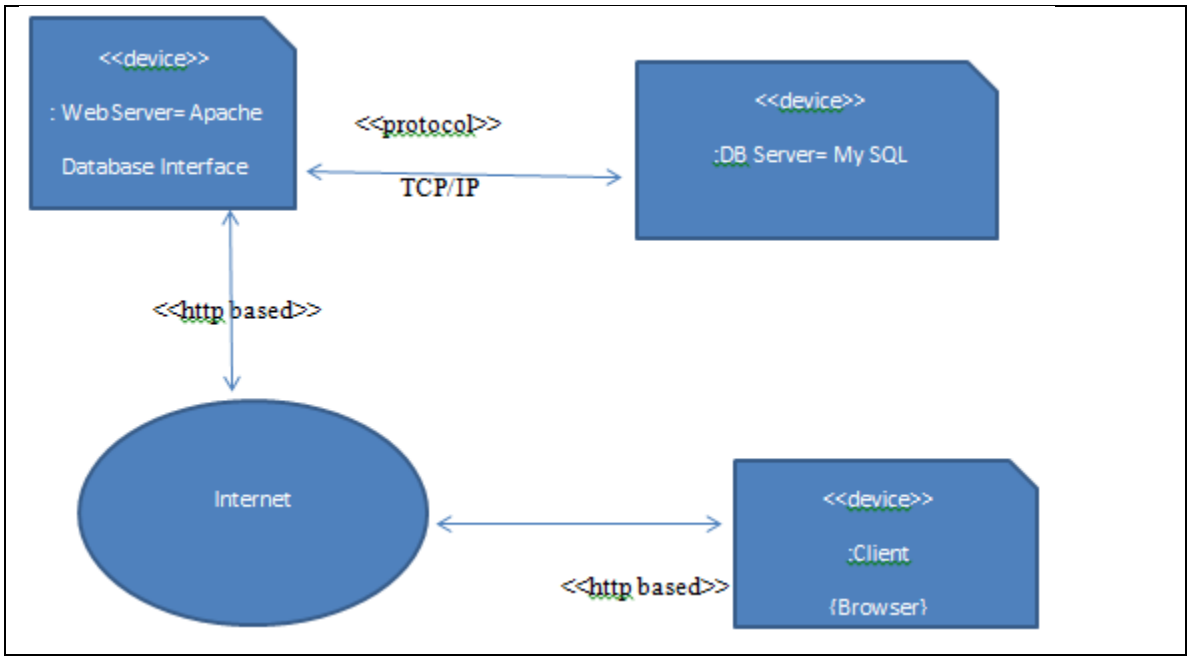


Fig 5.14c Deployment Diagram for the EMS MI

5.6 User Interface

In many organizations, data is often first recorded on paper-based forms and then latter recorded within application systems. When designing layouts to record or display information on paper-based forms, one should try to make both as similar [10] as much as possible .This rule has been followed in the developed system to make the system users at ease and the interface familiar.

Another concern that has been considered is the design of between-field navigation .As in the standard, screen navigation has followed from left to right and top just as in the paper-based forms.

Structuring of data entry has also been given attention. Information that could been calculated by the system don't have to be entered by the user , like current date and user name .Another consideration is that user should not be required to specify the dimension on a units of a particular value. Data entry prompts are formatted to make clear the type of data being requested.

One of the objectives of user design is to reduce data errors [10].As data are entered into the system ,the system checks that the data entered is valid before the data is send to the

server. Errors and warning messages have been used to confirm user's action before data being sent to the server.

In the design of the User Interface, the developer engaged in high user involvement to bring about system usability and user satisfaction to the system. The user interface has been design to be consistent so as the user navigate from one page to another. The similarity and consistency of design pattern will make the system simple and friendly to use .Screen shot of the user interfaces are attached in Annex-II.

5.7 Testing

Testing is performed at different levels involving the complete system or parts of it throughout the life cycle of a software product. A software system goes through four stages of testing before it is actually deployed. These four stages are known as unit, integration, system, and acceptance level testing [16].

In a Unit Testing (smallest testable part) functions and procedures are tasted. A program unit is tested in isolation, that is, in a stand-alone manner. There are two reasons for testing a unit in a stand-alone manner. First, errors found during testing can be attributed to a specific unit so that it can be easily fixed. Second, during unit testing it is desirable to verify that each distinct execution of a program unit produces the expected result [16].

For every function coded, a test case is created in parallel with the use case designed. In the test case for a given input values, the expected out value has been checked.

Validation has also been also been done both from client side (using JavaScript) and from the server (PHP).The advantage of using client side validation is that that it is faster and does not congest network traffic. The Error messages produces are short and self-explanatory.

The Objectives of integration testing is to take all the tested individuals models, integrate them, test them again, and develop the software, which is according to design specifications as in the figure below [17].

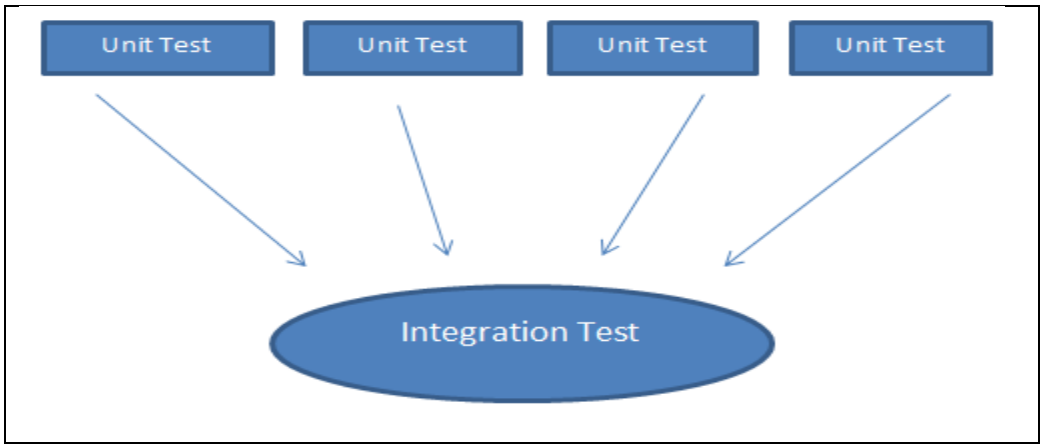


Fig 5.15: Integration of Individual Module

In the integration testing, it has been checked that all modules work together properly and communicate with each other interfaces accordingly. As incremental integration testing is followed, the already unit tested components are tested again in the integration testing. As a new module is integrated into the system a regression testing is done to make sure that no previously working components fails due to erroneous integration.

System testing compares the system with the non-functional system requirements, such as security, speed, accuracy, and reliability [17].Some of the features tested for are:

Usable: verify that the developed software is easy to use and is understandable. The system developed is user friendly and easy to navigate. It has small number of navigation to reach at the destination page. The system is easy to learn and the interface colors are not distractive to the eyes.

Security:

- Only authenticated user can log into the system.
- After number of incorrect password attempt to login into the system, the system will lock the user until sys admin unlock it
- Access to important or sensitive data is restricted even for those individuals who have authority to use the software.
- No direct access using URL, without creating a session is allowed.

Recoverable:

- Verify that there are adequate methods for recovery in case of database failure.

To recover from a MySQL server crash, the only requirement is to restart the MySQL server. InnoDB automatically checks the logs and performs a roll-forward of the database to the present [18].

User reaction during testing

1. User familiarization with the system
   - Members of the lesion office at Minlik II Hospital were selected to test the system .The testers have no previous experience as (encoder) data entry user. There were difficulty for the testers in the beginning until they adjust to the system interface .Once they get past the first number of prototype interfaces they become more proficient with the testing.
2. Communication Issues :
   - Even after completing the user requirement with the detail use case discussed, there were disagreement in how the system works during data entry and reports generated. So a correction has to be made on the requirement and a change on the user interface and data entry as needed.
3. Not enough time :
   - The users, the lesion team do not give enough time to practice on the system. One reason for this is that the demand for their service is too much at the hospital to handle both the manual and the system data entry at the same time.

5.8 Comparison with other Systems

A Comparison is done using two categories: pre-hospital activities and hospital activities .Objectives of the comparison is not to show superiority of one group over the other, but to show that different environment requires different solution. In the pre-hospital activities there is no involvement of the new system on the EMS activities. The table below is describes the current pre-activities in different countries [19].

Table 5.1: Emergency Pre-Hospital activities

Countries	Activities
Us(Seattle, New York)	-911 call is made by patient -responder determines types of emergency(medical, police or fire) - Responder App sends patient GPS coordinates to operator. -Ambulance takes the patient to hospital by selection of : closest facility, ambulance diversion, physician choice, law enforcement choice, patient or family choice, specialty resource center, and other[9]
Addis Ababa	- 939 call is made by patient - Responder determines type of emergency and address. -Ambulance takes the patient to the nearest Governmental Health Center and returns to its station - Depending on the severity of the emergency, the Health center refers the patient to a hospital using its own ambulance.
Egypt(Cairo)	- 123 call is made by patient - The operator then forwards the call to the ambulance dispatch center responsible for determining the caller's location to send the nearest ambulance. - Hospital Selection method undetermined.

Comparison of the services offered once the emergency patient arrived at the hospital is described in Table 5.2[20].

Table 5.2: Emergency Hospital software modules

Software Solutions	**Admissions Management**	**Bed Management**	**Discharge Management**	**Patient Flow Management**	**Patient Monitoring**	**Waiting Time Tracking**	**Historical Reporting**	**Patient Location Tracking**	**Real Time Reporting**
NextMe by NextMe	No	No	No	Yes	Yes	Yes	Yes	No	Yes
Health.Net By Dharma Healthcare	Yes	No	No	Yes	Yes	No	Yes	No	Yes
ECLIPSE Practice Management Software by MPN software Systems	No	No	No	Yes	No	Yes	Yes	Yes	No
EagleSoft By Patterson Dental Supply	Yes	No	Yes	Yes	No	No	Yes	No	Yes
PSC By Silverlink Software	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
CareRecord by NetSmart Technologies	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
PaRIS by The Spark Team	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes
Project Developed	Yes	Yes	Yes	No	Yes	No	Yes	No	No

As the feature of the project's that is developed depends on the statement of problems defined for the project, its modules will be different from the modules contained within the systems defined in the Table 5.2. The main difference between the system developed and the one listed in the table is that they have different objectives. Due to the specific objectivity of the project, it features may not include the more general features of Hospital Management system like Billing, lab and Appointment. Note that in table above where the feature of the developed system is compared with others, its functionality is not as inclusive as the other as it is designed to meet specific needs. Likewise the unique features of the system developed that is not included in most of the others emergency (hospital) system is the Bed Request module with its accountability feature.

If we are to compare advantage of Custom Software with off shelf Software solution, there is no winner as each has its advantage and disadvantage. Their name suggests their purpose: Custom Software are designed and developed to satisfy specific requirement in a unique circumstances which are not included in the off shelf solutions.

So, what is the unique circumstances and specific requirement of this system that is not covered in the off shelf solutions?

To answer the question, we have to compare first the medical Infrastructure in a developed country against the emergency medical Infrastructure in Addis Ababa. Most of the off shelf solutions are designed for an Infrastructure where there is an advanced emergency department with abundance of bed in different wards and no need for referral system is required. In the US, for example, most of its cities have specialized emergency department where the patients will simply be routed to directly from the site of an incident to emergency department [4] .On the other hand, in Addis Ababa, one of responsibility of the Command Post is to minimize the effect of short number of beds in hospital wards by facilitating the referral system.

The request for service module which is incorporated in the system helps in the management of the referral system while at the same time enhance the quality of service as the EMS personal will be accountable for the service they provided as the system has a module that measure responsiveness of the Emergency Medical team .

The developed system also has the unique feature of sending vital information to the referral hospitals so the emergency medical team could get ready with the necessary set up minimized the time that will be lost otherwise.

Chapter Six

Conclusions and Recommendations

6.1 Conclusions

In dealing with medical emergencies, the existence of Emergency Medical Services system plays an essential part. The system to be developed will helps in replacing the manual Emergency Medical System. As mentioned in the report, the system will coordinate the governmental hospitals residing in Addis Ababa linking in the management of medical emergency service across the hospitals.

The system will also be used placing responsibility and accountability upon the hospitals providing the services depending on their prompt response to emergencies. In addition the system can be used as a determinant factor for strategic planning on emergency medical service. Disaster Hospitals are special types of hospitals mentioned in the system. They are specially design for managing the unexpected large amount of populous in need of immediate medical or nutritional service due to natural or man-made disaster. In disaster Hospital, management of large number of patients will be difficult without the use of the system. The stock management sub system will be handy in overcoming the problem of managing resources (food, water, clothes, medicine and others) to large number of patients. To manage, a resource (stock management sub system) system is added to these hospitals. One of the best features of the system is its automated auditing feature .The auditing feature of the system monitors the response of hospitals to a request to bed .In case a hospital ignores request for a bed while there is an available bed in its requested ward it will be automatically be held accountable by the system.

6.2 Recommendations

- The system can be further be improved by developing and coordinating traffic police accident and fire brigade reporting system and integrating with the EMS.
- The system developed can be used as a pilot project to a fully functional disaster management system.
- The subsystem modules incorporated in the system can be used as a reference to student working on other system like (Patient registration as a reference for card system, Ambulance Tracing for Public vehicle Service, Item management for Inventory system.
- The project can be used as a spring board for students interested in developing a web base system.
- For researchers working on statistical data on emergency medical services, the system can modified to include reports with graphical presentation.
- For students (developers) aiming to develop national level Emergency system which includes regions and weredas, this project can serve as a spring board.
- The system can be modified to include algorithm which can help in determining the respondent to service request (e.g. first come first served or depending on priority of emergency).

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Annexes

Annex – I

Interviews made to determine User Requirement with Triage Team Unit

1. What are the objectives of Triage Team Unit?
2. What defines a patient as an emergency case or admission criteria?
3. What are the lists of activities conducted by triage?
4. How do you receive emergency patients? And from where?
5. What is the patient management flow for an emergency patient coming to the hospital?
6. Is the process (business flow) of managing emergency patient identical for all?
7. What processes will be under taken for a specific emergency patient that needs admittance?
8. How many emergency types do you get? What are they?
9. How do you manage ambulance service for the emergency patient?
10. How do you know if there is bed in another hospital for the emergency patient?

Interviews to determined Challenges encountered in Manual System

11. What action is taken if there is shortage of medicine triage unit?
12. How do you manage if you have an emergency patient and no bed available?
13. How do you manage if causality of emergencies request comes simultaneously?
14. How do you communicate if you need to send emergency patient to another hospital?
15. What steps are taken if your request for a bed to all hospitals results in negative responses?
16. Have you ever lost communication with another hospital? What happens if you can't communicate with them? What action do you take?
17. What are some of the problems you face on a daily basis?
18. What do you find most frustrating at work?
19. Is there anything more you would like to add?

Annex–II

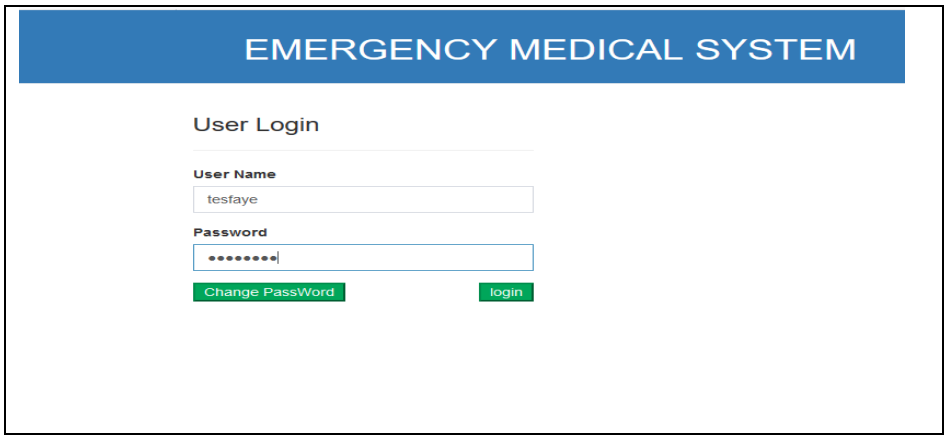


Fig 1: Login

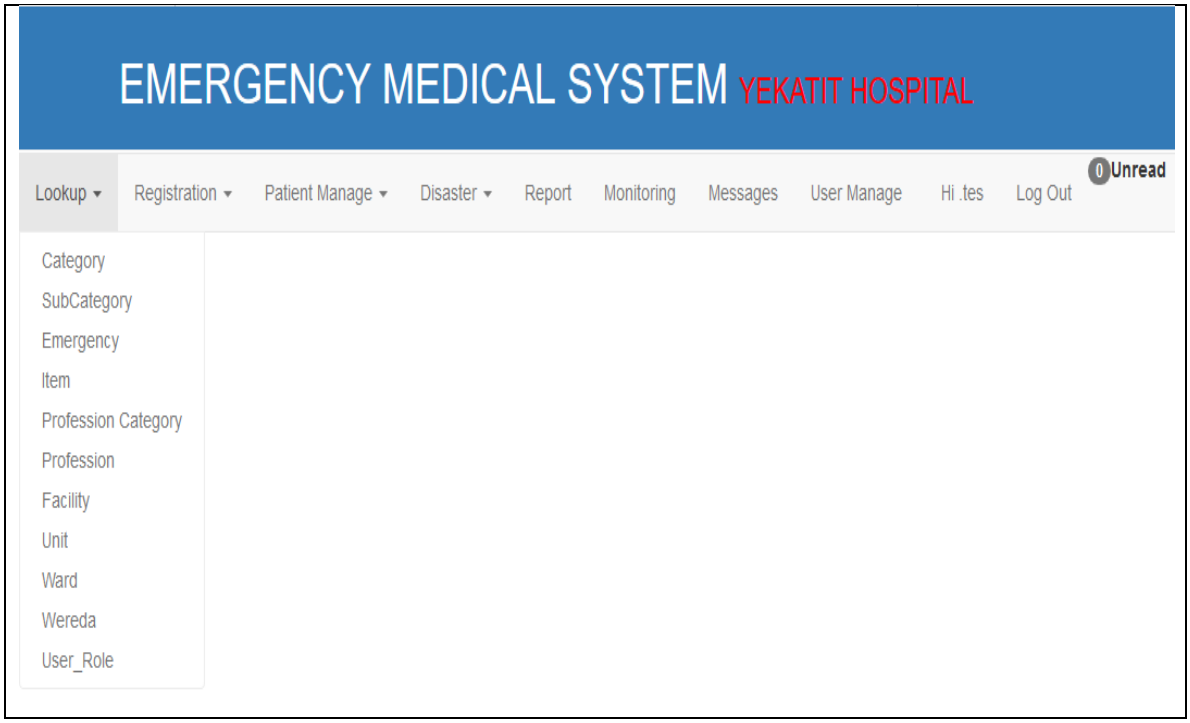


Fig 2: Lookup

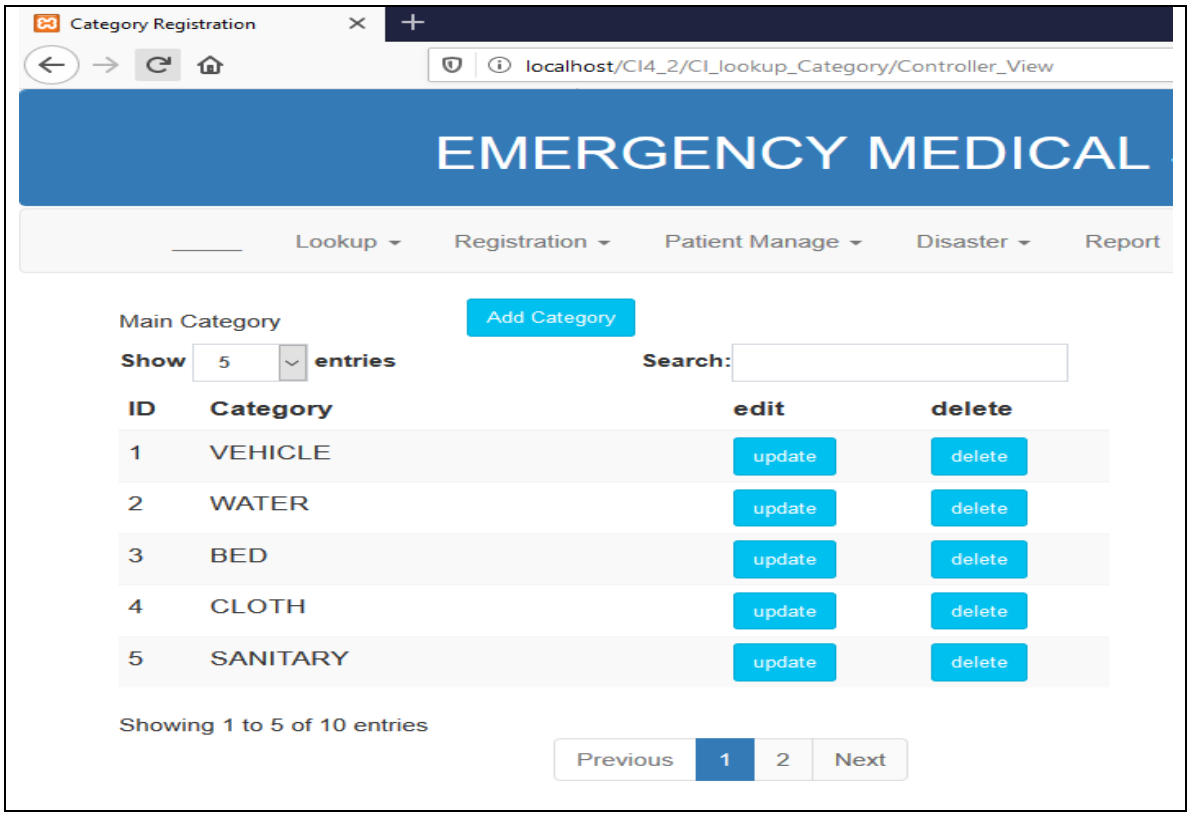


Fig.3: Category Registration

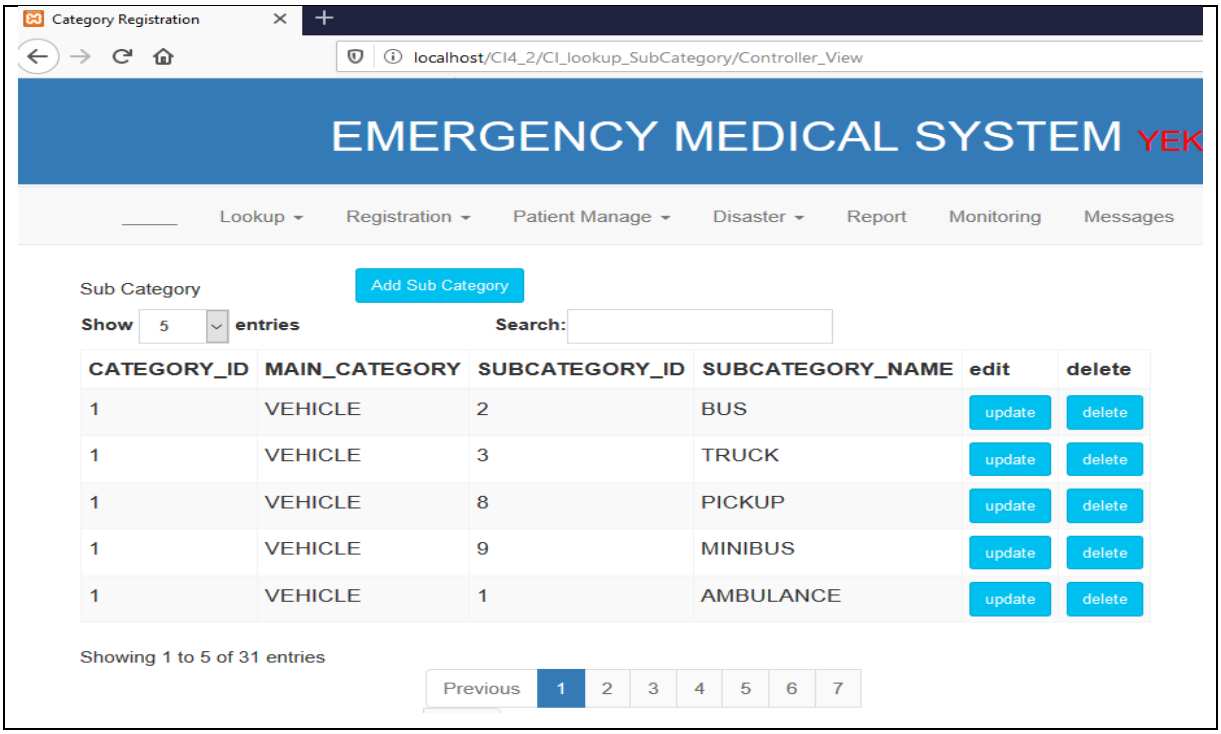


Fig 4: Subcategory Registration

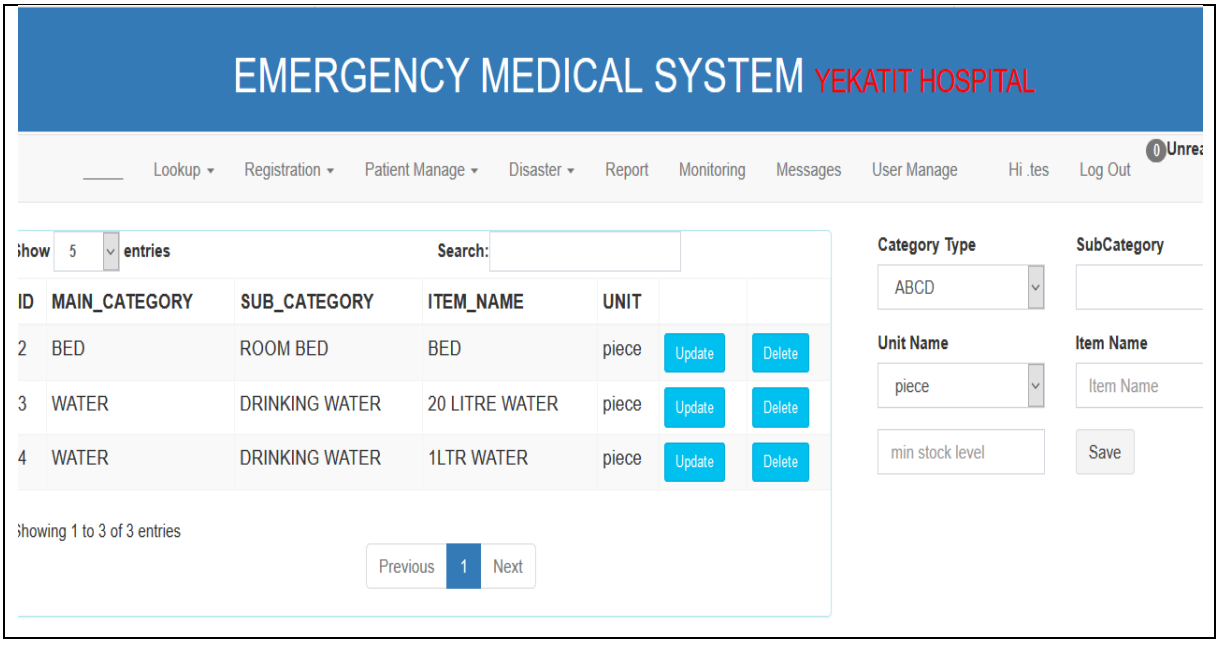


Fig 5: Item Registration

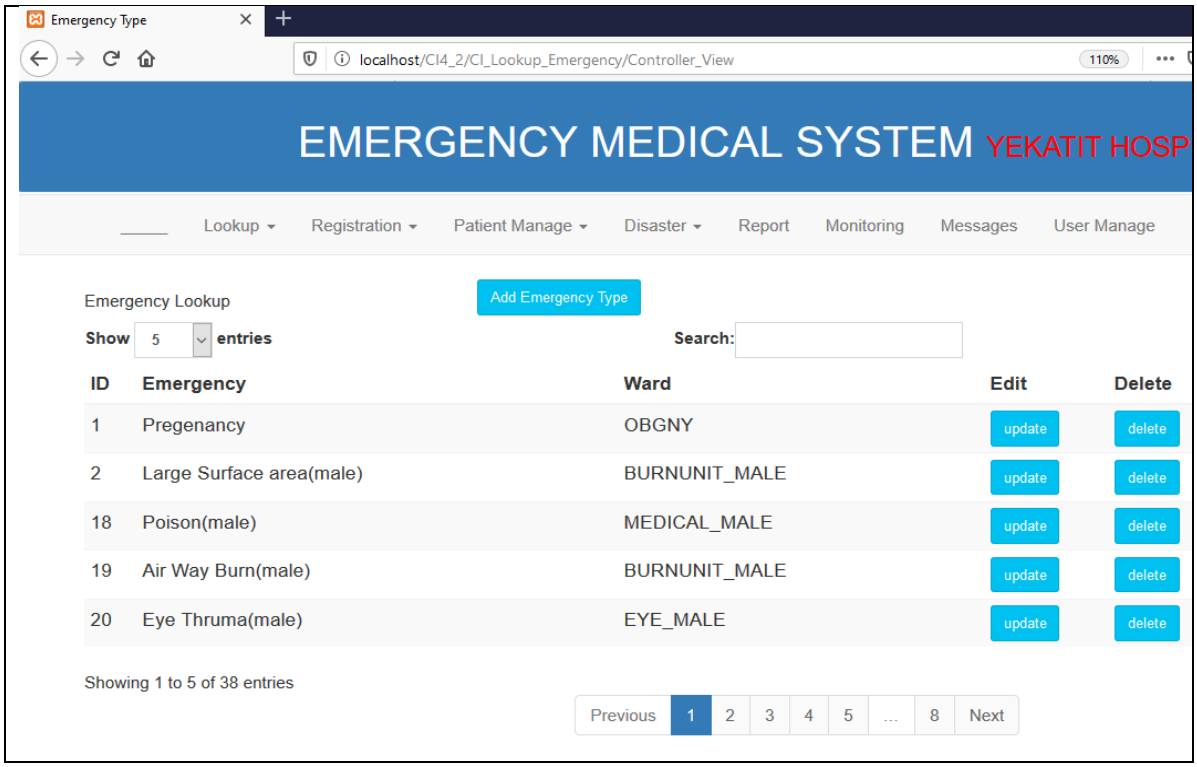


Fig 6: Emergency Type Registration

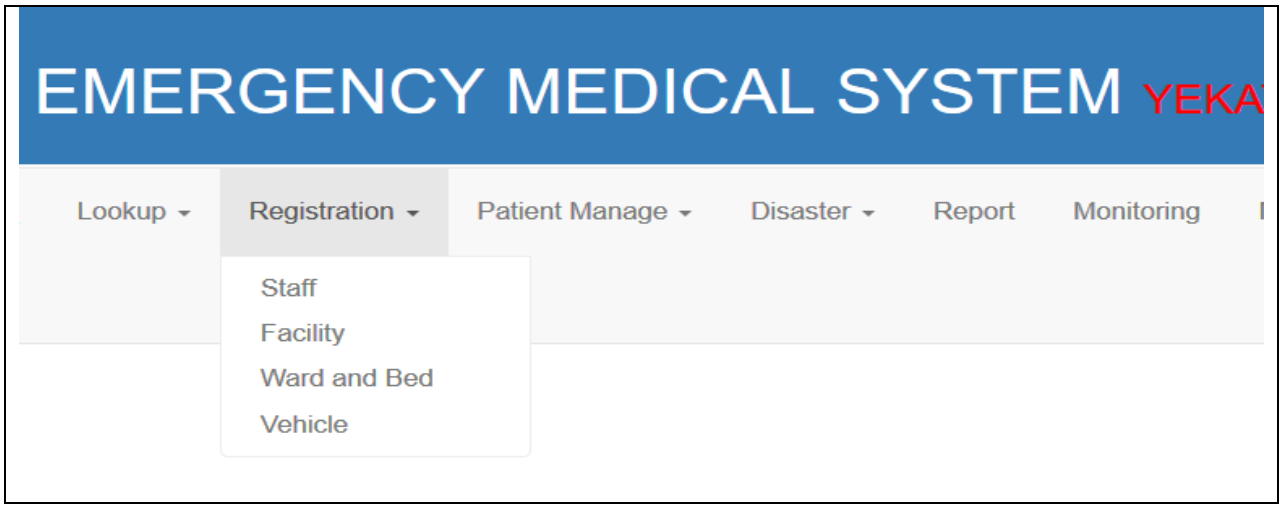


Fig 7: Registration

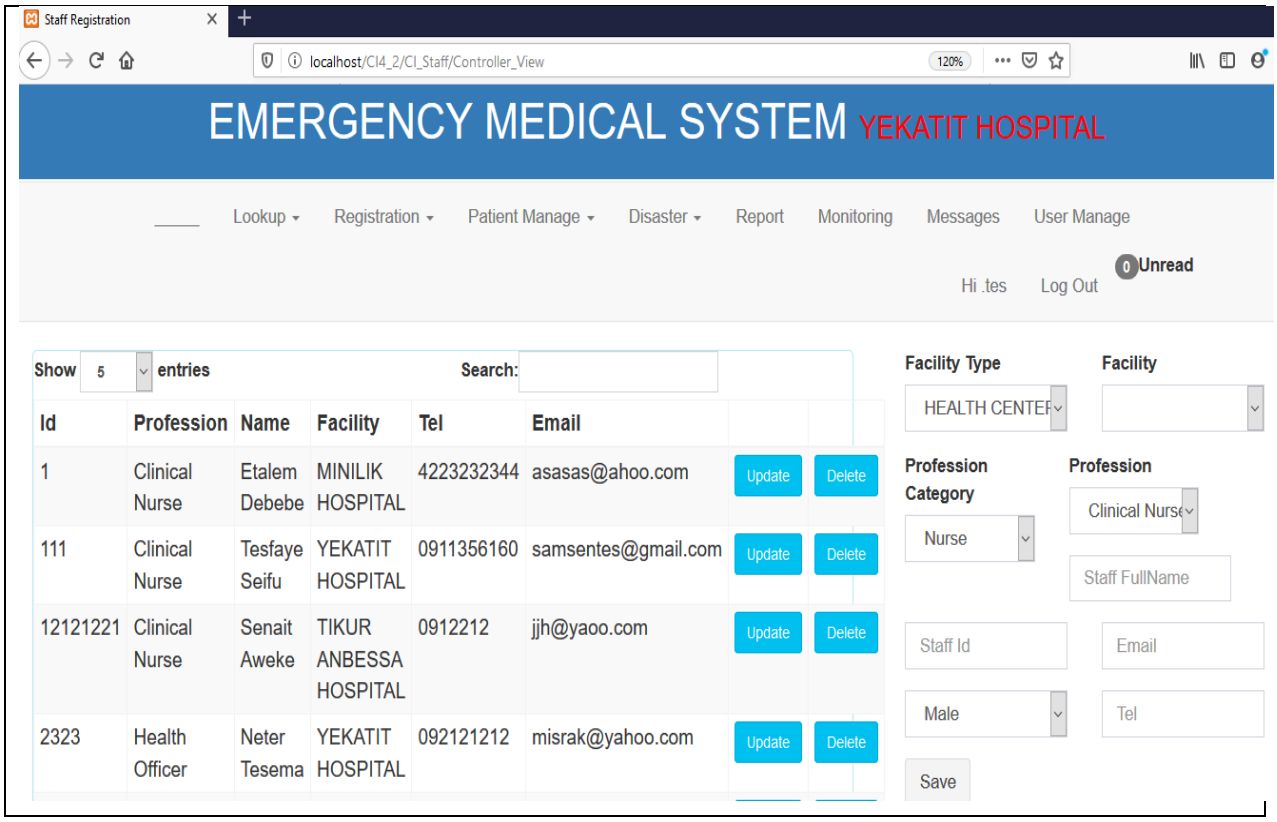


Fig 8: Staff Registration

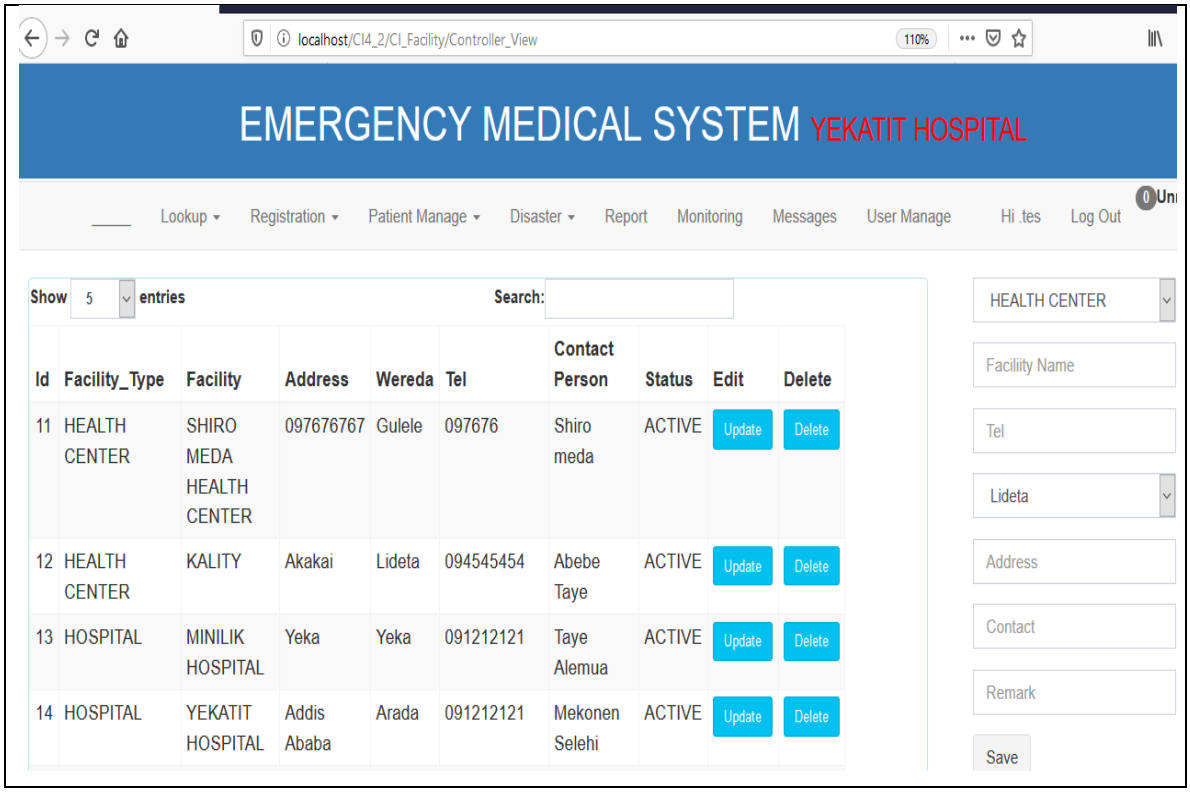


Fig 9: Facility Registration

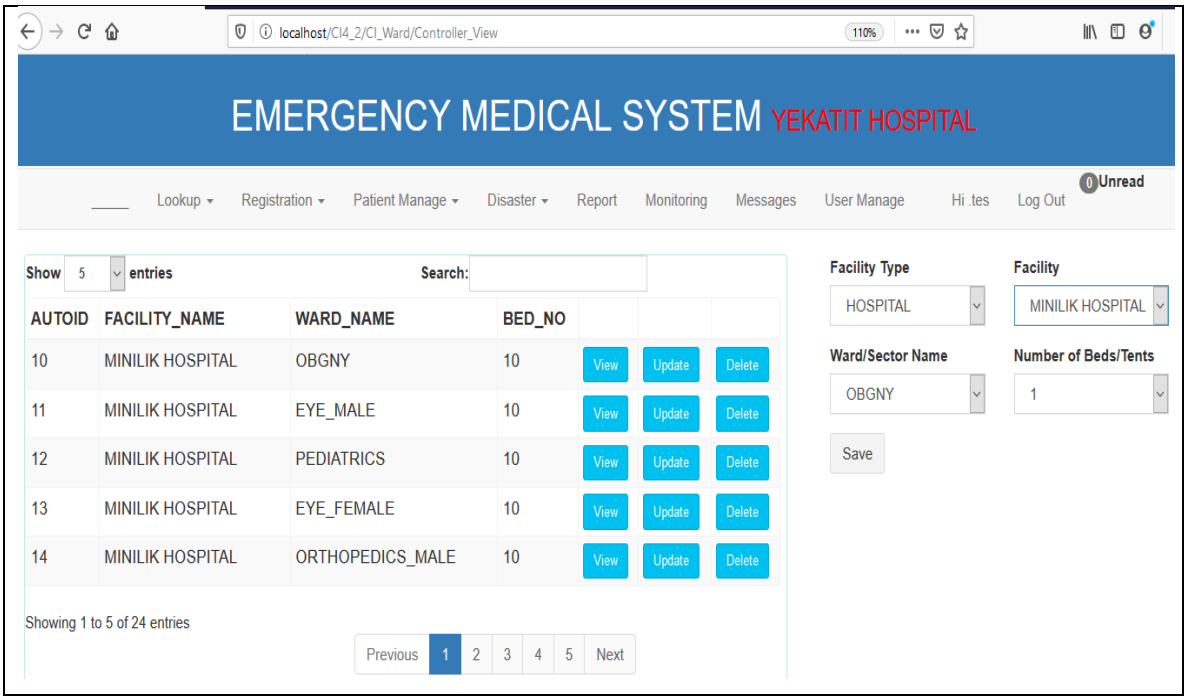


Fig 10: Ward Registration

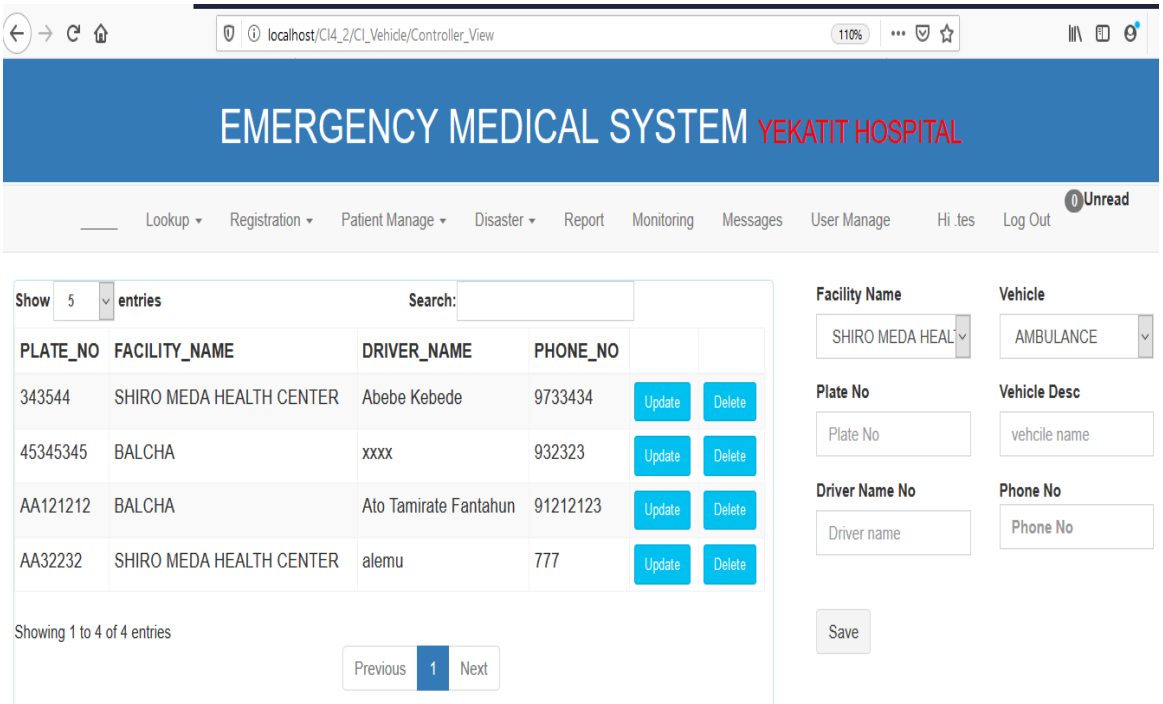


Fig 11: Vehicle Registration

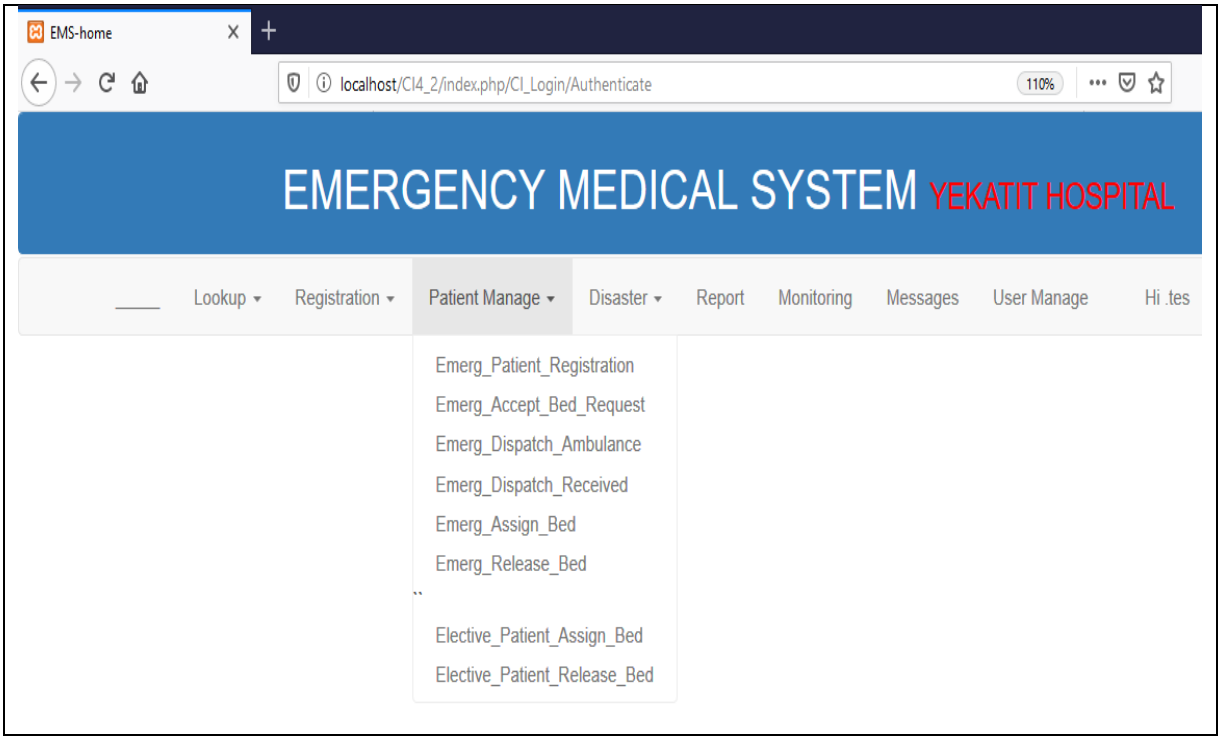


Fig 12: Patient Management

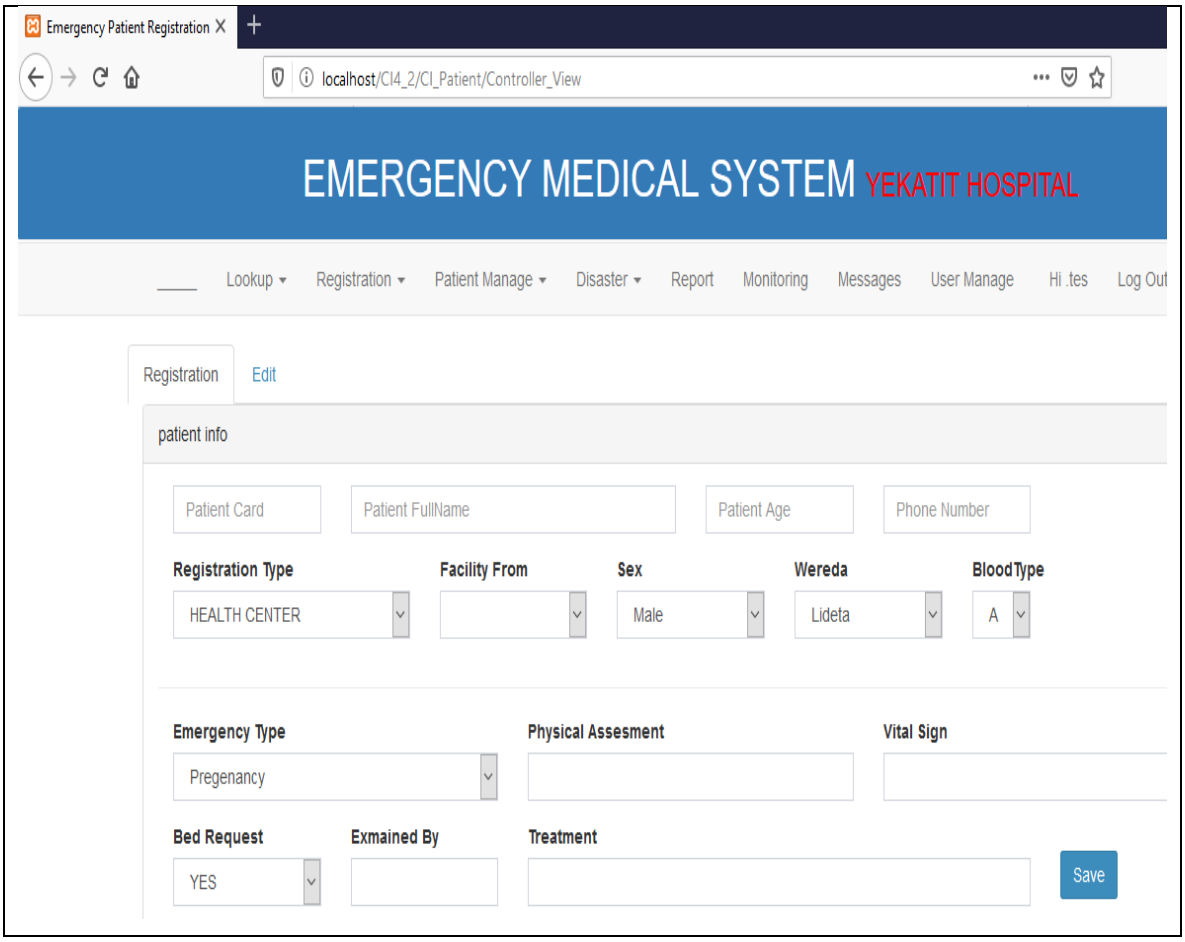


Fig 13: Patient Registration

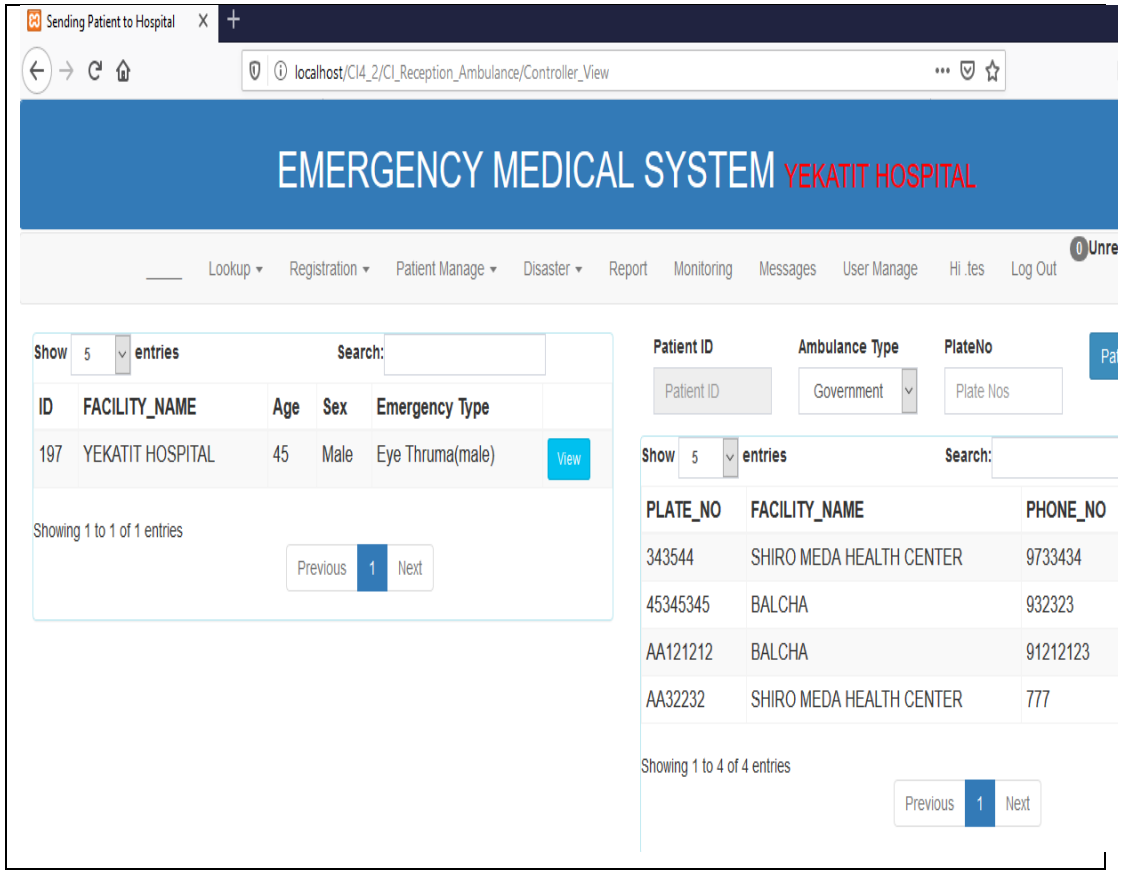


Fig 14: Patient Received _Sent

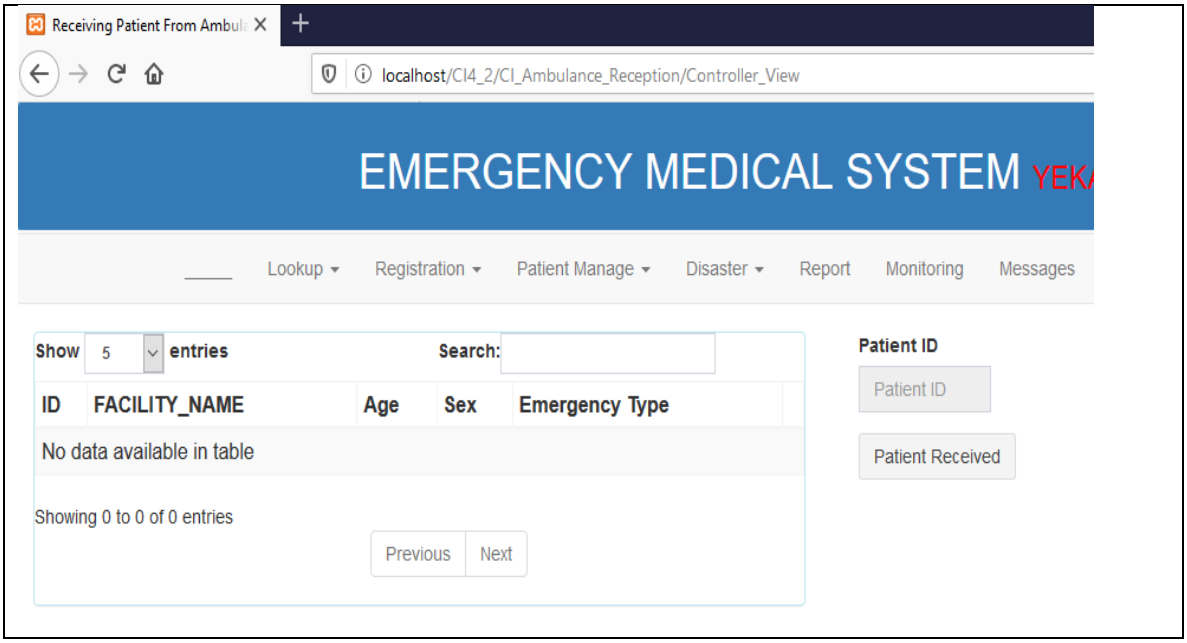


Fig 15: Ambulance Reception

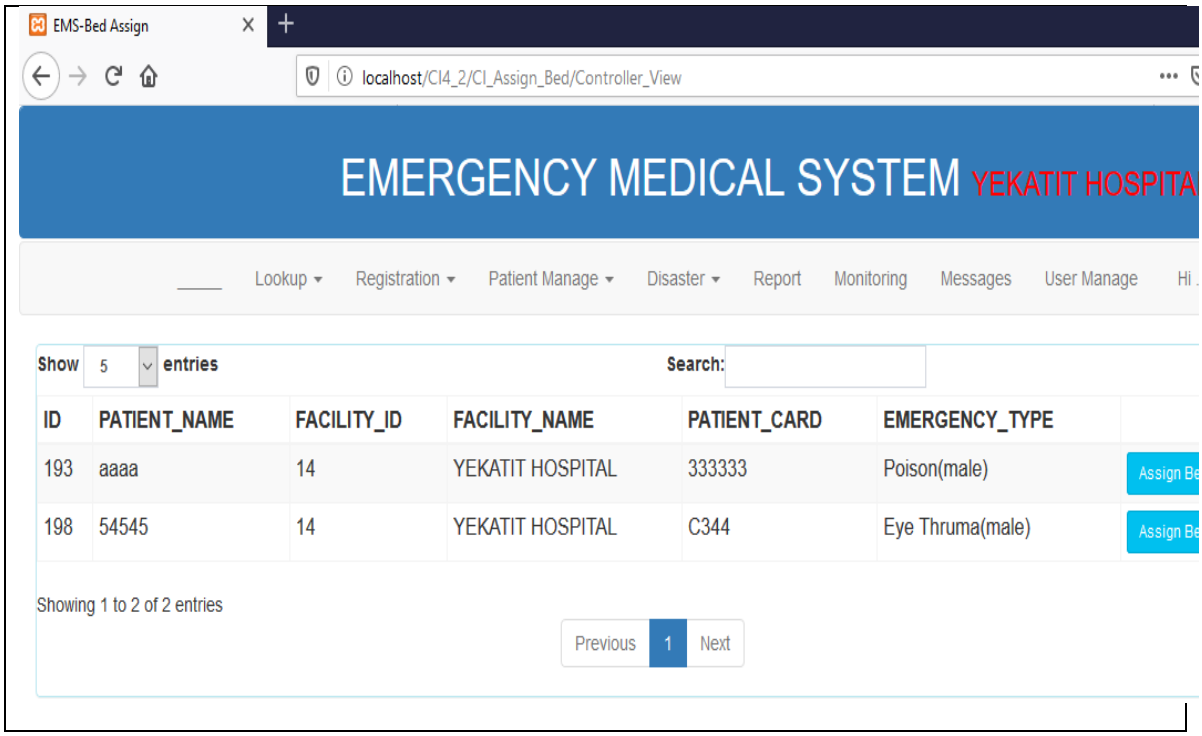


Fig 16: Assign Bed

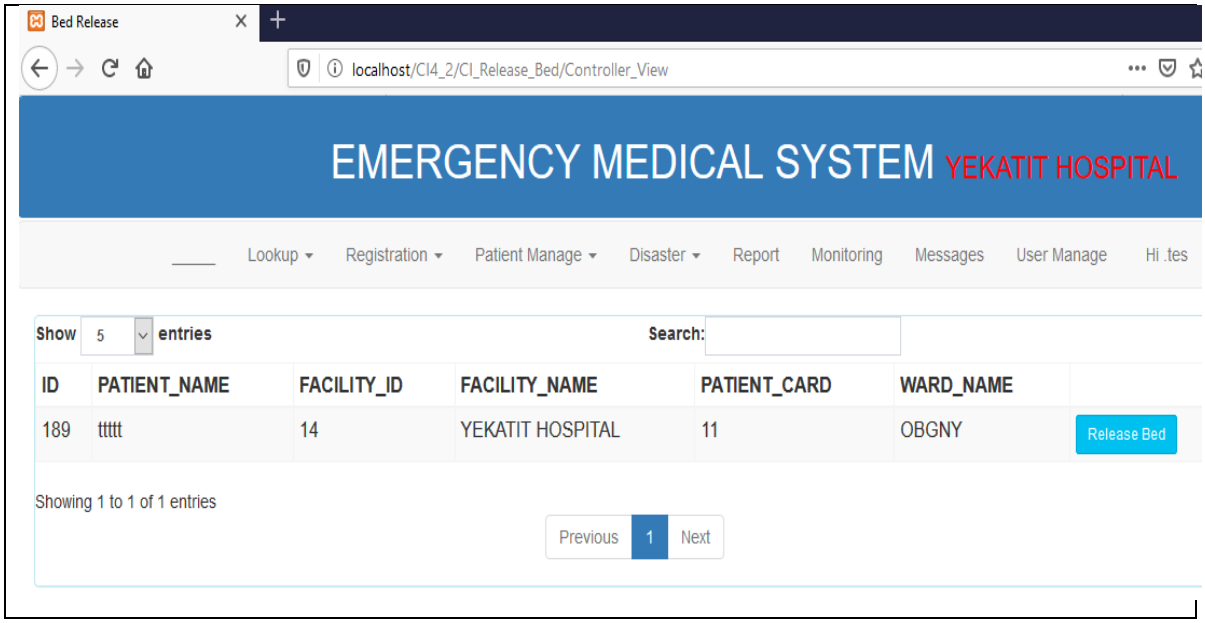


Fig 17: Discharge Patient

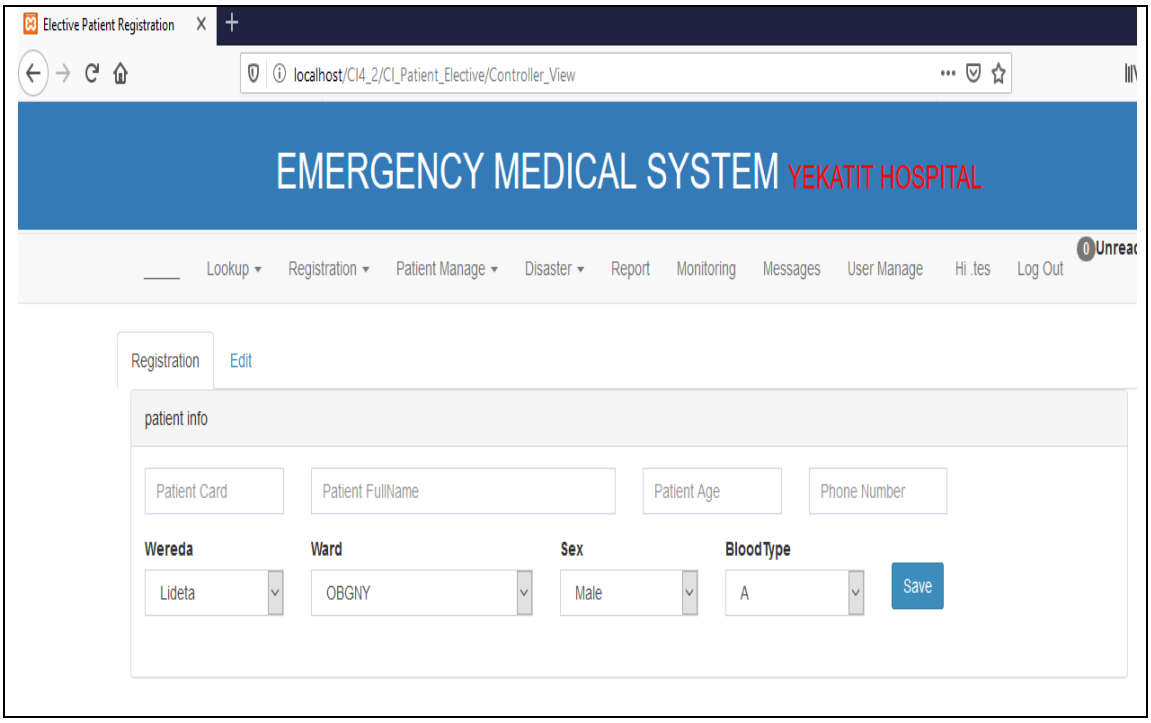


Fig 18: Elective Patient Registration

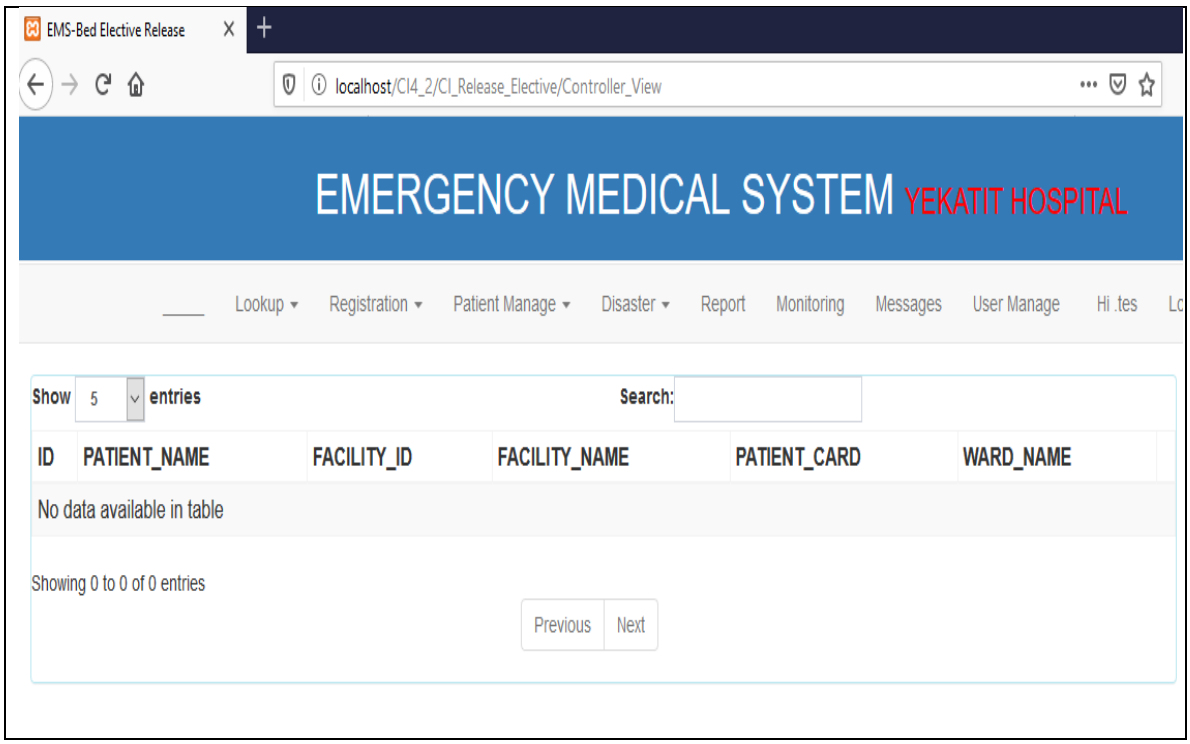


Fig 19: Release Elective Patient

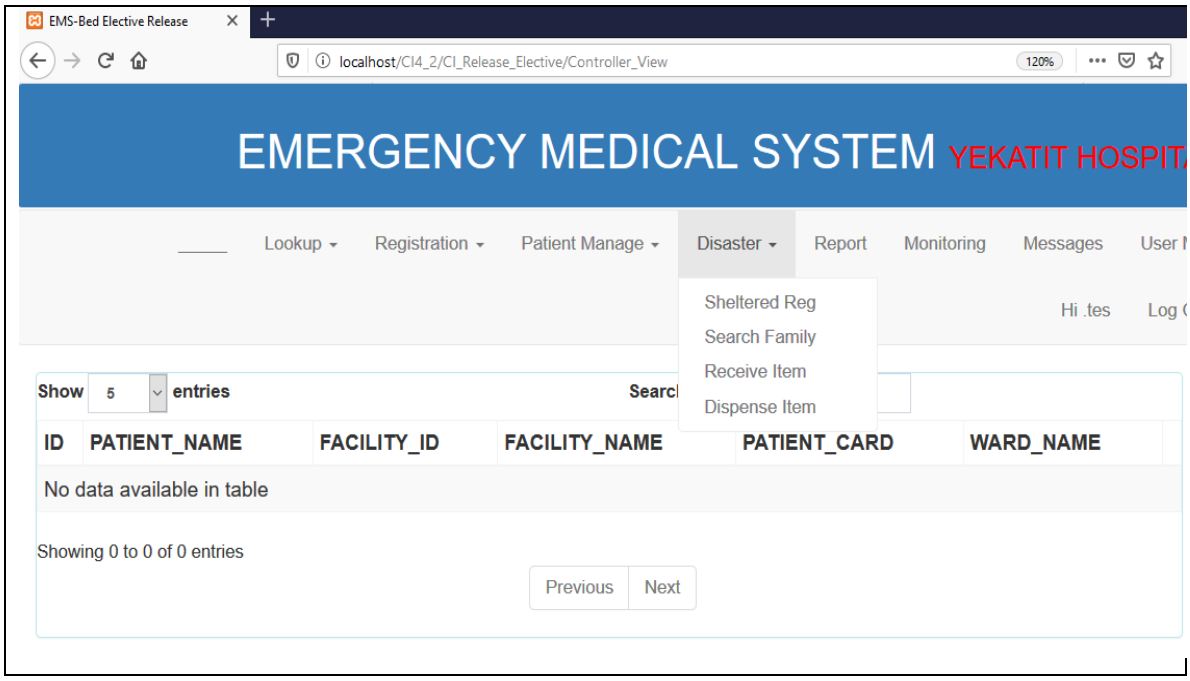


Fig 20: Disaster Sub module

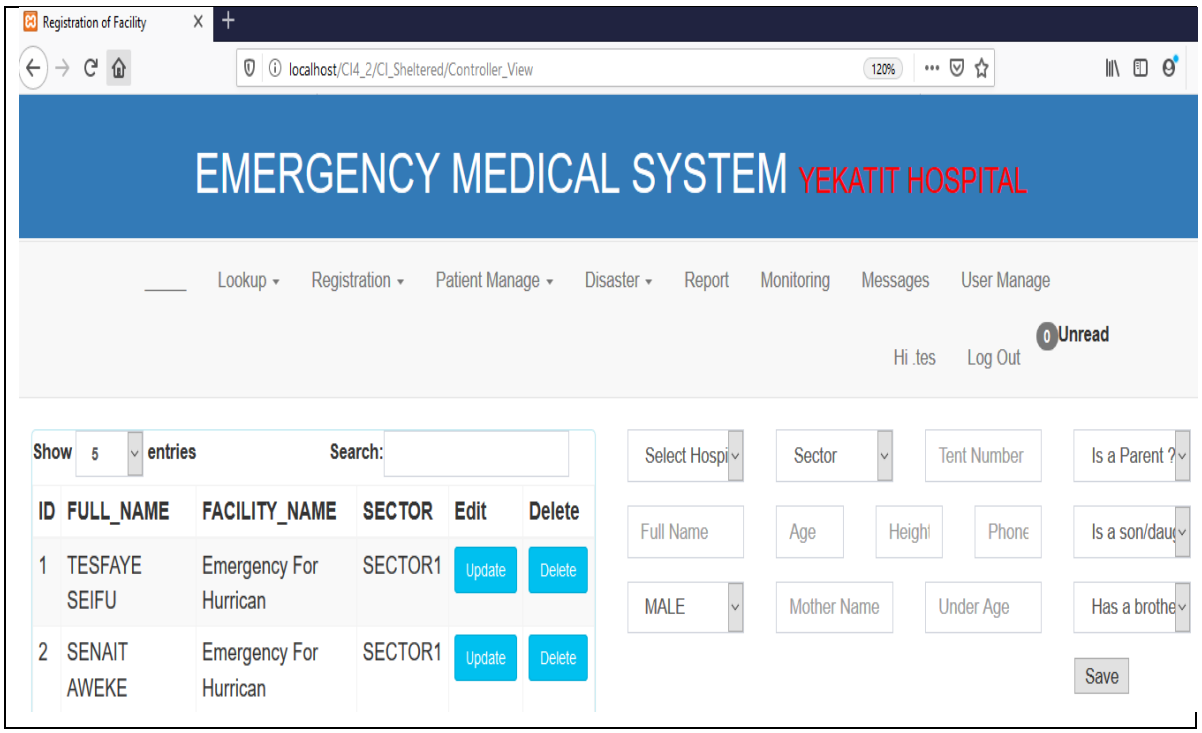


Fig 21: Sheltered Register

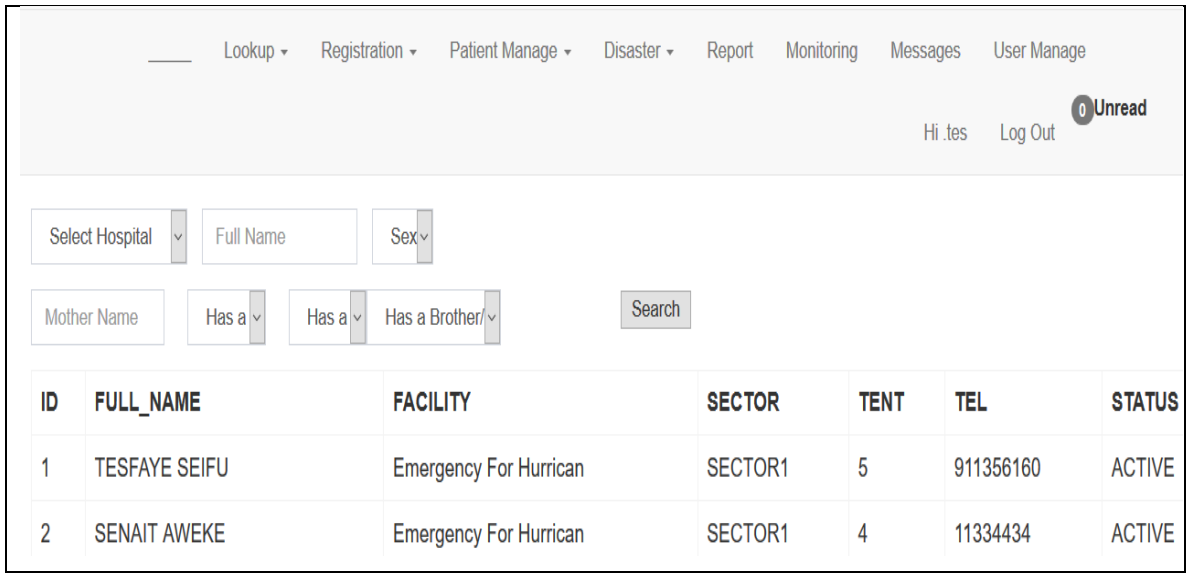


Fig 22: Search Sheltered

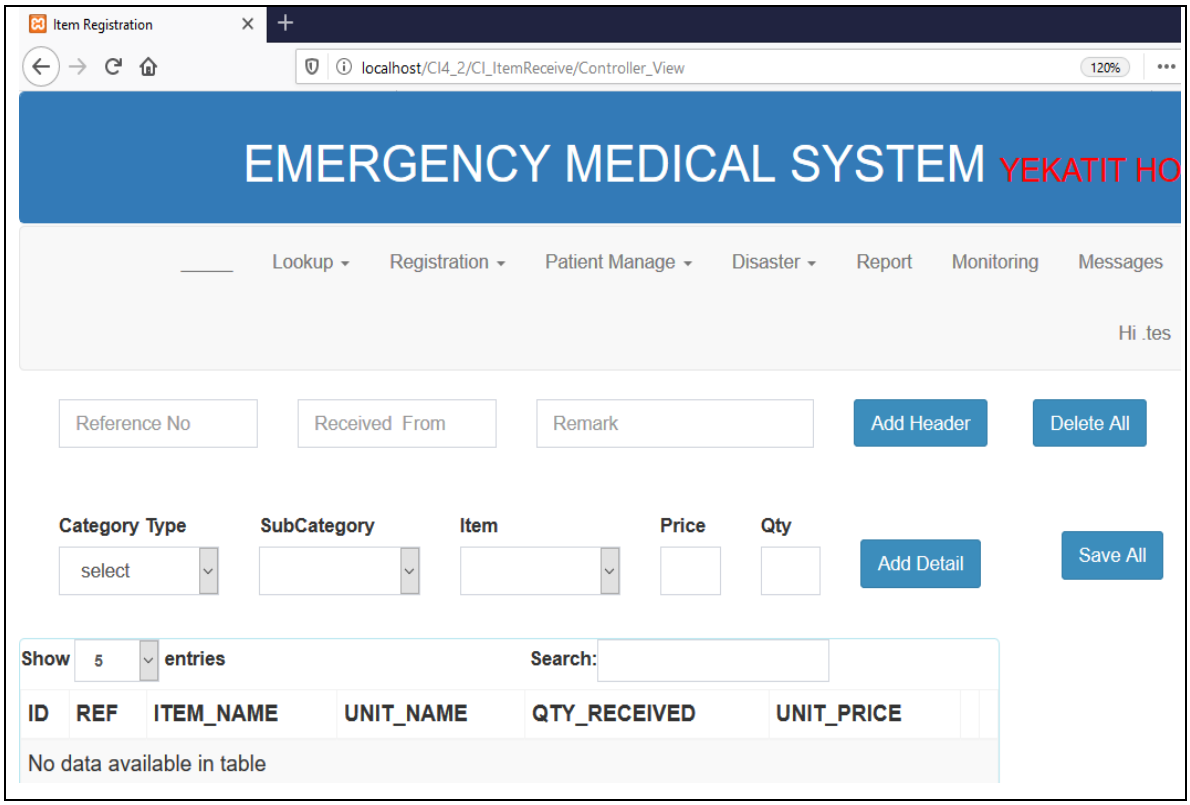


Fig 23: Item Receive

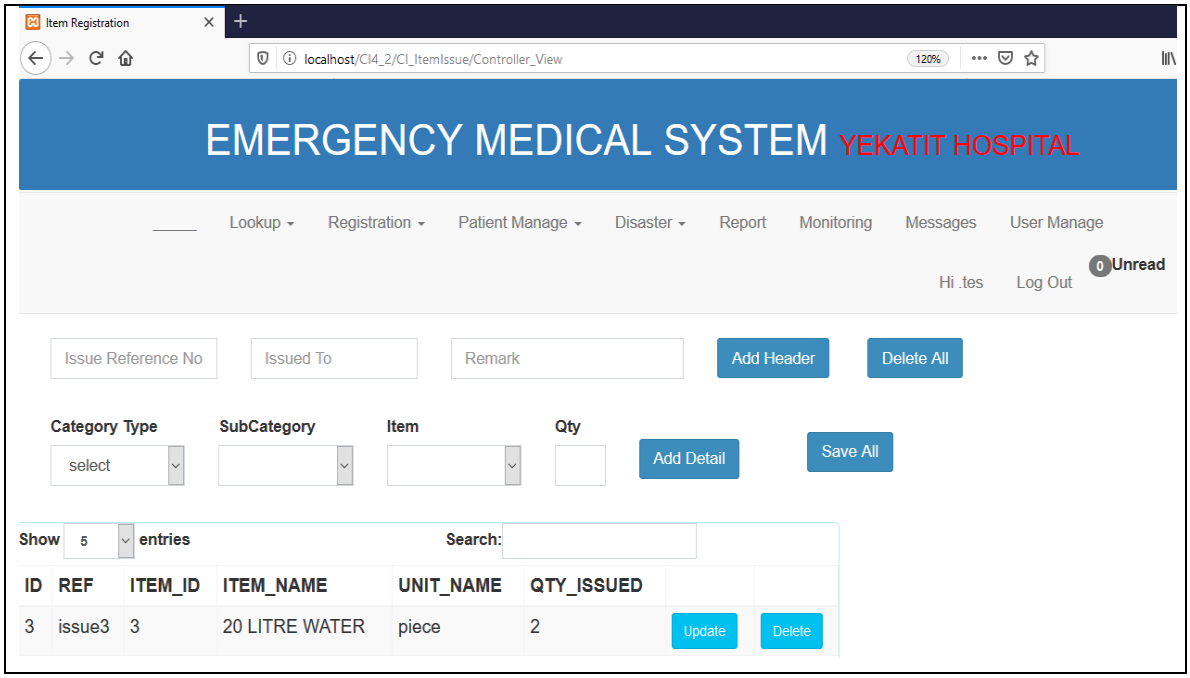


Fig 24: Item Issue

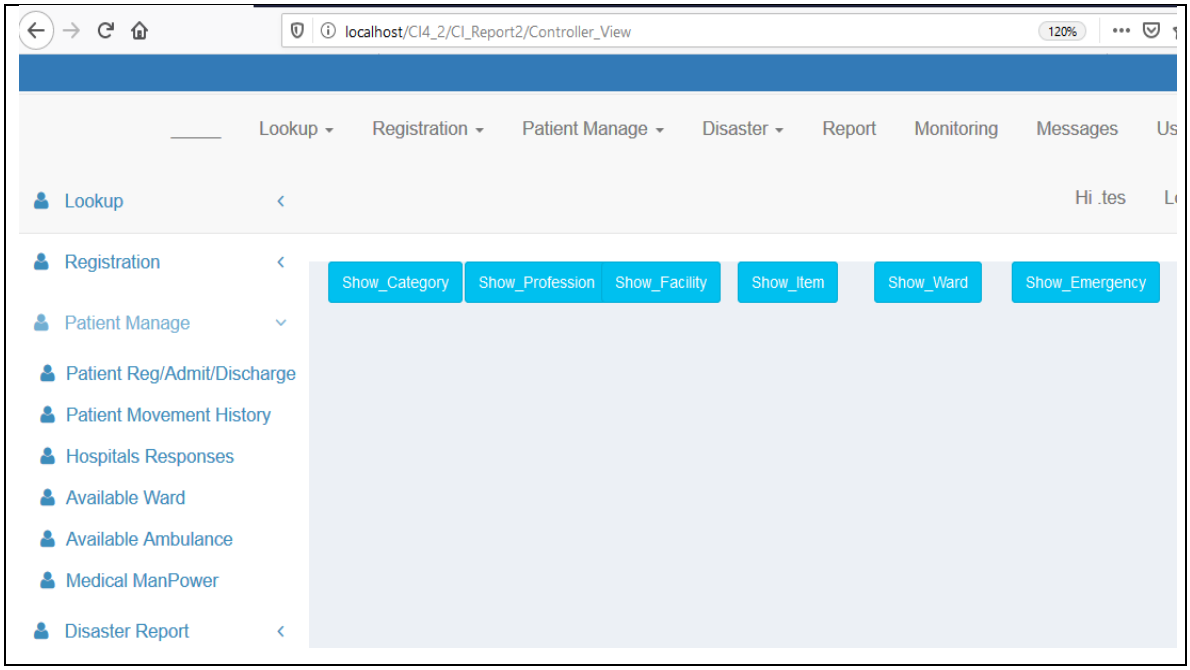


Fig 25: Report Module

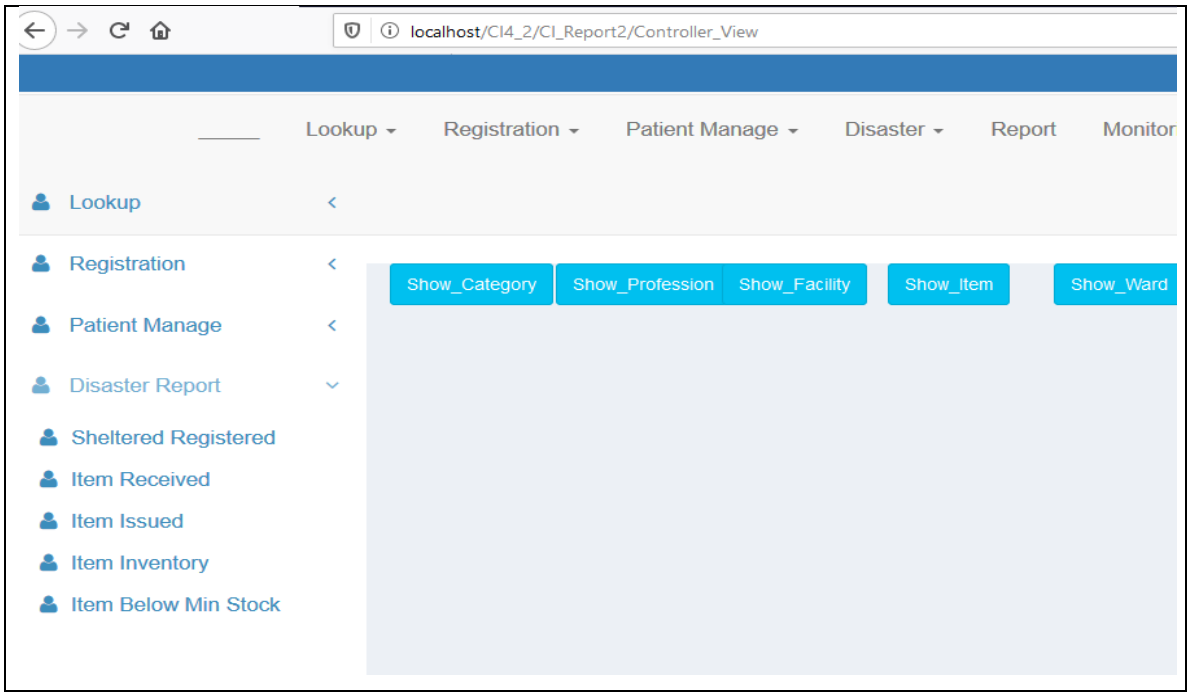
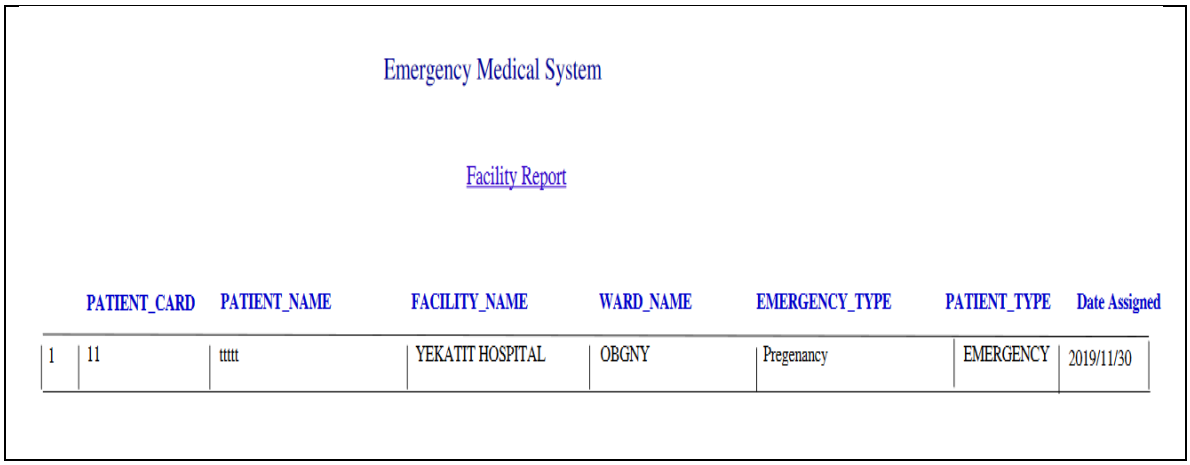


Fig 26: Report Module

Fig 27: Report Module



Emergency Medical System

Facility Report

PATIENT_CARD	PATIENT_NAME	FACILITY_NAME	WARD_NAME	EMERGENCY_TYPE	PATIENT_TYPE	Date Assigned
1	11	ttttt	YEKATIT HOSPITAL	OBGNY	Pregenancy	EMERGENCY	2019/11/30

Fig 27: Report Module

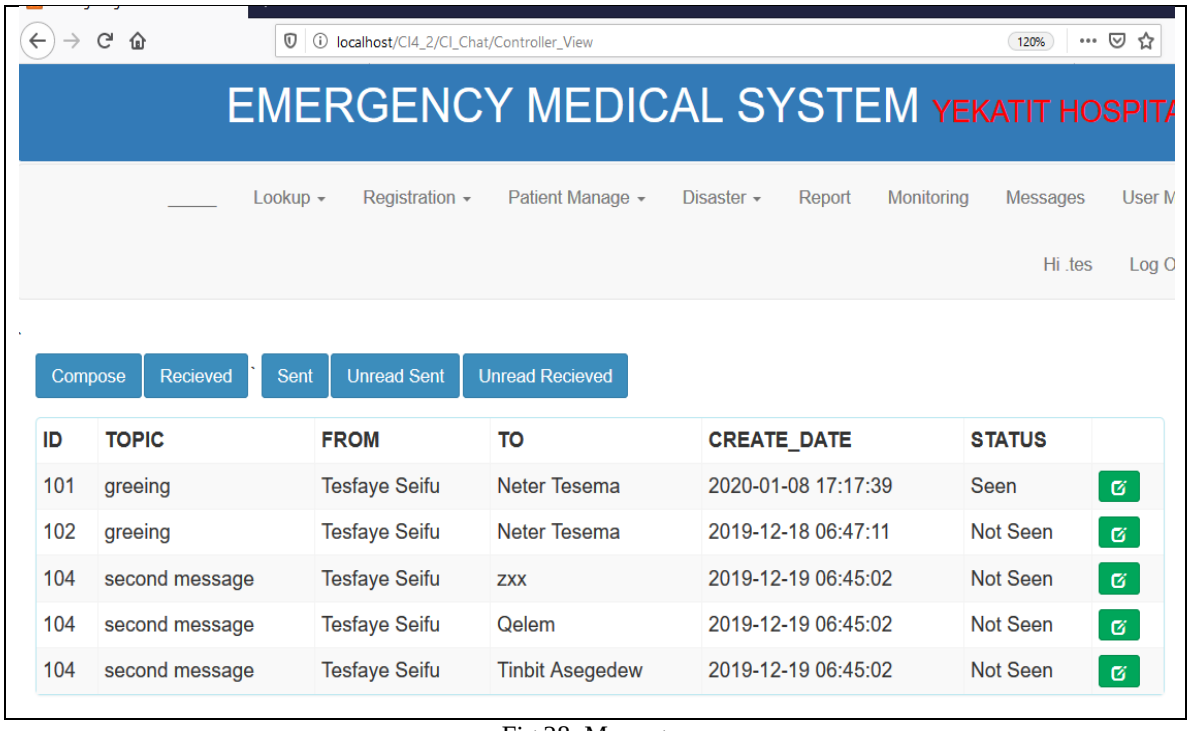


Fig 28: Messages

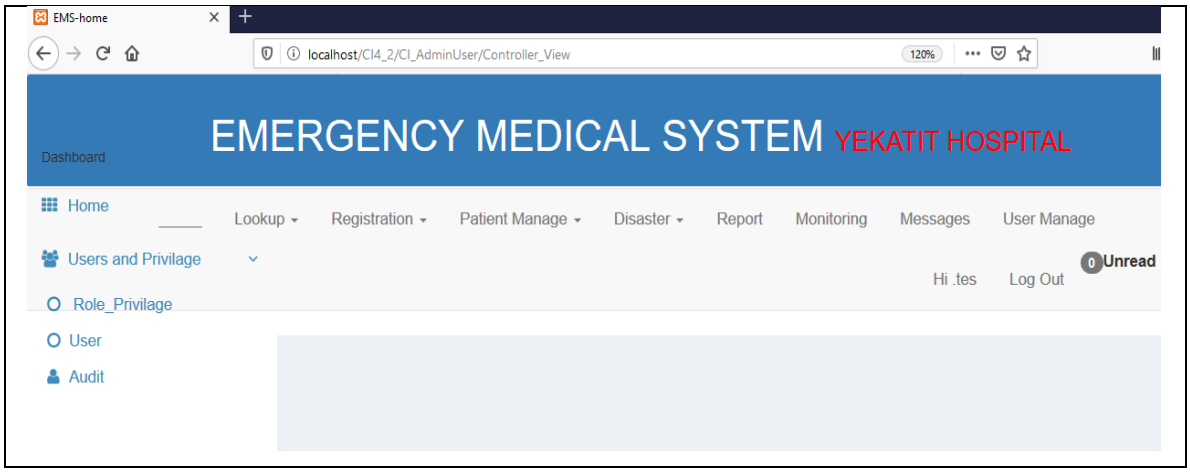


Fig 29: User Administration

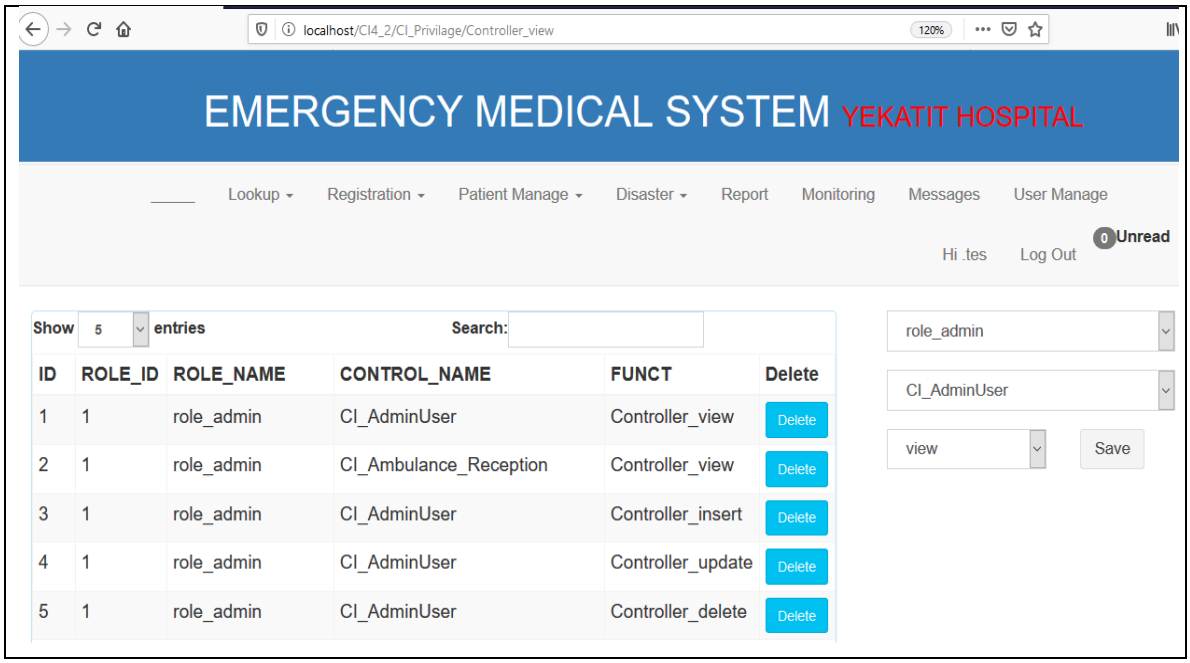


Fig 30: Role Management

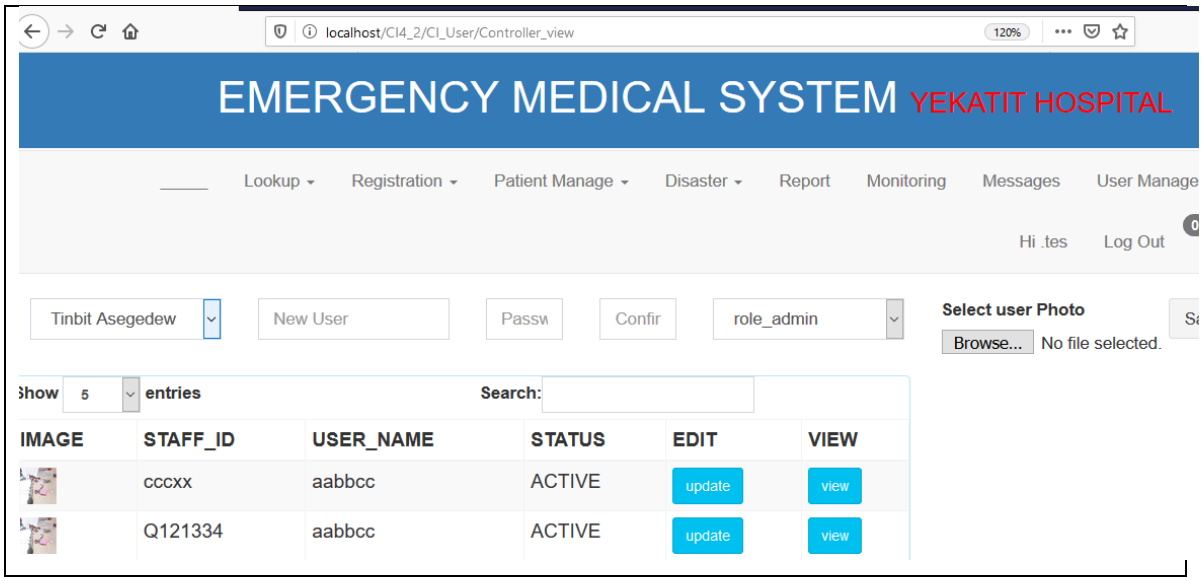


Fig 31: User Management

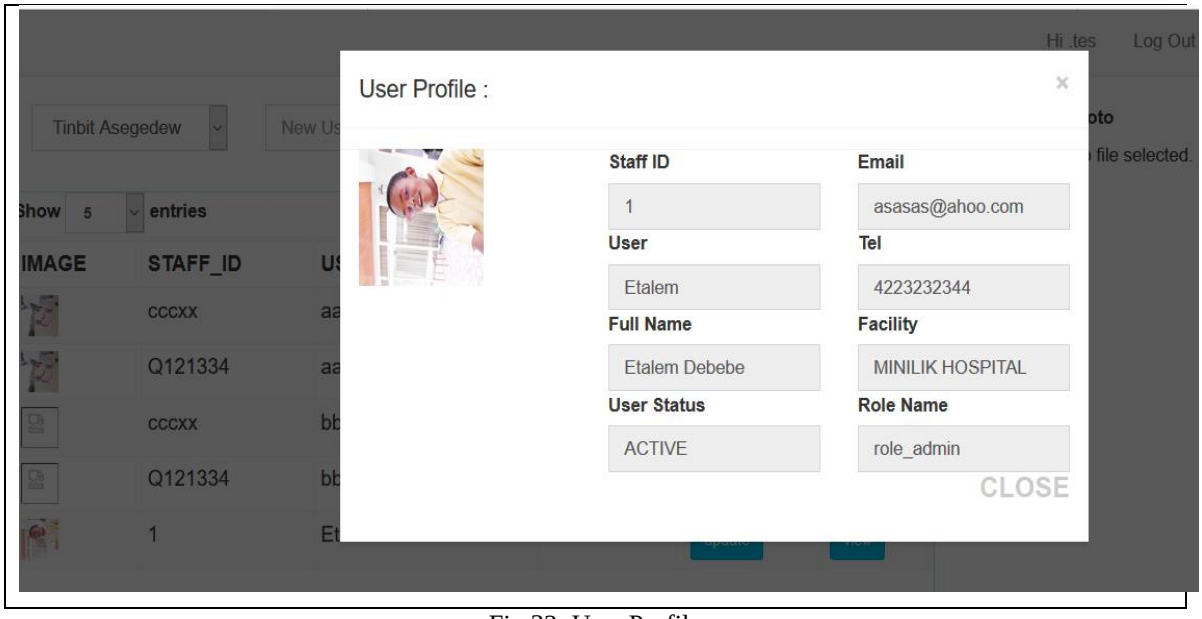


Fig 32: User Profile

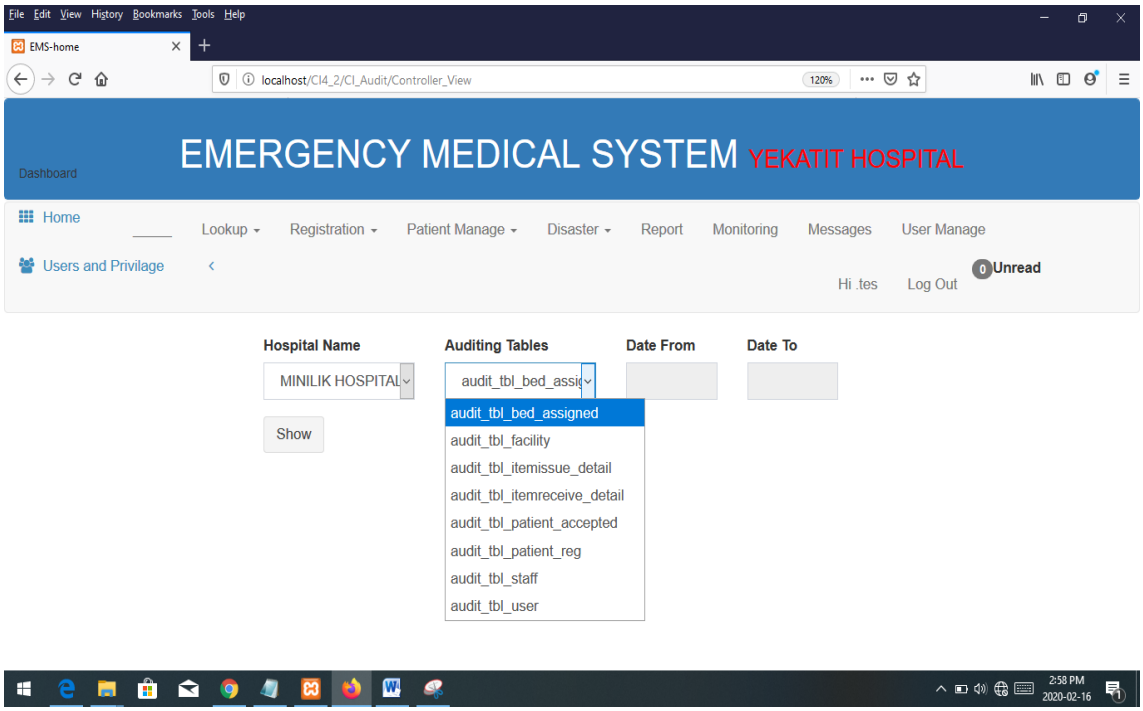


Fig 33: Auditing Report