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And

School of Public Health

M.Sc. In Health Informatics Programme

Developing Mobile Application for Public Health Emergency Management System for Ethiopia Public Health Institute

By

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Declaration

I declare that the project *"Developing Mobile Application for Public Health Emergency Management system for Ethiopia Public Health Institute"* is my original work and has not been presented for a degree in any other university.

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Dedication

First of all I would like to dedicate this to the almighty God, and staffs of Addis Ababa University particularly staffs of School of Information Science and Public Health for their two years effort for providing me the appropriate skills and knowledge on the area of Health Informatics. I would also like to dedicate this to my family and close friends who have been sharing their valuable ideas, and/or supports.

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Acronyms and Abbreviations

AAU	Addis Ababa University
AWD	Acute Watery Diarrhea
BCC	Behavior Change Communication
BPR	Business Process Re-engineering
CDMA	Code Division Multiple Access
CD/DVD	Compact Disk/Digital Video Disk
CHWs	Community Health Workers
CRS	Catholic Relief Services
EDHS	Ethiopian Demographic Health Survey
EHealth	Electronic Health
EHMIS	Electronic Health Management Information System
PANACeA	PAN Asian Collaboration for Evidence-based eHealth Adoption and Application
ETC	Ethiopian Telecommunication Corporation
EPHI	Ethiopian Public Health Institute
FMOH	Federal Ministry of Health
GPRS	General Packet Radio Service
GTMP	Global Trachoma Mapping Project
HMIS	Health Management Information System
HNI	Human Network International
HSDP	Health Sector Development Program
ICT	Information Communication Technology
IDRC	International Development Research Centre
IRD	Interactive Research Development
IVR	Interactive Voice Record
ITI	International Trachoma Initiatives

MDG	Millennium Development Goals
mHealth	Mobile Health
MIS	Malaria Indicator Survey
NGO	Non-Governmental Organization
NTD	Neglected Tropical Disease
PHCU	Primary Health Care Unit
PHEM	Public Health Emergency Management
RHB	Regional Health Bureau
RTBP	Real-Time Biosurveillance Program
SMS	Short Message Service
TIE	Tulane International Ethiopia
UK	United Kingdom
USAID	United States Agency for International Development
WHO	World Health Organization
PMA2020	Performance Monitoring and Accountability 2020
SPH/AAU	School of Public Health/Addis Ababa University
JHU	John Hopkins University

Abstract

Introduction: Public Health Emergency Management (PHEM) is one of the core business processes in Ethiopia Public Health Institute. The main function is to collect timely information about the occurrence of disease outbreaks throughout the country. This information would help the responsible organizations to take timely action if the number of cases is above the expected threshold level. The major problems in PHEM is lack of adequate communication media among all the responsible stakeholders, problem of getting quality and complete information on time.

Objectives: The objective of this project is to analyze, design, and develop a prototype mobile application for Public Health Emergency Management system for Ethiopia Public Health Institute.

Methods: All the important data/requirement collection instruments were used for this study. On the basis of the identified instruments we conducted interview for the selected respondents. The sample respondents were selected using purposive sampling techniques. In addition national PHEM guidelines and other related documents were reviewed along with the interview and observation we conducted. This helped us to determine the requirements of the new system. Later on we mentioned the methodology software development life cycle, and water fall approaches were used to develop the prototype mobile application.

Analysis and Design of the System: Then after analysis and design models were used like Use cases to describe the basic functions of the information system, and Use case description to show detail description of the activities and functions running in the early warning and surveillance sub-process and other health related services, data flow diagram to depicts the actual flow or movement of data in the system, activity diagram to show business process and work flow. The analysis and design model is finalized by identifying the relevant analysis classes, attributes and their respective operation for designing the new system, architectural design, entity relationship diagram and user interface diagram were applied to elicit the parts of the system.

Conclusion: Problem of on time data collection, organization and reporting about disease outbreak data are the main challenges in the public health emergency management system. In the meantime the rapid growth of mobile phones has been contributing a lot in human's daily activity and organizational business. Therefore, we understood that the application of mobile phones and its application in PHEM would play a vital role to bring a timely collection, organizing and summarizing of data for evidence based decision making processes therefore a prototype mobile application was developed to mitigate the above mentioned problems in PHEM.

Recommendation: We recommend the responsible scholars to develop a complete mobile application based on the analysis and design, the developed prototype mobile application done in

this study. To conduct summative usability testing and documenting all the necessary documents to the responsible government organization for sustainability and future usage of the system.

CHAPTER ONE

Introduction

1.1 Background

In the recent history of humans from 2001 – 2010 an average of more than 700 natural and technological emergencies have occurred in the globe every year. Due to this 270 million people were affected by those emergency cases, and the disasters became the cause of 130, 000 peoples death annually. Out of the 700 emergencies and 130, 000 deaths; 25 % of emergencies and 44 % of the death occur in less developed countries, which don't have the capability to respond timely to natural and technological disaster [2].

Ethiopia has three-tier healthcare delivery system. These healthcare systems are: at the outset woreda/district health system which comprises of a primary hospital which can serve 60, 000 up to 100, 000 people; health centers: in which one health center can provide health services to the community about 15, 000 – 25, 000; and health posts which can serve for 3000 – 5000 population. The second healthcare level of the country made up of general hospitals which can cover 1-1.5 million people; and lastly which is the biggest tier in the healthcare system of the country made up of specialized hospitals that can cover for 3.5 – 5 million peoples [1].

Since the development of the health policy in 1993 and HSDP I in 1998, the Federal Ministry of Health has formulated and implemented a number of policies and strategies that afforded an effective framework for improving health in the country including public health emergency management. This includes implementations of far reaching and focused strategies and guidelines, such as Ethiopia Strategy paper (2005), PHEM guidelines for Ethiopia (2012), Measles Surveillance National Guidelines (2012), National Malaria Guidelines (2012) and so forth**.** The major health problems of the country remain largely preventable communicable diseases and nutritional disorders, although the country is increasingly facing the double burden of diseases due to chronic health problems [2].

Consequently, Public Health Emergency Management Preparedness and Response is one of the core processes introduced under the BPR and implementation has been started. In order to establish PHEM teams at FMOH, and RHBs, 13 epidemic intelligence service officers are being trained at Masters Degree level in Addis Ababa University. Twenty diseases have been selected for surveillance and detection and a new forecasting, early warning, response and record system have been designed [1].

One of the interesting points mentioned in the 1993 Ethiopia Health Policy was the use of proactive technologies which further enhance the health status of the population. Due to this FMOH and Agencies with a close collaboration of stakeholders has been using various cost effective technologies in various areas to create accessible, cost effective and quality healthcare services to the community living at all level.

Inline to this, Ethiopia Public Health Institute has been using manuals to communicate information about the occurrence of the diseases. In the first place the major problems of manual public health emergency management system are lack of timely, complete and accurate data collection which finally leads the responsible bodies not to have real evidence

to make timely planning and decisions which particularly address the health demands of the population.

1.2 Statement of the Problem

Public Health Emergency Management (PHEM) is one of the core business processes designed and implemented by Ethiopia Public Health Institution. The main function of the system is to collect information about the occurrence of disease and magnitude to take a timely action if it is above the expected threshold level.

PHEM is implemented beginning from the smallest health units (health posts) up to tertiary hospitals. In general, it is implemented on the basis of the three-tire health care system of the country. This system has been operating manually for many years; data was collected, organized, analyzed and reported in paper based format. This way of doing business has created problem of coordination of data, aggregation and sharing between local communities and regional and national health information systems to inform decisions [3].

Pertaining to this, the Ministry of Health (MOH) has recognized the benefits of Information and Communication Technology (ICT) as a tool to support the health sector. On the basis of this, FMOH, Agencies, RHBs with close collaboration of Tulane University in Ethiopia has developed Electronic Health Management Information System (eHMIS) which comprise PHEM as one of its module. The experts will enter PHEM data into the software and send it to the higher level using tena mail server. While we believe that eHMIS has brought some changes particularly by enhancing patient registration at the health facility level, But there are a lot of challenges in the usage of electronic based PHEM.

Few of the major challenges in the abovementioned electronic system are: firstly, there are 14,416 Health Posts, 2822 Health Centers, 195 hospitals at the national level; the total health facility are 17, 433 but the eHMIS/PHEM which was developed by Tulane University in Ethiopia has only been implemented at 2499 health facilities which means that the rest health facilities are still using manual based PHEM system. Those health facilities who are working on the manual PHEM system uses excel spreadsheet to collect, organize and compile the report, and email to report to the higher level. Therefore, it is difficult to get uniform and complete emergency reports from all health facilities [4]. Secondly, from those 2499 health facilities which have already implemented eHMIS/PHEM most of the health facilities do not have internet connectivity and they are advised to report emergency reports to the higher level using CD/DVD which is very much time consuming activity. Thirdly, another challenge in the implementation of eHMIS/PHEM is inadequate of electric power at each woredas or health facilities. Due to the absence and continual interruption of power, reports have not been arriving at the next higher level on time. It is known that desktop does not store power because it doesn't have batteries unless we use it with UPS. When we talk about laptops/PDA, most commonly it stores power for a maximum of 6 hours per day without the presence of the normal gridline power. Fourth, user interface design and operation of eHMIS/PHEM system is complex, to enter the data users should configure or set up their institutions and enter the data and send the report to the higher level using tena mail server. While to open the reports the PHEM focal person at the federal level should import the message using eHMIS/PHEM to

open and use it. Due to lack of adequate ICT and power infrastructure tena mail server has failed many times for this reason reports were not triangulated between the responsible stakeholders. But when we come to mHealth; we will have the chance to use our mobiles for many hours in a day which is better when we compare it with laptop/desktop computers.

There is also another electronic system which was developed by FMOH, SNNPR RHB and JSI-Ethiopia used for Health Management Information System (HMIS) and PHEM reporting. In SNNPR, there are about 3855 health posts, 658 health centers and 22 hospitals. Routine data is collected from these health facilities using the monthly IPD disease reports, OPD disease reports, hospital service reports, Health Center and Health Post service reports. At the same time taking the advantage of the Data Element Definition, Reporting Form Designer and health facility database i.e. Health System Reference Database, the system (eHMIS) application can be expanded to collect, aggregate and analyze Integrated Disease Surveillance Report (IDSR) data weekly. It means that eHMIS which is developed and implemented by John Snow Incorporation (JSI) at the SNNPR region also comprises of PHEM system as one of its component [5]. In conjunction with it, currently out of 152 woreda in SNNPR 125 are using the eHMIS. And, upon the request from woreda, zones and the region the system is being improved and relevant reports and tools that are essential to support HMIS tasks are being incorporated. However, the other 25 woreda did not implement eHMIS/PHEM. This shows that those 25 woredas and health facilities sending disease surveillance report to the higher level using the manual business process. The major problems in SNNPR are also the challenges that are mentioned in the above.

Nowadays, in Ethiopia the normal mobile telecommunication network that is GSM and 2G internet connectivity coverage has reached to 85 % [6].Therefore, using the opportunity of mobile technology growth, the availability of the normal mobile telecommunication network and 2G/3G internet connectivity, due to the dynamic growth and cost effectiveness of the mobile technologies, we can easily collect complete, accurate, and timely information using mobile phones to notify the occurrence of diseases so early and intervene as soon as possible.

The purpose of this project is therefore to develop a mobile application that can be used to collect, organize, summarize and report disease outbreaks data to the responsible governmental office or bureaus and also stakeholders to let them to have complete and quality information for evidence based planning and decision making process.

1.3 Objectives

1.3.1 General Objectives

The general objective of this project is to develop mobile application for collection and organization of both daily and weekly disease outbreak data for Ethiopia Public Health Institute.

1.3.2 Specific Objectives

- To study the existing system and its gap.
- To identify, organize and document requirement of the system.
- To design mobile based user-interface for the system.
- To develop a prototype mobile application that is used to collect data about the occurrence of disease outbreaks.

1.4 Significance of the Project

Developing this system will have the following significances for various responsible bodies or stakeholders.

Benefit for Patients

In the first place the ultimate goal of PHEM is to save the lives of million of Ethiopians by early detection of disease occurrence in the country and provide responses to patients or the community as quick as possible. Therefore, using mobile application will be one of the mechanisms for timely information exchange which is very much advantageous for the community in danger to get early response from the responsible organizations and stakeholders.

Benefit for Health Professionals

Collecting, organizing and sending PHEM data to the next level is one of the duties of PHEM experts. Thus, using technologies like mobile application will make their day to day business operation very much easy.

Benefit for Health Facilities

Mobile application based PHEM system could have a benefit for the hospitals/health centers for giving an immediate and better health care services or responses to patients who are in danger of the new health threats, for keeping adequate records about diseases at EPHI and RHBs.

Benefit for Health Institution and Policy Makers

Health institutions like Federal Ministry of Health, Regional Health Bureaus, Zonal Health Bureaus, Woredas Health Bureaus and Health Agencies will benefit from this project. The main reason is they will have a chance to collect information in a timely manner for timely and adequate planning and budgeting, monitoring and evaluation, and intervening. Ultimately

it will enhance the effectiveness and efficiency of the Health Information System in the country.

Benefit for Medical Researches

In scientific research, disease surveillance record is a major source of data. One channel of collecting disease surveillance data is a mobile application based PHEM system. These data will help various researchers which are working on health and health related researches to investigate incidence and prevalence of the disease occurrence in the community and also to come up with new finding that enhance the health of the community.

Benefit for NGOs and the Environment

The main goals of NGOs are to serve the community by addressing the critical healthcare needs of the people who are living both in rural and urban areas. Thus, one way for the presence of critical healthcare needs, due to the occurrence of epidemics or outbreak within community. Therefore, this SMS based PHEM system will help NGOs to be informed and intervene early to eradicate or eliminate the diseases that occurred within the community.

1.5 Scope and Limitations

1.5.1 Inclusion

Activity Category

The major activities that were done are studying the existing system, identify its gap, gathering and analyzing the requirements, designing the architecture of the system, designing the user interface of the mobile application, developing a prototype mobile application, documentation and demonstration of the developed prototype mobile application.

System Requirement Category

It is clear that surveillance could not be carried out for all diseases and conditions. Therefore, priority should be given to those diseases that are of interest at national and international levels. In Ethiopia 20 diseases (13 are immediately reportable whereas 7 are weekly reportable) are selected to be included into the routine surveillance (see Table 1). These diseases and conditions are selected based on the following criteria:

- Diseases which have high epidemic potential (anthrax, avian human influenza, cholera, measles, meningococcal meningitis, pandemic influenza, smallpox, severe acute respiratory syndrome (SARS), viral hemorrhagic fever (VHF), and yellow fever).
- Required internationally under IHR2005 (smallpox, poliomyelitis due to wild-type poliovirus, human influenza caused by a new subtype, SARS).
- Diseases targeted for eradication or elimination (poliomyelitis due to wild-type poliovirus, dracunculiasis, neonatal tetanus (NNT),Diseases which have a significant public health importance (rabies, dysentery, malaria, relapsing fever, typhoid fever, typhus and severe malnutrition).Diseases that have available effective control and prevention measures for addressing the public health problem they pose [7].

Immediately Reportable Disease	Weekly Reportable Disease
1. Acute Flaccid Paralysis (AFP) / Polio	14. Dysentery
2. Anthrax	15. Malaria
3. Avian Human Influenza	16. Meningococcal Meningitis
4. Cholera	17. Relapsing fever
5. Dracunculiasis / Guinea worm	18. Severe Malnutrition
6. Measles	19. Typhoid fever
7. NNT	20. Typhus
8. Pandemic Influenza A	
9. Rabies	
10. Smallpox	
11. SARS	
12. VHF	
13. Yellow fever	

Table 1: Immediately and Weekly Reportable Disease

Health Institutions

It is known that the manual based PHEM system is implemented at the national level, it means that all satellite health posts, health centers, hospitals and other health facilities have implemented it. Therefore, due to constraint of time, budget and other factors, the mobile application based PHEM system will be applied to the following health institutions:

- Ethiopia Public Health Institute
- Public Health Emergency Management Directorate
- Health Information Communication Technology Directorate

1.5.2 Exclusion

Activity Category

In this study, complete development of the software, final testing and implementation were not done because of time and resource constraints.

Health Institutions

Health institutions like Regional Health Bureaus, Zonal Health Offices, Woreda Health Office, Tertiary Hospitals, General Hospitals, Primary Hospitals, Health Centers and Health Posts which implement the manual PHEM system will not be included in this study.

Other Diseases

- Clusters of respiratory illness (including upper or lower respiratory tract infections, difficulty breathing and Adult Respiratory Distress Syndrome).
- Clusters of gastrointestinal illness (including vomiting, diarrhea, abdominal pain, or any other gastrointestinal distress).

- Influenza-like constitutional symptoms and signs.
- Clusters neurologic symptoms or signs indicating the possibility of meningitis, encephalitis, or unexplained acute encephalopathy or delirium.
- Cluster of rash illness.
- Hemorrhagic illness.
- Botulism-like syndrome.
- Sepsis or unexplained shock.
- Febrile illness (illness with fever, chills or rigors).
- Disease caused by antimicrobial resistant organism.
- Non-traumatic coma or sudden death [7]

CHAPTER TWO

Literature Review

This chapter presents review of general and related literatures that are mentioned in this document are not exactly similar works rather somehow similar with this study because those general and related works are mobile based supported emergency management systems which are designed and developed particularly for specific disease, and also those diseases are part of the manual based PHEM system.

2.1 General Literature

2.1.1 Introduction

Information and Communication Technology (ICT)

Information Technology is a systematic and technological engineering technique used for capturing various information and its practicality and integration with social, economical and cultural related issues. Communication Technology is a digital devices used for information exchange among individuals or groups. Mostly it creates an environment to ease information exchange between an interested groups or individuals who are not nearby or present at the same location or areas. Some of the major media used for communication are telephone, telex, fax, radio, T.V. and Video as well as recent and most commonly used digital devices such as computers based technologies, comprises of digital data interchanges and email [8].

ICT is the bi-product of Information Technology and Communication technology. ICT consist of all the technologies that we have been using to collect, organize, process, send, retrieve and store information. It is the interconnection of different hardware and computer programs designed to perform a certain business or operations. The rapid development of technology and technology related creativities and presence of high technological market demands are deriving the ICT industry towards convergence. Because technological convergence has many benefits such as ease of data entry, flexibility, etc. encourage different service providers to come up with new business approaches, encourage competition, reduce cost of service, and widen the premises of services and technologies available to users [9].

Nowadays ICT is touching every part of social, political and economic relationships of any country. Many of these promising changes and developments were not difficult because of the availability of various policies and regulatory frameworks that facilitates investments, liberalization, and competition in the ICT industry. The enthusiasm of market and technological advancement trigger a phenomenon called “convergence”. The convergence of ICT drives the current world to shift from landline communication and desktop based information sharing to hand held small sized devices called mobile devices which can support both communication and information sharing and tremendously benefits both developed and developing countries. The occurrence of ICT convergence phenomenon requires different

aspects. Regard with technology level, convergence helps for the provision of multimedia communications across a range of network of networks that were working separately. This primarily changes the business of ICT: infrastructure, services, companies, content, and devices can now interact and work together in new, unprecedented ways, opening markets, challenging existing structures, and allowing innovative business models. At different level, we are observing the convergence across different sectors, whereby many social and business services are being rely on the rapidly growth of cellular network platforms such as mobile health, mobile education, mobile for agricultural industry, mobile banking, and so forth [10].

Therefore, the convergence of ICT brought the following small sized devices which are very much common on the current ICT industry; 1) *PDA-Personal Digital Assistant (PALM)* is hand-held small sized computer. As the name implies, it is a device that fits in the user's palm. Despite, the main purpose of having such device that is to assist the business function performed by users in mobile manner, it will not have high-tech capacity and computing power; 2) *Mobile Phone*is handy electronic devices used for communication among peoples at a distance or locating at different places. Recently mobile phones has transformed from simple communication device into a device that have many functions which can support various business operation of any sector. Those functions are Short Text Messaging (SMS), electronic mail, internet access,calculator, clock, alarm, audio/video recording, capturing and displaying photos, sending/ receiving multimedia messages (MMS), etc. has turned the mobile phone into an extremely useful device. A mobile device has been contributing a lot in the day to day activities of the modern society; 3**)** *Smartphone* is a device that combines the functional features of mobile phones, PDAs, and computers. Smartphone must use operating system to make it operate properly, which are the basis for application development. This mean that mobile applications will be developed based on the environment where it is going to be installed, configured and operated. Some instances of Smartphone based operating system are: Google Android, Symbian, Blackberry, Palm Pilot, and Windows Phone[11].

2.1.2 Electronic Health in Ethiopia

The World Health Organization defines E-Health as 'the combined use of electronic communication and information technology in the health sector.' In more practical terms, eHealth is the means of ensuring that the right health information is provided to the right person at the right place and time in a secure, electronic form for the purpose of optimizing the quality and efficiency of health care delivery. eHealth should be viewed as both the essential infrastructure underpinning information exchange between all participants in the Ethiopian health care system and as a key enabler and driver of improved health outcomes for all Ethiopians. eHealth is a group name for all electronic systems that are working in the health domain of any country. Some of the major electronic applications that are implemented in Ethiopia and included in this group name are Electronic Medical/Health Record (EMR/EHR), Human Resource Management Information Systems (HRMIS), Mobile Health, and so forth.

2.1.3 Mobile Technology in Health

WHO defines mHealth or mobile-Health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. mHealth is considered as a component or subset of eHealth that brings tremendous benefits to patients, healthcare providers, healthcare payers and governments. Currently the health sector is using mobile devices for the purpose of providing health and health related services to the community living at all level. It is one of the best technologies to change the style of health service provision across the globe. There are many factors that trigger this change in the current health care delivery system. These changes are speedy advances in mobile technologies and applications, coming up of new chances for the integration of mobile health into existing electronic health services, continual growth in coverage of mobile cellular networks. The International Telecommunication Union (ITU) estimated that there are over 5 billion wireless subscribers; about 70% of them found in low- and middle income countries. The Global System for Mobile (GSM) communication association report depicted that commercial wireless signals cover 85% of the world's population; it is beyond the coverage of the normal electrical grid [12].

mHealth is one of the major components of eHealth. To date, many scholars, an international institution defines mHealth differently, due to this still now there is no standardized and clear cut definition for the word mHealth.

mHealth is the use of mobile technologies to support the achievement of health objectives. Mobile health is the practice of medical and public health service with the support of mobile devices. Most commonly used mobile devices in health are mobile phones, personal digital assistants (PDAs), patient monitoring devices, and other wireless devices. mHealth focus and consider the use of core mobile device features such as Short Messaging Services(SMS), Voice Services and Internet based mobile services .Thus, using mobile devices it is possible to mitigate the potential health problems as listed below [13].

- Disparities in access to health services
- Inadequacies of the health infrastructure within countries
- Shortage of human resources for health
- High cost of accessing health and
- Limitations in the availability of financial resources.

2.1.4 mHealth Programmatic Areas

The application of mobile devices in health is tremendously different. The health sector can use mobile phones in the context of various core business functions to further achieve institution goals or objectives. But most commonly mHealth can be applied in the following five programmatic areas.

Behavior Change Communication (BCC)

mHealth interventions are repeatedly used for mobilizing the community, creating awareness, educating the community, and also for creating more demands. It is very much know that mHealth BCC programs are the most leading of all mHealth interventions and also one of the most triumph mHealth applications in health programs. This is because the center piece of various health interventions is the use of low-cost SMS texts to reach various customers. As a

result, this short-term behavior changes have been seen, though humble. Most mHealth application which are currently running on are stand-alone interventions that uses solely one communication channel that is SMS text to distribute viable information to potentials customers or voice call channel to help customers come with some questions or sending data. Such kind of health interventions can reach all the community who are seeking necessary and very important health and health related information including adolescents, those most at risk, or people living in hard to reach areas. In addition, there are only a few BCC mHealth interventions have been related with other communication channels for instance radio or TV programs. Nevertheless, this is changing with dynamic growth and usage of mobile phones. Besides other new BCC mHealth Applications helps patients or peoples to daily monitor their own health status, such as tracking menstruation cycles to help with family planning [13].

Data Collection

One of the programmatic areas in the health sector of any country is to collect truthful, complete and timely information for decision makers and planners. Enhancing routine data collection and reporting is the focus in the health sector by identifying the challenges associated with timely reporting of routine data beginning from the lower to the higher health facilities. Currently, timely reporting of health and health related data are facing many challenges such as poor infrastructure, remoteness of the health facilities and health workers should travel some distance to report the data to the higher level, data quality and completeness and so forth. Therefore, mobile phones can be used to overcome such problems and thus enhance information use for action at all levels of the health system. And ultimately, use of mobile phones changing the health sector data collection and reporting systems to become more effective and efficient [14].

Finance

Financial transaction is a core business in the health sector system of any country. Nowadays, financial transaction in the health sectors is mostly supported by mobile phones. Mobile phone-based financial transactions, commonly referred to as mobile money, improve financial process and can be used to address core financial challenges or barriers to health care access for poor. Most poor peoples who are living at the remote areas and don't have access to health facilities will spend high money from their pocket and excessive transportation costs to get health facilities. In this regard, mobile phones can help customers or patients to receive the health care service at their home or wherever they are without travelling long distance and spending more money. In addition, mobile money can also facilitate insurance programs through flexible mobile phone-based premium collections for populations in hard to reach areas and flexible payment options to cover costs for transportation. Furthermore, at the provide side, mobile money has shown hope in facilitating cash based registration, paying salary for health workers, claim payments and, voucher reimbursement, which can enable health systems to expand reach to remote areas and increase access to healthcare services to the community living at all level. And also mobile money application in finance also allow registered users to load money into their accounts, make transfers to other users, and withdraw money. Financial transaction especially cash payments in the health system has many vulnerabilities such as security risks, fraud, and leakages. Mobile money solutions can make financing more secure and efficient by reducing costs, logistical constraints, and

administrative problems associated with cash transactions. Mobile money also offers easily-accessed and traceable audit trails, which can increase transparency and improve governance in the financing flows of a health system. A good starting point for determining where mobile money can be integrated in health programs is to document cash flows through the health sector and assess where it can be replaced with mobile payments [15].

Logistics

Supply chain management system of the health sector is the core business process designed and implemented to provide health and health related logistics to health facilities. Logistics comprises of the delivery of drugs, medical equipments which are important for medical diagnosis and treatment of the patient or the customers. The main challenge in the supply chain management system is medical equipment or devices are not reaching at the health facilities on time. Health sector are facing this barriers for many years because most of the logistics operation has been doing manually, and the data collected and compiled has many discrepancy from the reality. In the meantime, the rapid growth of mobile phone is a great opportunity for the health sector. Mobile phone can support the sector to collect, organize, compile and report timely logistics data to the higher level for evidence based decision making and planning process. Availability of high quality logistics data helps patients to receive the medicines they need on time and increase the quality of health care delivery to the community. Therefore, mobile phones allow a lower-level health facility to transmit information regarding their supply of essential medicines to the higher-level facility or warehouse which then provides the commodities [16].

2.1.5 mHealth Experience in Different Countries

2.1.5.1 mHealth in USA

USA is one of the largest countries where mobile phones are used for various health and health related business activities. One survey on mobile phone usage for health data search shows that speed up growth of mobile phones cause a shift in the way users are accessing health and health related important information. The survey depicted that 17% of cell owners have used their phones for exchange or surfing of health or medical information on the internet. The survey pinpointed that 29% of cell owners of the age group from 18 to 29 have done health information searches and 9% of them were using their cell phones for downloading health application which they use to help track and manage their health. The profound use of health or medical related applications was by young adults. Currently a few of service providers in USA are providing healthcare applications for counting calories and nutritioninformation, logging fitness workouts, providing health tips, to calculate disease risks, to calculate body mass index, for keeping personal health information, for providing users' health information to physicians and emergency workers etc. Amazingly, the uppermost use of cell phone health-information seeking and downloading cell phone health applications was among the age group 18 to 29 years old at 29% and 15% respectively. In general, the government of USA so much welcomed the use of mobile phones for the delivery of accessible and quality healthcare services to the peoples, and also it is one of the mechanism to save various cost expenses by individuals or groups of customers or patient who wants to get health care services at their home or nearby health facilities [17].

2.1.5.2mHealth in China

China is very eager about the potential advantages of mHealth. For example, one of the survey conducted in china showed that 80% of Chinese people believe that widespread adoption of mHealth solutions is predictable and will happen in the near future, that compares to 70% of people living in the USA and 60% of people in India surveyed responded similarly.

Very much likely how the coming of the internet and mobile phones becoming the foundation for excitement and enthusiasm regarding future possibilities. There has been a close intact between mobile health and consumers and doctors in the health sector. In China consumers are anxious about the health care system's lack of access, quality of services, clarity, as well as the burden of health care costs. Mobile health applications that will authorize them to take control of their health care have naturally become appealing solutions. The study showed that 45% of consumers surveyed hope to use mHealth as a way to create access to doctors more convenient and more effective; 36% believe that mHealth will also reduce health care costs [18].

2.1.5.3 mHealth in India

It is very formal to see mobile phones in the hand of poor and rich peoples of India. This is a country where billions of peoples are living and most of them are living in the rural areas. Using mobile phone in this country is one of the best option to provide healthcare services especially to the peoples who are difficult to reach them, don't have access to health facilities nearby, and facing problems of getting latest health and health related information and high level medical services. In this regard, m-Health provides healthcare access, as m-Health is based on mobile technology, healthcare through information and delivery, can better reach areas, people, and/or healthcare practitioners with previously limited exposure to aspects of healthcare. Recently communicable and non-communicable disease epidemics are becoming a threat to the health sector and together with shortage of healthcare professionals is a real challenge in developing countries like India in achieving the health related Millennium Development Goals (HR-MDGs). These problems can be solved by rapid growth of mobile phones offering a new opportunity in promotion of quality healthcare of Indian people. Mobile phones have been found to be an appropriate and very promising tool for disease control interventions in developing countries like India, where its use has been done in key diseases like HIV/AIDS and that too by way of bulk-SMS (push& voice) messaging and this is found to be well accepted by the population. Some instance of mobile application in public health system of India by way of mobile devices: Remote data collection, Delivery of healthcare information to practitioners, researchers, and patients, Real-time monitoring of patient vital signs, epidemic outbreak tracking, Patients education and awareness etc [19].

2.1.6 mHealth in Ethiopia

Ethiopia is at a pivotal moment in its efforts to improve the health status of its people and move the country into a new phase of social and economic development. Even as the country has made progress toward its health-related Millennium Development Goals (MDGs), the government and its partners realize that advances need to be accelerated if targets in maternal and child mortality and infectious diseases are to be achieved. Mobile technology is one potential avenue for doing so. Throughout the world, health service providers and decision

makers are trying to capitalize on the revolution in mobile communications to strengthen health systems and boost efforts at extending the reach of health workers into underserved communities. Hence, FMOH with a close collaboration of different partners has been implemented various mHealth initiatives which further improve the accessibility and quality of healthcare delivery at the health facilities [20]. Here below are a few of the promising mHealth projects implemented by different stakeholders found in Ethiopia.

Performance, Monitoring and Accountability 2020 Project

PMA2020 project is led by the Addis Ababa University's School of Public Health at the College of Health Sciences (AAU/SPH/CHS), in collaboration with regional universities, the Federal Ministry of Health and the Central Statistics Agency. PMA2020 is a five-year project that uses innovative mobile technology to support low-cost, rapid-turnaround, national-representative surveys to monitor key indicators for family planning. The major aim of this project is to use a mobile-assisted data collection system to conduct nationally representative surveys and disseminate data on family planning and water and sanitation indicators. PMA2020 surveys capture several key family planning indicators on demand and utilization. They also capture unique of access, choice and quality of family planning. Thus, the first round data collected and successfully completed in March 2014 and then the result was launched in May 2014 [21].

RapidSMS Nutrition Project, UNICEF-Ethiopia

UNICEF has previously used the RapidSMS platform for field data collection purposes in Ethiopia. The Ethiopia system was built to monitor the supply and distribution of a ready-to-use therapeutic food (RUTF) called Plumpy'Nut. With assistance from UNICEF Innovations, this platform was significantly modified to meet the needs of the Malawi INFSS system. From a technical requirements point of view, RapidSMS has extremely basic requirements. The RapidSMS platform is comprised of three parts – the end-user's mobile phone, the server-based backend, and the server-based frontend website. Minimum platform requirements include a central server with Internet access and attached GSM modems [22].

ENAT Messenger Project

ENAT messenger is mHealth initiatives developed and implemented with a consolidated effort of School of Information Science at Addis Ababa University (AAU), a consultant from the Federal Ministry of Health (FMOH), members of the MNCH program and the IT manager at CHAI. The ultimate aim of this project is to support and enhance the Maternal and Newborn Child Healthcare services using low cost mobile applications. The emergency nature of child birth, as it is very difficult to predict the onset of labor, means that emergency referral aided with an effective communication system is a must-have to facilitate the provision of life saving emergency services for mothers and newborns. The process of increasing uptake of Maternal and Neonatal Child Health (MNCH) services particularly for Skilled Birth Attendance (SBA) requires addressing the commonly known "three delays": delay in seeking care, delay in reaching care, and delay in receiving care. The following are functionalities of the SMS management sub-system of ENAT messenger; 1) Sending Reminder and 2) Receiving Confirmations [23].

EpiSurveyor Data Collection JSI/L10K Project

In Ethiopia the use of mHealth for strengthening its health systems is promising because the country has an extensive mobile network that reaches 85% of its population and provides web access allowing very efficient transmission of data. Accordingly, the L10K Project explored the potential of using mHealth and found that it was feasible to enhance its MIS by adapting EpiSurveyor, a web-based mHealth platform developed by DataDyne (http://www.episurveyor.org), without incurring expense for technical support. The adaptation of the EpiSurveyor required a very good understanding of survey database designs a skill that the Project's Monitoring and Evaluation team have. The EpiSurveyor allows users to develop questionnaires on its web-site which are then installed to a cell phone that can access the internet. The cell phone is used to collect data, offline, using the installed questionnaire; capturing information from remote areas where there is no mobile network. Whenever a mobile network is detected, the data collector is able to transmit the data from the phone to a remote EpiSurveyor server. The EpiSurveyor platform includes a data analysis tool that allows end users to analyze the data uploaded on the server. Thus, the time between data collection from remote areas and the time taken for programmatic action, is drastically reduced. Moreover, data quality is improved by reducing errors associated with manually aggregating data at the different management levels before it is computerized. The EpiSurveyor platform is free to use if the number of questions in a questionnaire is limited to 100 and if the number of records transmitted to the server do not exceed six thousand in a year [24].

2.2 Related Works

Real life examples demonstrate that m-Health solutions not only enhance prevention, diagnosis, treatment and monitoring of diseases but they also contribute to strengthen health care systems through improvements in emergency response, healthcare practitioner support, healthcare surveillance and administration. Across the diversity of global health programmes, innovative ways to leverage mobile technologies including wireless communications infrastructure have emerged and been applied in a number of settings. From the most basic application of mobile telephony – that of person to person communication by voice or text - to more sophisticated systems that provide health workers with decision-support tools, scheduling algorithms or point-of-care diagnostics, mobile phones are being seen as an additional tool in the global quest to improve population and individual health, as well as decrease pressure on healthcare systems and associated cost savings [25]. Here below are some brief descriptions of systems deployed in different countries which are related with this study.

Sri Lanka and India

The Real-Time Biosurveillance Program (RTBP) is a multi-partner research initiative to study the potential for new Information and Communication Technologies (ICTs) to improve early detection and notification of infectious disease outbreaks in Sri Lanka and India. Under the current systems in Sri Lanka and India, patient data from regional and community health centre is gathered using paper-based forms and procedures. These forms are then sent to regional health officials where data analysis is carried out by qualified staff to identify potential disease outbreaks. Notifications are then issued from the regional health

administrations to local authorities, again using paper-based reporting methods. Under the present system it can take up to 30 days for information to move through these various steps, leading to delays in both outbreak detection and notification. Leading experts in the field of Biosurveillance and health informatics have argued that improvements in disease detection and notification can be achieved by introducing more efficient means of gathering, analyzing, and reporting on data from multiple locations. The introduction of new information and communication technologies (ICTs) is regarded as a central means to achieve these efficiency gains. The primary research objective of the Real-time Biosurveillance Program (RTBP) is to examine these claims more closely by producing evidence to indicate in what ways and to what extent the introduction of new ICTs might achieve efficiency gains when integrated with existing disease surveillance and detection systems. The RTBP project is a pilot study that involves digitizing current paper-based procedures using advanced ICT components. A key step in this process is introducing an efficient and cost-effective means of digitizing patient data at front line health centers. Once indigital form, patient data can be transmitted immediately to a central server where rapid analysis can take place using statistical data mining software developed by the Auton Lab at Carnegie Mellon University [2]. Results of this analysis are then made available on an ongoing basis to regional and local health officials as electronic notifications accessible through a variety of means, including mobile phones [26].

Jordan

More than 622,384 Syrian refugees were registered in Jordan up to 7 January 2015, comprising approximately 10% of the entire Jordanian population. Communicable diseases remain of public health concern in Jordan and little to no information is known of the burden of mental health and non-communicable disease among displaced populations. There is a need to strengthen national public health surveillance in Jordan in order to monitor the epidemiology of priority public health diseases, conditions and events. A pilot public health surveillance project was initiated in Jordan in May 2014 that introduced case-based, integrated disease surveillance of mental health, non-communicable disease and communicable disease, and was programmed using mobile technology and an online framework. The clinician used the system within the consultation, which introduced clinical-decision support (of case definition, signs and symptoms, risk factors and laboratory advisories) as well as real-time reporting of information. Automated real-time notifications and alerts were generated, by SMS and email, within one hour of reporting to inform outbreak investigation and response at the appropriate level of decision-making.and could be accessed at all levels of MOH. Mobile information technology enables standardized, coded data to be collected, analyzed and reported in real-time. This is the first time mobile tools have been applied to national public health surveillance in Jordan. Data were entered electronically using mobile tools and uploaded in real-time for data analysis and reporting. Some of the diseases cases reported by SMS are Hepatitis A, Meningitis, Mumps, Measles, and Acute Flaccid Paralysis etc. Data is entered using XML forms and ODK mobile application Electronic forms were designed in Extensible Markup Language (XML) and presented on mobile devices using a customized version of the ODK Collect application (http://www.opendatakit.org). The Lenovo Idea Tab 7” A3000 and A3500 mobile tablets with Android operating system were used in clinics and data transmitted via 3G mobile data connection hosted by Orange. Data was collected from

mobile devices using Form Hub (http://www.formhub.com), a simplified framework developed at the Sustainable Engineering Lab, University of Columbia, to generate forms and receive data. The project used its own custom installation of Form Hub for hosting project data [27].

Pakistan

An estimated 17% of the 8.8 million deaths worldwide each year in children under five are attributed to vaccine-preventable illnesses. Through education and small incentives, Interactive Research & Development (IRD) hopes to decrease the burden of vaccine-preventable diseases by increasing the immunization coverage and timeliness among Pakistani children. IRD, in collaboration with the Government of Pakistan and the Department of Health in Sindh Province, implemented Interactive Alerts, a mobile phone-based vaccine registry system that uses SMS reminders to caregivers and conditional cash transfers to care givers and health workers to improve immunization coverage among children in and around Karachi, Pakistan [28].

Afghanistan

The Disease Early Warning System (DEWS) project began in December 2006, and for the past seven years has been Afghanistan's core surveillance mechanism covering multiple priority public health diseases, conditions, and events. USAID supports the Afghanistan Ministry of Public Health (MoPH) to implement DEWs by channeling funding and technical support through the World Health Organization (WHO). One aspect of the DEWS strategy involves indicator-based surveillance: on a weekly basis focal points gather and analyze information on a set of diseases and conditions. If the threshold for a specific disease or condition is reached, an alert is declared, DEWS staff investigates and respond within 48 hours, and confirmed outbreaks are reported to the provincial and national DEWS offices. All regional and all provincial DEWS officers surveyed had personal cell phones and uses their mobile phones to report to the higher level about the occurrence of diseases [29].

Bangladesh

Using nothing more than a common mobile phone, Bangladesh's SMS Gateway system has dramatically changed the time it takes for the government to receive and respond to reports of highly pathogenic avian influenza outbreaks. A combination of web-based software, infrastructure, skills and commitment has resulted in a dramatically effective model of rapid response to H5N1 HPAI. The process begins with a community animal health worker at the affected farm, and then moves through a diverse chain that includes upazila livestock officers, veterinary surgeons, couriers, laboratory scientists, the chief veterinary officer, and a rapid response team of culling workers. The Short Messaging System (SMS) Gateway system in Bangladesh was developed in 2010 by the Food and Agriculture Organization of the United Nations (FAO), with support from the United Stated Agency for International Development (USAID). By dialing a unique four-digit number that has been set aside by prior agreement between all cellphone service providers, a coded message from the field is relayed directly to a server at FAO. If the message indicates the suspicion of an outbreak, an automatic SMS from the server instantly alerts the Upazila Livestock Officer and the Additional Veterinary

Surgeon, who will arrange an immediate investigation. If the threat is assessed as real and serious, a sample carcass is collected and couriered to one of seven Field Disease Investigation Laboratories or the Central Disease Investigation Laboratory in Dhaka. If H5N1 HPAI is confirmed, then the flock is culled within hours**.** This real---time reporting using SMS has been contributing to effective HPAI outbreak response and control. The key to the success may be its simple approach and clearly defined work---sharing through the use of a familiar instrument (the mobile phone). Since October 2008, 21 HPAI outbreaks out of a total of 35 have been detected through this active surveillance program [30].

Swaziland

The strengths of Swaziland's malaria surveillance system include rapid case reporting through the Immediate Disease Notification System (IDNS), a surveillance system integrated with the notifiable disease system and surveillance outputs rapidly relayed to a team that can initiate a response. The health facility staff members use a toll-free phone number and promptly report cases to the IDNS. The system then automatically sends an SMS to the local NMCP program manager, as well as the surveillance team, with details of the case. Members of this group investigate the case within 48 hours. During the seasonal peak in malaria, additional surveillance agents were added for the first time in 2013 to improve case investigation and rate and timeliness of follow-up. Case details are collected at the health facility and include address and mobile phone number when available. The surveillance team then visits the case, collects additional information and conducts a response when necessary. All data are recorded on computer tablets that have built in GPS software and satellite maps, both of which support the surveillance team in locating households that need to be screened in response to a confirmed case. Confirmed cases and details of case investigations are reported weekly and monthly to the Health Management Information System, to ensure that it contains malaria data. Weekly goals, feedback and prioritization are provided to the surveillance officers to improve coverage rates and speed of follow-up and screening [31].

Zambia

Zambia's National Malaria Control Centre has implemented a rapid reporting system in response to decreasing levels of malaria in Southern and Western Provinces. Every week, health facility workers submit basic information on malaria burden by mobile phones that are enabled with a JAVA-based data entry form. Once data is entered into a phone, it is sent through a data-enabled mobile telephone network to a centralized data server. This server is pre-programmed with an Excel dashboard for convenient presentation of information and reports. Health officials can then access this data on the internet, viewing the local malaria situation in real time and monitoring facility-level progress in reducing malaria transmission. Importantly, this system links a community's malaria burden with its malaria commodities, thereby streamlining the supply chain. A process that used to take three or four months to complete now takes only one week, allowing countries critical time to respond to any changes in parasitemia rates [32].

Uganda and Senegal

In Uganda, UNICEF supported Uganda's National Task Force on Ebola to operationalize an mHealth platform, mTrac, into their response to the 2012 Uganda Ebola outbreak. mTrac enables real time alerts and surveillance and uses mobile phones via SMS from communities and health workers. It is viewed and managed through an online dashboard by District Health Teams (DHTs) and the Ministry of Health (MoH). mTrac's role in the fight against Ebola included: 1) engaging the community via a free SMS hotline to report suspected Ebola cases; 2) receiving suspected Ebola case alerts from DHTs and health facility workers free of charge; and 3) sending targeted MoH-approved messages to DHTs, health facility workers, and village health teams (VHTs) in the affected districts. The messages reached 2,000 DHTs and health facility workers in these districts every two days and also in tandem with the spread to new districts. In partnership with major mobile phone operators, Senegal's MoH sent four million SMSs to the general public warning of the dangers of Ebola and how to prevent it and encouraging individuals to alert health authorities of anyone showing signs of a fever and bleeding by calling a toll-free number. Sent in response to Senegal's first EVD case, the SMSs were delivered using the mDiabetes platform, which was developed with support from WHO, the International Telecommunications Union, and Alcatel-Lucent[33].

Tanzania

Tanzania is a country early understood the importance of mHealth for data collection; organization and analyzing health information for evidence based planning and timely decision making process. DHIS2 is a free, open source platform, which issued by Ministry of Health of Tanzania for collection and aggregation of data about health indicators. In the mean time, this system can be tailored to any reporting needs, and where the user organization is in charge of defining the data elements and indicators of their installation. The DHIS2 also has a mobile phone module, so that data can be reported from a phone and entered directly into the national database and data can be returned to the phone. This architecture thereby allows extending the national database with a mobile phone interface into villages without electricity. In this sense, it differs from many stand-alone mobile phone applications, where the data is not distributed further than the receiving computer. The technology works on the lowest cost Java enabled phones. The phones have a built in application, which transmits SMS to the server. The server has an installed GSM modem and it converts the SMSs and imports the received data into the DHIS2 database. The mobile phone module of DHIS2 was used for developing the handset application. The functionality is presented to the user in a series of steps. After selecting the date, the user needs to enter the data element values in a sequence. The form has thirteen data elements which report data on the cases of diseases for less than 5 years, cases of diseases for above 5 years, Deaths due to the disease for less than 5 years and Deaths due to diseases for above 5 years. At the server side, automatic import of messages occurs when the SMSs get received from the phones while the SMS Service is running. If the service is not running, the messages will be stored in the computer and can be imported when starting the SMS Service software. Upon receipt of the weekly report, the DHIS2 application sends an acknowledgement SMS to the health provider. If the report is not received during the week, the message below is sent to the health provider. "Your report for this week is not received" [34].

Kenya

Kenya is one of the countries which had implemented Integrated Disease Surveillance &Response (IDSR) system on the basis of World Health Organization guidelines and procedures. Most common reportable disease lists are; Adverse events following immunization , Anthrax , Cholera, Dengue Fever, Dysentery , Guinea worm disease , Measles , Neonatal Tetanus , Plague , Rift Valley Fever, Severe respiratory illness , Viral Hemorrhagic Fever , Yellow Fever and Any public health event of international concern which are very much similar with immediately and weekly reportable disease list of Ethiopia. Consequently, they used Mobile SMS-based disease outbreak alert system called mSOS to collect, organize and analysis information about disease outbreak and response. The major functions of mSOS are; 1) Health facility workers send information, 2) Server sort's messages according to threshold levels and 3) Suspected outbreak information received by MOH [35].

CHAPTER THREE

Methodology

3.1 Introduction

A phased development methodology of object- oriented approach was applied to the study of the design system. Interview and document analysis were used as the main tools to capture the business system requirement along with observation. Unified modeling language (UML) development techniques applied in the process of requirements capture, model organization business system and design. Visio and Argo UML Software were employed in analysis and design models diagramming. Besides, the study result disseminated to the responsible stakeholders by considering ethical issues with the appropriate operational definition.

3.2 The Study Setting

The study is conducted in Ethiopia Public Health Institute formerly known as Ethiopia Health and Nutrition Research Institute. It is one of the oldest research institutes and /or agencies which are governed by Federal Ministry of Health of Ethiopia. One of the core business functions of the organization is Public Health Emergency Management (PHEM). PHEM is the process of anticipating, preventing, preparing for, detecting, responding to, controlling, and recovering from the consequences of public health threats in order that health and economic impacts are minimized. PHEM is designed to ensure rapid detection of any public health threats, preparedness related to logistic and fund administration, and prompt response to and recovery from various public health emergencies, which range from recurrent epidemics, emerging infections, nutritional emergencies, chemical spills, and bioterrorism. The activities under this core process are to be implemented by appropriately trained and capable professionals. This core process is comprised of four sub-processes which are: *Public Health Emergency Preparedness, Early Warning, Response, and Recovery*. It is located in North-West part of Addis Ababa in Gullele Sub-city. The major public health risks identified in the Ethiopian health system are listed below. Note that the lists are in order of priority – from high priority to low priority.

- Epidemics of communicable disease
- Drought conditions with malnutrition
- Food contamination
- Flood

Currently there are 250 health professionals and 255 supportive staffs working in the institute.

3.3 Source and Population

The source population of the study was staffs working at EPHI. And the study populations are all health professionals and others who are directly or indirectly working on PHEM

activity. Deputy Director General, PHEM and ICT Directorate Directors and end user of the system were included in the study. Observation of the overall activities to seek additional information was done.

3.4 Sampling

Due to routine work and other daily business operation it is difficult to get all the responsible experts for interview. Therefore, purposive sampling technique was employed to conduct interview and collect all the necessary information.

The study covered 11 experts and concentrated within specified institute that is EPHI. The study included Deputy Director General (1), PHEM and ICT Directorate Directors (2) and end users of the system (8).

3.5 Software Development Life Cycle (SDLC)

A systems development life cycle is composed of a number of clearly defined and distinct work phases which are used by systems engineers and systems developers to plan for, design, build, test, and deliver information systems. An SDLC aims to produce high quality systems that meet or exceed customer expectations, based on customer requirements, by delivering systems which move through each clearly defined phase, within scheduled time-frames and cost estimates. To manage this level of software development life cycle, a number of SDLC models or methodologies have been created, such as "waterfall".

3.5.1 Water Fall Approach

The total time given for the accomplishment of the project was about 4 months and also selected respondents from the study area, source and study population were not available all the time to collect the relevant information. Therefore, for delivering the project within the specified time and due to the constraints of other resources Water Fall software development methodology is applied in the study. This method follows the following major phases in a sequential manner.

1. System Investigation phase
2. System Analysis Phase
3. System Design Phase
4. System Implementation or coding phase
5. System Testing phase
6. System Deployment phase
7. System Maintenance phase

3.5.1.1 System Investigation Phase

Requirement Collection Instruments

Requirement collection instruments are used to collect detail and relevant information from managers and end users who are actually responsible and work on the current PHEM system. It has helped us to collect the functional, non-functional requirements and also development of the mobile application.

The requirement were collected using different types of instruments, including document review, observation, and interview. Interview was conduct for 11 peoples. It's used because through interview the feeling and opinions of the peoples can be understood easily rather than observation and documentation analysis. Interview and document analysis were used to know about how the existing system works especially to see how the data is collected, organized and summarize for report purpose , and also the different manual format they used for data entry and communication and hardware and software aspects existing infrastructure assessment through observation and document analysis was done.

Interview Guide

The interview guide is taken from other similar study that was mSOS mobile application deployed in Kenya, and adopted with the context of this study. Interview guide of Deputy Director General, PHEM and ICT Directorate Directors and end user of the system includes questions about their opinion, resource available, experiences/lessons learned, future plan and recommendation about the application of this study in the institute.

Data/ Requirement Collection Instruments

Requirements for the project were collected from PHEM experts in the institute, in order to gather facts and opinions through interview, observation and document review;

- **Interview**

  In this project, Deputy Director General, PHEM and ICT Directorate Directors and end user of the system were interviewed about the current paper based system and related business in order to identify the core problems that are happing in the existing system. Most of the functional and non-functional problems of the designed and developed system are identified using interview guide.

- **Observation**

  The current business process, the data flow of the current system in general the day to day activities were observed in order to identify problems with the current system which is the PHEM system.

- **Document review**

  Some literature reviews, formats, guidelines which are cased based RF influenza, weekly reporting format, cased based laboratory reporting format, daily epidemic reporting format, line list and AFP case investigation history formats and PHEM guidelines were reviewed to understand and define problems.

3.5.1.2 System Analysis Phase

After requirement was captured using the interview, observation and document review the result was analyzed. The result was presented being summarized from the notes taken during the requirement collection. The result of the system modeling that helps to understand the system models used for analysis of the system was done using tools like the use cases, contextual diagram, flow chart, DFD (Data flow Diagram).

Models

A model is a representation of an important aspect of the real world. It is sometimes called an abstraction as it is used to separate out and aspect of particular importance. Data depiction were made using the following models

- System Use Case Description
- Contextual Diagram
- Data Flow Diagram
- Class Diagram
- Activity Diagram
- Entity Relationship Diagram

Tools

A tool in software development is software support that helps create models or other components required in the project. The tools used for analysis and design in this project were.

- Microsoft Visio for drawing various modeling diagrams
- MYSQL Database Applications to store information
- Microsoft Project for planning

Techniques

A technique in system development is a collection of guidelines that help an analyst complete a system development activity or task. The techniques used in SSADM are logical data modeling, data flow modeling and entity behavior modeling.

- **Logical Data Modeling**

  The process of identifying, modeling and documenting the data requirements of the system being designed. The result is a data model containing entities (things about which a business needs to record information), attributes (facts about the entities) and relationships (associations between the entities).

- **Data Flow Modeling**

  The process of identifying, modeling and documenting how data moves around an information system. Data Flow Modeling examines processes (activities that transform data from one form to another), data stores (the holding areas for data), external entities (what sends data into a system or receives data from a system), and data flows (routes by which data can flow).

- **Entity Event Modeling**

  A two-stranded process: Entity Behavior Modeling, identifying, modeling and documenting the events that affect each entity and the sequence (or life history) in which these events occur, and Event Modeling, designing for each event the process to coordinate entity life histories.

3.5.1.3 System Design Phase

In this phase the system and software design is prepared from the requirement specifications which were studied in the first phase. System Design helps in specifying hardware and system requirements and also helps in defining overall system architecture. The system design was done on the basis of the functional and non-functional requirements identified on the previous phase. We used Microsoft Visio 2007/2013 to design the architecture of the mobile application developed, and also we used hard paper to depict the lower level user interface design of the mobile application.

3.5.1.4 System Implementation/Coding Phase

In this phase, the prototype mobile application is developed which address all of the functional and non-functional requirements which were identified in system analysis phase of SDLC. We used eclipse platform with integration of android development tool with java based programming language.

3.5.1.5 System Testing Phase

We used formative usability testing to maximize the usability of the prototype mobile application developed. The prototype mobile application is tested against the requirements to make sure that the system developed is actually solving the needs address and gathered during the requirement phase.

Phases of the software development	**Models and Techniques**	**Tools**	**Methods**
Feasibility, requirement gathering /planning phase	• Interview • Observation • Document analysis	• Questionnaire • Observation Checklist	Water fall approach
Analysis phase	• System Use Case Description • Contextual Diagram • Data Flow Diagram • Class Diagram • Activity Diagram • Entity Relationship Diagram	• Microsoft Visio 2007/2013	
Design phase	• Architecture layout of the proposed system. • Working process of the mobile application. • User interface design	• Microsoft Visio 2007/2013	

	diagram		
Development Phase	➲ Object Oriented Analysis and Design Programming	➲Android Development Studio with Eclipse platform ➲Android Based Open Source Code	
Testing Phase	➲ Informal software usability testing	➲ Questionnaire checklist	

Table 2: Summary of methods, techniques, and tools used in each phase of the project

3.6 Methods of Dissemination of Result

After the study is completed, the report will be forwarded to Ethiopia Public Health Institute where the study was conducted and to AAU as partial fulfillment of MSc degree in health informatics.

3.7 Operational definition

Data Flow Diagram: is a graphical representation of the "flow" of data through an information system, modeling its process aspects. Often they are a preliminary step used to create an overview of the system which can later be elaborated.

Data Flow Model: A data flow model is diagrammatic representation of the flow and exchange of information within a system. Data flow models are used to graphically represent the flow of data in an information system by describing the processes involved in transferring data from input to file storage and reports generation.

Mobile Application: is defined as the use of short message service features of mobile phones for the primary purpose of providing and exchange data or information.

Entity Relationship Diagram: An entity-relationship diagram (ERD) is a data modeling technique that graphically illustrates an information system's entities and the relationships between those entities. An ERD is a conceptual and representational model of data used to represent the entity framework infrastructure.

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

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

Use Case Diagram: is a graphic depiction of the interactions among the elements of a system.

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

CHAPTER FOUR

Analysis and Design of the System

In this chapter the current system, the business process, the functional and non-functional requirements were determined. Use cases, process models, data models and the design of the system are presented. In addition, each models, tools and techniques were discussed and explained based on each phases of SDLC as shown below.

4.1 System Investigation

4.1.1 Business Process Description

Public Health Emergency Management (PHEM) is one of the core processes which comprise the following four mandatory sub processes.

Public Health Emergency Preparedness Sub-process

The business process of the public health emergency preparedness department is described as follows;

Preparedness is defined as "the range of deliberate, critical tasks and activities necessary to build, sustain, and improve the operational capability to prevent, protect against, respond to, and recover from incidents". Preparedness activities and tasks are those things that should be done prior to the occurrence of emergency. Development of plans, procedures, protocols, and systems; establishment of mutual aid agreements; provision of training; and the conduct of exercises are among other preparedness tasks. The public health emergency preparedness capabilities include:

- Putting in place the necessary logistics and funding,
- Building the essential systems specific to protection, prevention and response;
- Equipping public health personnel and respondents with the necessary knowledge and tools, and
- Educating the public on related measures to be taken to prevent and control the event.

Early Warning and Surveillance Sub-process

The business process of early warning and surveillance department is described as follows;

In this process public health threat would be identified closely and frequently monitored and predicting the risk it poses on the health of the public and the health system. An early warning system uses an event-based surveillance and indicator-based surveillance, to monitor threats, risks and priority diseases respectively. As a basic principle of public health intelligence, both components are given equal attention and processed in the same way, since a signal leading to a public health alert can originate from either of one as shown in the diagram below.

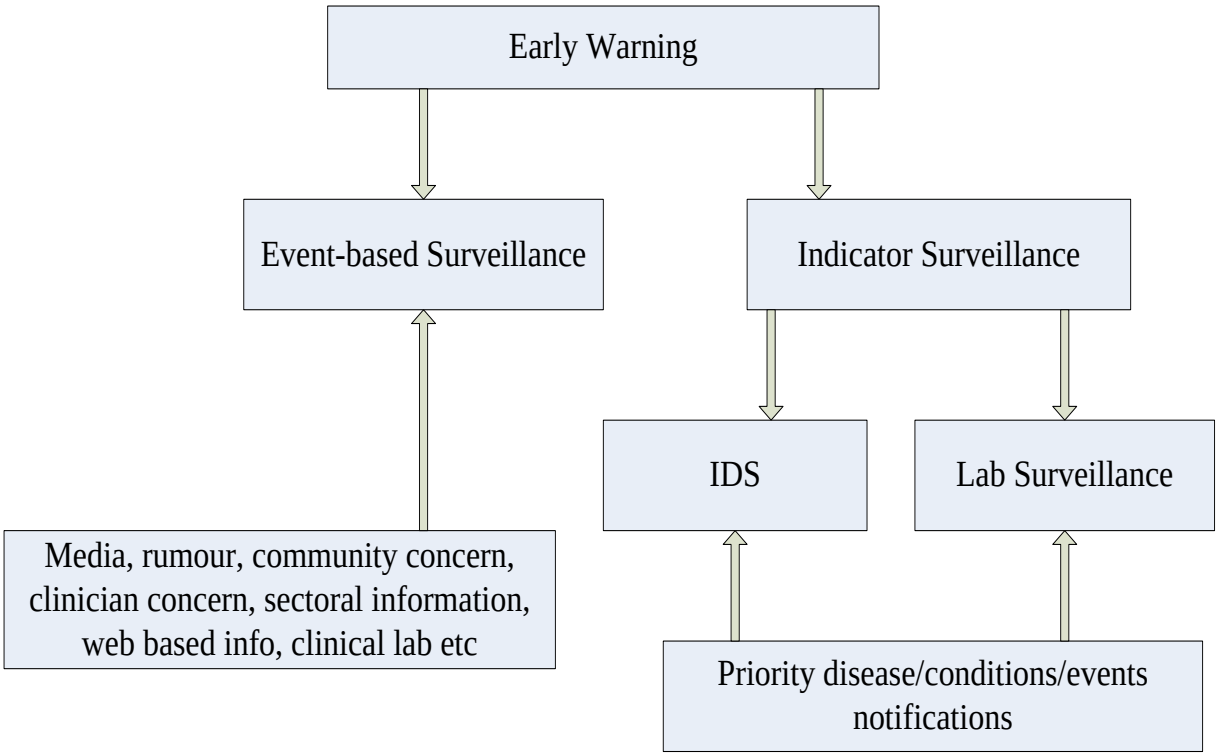

Figure 1: Components of Early Warning System

Public Health Emergency Reponses Sub-process

The business process of early warning and surveillance department is described as follows;

The public health emergency response sub-process focuses on rapid assessment of outbreaks, outbreak investigations, implementing control and prevention measures, and monitoring of the interventions. Upon receipt of an alert, rumor, or detection of a deviation the disease or condition from the expected trend while performing weekly surveillance data analysis, communicate the respective level immediately for verification. For some communicable diseases, a single suspect case is the trigger for taking action, reporting the case to a higher level, and conducting an investigation. For other diseases, the trigger is when a case threshold is reached.

Recovery Public Health Emergency Sub-process

The business process of Recovery Public Health Emergency Department is described as follows;

Recovery is the process of rebuilding, restoring, and rehabilitating the community following an emergency, but it is more than simply the replacement of what has been destroyed and the rehabilitation of those affected. It is a complex social and developmental process rather than just a remedial process. The manner in which recovery processes are undertaken is critical to their success. Recovery is best achieved when the affected community is able to exercise a high degree of self-determination. There will be parallel plan and activities aimed at protecting lives and reducing disease, malnutrition and disabilities among the vulnerable populations in the affected areas, and strengthening of longer term health development goals.

Recovery is a complex and long running process that will involve many more sectors and participants. Therefore recovery plans are implemented and coordinated with all responsible government sectors at all levels, in collaboration with the non-profit sector and nongovernmental relief organizations. Economic and social impacts estimation and priority setting for recovery activities have to be made together. Some of the major activities that should be done in this process are:

- Remain vigilant about outbreak /possibility of any epidemics and take effective steps against them.
- Determine the need for recovery or rehabilitation (sanitation, temporary settlements, psychosocial assistance, reconstruction etc.) and disseminate those needs to partners.
- Send reports of health related activities in affected areas to the national level for future planning purposes.
- To account for expenditures and determine the cost of the emergency.
- Organize, when appropriate, a lessons learned workshop or meeting for improving future preparedness and response. Consider the convenience of including selected (most active) partners in this exercise.

4.1.2 Presentation of the Data Collected

Interview

The following questions were asked with respective responses during the semi structured interview.

- **Major activities carried out in PHEM business**

There are four major sub-processes in PHEM directorate. In these sub-processes there are many activities has been done so far. Some of the major activities are early preparedness which means that planning for logistics and funding to be ready for early response whenever epidemic occur. Early warning and surveillance which means that continual follow up of disease occurrence related information beginning from the community up to federal level. The other is early response which comprises of rapid assessment of outbreaks, outbreak investigations, implementing control and prevention measures, and monitoring of the interventions. Collecting, organizing and analyzing immediately and weekly disease outbreak data collected. The last major activity is recovery, is the process of rehabilitating the community affected by the disease outbreak.

- **Customers of PHEM and their types**

The community living at all level, health posts, health centers, hospitals, woreda health bureaus, zonal health bureaus, regional health bureaus and also local and international non-governmental offices.

- **Services they accept and or rendering to the PHEM system**

Proving technical and financial support, reporting disease outbreak data daily and weekly, and also requesting and getting reports on the occurrence of disease outbreak.

- **Services incorporated into database information system**

Daily and weekly reportable disease outbreak data would be incorporated into the database information system.

- **Data captured and going on each activity**

Data can be captured from the following forms:

- Weekly Reporting Form for HEW
- Weekly Reporting Form For Out Patient and Inpatient Cases and Death
- Daily Epidemic Reporting Form only For Woredas
- Daily Epidemic Reporting Form only For Region
- Line List for HF to Woredas/zone/region/National PHEM and for Use during Epidemics
- Case Based Laboratory Reporting Form for National, Regional or Hospital Lab Use Only
- Case Based Reporting form from HF-Woredas Health Officer- and/or Regional/National Lab
- Case Based RF Influenza
- AFP Case Investigation Form

- **Rules, guide lines and standards guiding for PHEM related activities**

Every health facilities and/or institutions has PHEM guideline document. The relevant guidelines and standards are already mentioned in this document. Therefore PHEM related health services would practice by this document.

- **Parties involved in PHEM activities or transaction**

Community Health Promoters, Health Extension Workers, IPD/OPD clinicians, PHEM Focal Person or Surveillance Officer , Deputy General Director and Directorate Directors .

- **Reports that organized**

Daily, weekly, quarterly, six month, annual report by disease, health post, health center, hospitals, woreda, zone, region and national level.

- **Current manual PHEM system supported by electronic system**

We don't have completely functional electronic system which helps us to collect and generate a report based on our needs but there was one electronic system developed by Tulane University but not that much functional. Besides lack of infrastructure including electricity and ICT infrastructure are the main barriers not to use the software developed by our partners. , and still we are using the manual system for our daily business operation.

- **Problems of the electronic PHEM system**

This electronic system did not generate daily, weekly, monthly, quarterly, six month, annual report rather we are using it just to collect data from few health facilities and/or institutions. Data organization and analyzing has been done by excel.

- **Current manual PHEM system supported by mobile application**

In most cases disease outbreaks have been occurred in the community where very much difficult to carry medical supplies and collect information due to lack of mobile technologies and other related infrastructures. Consequently, we believe that rapid growth of mobile technologies will help us to exchange information and make timely decisions without the limit of distances between the community living at the remote site and also health facilities and / or institutions.

In general the above question number 1 helped to get the blueprint of the activities, no. 2 and 7 helped to find actors of the system, no. 3 and 4 to understand the business domain, integration domain respectively. Whereas question no. 5 served a tool for class and attributes articulation, no. 6 and 8 consisted the business rule and report requirements respectively, and no. 9, 10 and 9 to understand gaps and identify the functional requirement of the new systems.

Observation

Microsoft excel used for gathering of information, organizing, sharing and communication of disease outbreak data were observed. The eHMIS/PHEM software which was originally developed for PHEM related activities not that much usable by EPHI/PHEM department experts. At the health facility level we have seen eHMIS/PHEM software for data entry and sending of reports to the higher level.

Document Review

PHEM guideline document which was prepared by FMOH and EPHI with the collaboration of other responsible stakeholders was the major source of information for this study. The major functional requirements of the study were taken from this valuable document. For instance the list of 13 immediately and 7 weekly reportable diseases lists names. In addition early warning and surveillance sub-process diagram and also case based reportable disease list form was also taken from this document.

4.2. System Analysis

4.2.1 Requirement definition

The requirements definition report usually called the requirements definition— is a straight forward text report that simply lists the functional and nonfunctional requirements in an outline format.

4.2.1.1 Functional requirements

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

- The system should be able to register new users account including its address
- The system record information about Acute Flaccid Paralysis (AFP) / Polio
- The system record information about Anthrax
- The system record information about Avian Human Influenza
- The system record information about Cholera

- The system record information about Dracunculiasis / Guinea worm
- The system record information about Measles
- The system record information about NNT
- The system record information about Pandemic Influenza A
- The system record information about Rabies
- The system record information about Smallpox
- The system record information about SARS
- The system record information about VHF
- The system record information about Yellow Fever
- The system record information about Dysentery
- The system record information about Malaria
- The system record information about Meningitis
- The system record information about Relapsing fever
- The system record information about Severe Malnutrition
- The system record information about Typhoid fever
- The system record information about Typhus
- The system sends the recorded immediately and weekly reportable disease information to the next higher level.
- The system updates user account.
- The system records case based laboratory results

4.2.1.2 Non functional requirements

A nonfunctional requirement describes user behavioral properties that the system must have, such as performance and usability. The ability to access the system using mobile phones would be considered a nonfunctional requirement. The non functional requirements correspond to the process of explaining the features, characteristics, attributes, and constraints of the information system used to limit the boundaries of the proposed solution. The nonfunctional requirements describe a variety of characteristics regarding the system:

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

Virus Control Requirements; systems require that all information systems permitting the import or upload of files (information about disease occurrence) check those files for viruses before they are stored in the system.

Availability: - The system should be available all the time 24 hours/day, and there should be electricity to charge the mobile phones and to make mobile phones available all the time, and back up source such as UPS or generator for the main server to work the system without interruption.

Maintainability; the system will be easily maintained by the developer as well as other authorized trained person. The system will also be modifiable at any time to enhance features based on the office needs. As needs change from time to time the original system will be

made available to fill the gap between the system and the newly emerging needs. The system could be enhanced by adding new functionalities without necessarily changing the basics.

Error handling; - the system is expected to handle errors encountered during run time. Errors could arise from users and from the system. Errors that occurred from the wrong doing of users will be handled by appropriate exception handling mechanisms.

Performance; - performance is an important issue for the system because one of the drawbacks of the current system is performance issue. So this system makes fast the activities by exchanging viable information in real time.

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

Quality issue; - Quality can be achieved through reliability, availability and robustness of the system. The system should be designed to have the best quality.

4.2.2 Identified actors

No	Actors	Description
1.	Community Health Promoter(CHP)	CHP refers to a person who will identify priority conditions for notification and upon encountering events/conditions notify the HEW or the nearest available health facility and administrative level.
2.	Health Extension Workers	HEWs refers to health professional who will receive disease report from CHP and conduct further investigation on priority conditions for notification and upon encountering events/conditionsnotify the nearest available health facility and administrative level.
3.	OPD clinician	Refers to health professional who will investigate the case using the standard case definition identify priority conditions for notification and detection of cases in addition to using the available laboratory service for confirmation of some diseases and inform to PHEM focal person at the HC.
4.	IPD clinician	Refers to health professional who will investigate the case using the standard case definition identify priority conditions for notification and detection of cases in addition to using the available laboratory service for

		confirmation of some diseases and inform to PHEM focal person at the HC.
5.	PHEM Focal Person at HC	Refers to the person who shall assess the situation to verify the report and communicate immediately the result to the woredas.
6.	PHEM Focal Person /Woredas Health Office Surveillance Officer/	Refers to the person who will collect data, check for consistency, timeliness, completeness, conduct analysis and interpretation and send alert to neighboring woredas and concerned stakeholders.
7.	PHEM Focal Person at Regional Level/ Regional Health Bureau Surveillance Officer/	Refers to the person who will collect data, check for consistency, timeliness, completeness, conduct analysis and interpretation and send alert to neighboring regions and concerned stakeholders.
8.	PHEM Focal Person at Federal Level	Refers to the person who will collect data, check for consistency, timeliness, completeness, conduct analysis and interpretation and send alert to concerned stakeholders.
9	Administrator	Refers to the person who will manage the database by creating databases, tables, and make SQL queries and also create user accounts for the users.
10	Programmers	Refers to the person who will manage future expansion of the mobile application whenever new requirements come from customers or different parties who are working on the system.
11	IT Support Technicians	Refers to the person who will provide technical support on the usage of the mobile application to end users of the system.

4.2.3 Identified Use Cases

- Login on Mobile Application
- Register and Send Disease Data
- Generate Alarm Message
- Generate a Report

4.2.3.1 System Use Case Description

Use Case 1: Login on Mobile Application

Use Case ID	UC_1
Use Case Name	Login on Mobile Application

Priority	High
Stakeholder And Interests	Wants to log into the system
Primary Actor	User (Community Health Worker, Health Extension Worker, OPD Clinicians, IPD Clinicians, PHEM Focal Person at Health Center, Woredas, Regions, City Administration and Federal.)
Trigger	When the user starts the mobile application
Pre-Condition	The user must have user name and password
Post-Condition	The user logs into the system
Process of Main Courses	1. The system displays the log in screen. 2. The user enters the username and password 3. The system verifies the information and set access permission. 4. The system will display the main screen. 5. Use Case Ends
Alternative path	3a. If the username or password is not valid, an error message is displayed. I. The user clicks an ok button. II. The user is returned to login screen and reenters user name and password.
Frequency of Use	40-50/month
Business rules	After 3 trial the system shutdown automatically

Use Case 2: Record and Send Disease Data

Use Case ID	UC_2
Use Case Name	Register and Send Disease Data
Priority	High
Stakeholder And Interests	Wants to record and send disease data to the next higher level
Primary Actor	User (Community Health Worker, Health Extension Worker,

	OPD Clinicians, IPD Clinicians, PHEM Focal Person at Health Center, Woredas, Regions and City Administration.)
Trigger	When the system display the two disease data entry form
Pre-Condition	The user is logged in to the system
Post-Condition	The disease data is recorded and sent to the next higher level
Process of Main Courses	1.The system displays main menu screen 2. The system display two disease data entry form 3. The user select immediately reportable disease form 4. The system display immediately reportable disease form 4.The user fills the form and submits to the system 5.The system validates and adds disease information on the database 6. Use Case Ends
Alternative path	2.1To register weekly reportable disease 3.1.a The user selects weekly reportable disease form 4.1.aThe system display weekly reportable disease form 5.1.a The user fills the form and submits to the system
Frequency of Use	30/month
Business rules	The case is under notifiable for Health Centers, Woredas, Regions, City Administration and Federal Public Health Emergency Management office or Bureaus.

Use Case 3: Generate Alarm Message

Use Case ID	UC_3
Use Case Name	Generate alarm message
Priority	This use case describes epidemic identification process
Stakeholder And Interests	Stakeholders wants to be aware about the occurrence of epidemic early
Primary Actor	The system start to recognize the expected level of the disease
Trigger	The system start to recognize the expected level

Pre-Condition	All data has been registered in the system database
Post-Condition	The system sent alarm or notification message by SMS /email to the user
Process of Main Courses	1. The system start to recognize over the expected level 2. The system identifies an epidemic 3. The system produces alarm message 4. The alarm message is sent to the responsible actors 5. Use Case Ends
Alternative path	2.1 If there is any pattern change 3.1 The system send notification message about the condition
Frequency of Use	330 /month
Business rules	All the responsible stakeholders should be awarded about the occurrence of epidemic to take action as soon as possible.

Use Case 4: Generate a Report

Use Case ID	UC_4
Use Case Name	Generate a Report
Priority	This use case describes generating a report
Stakeholder And Interests	Stakeholders' wants to get the report for the purpose of evidence based decision making and planning process.
Primary Actor	Ethiopia Public Health Institute/PHEM Department
Trigger	When the responsible user click on the report menu
Pre-Condition	The user has logged in to the system
Post-Condition	Report generated
Process of Main Courses	1. The system displays main menu screen 2. The user clicks on the report button 3. The system displays the report option 4. The user selects the daily report option by cases, facility etc 5. The system generates daily report

	6. The user saves and/or print out or email the report for EPHI/PHEM Department, EPHI- Deputy General Director and so forth 7. The system adds the information on the database
Alternative path	3.1 If the user want to generate weekly reports by cases, facility etc 3.1a The user selects weekly report by cases, facility and so forth 4.1a The system generate the report
Frequency of Use	34 /month
Business rules	Real time data entry has performed

4.2.4 Process Modeling

A process model is a formal representation of how a given business process functioning or operates. It depicts the various activities that are performed and how the data move among the different activities. In addition, a process model can also be used to document the current properly functioning system or the new system being developed [36].

4.2.4.1 Contextual Diagram

Contextual diagram is the first data flow diagram in every business environment whether it is manual or computerized system. As the name indicates, contextual diagram depicts the complete picture of the system in context with its environment. It represents the overall business process as one business process contextually.

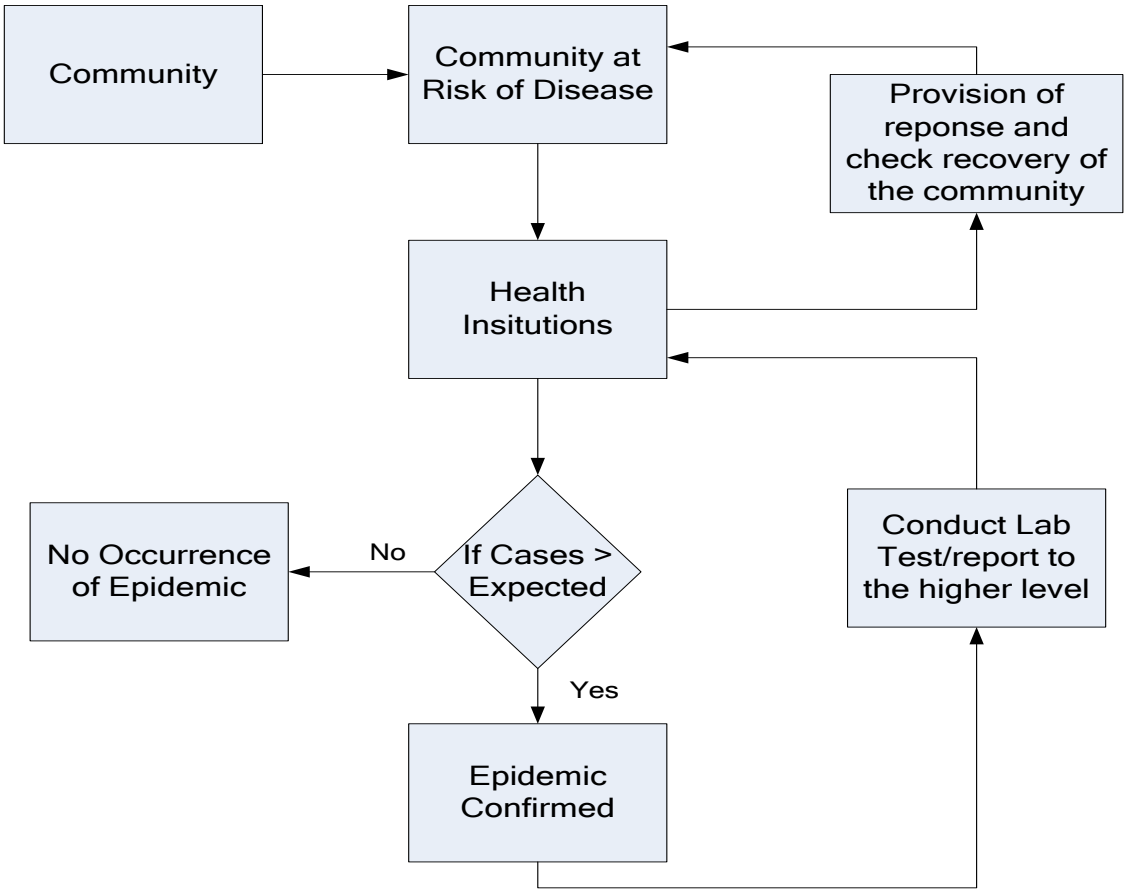

Figure 2: Contextual Diagram

4.2.4.2 Data Flow Diagram

It is the most commonly used way of designating the processing of current and future intended systems. As the name indicates, it is pictorial way of depicting the flow of data into, around and out of the system [37].

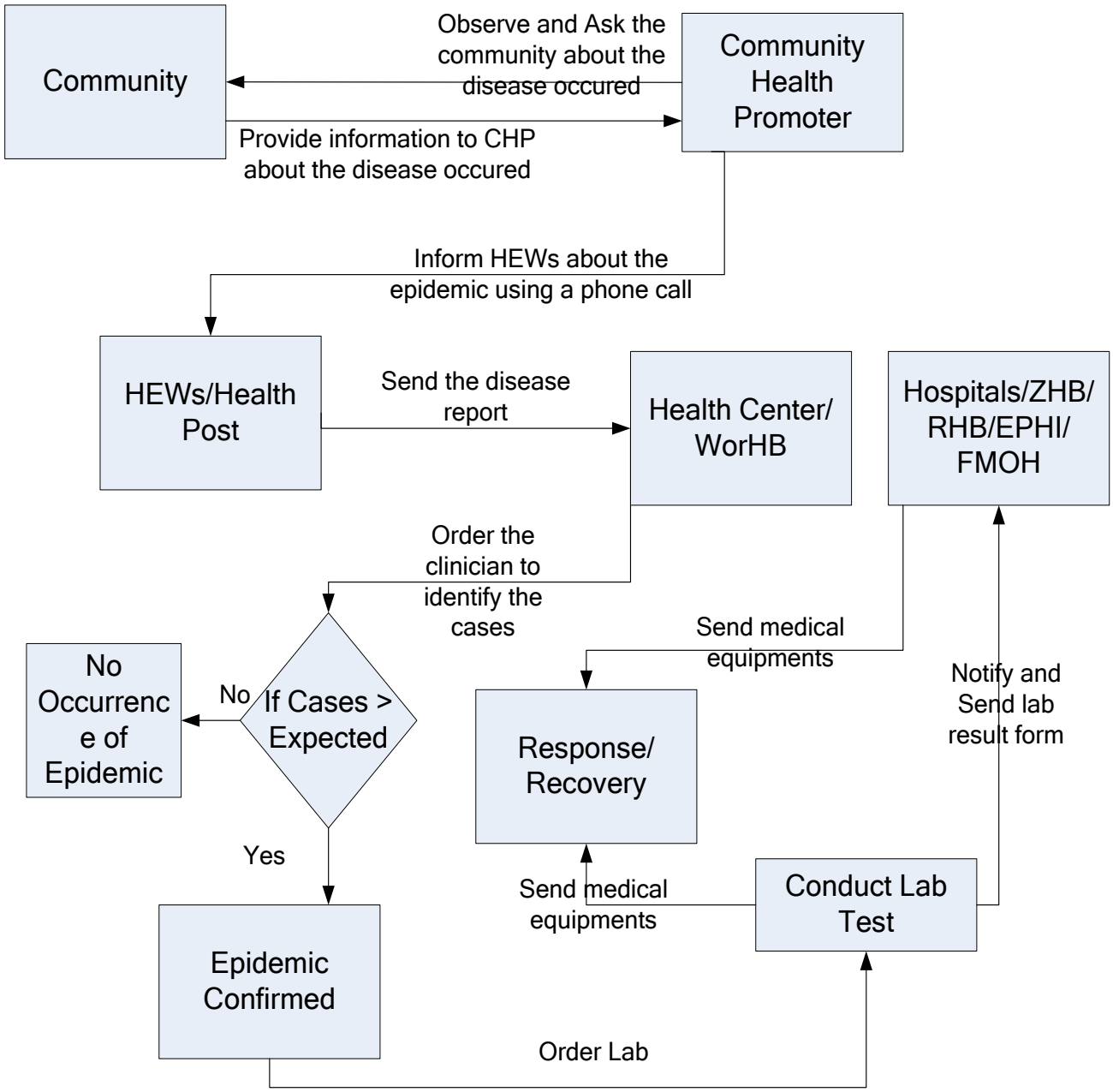

Figure 3: Data Flow Diagram

4.2.5 Entity Relationship Diagram (ERD)

Relationships are associations between entities, and they are shown by lines that connect the entities together. Every relationship has a parent entity and a child entity, the parent being the first entity in the relationship, and the child being the second.

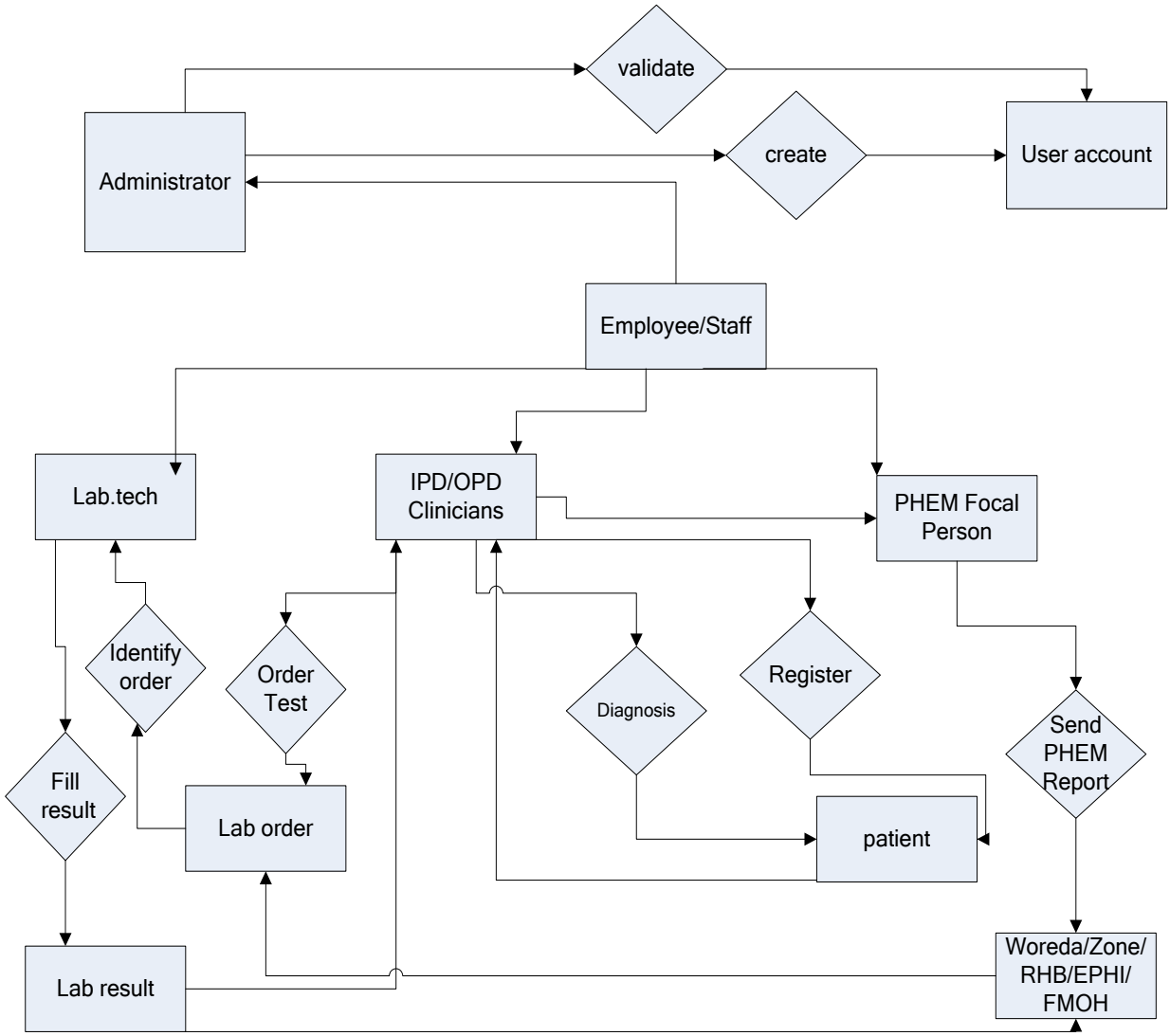

Figure 10 Entity Relationship Diagram

4.2.6 Class Diagram (CD)

Class Diagram shows the diagrammatic specifications of the software classes and interfaces in an application to be developed and implemented. It shows the definition of the software classes rather than the reflection of the real world concepts. Furthermore, it expresses the definition of the software classes as software components [38].

Entity and Attributes

Table 1 User Attribute Description

Table 2 User Role Attribute Description

Table 3 Record Data Attributes Description

Table 4 Alert Messages Attributes Description

Table 5 Reports Attributes Description

Table 6 Lab Order Attributes Description

Table 7 Lab Test Result Attributes Description

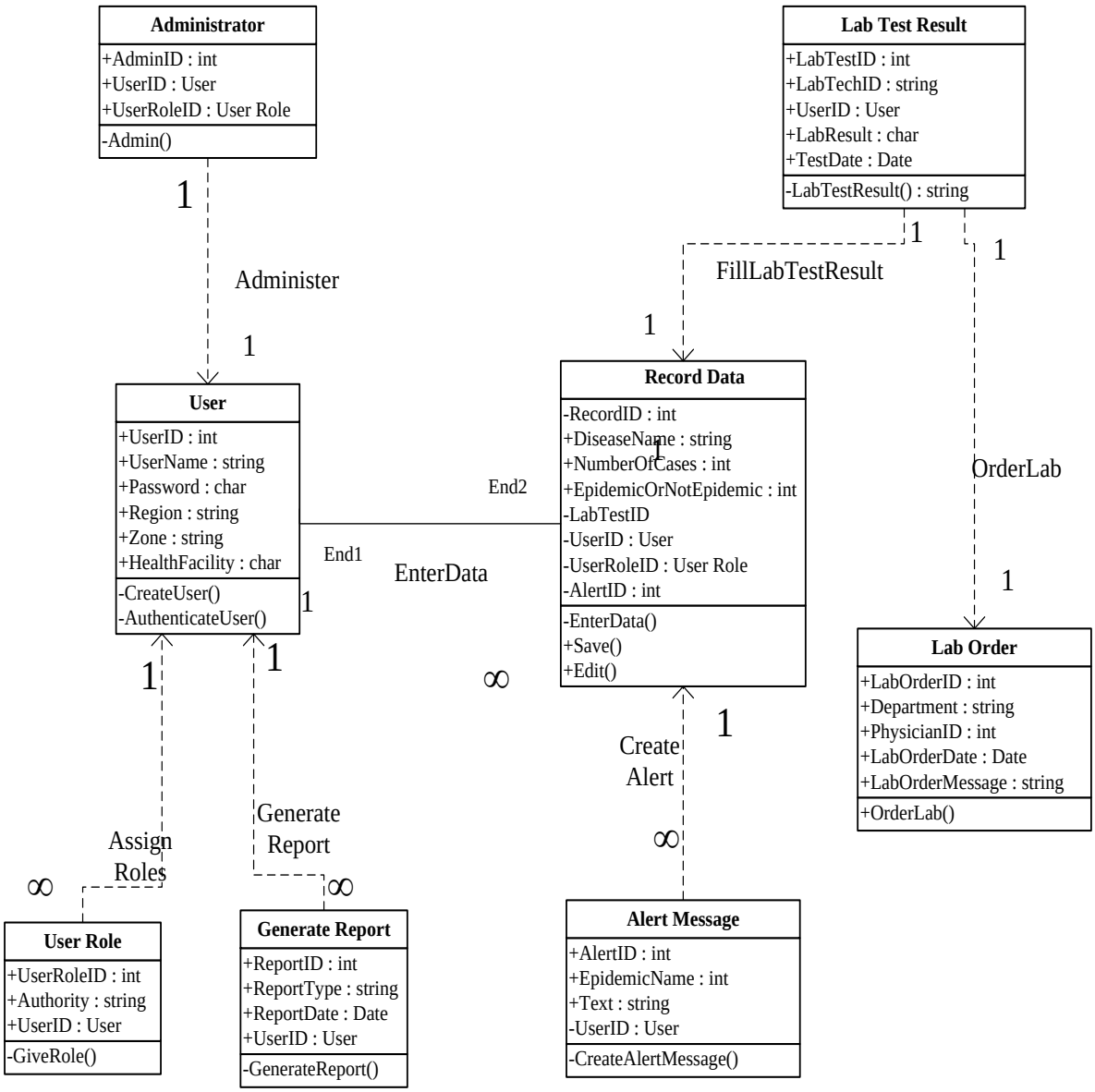

Figure 4 Class Diagram of the Proposed System

4.2.7 Activity Diagram

Activity Diagram is a unified modeling language (UML) diagram which are used to model sequential (possibly concurrent) steps in a computational process. It is used to model the flow of an object as it moves from state to state at different points in the flow of control. Thus, emphasize the flow of control from activity to activity.

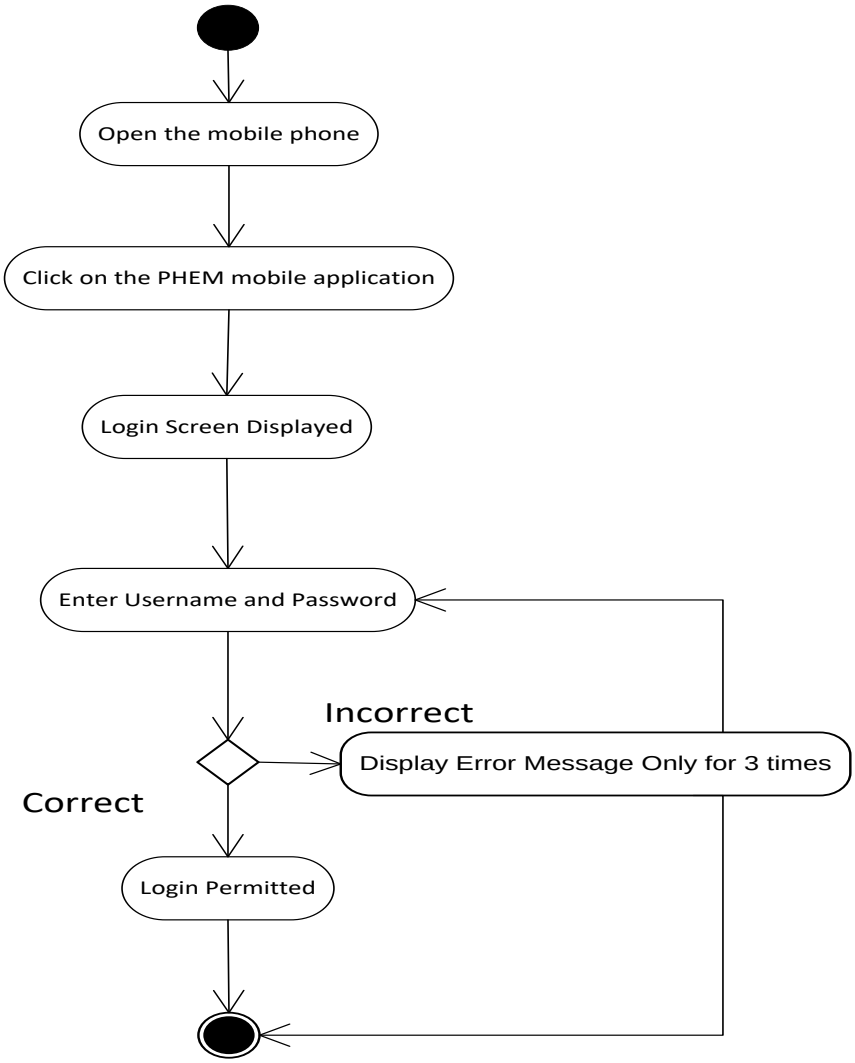

Figure 5: Login Activity Diagram

Figure 6 Record Data Activity Diagram

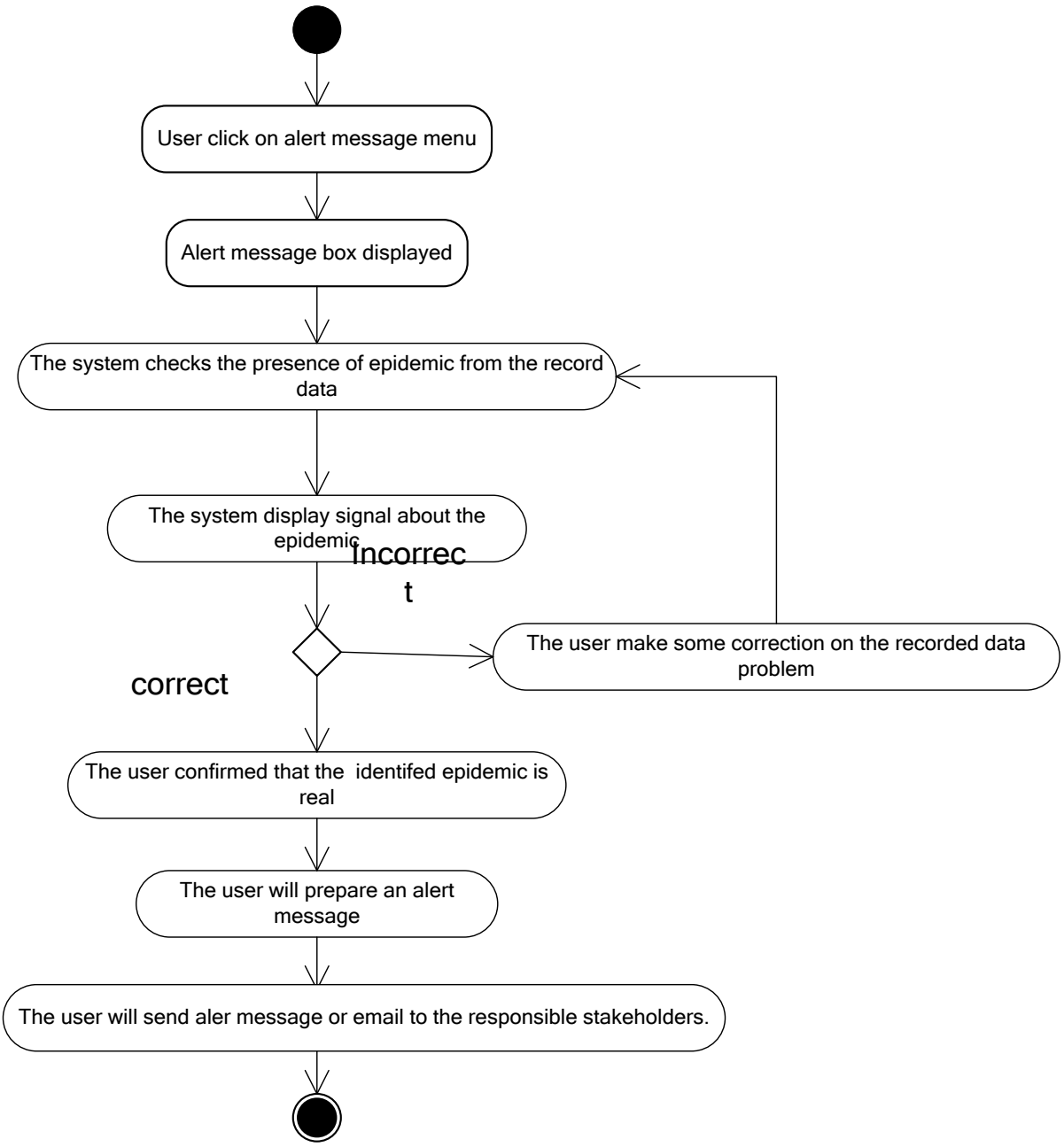

Figure 7 Alert Message Activity Diagram

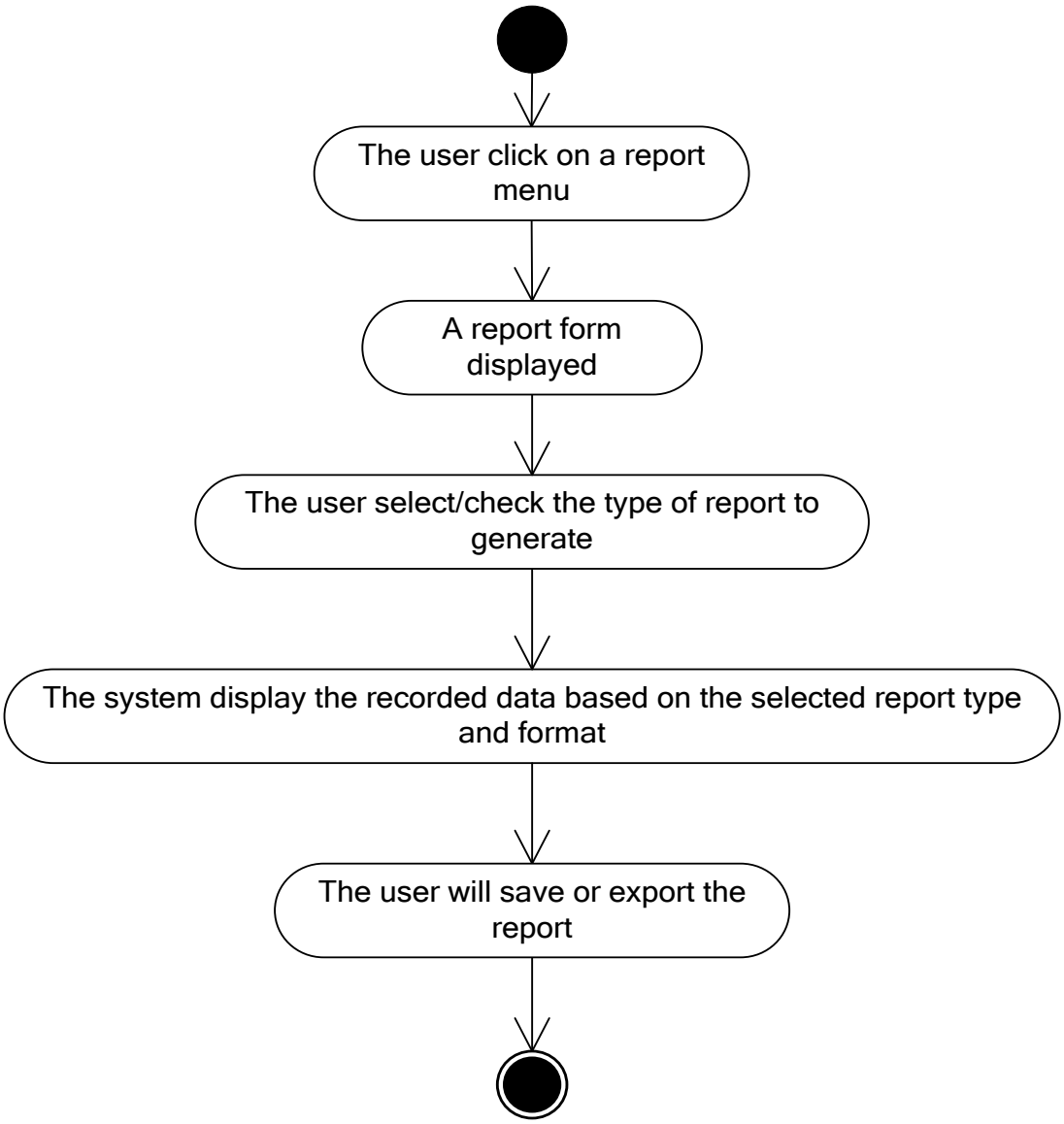

Figure 8 Report Activity Diagram

4.3 System Design

System Design Model is one of the formal ways of designating the data that are used and created by any business system. This shows the objects or peoples, the places, or things about which information is captured and the relationship among each other's.

4.3.1 Architecture of the System

The proposed system works on mobile phones and computers via a mobile communication network in line with the requirements of end users. There is a centralized database to store information about daily and weekly occurrence of disease outbreak as well as integrate Early Warning and Surveillance sub-process at EPHI with regional, zonal, woreda health bureaus and also health facilities.

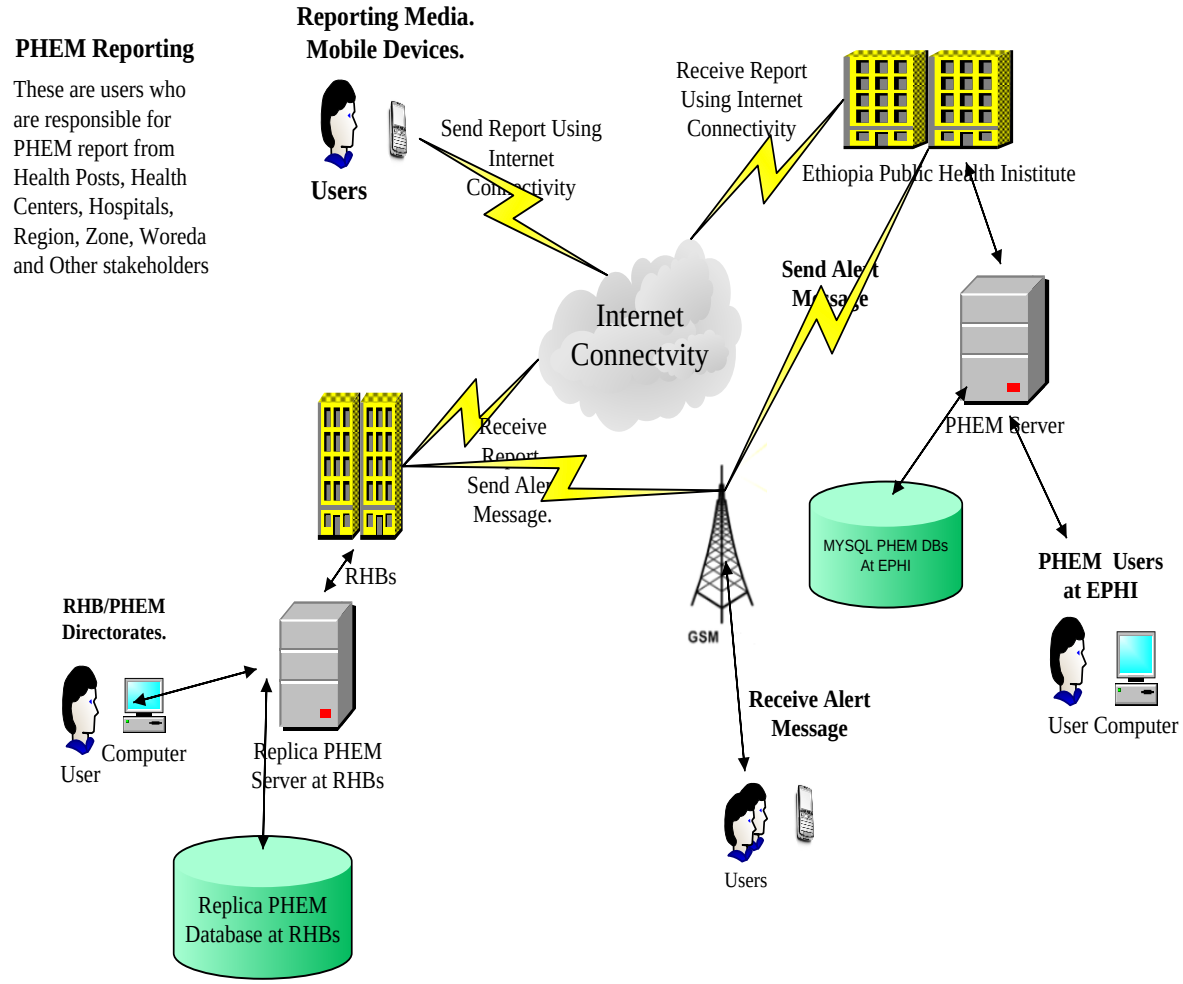

Figure 9 Physical Communication Layout of the Proposed System

4.3.2 Working Process of the Mobile Application

The figure as shown below depicted the logical working process of the developed prototype.

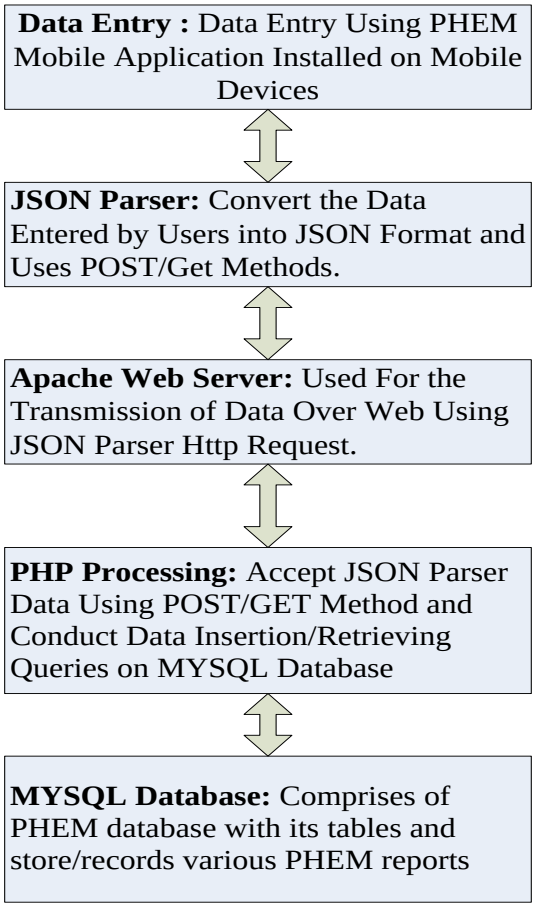

Figure 10: Working Processes of the Mobile Application

4.3.3 User Interface Diagram

User Interface Diagram is a diagram used to show the high level fidelity prototype of the application intended to develop. It is the graphical representation of the actual appearance of the application to be developed.

Figure 11 Login User Interface Design

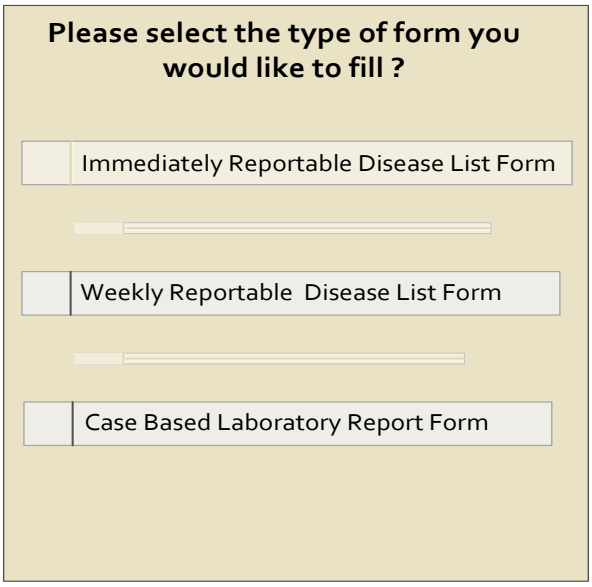

Figure 12 Record Data User Interface Design

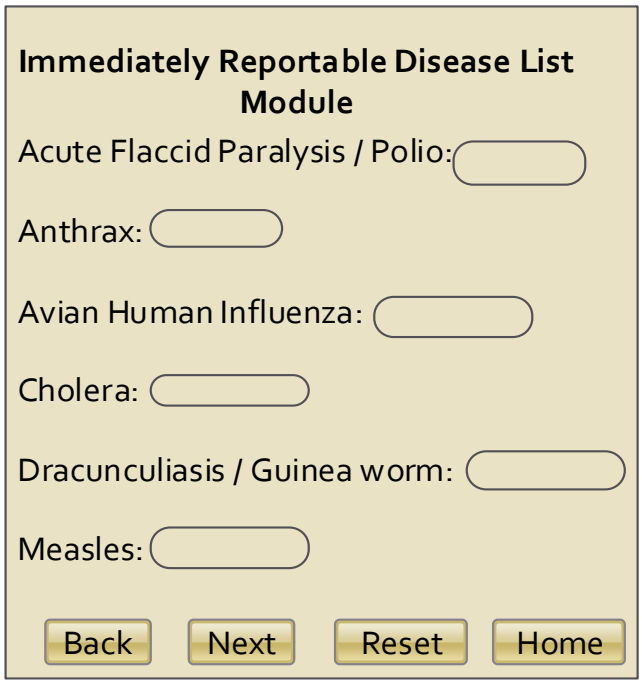

Figure 13 Immediately Reportable Diseases User Interface Design

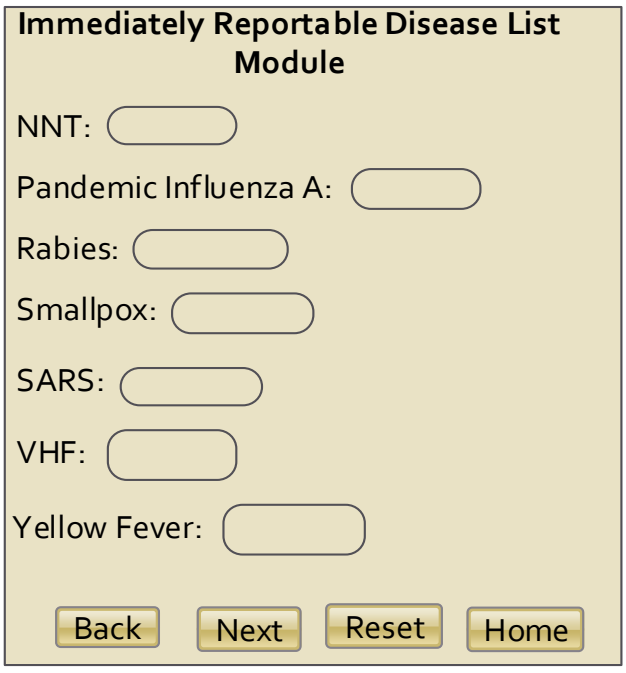

Figure 14 Immediately Reportable Diseases User Interface Design

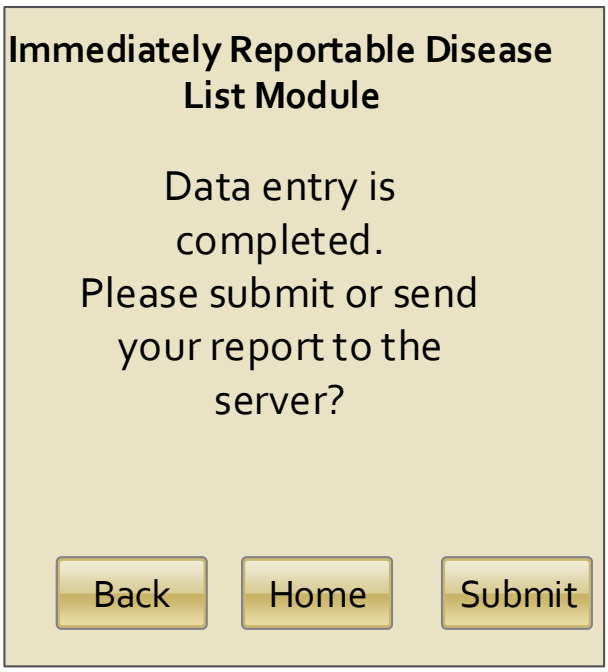

Figure 15 Immediately Reportable Diseases User Interface Design

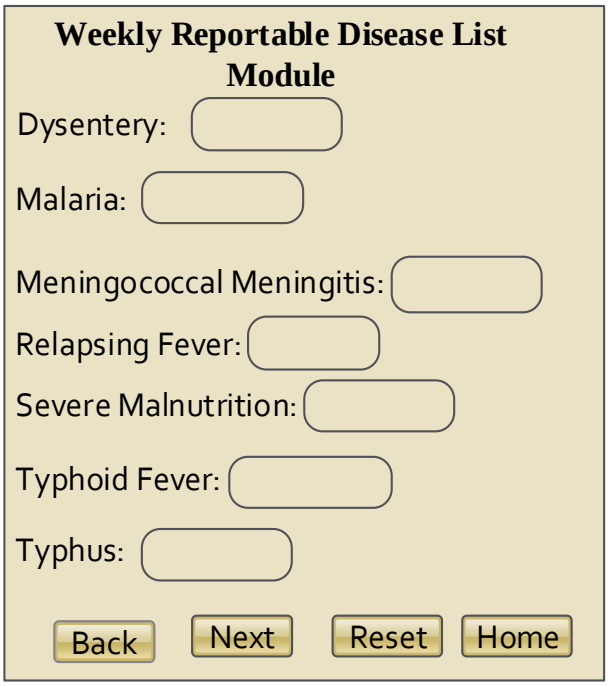

Figure 16 Weekly Reportable Diseases User Interface Design

Figure 17 Weekly Reportable Diseases User Interface Design

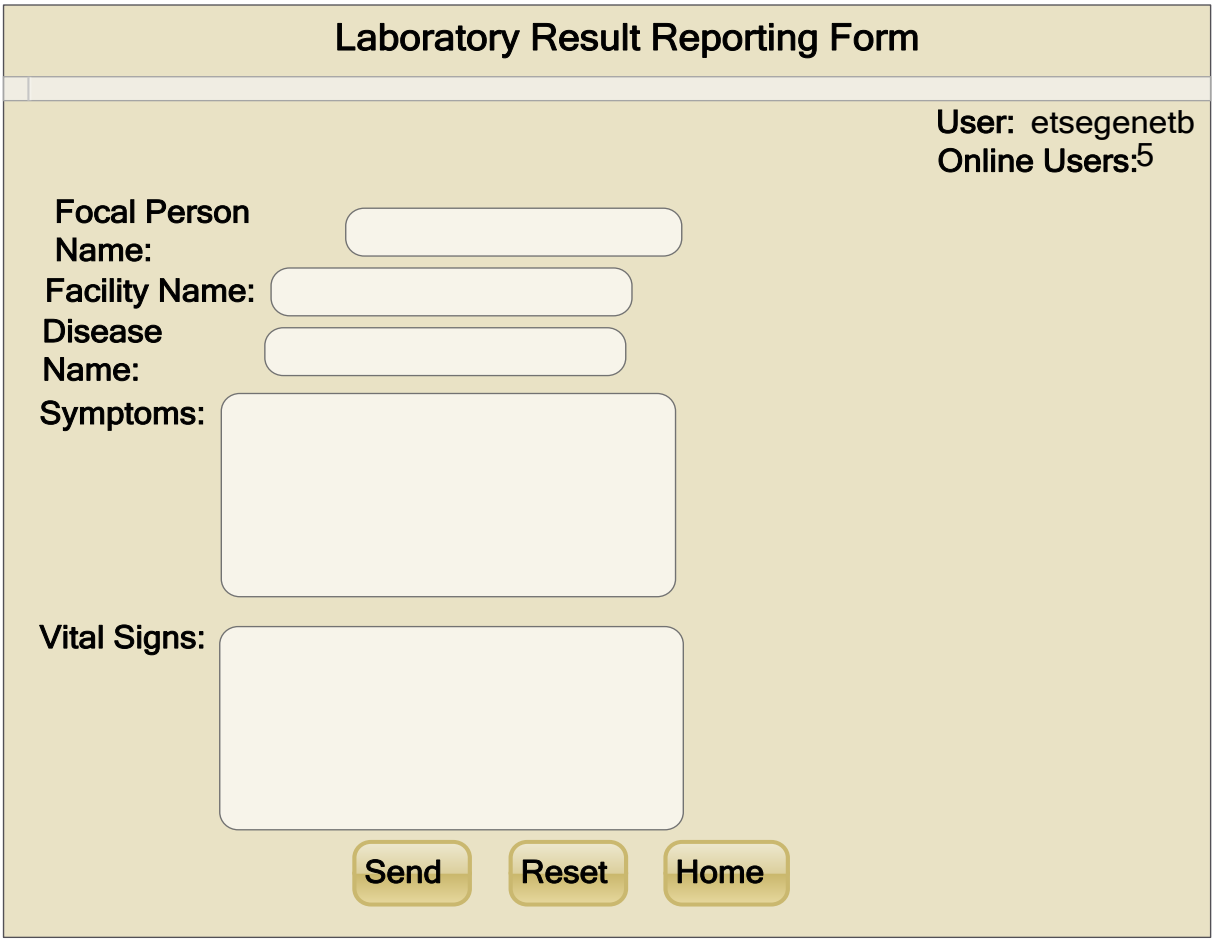

Figure 18 Cased Based Laboratory Result Reporting User Interface Design

Figure 18 Cased Based Reporting User Interface Design

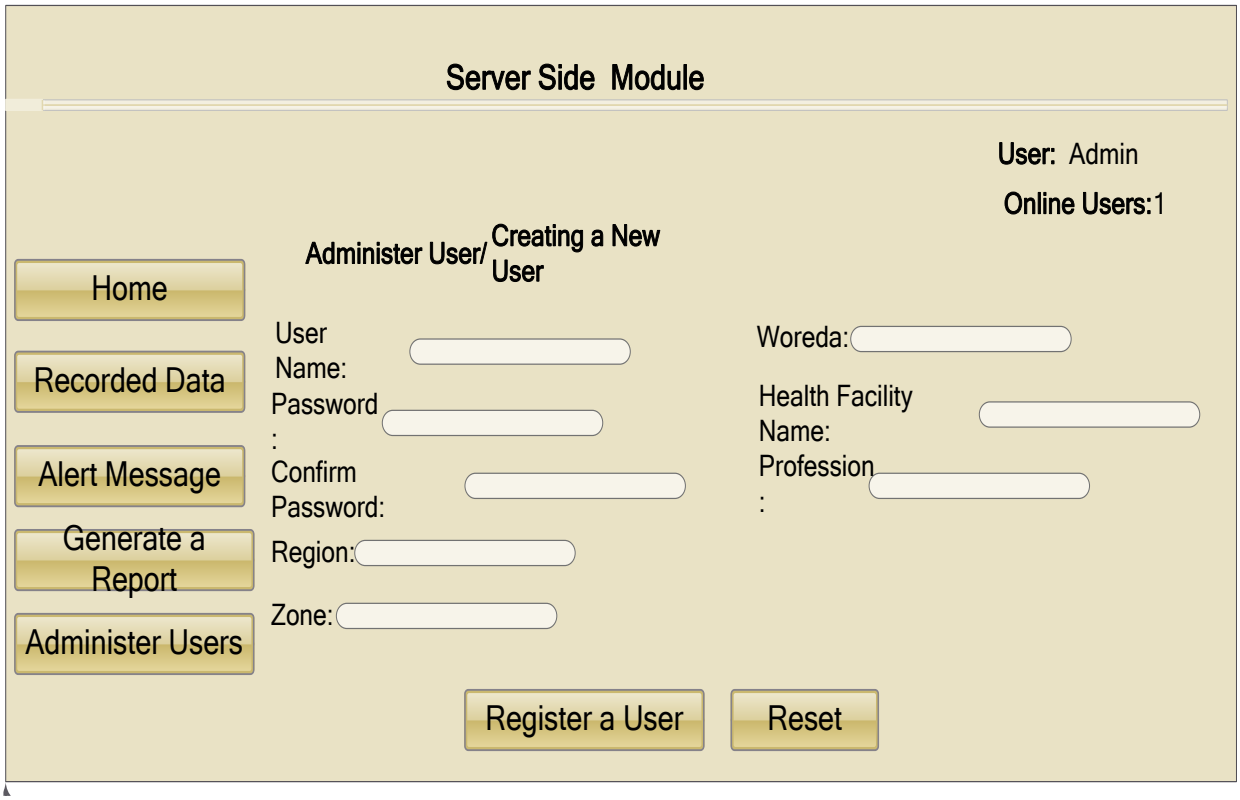

Figure 19 Server Side User Interface design

Figure 20 Alert Message User Interface Design

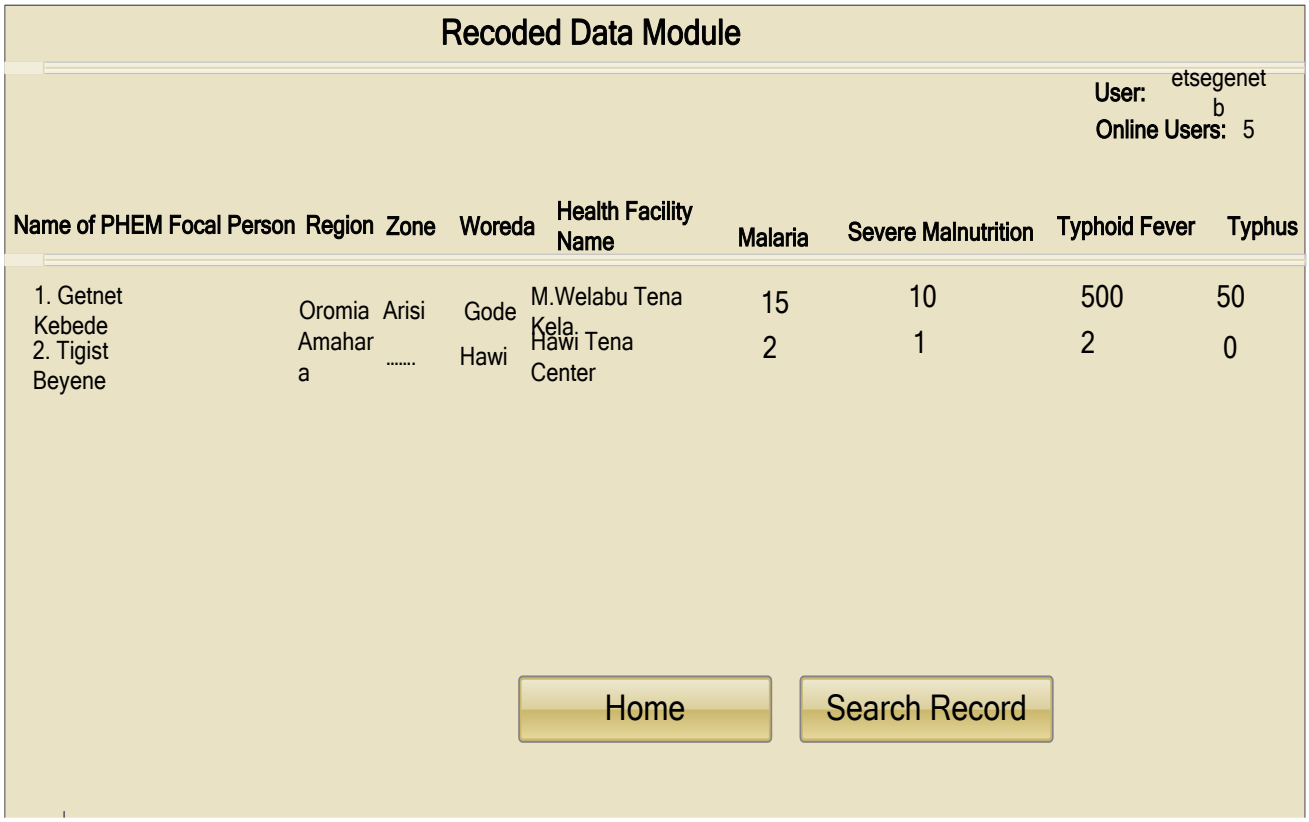

Figure 21 Recorded Data User Interface Design

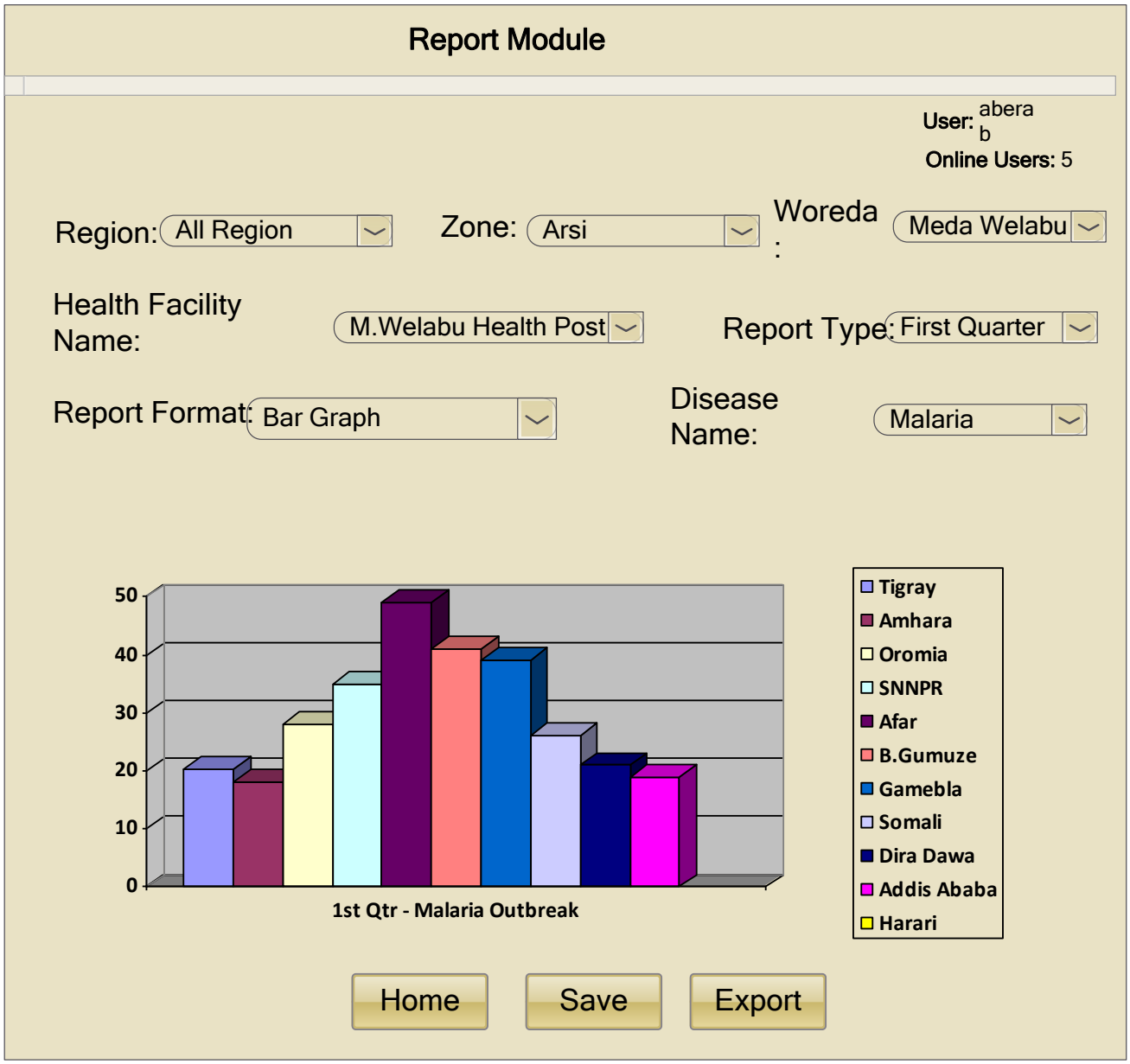

Figure 22 Report User Interface Design

4.4 System Implementation/Coding

The coding of the prototype mobile application were done using android based open source code which was download from the following site http://www.androidhive.com. The main reason for the selection of this open source code was its design and functionality was similar with this study.

The database of this prototype mobile application was done using XAMPP software used as an installer, and comprises of Apache Web Server, PHP and MySQL. Apache Web Server used for sending and receiving of reports over the internet using the developed prototype mobile application, PHP used for insertion or retrieval of data from the database tables using MYSQL queries, and MySQL used for the purpose of creating PHEM database and its tables.

We used eclipse platform with integration of android development tool with java programming language. The open source code imported into eclipse platform and customized based on the identified functional, non-functional and design of the proposed system.

4.5 System Testing

Informal usability testing used to test the usability of the developed prototype mobile application. The developed prototype application was given to employees of EPHI/PHEM directorates for their valuable comments, ideas and suggestions. The tasks as shown below were used during the usability testing.

1. Open the prototype mobile application
2. Enter username and password and click login
3. Enter immediately reportable disease list data and send the report.
4. Enter weekly reportable disease list data and send the report.
5. Enter the major vital sign and symptoms of the outbreak disease and send the report.

Findings of Usability Testing

The participant were delighted on the functionality of the application especially about the entire immediately and weekly reportable disease list, and alert and report generating module of the application. In the meantime they did not fell good on the selected color used for the user interface design of the application.

CHAPTER FIVE

Conclusion and Recommendation

5.1 Conclusion

The rapid growth of mobile technologies and its applications makes human beings, private and public sectors to be dependent on it. The health sector is one of the sector which has been applying mobile technologies for finance, health and health related data collection, health education and supply chain management related transactions. Management of disease outbreak occurrence is one of the center piece business activity performed by the Ethiopia Public Health Institute in the directorates of Public Health Emergency Management. Most of its activities done by manuals, data collection and compilation has been done by normal excel spreadsheet. Doing this activity manually has created not to have timely data collection, organization and communication among the responsible stakeholders.

The project report depicts a large spectrum of public health emergency management system with its smaller sub-process, and the different activities performed in each sub- systems particularly in enhancing the timely data collection, organization and ease of communication to the public to cut-off the occurrence and spread of disease outbreak at the community level as early as possible. In addition the study discussed guidelines, locally and international accepted practices.

Beside data/requirement collection instruments used in this study were identified and defined. Thus, national PHEM guidelines and other related documents were consulted along with interview, observation and document review with directorate directors, PHEM focal persons and other responsible bodies in order to determine the requirement for the new system. Later on we mentioned the methodology software development life cycle, and water fall approaches were used to develop the prototype mobile application.

Then after analysis and design models were used like Use cases to describe the basic functions of the information system, and Use case description to show detail description of the activities and functions running in the early warning and surveillance sub-process and other health related services, data flow diagram to depicts the actual flow or movement of data in the system, activity diagram to show business process and work flow. The analysis and design model is finalized by identifying the relevant analysis classes, attributes and their respective operation for designing the new system, architectural design, entity relationship diagram and user interface diagram were applied to elicit the parts of the system.

Untimely data collection and organizing, difficulty to generate a report based on the need of all responsible bodies, lack of infrastructure including electricity and ICT infrastructure, and usage of immobile and cost effective ICT devices were the main challenges investigated and analyzed during the conduct of this project.

Therefore the developed and demonstrated prototype mobile application together with the rapid growth of mobile technologies and related opportunities would help for timely

communication and data collection to improve evidence based decision making and planning process of public health emergency management system at EPHI.

5.2 Recommendation

- Complete system development and deployment phase of the study did not conduct due to time and other resources constraints therefore I urge the responsible body to finalize the development and deployment of the system.

- Based on the proposed system architecture layout. It is better to make the deployment of the mobile application decentralized. This will enhance the accessibility and utilization of data at the local level for evidence based planning and decision making process.

- The development process of the mobile application can consider other development methodologies which gives more chance for more participation of users. This means that customers can participate iteratively throughout the development process of the mobile application. Thus, it will facilitate to get a mobile application which addresses the actual functional and non-functional requirement of the customers.

- To make sure that the developed mobile application is addressing all the functional and non-functional requirements of the users. The appropriate software usability testing will be done ahead of full scale up or deployment of the developed mobile application.

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7 Annex

I. Interview Guide/Checklist

Purpose: the interview question will help to investigate the current system, identify requirements and design and development of the prototype mobile application for PHEM.

General Information

Institution Name: ----------
Directorate Name: ----------
Interviewee: ----------
Responsibility: ----------

1. What are the major activities carried out in PHEM business?
2. What are your customers and their types?
3. What sort of services they accept and or rendering to the section?
4. Which of the services incorporated into database information system?
5. What data are captured and how it is going on each activity?
6. What are the rules, guide lines and standards guiding for PHEM related activities?
7. What parties are involved in PHEM activities or transaction?
8. What reports are organized?
9. Does the current manual PHEM system supported by electronic system?
10. What are the problems of this electronic PHEM system?
11. What do you think if the current manual PHEM system will support by mobile application?

II. Daily Epidemic Reporting Format for Woredas

Daily Epidemic Reporting Format for Woreda (DERF – W)

Region _____Zone:_____ Woreda:_____Reporting Date____/ ____/ ___

(day)(month)(Year - EC)

Reported Cases for the Day

Epidemic Disease	Name ofKebeles Affected	Date of onset of the Epidemic	<5 years		5-14 years		15-44 years		45+ years		Total		
			M	F	M	F	M	F	M	F	M	F	M+F

Reported Deaths for the Day(facility and verified community deaths)

III. Daily Epidemic Reporting Format for Regions

Daily Epidemic Reporting Format for Regions (DERF – R)

Region _____ Epidemic Event_____ Reporting Da

_____

(day) (month) (Year - EC)

Total Reported Cases for the Day

Zone	Woreda	Number of Kebeles Affected	Date of onset of the Epidemic	<5		5-14		15-44		45+	
				M	F	M	F	M	F	M	

Reported Deaths for the Day(facility and verified community deaths)

Laboratory Investigation Result

IV. Line List for Reporting From Health Facilities to Woreda/Zone/Region/National and for Use During Outbreaks

Health Facility:	Date received at Woreda/zone:
Woreda/zone/Region:	Disease/Condition:

Serial number	(O) Out/ /(I) In-Patient	Name	Kebele/ PA's Town, House No.	Sex	Age **	Date seen at health facility	Date of onset of disease	Blank variable	Blank variable	Blank variable	Lab Tests	
											Specimen taken (Yes/No)	If yes, date
1												
2												
3												
4												
5												
6												

V. Weekly Reporting Forms For Health Extension Work (WRF_HEW)

1. Record below the total number of cases for each disease/condition for the current week.

Indicator		Total Cases
Total Malaria (confirmed by RDT +clinically diagnosed as malaria)		
Total malaria suspected fever cases examined by RDT		
Number of fever cases positive for malariaparasites (by RDT)	P. falciparum	
	P. vivax	
Meningitis (suspected)		
Bloody Diarrhea		
Acute febrile illness (other than malaria and meningitis)		
Severe Acute Malnutrition (MUAC < 11cmand/orBilateral Edema in under 5 years children (new cases only))		

RDT = Rapid Diagnostic Test;MUAC = mid upper arm circumference

2. Summary for Immediately Reportable Diseases/Conditions:

DISEASE	C	D	DISEASE	C	D	DISEASE	C	D
AFP/Polio			Fever + Rash			Hemorrhagic Diseases		
Anthrax			Neonatal Tetanus			Guinea worm		
Acute Watery Diarrhea			Influenza Like Illnesses			Other (specify):_____		
Rabies			Other (specify):_____			Other (specify):_____		

C = case; D = death

VI. Weekly Disease Report Form for Outpatient and Inpatient Cases and Deaths

Health facility name and type		Woreda	
Zone		Region	
Start of week from Monday _____/_____/_____toSunday_____/_____/_____ (day)(month)(Year in Ethiopian Calendar)(day) (month)(Year in EC)			

1.Record below the total number of cases and deaths for each disease/condition for the current week.

Indicator		Out - Patient	In - Patient	
		Cases	Cases	Deaths
Total Malaria (confirmed andclinical)				
Total malaria suspected fever cases examined by RDT or Microscopy				
Number cases positive for malariaparasites (either by RDT or Microscopy)	P. falciparum			
	P. vivax			
Meningitis				
Dysentery				
Typhoid fever				
Relapsing fever				
Epidemic Typhus				
Severe Acute Malnutrition /MUAC < 11cmand/orBilateral Edema in under 5 years children (new cases only)				

RDT = Rapid Diagnostic Test;MUAC = mid upper arm circumference

VII. Cased Based Reporting Format (CRF)

Reporting Health Facility:_____					Reporting Woreda_____ Zone _____ REGION: _____			
Disease type (put tick mark ✓)	Anthrax	Cholera	Measles	Meningitis	Neonatal Tetanus	Hemorrhagic Fever	Yellow Fever	Others/Specify
Name of Patient:								
Date of Birth (DOB): / / (Day/Month/Year)					Age (If DOB unknown):		Year	Month (if <12)
Sex:		Write M for Male F for Female						
Patient's Address:	Kebele:				House number:			
Woreda:		Zone:			Region:			
Locating Information	Location when symptom started				Current location			
	If applicable or If the patient is neonate or child, please write full name of mother and father of the patient							
Date seen at Health Facility: / /	Date Health Facility notified Woreda/zone: / /				Date of Onset: / /			
Number of vaccine/TT doses received:								
	For cases of NNT* , Measles, Yellow Fever, and Meningitis (For NNT, Measles, Yellow Fever – refer immunization card & for Meningitis - ask history) **For NNT cases please complete the additional case investigation form*							
Date of last vaccination:	/ /							
	(NNT, Measles, Yellow Fever and Meningitis only)							
Associated with epidemics?	1=YES 2= NO							
In/Out Patient	1=Inpatient				2=outpatient			
Treatment given	1=YES (specify)				2= NO			
Outcome of the patient at the time of report	1=Alive				2=Dead		3=Unknown	

VIII. Cased Based Laboratory Reporting Format

Complete the following information and send a copy of this form to the corresponding Surveillance team						
ID Number:						
Date of specimen received://Receiving laboratory:_____						
Type of specimen:	Stool	Blood	Serum	CSF	Throat swab	Other/specify
Specimen Condition:		Adequate		Not adequate		
Disease / Condition:						
Result:		+ = Positive		- = Negative	P = pending	
Cholera direct exam, Culture; RDT, specify the method used: _____						
Meningitis: N meningitides	Culture					
	Latex					
	Gram stain					
Meningitis: S. pneumoniae	Culture					
	Latex					
	Gram stain					
Meningitis: H. influenzae	Culture					
	Latex					
	Gram stain					
Typhoid Fever	Widal ("O" > 1:160)					
	Blood culture					
	Stool culture					
Anthrax	Gram stain or culture					
Epidemic Typhus: Serum test(OX19)						

MainScreenActivity.Java

```
package com.example.androidhive;

import android.app.Activity;
import android.content.Intent;
import android.os.Bundle;
import android.view.View;
import android.widget.Button;


public class MainScreenActivity extends Activity{

		Button btnDiseaseList;

	@Override
	public void onCreate(Bundle savedInstanceState) {
		super.onCreate(savedInstanceState);
		setContentView(R.layout.main_screen);

		// Buttons
		btnDiseaseList = (Button) findViewById(R.id.btnDiseaseList);

		/* view products click event
		//btnViewProducts.setOnClickListener(new View.OnClickListener() {

		//	@Override
		//	public void onClick(View view) {
				// Launching All products Activity
		//		Intent i = new Intent(getApplicationContext(),
AllProductsActivity.class);
		//		startActivity(i);

			}
		}); */

		// view products click event
		btnDiseaseList.setOnClickListener(new View.OnClickListener() {

			@Override
			public void onClick(View view) {
				// Launching create new product activity
				Intent i = new Intent(getApplicationContext(),
DiseaseRecordActivity.class);
				startActivity(i);

			}
		});
	}
```

}

DiseaseRecordActivity.Java

```
package com.example.androidhive;

import java.util.ArrayList;
import java.util.List;

import org.apache.http.NameValuePair;
import org.apache.http.message.BasicNameValuePair;
import org.json.JSONException;
import org.json.JSONObject;

import android.app.Activity;
import android.app.ProgressDialog;
import android.content.Intent;
import android.os.AsyncTask;
import android.os.Bundle;
import android.util.Log;
import android.view.View;
import android.widget.Button;
import android.widget.EditText;
import android.widget.Toast;


public class DiseaseRecordActivity extends Activity {

	// Progress Dialog
	private ProgressDialog pDialog;
	JSONParser jsonParser = new JSONParser();
	EditText etxtafp;
	EditText etxtanthrax;

	// url to create new product
	private static String url_Insert_DiseaseInformation =
"http://10.0.2.2/android_connect/create_product.php";
	// JSON Node names
	private static final String TAG_SUCCESS = "success";

	@Override
		public void onCreate(Bundle savedInstanceState)
	{
		super.onCreate(savedInstanceState);
		setContentView(R.layout.add_product);
```

```
        // Edit Text
        etxtafp = (EditText) findViewById(R.id.etxtafp);
        etxtanthrax = (EditText) findViewById(R.id.etxtanthrax);


        // Create button
        Button btnSubmit = (Button) findViewById(R.id.btnSubmit);


        // button click event
        btnSubmit.setOnClickListener(new View.OnClickListener() {

                @Override
                public void onClick(View view) {
                        // creating new product in background thread
                        new InsertDiseaseInformation().execute();
                }
        });

}

/**
 * Background Async Task to Create new product
 * */
class InsertDiseaseInformation extends AsyncTask<String, String, String> {

        /**
         * Before starting background thread Show Progress Dialog
         * */
        @Override
        protected void onPreExecute() {
                super.onPreExecute();
                pDialog = new ProgressDialog(DiseaseRecordActivity.this);
                pDialog.setMessage("Submiting Report..");
                pDialog.setIndeterminate(false);
                pDialog.setCancelable(true);
                pDialog.show();
        }

        /**
         * Creating product
         * */
        protected String doInBackground(String... args) {
                String AFP = etxtafp.getText().toString();
                String Anthrax = etxtanthrax.getText().toString();

                // Building Parameters
```

```
                        List<NameValuePair> params = new ArrayList<NameValuePair>();
                        params.add(new BasicNameValuePair("AFP", AFP));
                        params.add(new BasicNameValuePair("Anthrax", Anthrax));

                        // getting JSON Object
                        // Note that create product url accepts POST method
                        JSONObject json =
jsonParser.makeHttpRequest(url_Insert_DiseaseInformation,
                                        "POST", params);

                        // check log cat fro response
                        Log.d("Create Response", json.toString());

                        // check for success tag
                        try {
                                int success = json.getInt(TAG_SUCCESS);

                                if (success == 1) {
                                        // successfully created product
                                        Intent i = new Intent(getApplicationContext(),
DiseaseRecordActivity.class);
                                        startActivity(i);
                                          finish();
                                } else {
                                        // failed to create product
                                }
                        } catch (JSONException e) {
                                e.printStackTrace();
                        }

                        return null;
                }

                /**
                 * After completing background task Dismiss the progress dialog
                 * **/
                protected void onPostExecute(String file_url) {
                        // dismiss the dialog once done
                        pDialog.dismiss();
                        Toast.makeText(getApplicationContext(), "Report submission is
completed.", Toast.LENGTH_LONG).show();
                }

        }
}

package com.example.androidhive;
```

```
import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStream;
import java.io.InputStreamReader;
import java.io.UnsupportedEncodingException;
import java.util.List;
import org.apache.http.HttpEntity;
import org.apache.http.HttpResponse;
import org.apache.http.NameValuePair;
import org.apache.http.client.ClientProtocolException;
import org.apache.http.client.entity.UrlEncodedFormEntity;
import org.apache.http.client.methods.HttpGet;
import org.apache.http.client.methods.HttpPost;
import org.apache.http.client.utils.URLEncodedUtils;
import org.apache.http.impl.client.DefaultHttpClient;
import org.json.JSONException;
import org.json.JSONObject;
import android.util.Log;
```

JSONParser.Java

```
public class JSONParser {

	static InputStream is = null;
	static JSONObject jObj = null;
	static String json = "";

	// constructor
	public JSONParser() {

	}

	// function get json from url
	// by making HTTP POST or GET mehtod
	public JSONObject makeHttpRequest(String url, String method,
			List<NameValuePair> params) {

		// Making HTTP request
		try {

			// check for request method
			if(method == "POST"){
				// request method is POST
				// defaultHttpClient
				DefaultHttpClient httpClient = new DefaultHttpClient();
				HttpPost httpPost = new HttpPost(url);
				httpPost.setEntity(new UrlEncodedFormEntity(params));
				HttpResponse httpResponse = httpClient.execute(httpPost);
```

```
                HttpEntity httpEntity = httpResponse.getEntity();
                is = httpEntity.getContent();

        } else if(method == "GET"){
                // request method is GET
                DefaultHttpClient httpClient = new DefaultHttpClient();
                String paramString = URLEncodedUtils.format(params, "utf-8");
                url += "?" + paramString;
                HttpGet httpGet = new HttpGet(url);

                HttpResponse httpResponse = httpClient.execute(httpGet);
                HttpEntity httpEntity = httpResponse.getEntity();
                is = httpEntity.getContent();
        }


} catch (UnsupportedEncodingException e) {
        e.printStackTrace();
} catch (ClientProtocolException e) {
        e.printStackTrace();
} catch (IOException e) {
        e.printStackTrace();
} catch (RuntimeException e) {
        e.printStackTrace();
}

try {
        BufferedReader reader = new BufferedReader(new InputStreamReader(
                        is, "iso-8859-1"), 8);
        StringBuilder sb = new StringBuilder();
        String line = null;
        while ((line = reader.readLine()) != null) {
                sb.append(line + "\n");
        }
        is.close();
        json = sb.toString();
} catch (Exception e) {
        Log.e("Buffer Error", "Error converting result " + e.toString());
}

// try parse the string to a JSON object
try {
        jObj = new JSONObject(json);
} catch (JSONException e) {
        Log.e("JSON Parser", "Error parsing data " + e.toString());
}
```

```
            // return JSON String
            return jObj;

        }
}
```

db_config.php

```
<?php

/*
 * All database connection variables
 */

define('DB_USER', "root"); // db user
define('DB_PASSWORD', "root"); // db password (mention your db password here)
define('DB_DATABASE', "phemdba"); // database name
define('DB_SERVER', "localhost"); // db server
?>
```

db_connect.php

```
<?php

/**
 * A class file to connect to database
 */
class DB_CONNECT {

    // constructor
    function __construct() {
        // connecting to database
        $this->connect();
    }

    // destructor
    function __destruct() {
        // closing db connection
        $this->close();
    }

    /**
     * Function to connect with database
     */
    function connect() {
        // import database connection variables
        require_once __DIR__ . '/db_config.php';
```

```
        // Connecting to mysql database
        $con = mysql_connect(DB_SERVER, DB_USER, DB_PASSWORD) or
die(mysql_error());

        // Selecing database
        $db = mysql_select_db(DB_DATABASE) or die(mysql_error()) or die(mysql_error());

        // returing connection cursor
        return $con;
    }

    /**
     * Function to close db connection
     */
    function close() {
        // closing db connection
        mysql_close();
    }

}

?>
```

Create_Record.php

```
<?php

/*
 * Following code will create a new product row
 * All product details are read from HTTP Post Request
 */

// array for JSON response
$response = array();

// check for required fields
if (isset($_POST['AFP']) && isset($_POST['Anthrax'])) {

    $AFP = $_POST['AFP'];
    $Anthrax = $_POST['Anthrax'];

    // include db connect class
    require_once __DIR__ . '/db_connect.php';

    // connecting to db
```

```
    $db = new DB_CONNECT();

    // mysql inserting a new row
    $result = mysql_query("INSERT INTO diseaserecord(AFP, Anthrax) VALUES('$AFP',
'$Anthrax')");

    // check if row inserted or not
    if ($result) {
        // successfully inserted into database
        $response["success"] = 1;
        $response["message"] = "Product successfully created.";

        // echoing JSON response
        echo json_encode($response);
    } else {
        // failed to insert row
        $response["success"] = 0;
        $response["message"] = "Oops! An error occurred.";

        // echoing JSON response
        echo json_encode($response);
    }
} else {
    // required field is missing
    $response["success"] = 0;
    $response["message"] = "Required field(s) is missing";

    // echoing JSON response
    echo json_encode($response);
}
?>
```