**Sudan University of Science
and Technology
College of Computer Science &
Information Technology
Post Graduate Studies**

**An Infrastructure for the Exchange of Healthcare
Information among Public Hospitals**

بنية تحتية لتبادل معلومات الرعاية الصحية بين المستشفيات العامة

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بسم الله الرحمن الرحيم

In the Name of Allah Most

Gracious Most Merciful

الايـــــــة

﴿الَّذِي خَلَقَنِي فَهُوَ يَهْدِينِ * وَالَّذِي هُوَ يُطْعِمُنِي وَيَسْقِينِ * وَإِذَا مَرِضْتُ فَهُوَ يَشْفِينِ﴾

(الشعراء: 78: 80)

﴿قَالَ رَبِّ اشْرَحْ لِي صَدْرِي * وَيَسِّرْ لِي أَمْرِي * وَاحْلُلْ عُقْدَةً مِّن لِّسَانِي * يَفْقَهُوا قَوْلِي ﴾

(طه: 25 : 28)

﴿وَلَا تُصَعِّرْ خَدَّكَ لِلنَّاسِ وَلَا تَمْشِ فِي الْأَرْضِ مَرَحًا إِنَّ اللَّهَ لَا يُحِبُّ كُلَّ مُخْتَالٍ فَخُورٍ﴾

(لقمان: 17 : 18)

صدق الله العظيم

Abstract:

Healthcare Information Infrastructures for Public Hospitals, in the Republic of Sudan, especially Khartoum State, and Healthcare Information Exchange, are essential steps for civilizing Healthcare in Sudan. Better health is what we seek for our people, families, children, neighbours, friends and for everyone over the world. With the total number of Sudanese citizens which is approximately more than thirty-three million people, beneficiaries from the Sudanese public hospitals' facilities, which are work manually (most of them). It is clear that the manual systems of public hospitals in Sudan do not satisfy the reporting needs of beneficiaries (patients and medical staff). This kind of inefficiency and problems created by such a system include poor administration for clinical data, poor doctor-patient communication, poor communication among medical staff, unavailability of information about the patients timely, queuing, time-consuming, slow retrieval of data, paper wastage, poor data storage and the loss of patient's medical information. The research methodology included Ethnography studies, Mock-up, Case studies, a framework and a prototype. This thesis presents a novel framework for Healthcare Information Infrastructure and Health Information Exchange (HIE). That introduces an effective Integrated Information System Model for Electronic Exchange of Healthcare Information among Public hospitals in the Republic of Sudan. In terms of information infrastructure; the backbone of healthcare information infrastructure and health Information exchange solution is highly secured and the modular IT

information infrastructure are implemented for healthcare information exchange. The proposed framework provides seamless access to the existing patient information by standardizing and synchronizing care across hospital units as it allows the exchange of health information among public hospitals in Khartoum, Sudan. Also, the proposed framework and system can (potentially) be trusted, faster and more efficient than existing systems as it leads to shorter service time, quicker retrieval of data, less paper wastage, rich data storage, elimination of the loss of information, and enhancement of the work of the current public Sudanese hospitals systems.

ملخص البحث

تعتبر البنية التحتية لمعلومات الرعاية الصحية للمستشفيات العامة في جمهورية السودان وخاصة ولاية الخرطوم وتبادل معلومات الرعاية الصحية خطوات أساسية لحضارة الرعاية الصحية في السودان. صحة أفضل هي ما نسعى إليه لشعبنا وعائلاتنا وأطفالنا وجيراننا وأصدقائنا وللجميع في جميع أنحاء العالم. مع العدد الإجمالي للمواطنين السودانيين وهو ما يقرب من ثلاثة وثلاثين مليون شخص، المستفيدين من مرافق المستشفيات العامة السودانية، والتي تعمل يدويا (معظمها). من الواضح أن الأنظمة اليدوية للمستشفيات العامة في السودان لا تلبي احتياجات الإبلاغ للمستفيدين (المرضى والموظفين الطبيين). هذا النوع من عدم الكفاءة والمشاكل الناجمة عن مثل هذه الأنظمة تشمل: سوء الإدارة للبيانات الصحية، ضعف التواصل بين الطبيب والمريض، ضعف التواصل بين الطاقم الطبي، عدم توفر المعلومات حول المرضى في الوقت المناسب، الطابور، استغراق الوقت، الاسترجاع البطيء للبيانات، إهدار الورق وسوء تخزين البيانات وفقدان المعلومات الطبية للمريض. تقدم هذه الأطروحة إطارا جديدا للبنية التحتية لمعلومات الرعاية الصحية وتبادل المعلومات الصحية.كما تقدم نموذجًا فعالًا لنظام المعلومات المتكامل للتبادل الإلكتروني لمعلومات الرعاية الصحية بين المستشفيات العامة في جمهورية السودان. منهجية البحث شملت: دراسات إثنوغرافية، نموذج Mock-Up، دراسات حالة، نموذج أولي وإطار عمل. من حيث البنية التحتية للمعلومات: العمود الفقري للبنية التحتية للمعلومات الصحية والاطار المقترح لتبادل المعلومات الصحية مضمون وامن بدرجة عالية، حيث تم تطبيق نظام المعلومات الالكتروني المصاحب له لتبادل المعلومات المتعلقة بالرعاية الصحية، حيث ان نظام المعلومات الجديد يمتاز بالوصول السريع و السلس إلى معلومات المريض الحالية من خلال توحيد ومزامنة الرعاية عبر وحدات المستشفى. حيث ان النظام المقترح يسمح بتبادل المعلومات الصحية بين المستشفيات العامة في السودان.

يمكن ايضاً أن يكون الإطار والنظام المقترحان موثوقين، وأسرع وأكثر كفاءة من الانظمة الاخري الموجودة حالياً، وأقل انتظاراً، وأقل استهلاكًا للوقت، واسترجاعًا أسرع للبيانات، ويقلل من هدر الورق، وتخزينًا غنيًا للبيانات، والقضاء على فقدان المعلومات، وتعزيز العمل في أنظمة المستشفيات السودانية العامة الحالية.

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First of all, with my highest sense of gratitude, I wish to thank my advisor Professor Lars Rune Christensen without whom this work would not be possible to accomplish. I am deeply indebted to him for providing thoughtful guidelines for my PhD Research and detailed comments on the multiple draft versions of this thesis, during numerous discussions over the past two years. I am gratified to him, Professor Lars Rune Christensen whose vision is always ahead. There are no words to describe the support provided by him right from the beginning of this thesis. I hope that the outcome will help to bring into being the vision he has in his mind.

Also, I would like to express my thanks to my godfather Professor Ezz Eldien Mohammed Osman for all his support and guidance God bless him. Also, I would like to express my sincere gratitude to my teacher's Dr Salah Eldien Alfaky Alrofaay ،Dr Talat Mohi Eldin Wahby ، Professor Taj elsir Hassan،Dr Neama Ezz Eldien Mohammed Osman ، Dr Hisham Abdalla Mansour ،Dr Mohammed Elhafiz ،Dr Osama Ahmid Ebrahim ،Dr Wafa Faisal ،Dr Nejood Mohammed Eltegani ،Uz Azhary Mohammed ،Dr Mohammed Adany ،Dr Waleed Ali Merghani ،Uz Sara Mohammed and my Colleagues.

Last, but not the least, I wish to express my thanks to my mother's Zainab (Rest in peace) and Fawzia Sed Ahmid ،and fathers Atta and Gassim Badry ،my lovely wife Suhanda, my son Hatim ،my brothers ، my sisters for their love and support ،their faith in me and love will always be a guiding force in my life.

Table of Contents

Table of Figures:

List of Tables:

The List of Abbreviations:

ICT   Information and Communication Technology

HIE   Health Information Exchange

IT   Information and Technology

HIIPS   Healthcare Information Infrastructures among Public Hospitals

NGOs   Non-Governmental Organizations

EEHI   Electronic Exchange of Healthcare Information

EPR   Electronic Patient Record

HIS   Hospital Information Systems

CSCW   Computer Support Cooperative Work

UML   Unified Modeling Language

EHR   Electronic Health Record

NIC   National Information Centre

SCABS   Name

HHIS   Hospital Health Information System

ID   Identification/Identity

KSHIC   Khartoum State Health Insurance Corporation

EMR   Electronic Medical Record

GFMP   The Gazera Family Medicine Project

LCD   A liquid-Crystal Display

OOVOO   Name

ECG   An electrocardiogram

Cisco webEx Name

ER   Emergency Rooms

ED   Emergency Department

HMO   Health Maintenance Organization

CAS   Complex Adaptive Systems

WHO   World Health Organization

NHII   National Health Information Infrastructure

ISO   International Organization for Standardization

US   United States

UK   United Kingdom

NZ   New Zealand

E-health   Electronic-health

E-learning Electronic-learning

RHIO   Regional Health Information Organization

PhD   Doctor of Philosophy Degree

AHA   American Hospital Association

PACS   Picture Archiving Communication Systems

RIS   Radiological Information Systems

IS   Information System

CHMISs   Community Health Management Information Systems

RHIO   Regional Health Information Organization

EMM   Electronic Medication Module

WHO   World Health Organization

Xenix   Systems

BC   Business Use-Case

SC   System Use-Cases

DBMS   Data-Base Management System

IHS   Integrated Hospital System

KTH   Khartoum Teaching Hospital

OTH   Omdurman Teaching Hospital

PHIEEDS   Practices of Healthcare Information Exchange in the Emergency Department of a Sudanese Hospital

ICU   Intensive Care Unit

RUH   AL-Rabat University Hospital

RUHED   AL-Rabat University Hospital Emergency Department

CT   A computerized tomography scan

MRI   Magnetic Resonance Imaging

RTA   Road Traffic Accidents

QoS   Lack of Quality of Service

KSHIC   Khartoum State Health Insurance Corporation

HHIS   Hospital Health Information System

E15   Electronic Receipt

AUW-HC   Ahfad University for Women-Health Centre

The List of Publications:

1 - AAA Mohammed (2017) 'A Review of HIIPS : Healthcare Information Infrastructures among Public Hospitals (Case Study Sudan)', *International Journal of Computer Science Trends and Technology (IJCST)*, 5(4), pp. 104–112.

2- AAA Mohammed and L. R. Christensen, "Practices of Healthcare Information Exchange in the Emergency Department of a Sudanese Hospital," Int. J. Comput. Sci. Trends Technol., vol. 6, no. 3, pp. 171–177, 2018.

3- AAA Mohammed and L. R. Christensen, "A Review Of 28 Years of Health Information Exchange Research: Achievements, Challenges and Future Work," Int. J. Comput. Sci. Trends Technol., vol. 6, no. 3, pp. 178–187, 2018.

CHAPTER ONE

INTRODUCTION

1. General Introduction

1.1.   Motivations:

Today's most information is generated in some form of electronic media, the information systems are becoming the most critical component in the information distribution mechanism (Bansler and Kensing, 2010)(Kodner and Spreeuwenberg, 2002), (Johnson *et al.*, 2011), (Essential Hospitals Institute, 2013), (Peppard and Ward, 2016), (Govindhan *et al.*, 2018). Therefore, there is a need for information system capability to manage the hospitals (Lammers, Adler-milstein and Kocher, 2014),(Buntin *et al.*, 2011). Bearing in mind that the healthcare sector in Sudan is divided into three healthcare providers, which are: Public Organizations, a private organization, and Non-Governmental Organizations (NGOs). All those organizations are potential beneficiaries and vital for use our electronic exchange of healthcare information system EEHI system, the concept EEHI is a proposed Hospitals Information System project, that will be set in the public hospitals in Khartoum, Sudan. Initially, after that, it will be generalized to cover the whole Sudanese public hospital and link them together with the Ministry of Healthcare in the Republic of Sudan. In order to make the information about the Sudanese citizens' (patients) available and timely accessed, and make some sort of Electronically Exchange of Electronic Patient Record (EPR) in the emergency department to collect the patient information and to do the triage process (Nugus *et al.*, 2010)(Bansler and Kensing, 2010), (Aacharya, Gastmans and Denier, 2011). after that exchanging the patient information and circulate it among Public Sudanese Hospitals (Unertl, Johnson and Lorenzi, 2012),(Pearson *et al.*, 2016).

1.2. The Scientific Problem:

With the total number of Sudanese citizens approximately more thirty-three-million-person beneficiary from the Sudanese public hospitals facilities which they are work manually (most of them). It's clear that the manual systems of public hospitals in Sudan do not satisfy the reporting needs of beneficiaries (patients and medical staff).

This kind of inefficiency and problem created by such systems includes:

Poor admin for clinical data, poor Doctor-patient communication, poor communication among medical staff, unavailability of information about the patients timely, queuing, time-consuming, slow retrieval of data, paper wastage, poor data storage and the loss of patient's medical information.

An effective Information System should be capable of maintaining an institutional memory, where the information about beneficiary (patients) or (citizens) is easy to access (Wu *et al.*, 2012). A computerized system such as Electronic Exchange of Healthcare Information (Vahdat, Hessam and Dadashi, 2018), (Hinchman *et al.*, 2018) among public Sudanese Hospitals can address such problems and provide advanced services for ordering and reporting of Hospital Information Systems (HIS).

1.3. The Research Objectives:

This research aims to come-up with a novel framework for healthcare information infrastructure and healthcare information exchange. And designing an integrating Hospital Information System (HIS) for public hospitals. In order to improve the efficiency and effectiveness of hospital services by computerizing all the manual works, activities and integrating all the procedures with an effective information system by:

1.   Analysis of the existing systems in public Sudanese hospitals.

2.   Introduce a novel framework that introduces an effective of an information system for Electronic Exchange of Healthcare Information among public hospitals in Sudan.

3.   Design a novel framework that introduces an effective model of an information system, for Electronically Exchange of Healthcare Information among public Sudanese hospitals.

4.   Develops and maintain the Hospitals Information Systems (HIS).

5.   Evaluate and validate the proposed Framework using a questionnaire.

6.   To Explore and highlight the features of effective information systems.

7.   To add to the literature review in the area of Computer Support Cooperative Work (CSCW).

1.4. The Study Questions:

This study revolves around two main questions: 1) what are the current practices of information exchange among hospitals in Sudan? And 2) how may these practices be improved with new healthcare information infrastructure?

1.4.1.   Sub-Questions:

1.   How do people work together now?

2.   And how would we like them to work in the future?

3.   How may our computer system make people work more efficiently?

4.   May the electronic exchange of healthcare information among hospitals, potentially help the medical staff to do their job better and in a more efficient way?

5.   May the implementing of electronic exchange of healthcare information among hospitals enhance the Doctor-Patient communication?

1.5.   The Academic-State-of-the-Art:

In this part we will describe briefly two main concepts, in chapter two we will dig deeper into the literature in the area of electronic patient record EPR and the health information exchange HIE network. And, also the benefits and challenges that may be expected from the field of Computer Support Cooperative Work CSCW in the health care sector.

1.5.1.   What is Information Infrastructure?

The term *Information Infrastructure* in the field of Computer Support Cooperative Work (CSCW) refers to the digital facilities and services that work within digital environment and connected to the internet that provides computational services, consist of help desk and data repositories' (Axelsson and S. B. Axelsson, 2006), (Coiera, 2006)(Fitzpatrick and Ellingsen, 2013b).

1.5.2.   What is Cyber-Infrastructure?

Cyber-infrastructure integrates hardware for computing, data, and networks digitally enabled-sensors, observatories and experimental facilities, and an interoperable suite of software and middleware services and tools. However, (Stewart *et al.*, 2010), (Collen, 2015) defining Cyber-infrastructure as those layers that sit between base technology (a computer science concern) and discipline-specific science. According to the Atkins report, Cyber-Infrastructure consists of "hardware, software, personnel, services and organizations" (Bowker *et al.*, 2010). Another definition from (Stewart *et al.*, 2010) Cyber-Infrastructure consists of computational systems, data and

information management, advanced instruments, visualization environments and people, all linked together by software and advanced networks to improve scholarly productivity and enable knowledge breakthroughs and discoveries not otherwise possible.

1.6. The Potential Benefits:

1.   A certain extra facility for Doctor-Patient communication (a) increases patient satisfaction, and (b) release cognitive load from practitioners.

2.   Better recording and exchange of patient's medical history will improve patient satisfaction via better healthcare delivery updating.

3.   Using the EEHI system may improve patient examination and treatment scheduling and it may improve coordination among doctors and hospital departments.

4.   The EEHI may help doctors examine and treat more patients that previously visited one of our hospitals because they now have a patient history.

5.   The EEHI system may enable doctors to make fewer mistakes.

6.   The EEHI system may make the laboratory technicians deliver test results timelier and with higher accuracy.

7.   Using the electronic exchange of healthcare information among hospitals may enhance the information circulation, which may result in better communication, in terms of timely and complete delivery of patient information and medical history.

8.   Electronic exchange of healthcare information among hospitals EEHI is easy to use in terms of both interfaces' usability and understandability.

1.7.   The Study Scope:

In this research, we introduce a novel Framework for Healthcare Information Infrastructure that introduces an effective integrated information system for Electronic Exchange of Healthcare Information among public Hospitals in the Republic of Sudan.

1.8.   The Methods:

Initially, based on the literature, The second method in this Thesis is Ethnography Study field work (Riddley, 2018), the third one is observation of a phenomena exists in the most Sudanese's public hospitals which they work without computerizing system, the fourth method is interview , which compromise of two types, Structured and Unstructured interview, and the fifth method is questionnaire. In addition, from this phenomenon, we abstracted our research question and then the potential benefits, the principal tools used in this research are divided into three categorize: 1) Computer software. 2) Computer hardware. 3) And the people. We will describe them below:

1.8.1. Computer software:

The proposed scheme has one main goal is to design a conceptual framework to manage and integrate the public Sudanese hospital in one system. And make the information about patients available in the whole public hospitals in the Republic of Sudan. The proposed system should be capable of doing this.

The System will be divided into three subsystems, the Doctor Sub-System, the Administration office Sub-System, and the laboratory Sub-System. Of course, this system has a database to store patient records, and have interfaces to facilitate the input and output process.

1.8.2. Computer hardware:

The computer hardware involves the ICT infrastructure equipment's that required for the system, like PCs printers network cables and so on.

1.8.3. People:

On this study, the word people means; the users which they will interact with our proposed EEHI system (Dauwed *et al.*, 2018), the users of the system involves the Doctors, the Administration office employees ,and the Laboratory Technician, those users who have authorization to access the system , by using their User-Names and Password to control access, (Yüksel, Küpçü and Özkasap, 2017),(West *et al.*, 2018).

Other tools and methods included in our work are: Mind-Map software, Conceptual-Map, and Ideational-Map, the system Mock-ups, and finally the Prototype as shown in advance chapters.

1.9. The Research Contribution:

1.   The Infrastructure: in term Infrastructure, the backbone of HIIPS solution is highly secured and the modular IT information infrastructure are implemented for healthcare information exchange.

2.   We provide seamless access to the existing patient data by standardizing and synchronizing care across hospital units.

3.   In this Research, we introduced a novel Framework for HIE.

4.   That introduces an effective integrated information system Model for Electronically Exchange Healthcare Information among Hospitals.

5.   The proposed system and framework can (potentially) be trusted, faster and more efficient than existing system, shorter time of service, less queuing, less time consuming, quicker retrieval of data, less paper wastage, rich data storage and eliminate the loss of information, and

enhance the work that is results of the current public Sudanese hospitals systems.

1.10. Thesis Organization:

Chapter Two:

This chapter presents a theoretical background and literature review. This study reviewed the reviewed the literature for the past twenty-eight years in the areas of Computer Support Cooperative Work CSCW, Healthcare Information Exchange HIE, and Electronic Patient Record EPR research in healthcare. Also, we did an investigation study to understand the CSCW and its contribution to and challenges in Healthcare.

Chapter Three:

This chapter is dedicated for the Analysis of the current situation of a hospitals department in thirteen healthcare organizations in Sudan, we did an extensive analysis to understand how the current situation work from the business perspective and from the developer perspective flowed by communication diagram and use-case diagram in the next chapter using UML. Also, we Identifying Business Actors.

Chapter Four:

This chapter is dedicated for A Framework for the Exchange of Healthcare Information among Public Hospitals, we work out how to solve the current problems regarding existing healthcare systems, in order to improve the current situation, and developing a novel framework, that allows the patient's information to be an exchange and circulate among hospitals.

Chapter Five:

This chapter introduces a case study of a hospital system "Practice of Healthcare Information Exchange (Case Study Al Ribat Hospital) "A paper has been published about this case study.

Chapter Six:

In this chapter, we stated the results of the study and a questionnaire was developed to measure the medical staff satisfaction from the electronic exchange of healthcare information among hospitals EEHI from the point of view of Doctors, Administration office employees and laboratory technicians.

Chapter Seven:

This chapter is dedicated to discussing the result from the previous chapter.

Chapter Eight:

In this chapter, we presented the conclusion of the study work. Also, we mentioned the open issues for new researchers in the same field.

CHAPTER TWO

LITERATURE REVIEW

2. Theoretical Background and the Literature Review:

2.1. Theoretical Background:

Computer Support Cooperative Work (CSCW) research has been started many years ago (Fitzpatrick and Ellingsen, 2013b), (Blomberg and Karasti, 2013). In this study, the literature was reviewed for the past twenty-eight years of CSCW research in healthcare. We did an investigation study to understand the CSCW and its contribution to and challenges in healthcare. To practically achieved and designing a Framework and also assistant prototype system to support that work.

2.2. Literature Review:

This study outlines and produces a strategy for health information infrastructure for integrating the public hospitals in the Republic of Sudan and implementing Health Information Exchange system among them (Who, 2006), (Dobrev *et al.*, 2008)(Nugus *et al.*, 2010). Also, defined a number of factors those are essential in the process of the Information Infrastructure for hospitals and the patient's information and its circulation (Riddley, 2018), including 1) Electronic Patient Record EPR. 2) Electronic Health Record EHR. And methods including: 3) Health Information Exchange System HIE. And some concepts such as 4) interoperability.

2.2.1. Electronic Health Record EHR:

EHR is a computer-based solution, or platform,(Management and Controls, 2011),(Services and Information, 2013), (Hodgkins *et al.*, 2017) ,(Services and Information, 2013). That provides integrated information about the people in a single set or Record about individuals in all hospitals those engaged in the specific HIE system (Dobrev *et al.*,

2008),(Polanco *et al.*, 2015), (Clarke *et al.*, 2015),. This record is used by the beneficiaries who are the physician and their team.

2.2.2. Key benefits for Patients:

• The patients will not need to repeat their health story every time they visited hospitals.

• EHR will be very useful especially for the people who cannot talk by them self. For example, people who have Diabetic Coma.

2.2.3. Key benefits for Clinician:

• Reduce the cognitive load from the clinician.

• Better information at the moment of care result in good decision making about diagnosing and avoid misdiagnosing and error.

2.2.4. What is an Electronic Patient Record EPR?

An EPR allows people to communicate their symptoms, preferences and experiences as a 'health story'. It will collect and present existing health information into a single record view accessible to consumers, careers and decision-makers (Tang *et al.*, 2006), (Essential Hospitals Institute, 2013), (Hodgkins *et al.*, 2017) (Everson, Kocher and Adler-Milstein, 2017).

2.2.5. What is Interoperability?

Interoperability means the ability of two or more health information systems to work together within and across hospitals boundary. In order to develop an effective and advance healthcare system for individuals and societies (Ben-Assuli, Shabtai and Leshno, 2013)(Furukawa *et al.*, 2013).

Interoperability describes the extent to which two systems and devices can circulate, share, and exchange the data (Brailer, 2005)(Furukawa *et*

al., 2013). The two systems must be able to access and exchange that data such that may be understood by a people (DeSalvo, 2016), (Abdulnabi *et al.*, 2017).

In healthcare, Interoperability means the ability of two systems with a different information technology platform to communicate together, share, exchange data and use of this data (Gross and Gross, 2013),(Mohammed, 2017).

2.3. Part One: The Current Situation of Information Infrastructure in Healthcare and Health Information Exchange:

Healthcare Information Infrastructures for Public Hospitals in Sudan (Khartoum State) is a necessary step for improving health in our nation. It well requires a collaborative work and efforts by public and private health sectors organizations, (Bansler and Kensing, 2010)(American Recover, 2014), (DeSalvo, 2016), and for sure by the government of Republic of Sudan especially the ministry of health and National Information Centre NIC. Better health is what we seek for our population, our family, our neighbors, our friends and nation and for all people over the world. It becomes a matter of life for people in developing countries, especially in Africa. However, it's not matters of quality of life for our nation in Sudan. It is a matter of stability and happiness within our communities, better health may result in improved and increased the productivity of industry, and the satisfaction of the healthcare workers. The call for action was headed by the researchers, who began to study information infrastructure for the healthcare sector. For example, in the Republic of Sudan, we did an extensive analysis to understand the current situation of healthcare's organizations' workflows process and Health Information Exchange HIE. The analysis

covered some of the public hospitals such as 1) National Ribat Teaching Hospital/police hospital. 2) Bahry teaching Hospitals. 3) Al - Tajani Al - Mahi Hospital. and 4) East Nile hospital. Also, the private organizations are no exception, we analyzed some of the private Hospitals such as 5) Omer Sawi Hospital. 6) Alia Specialized Hospital. 7) Yestabshroon Hospital. In addition, the study analyzed two healthcare Centers which are 8) Al Ahfad healthcare Centre and 9) Derby wounds care Centre. Also, we did an investigation to detect the government organizations that are involved in the operation of developing the health care sector related Information systems, such as 10) National Information Centre NIC. And 11) Health Insurance Khartoum State, And 12) Ministry of Health Sudan. finally, we studied Telemedicine and E-Learning in a Primary Care Setting in Sudan, especially the Experience of the 13) Gezira Family Medicine Project. Below we will give an overview for some of them briefly.

2.3.1.   Public Hospitals:

2.3.1.1.   National Ribat Teaching Hospital.

We dedicated chapter five for National Ribat Teaching Hospital because we took it as a case-study in our study and we published a scientific paper about it.

2.3.1.2.   East Nile Hospital-Current Practice:

The East Nile Specialist Hospital is a hospital owned by the social security investment system. It is equal in medical service between the employees of the health insurance, the private sector and the emergency treatment. Hospitalization service varies, the hospital Includes all recognized medical departments such as Department of Plastic Surgery, Obstetrics and Gynecology Department, Orthopedic Departments, Department of Organ Transplantation and Kidney Transplantation. The

hospital works in a self-management system, meaning that it does not receive any financial support from the Government of Sudan.

The hospital has developed two applications systems to computerize the manual work, one is dedicated for the accounting department called SCABS and the other one is dedicated for the administration offices SCABS called "Patient Registration and Master Index". This system is used to collect the patient's personal information and patient's demographic data and health insurance details. The systems are totally made in Sudan by Bioinformatics engineering named Salih Hassan Babeker. see figure (1) below.

Figure 1: East Nile Reception

2.3.1.3.　Al - Tajani Al - Mahi Hospital:

Al-Tajani Hospital is the first Sudanese hospital specializing in the diagnosis and treatment of mental and neurological diseases. Established in 1971, this hospital is located in Omdurman. This name is named after the Sudanese psychiatrist Tijani Al-Mahi, in this hospital They adopted a manual system to manage their work, Bahry Teaching Hospitals too.

2.3.2.　Private Hospitals:

2.3.2.1.　Omer Sawi Hospital:

Omer Sawi Hospital is a private, the hospitalization service varies, the hospital Includes all recognized medical departments such as the Department of Plastic Surgery, Obstetrics and Gynecology Department, Orthopedic Departments, Department of Organ Transplantation and Kidney Transplantation. The hospital belongs to police force. In 2016 Hospital Health Information System (HHIS) was deployed and installed consist of fifteen modules, which are 1) Admission Registration 2) polyclinic 3) Cash Desk 4) invoicing 5)Imaging 6) Laboratory 7) Staff 8) system configuration 8) Hospitalization 9)Blood Bank 10) Queries and Analysis 11)Health statistics and report 12)Pharmacy 13) Medical supply 14) intercommunication 15) Visit Pass. See figure (2) below.

Figure 2 Hospital Health Information System

2.3.2.2.   How the HHIS System Work:

The administration office employee collect the patient's personal information and the patient's demographic information such as: health ID,Given name, father name, grandfather name, last name, mother name, Gender, date of birth, ID type, ID issue date , ID issue place, nationality ,address, state, locality, administrative unit, telephone number and the email address. See figure (3) below.

Figure 3 Patient Admission

Once the above data regarding the patient is collected and submitted into the Admission Registration sub-system the patient ID and file number will issue and become available in the other modules and sub-systems. For Example, the file number will be used in the polyclinic by the doctor, to search the patient using his/her file number and add any type of diagnoses and test to be done in the laboratory. Unfortunately, this process cannot be done smoothly, because there is no integration between the polyclinic subsystem and laboratory subsystem, so this process is totally work in a manual manner now. The HHIS system right now suffers from a number of deficiencies we will discuss it in Chapter Seven.

2.3.2.3. Alia Specialized Hospital:

Alia Specialized Hospital Omdurman is one of the largest private hospitals in Sudan, located in the city of Omdurman towards the

geographical south of the Youth and Children's Palace. At the entrance of the White Nile Bridge on the western side, the hospital is designed to meet the highest standards for health institutions. The selection of medical and administrative devices and systems from the latest technology of medical science. The hospital receives all emergency and cold cases and contracts with all the institutions and the largest medical insurance companies, covering all segments of society from the constitutional and businessmen, citizens and foreigners.

• The hospital is keen to provide the finest medical services through qualified staff, equipment and modern technology and the building equipped with the highest standards.

• Localization of treatment is considered one of the main objectives of the hospital.

• Attract patients from neighboring countries by providing a distinguished medical tourism service.

• The hospital is working on the development, training and continuous improvement of the medical service through the method of monitoring and analysis of data related to the service provided.

Two years before, the hospital contracted with "SCABS Engineering Company" to design a hospital information system, it was. Now the hospital has its own heath information system that consists of five modules; which are 1) Patient Registration. 2) Patient Billing System. 3) Medical Records System. 4) Laboratory Information System. And 5) Pharmacy Management System.   We have to mention that the physicians and nurses work are totally manual, and all these modules are under experimentation phase, which means the system is not completed yet.

2.3.2.4. Software and operating systems used for development:

1. The Operating Systems:
- Microsoft Windows Server 2008 ,2012.
2. The Programming languages:
- Microsoft Visual Basic 6 Language.
- Microsoft Visual Basic .NET 2010.
- Microsoft crystal report 2008, 2012.
3. The Data base:
- Microsoft SQL Server 2012.

2.3.2.5. Yastabshiroon hospital:

A private hospital owned by the Minister of Health in Khartoum State, Professor Mamoon Houmida. the hospital Includes all recognized medical departments such as the Obstetrics and Gynecology Department, Orthopedic Departments, Department of Organ Transplantation and Kidney. the hospital contracted with "SCABS Engineering Company" to design a hospital information system. Now the hospital has its own heath information system that consists of seven modules; which are 1) Patient Registration. 2) Patient Billing System. 3) Medical Records System. 4) Laboratory Information System. 5) Pharmacy Management System.   6) nurse's module and 7) physicians' module. mentioned that all these modules are under experimentation phase, which means the system is not completed yet.

2.3.2.6. Software and operating systems used for development:

2.3.2.6.1. The Operating Systems:

- Microsoft Windows Server 2008 ,2012.

2.3.2.6.2. The Programming languages:

- Microsoft Visual Basic 6 Language.

Microsoft Visual Basic .NET 2010.

- Microsoft crystal report 2008, 2012.

2.3.2.6.3. The Data base:

- Microsoft SQL Server 2012.

2.3.3. Healthcare Centers:

Ahfad healthcare Centre.

Derby wounds care Centre.

2.3.4. Government Regulatory Bodies:

2.3.4.1. National Information Centre NIC.

The Centre was officially opened in December 30th 2001 by the president of the Republic Omer Hassan Ahmid Albashir. It Works in several axes. Such as Infrastructure, systems and applications, standards, policies and methodologies in the field of information. Participates actively in the development and implementation of the country's information strategy.

2.3.4.1.1. The aims of the Centre:

Giving great attention to the information of all varieties, types, systems, technology in Sudan and organizes them with co-operation with specialized authority.

Participating in information development, its uses and manufacture special technology for Sudan.

Giving consideration and spread the culture of information to build the society of knowledge in Sudan.

Develop the information construction, they apply and uses by the different levels of the government. Feeding the government with information to manage the country `s affairs

and create development in all sectors.

Protect and secure information and strategic information.

Constructing human and institutions abilities in technology.

Bridging the digit gap in information technology

Encourage the private sector to participate effectively in developing the information infrastructure.

To join intelligent sharing with the institutions working in Information Technology.

2.3.4.1.2. The Center's Authorities and Specialization:

Make the general policies and strategies to develop manufacturing information technology and their uses in Sudan.

Look after the applied electronic projects especially the electronic government with collaboration with all the governmental units and civil society organizations.

Construct the national information net and manage and operate according to advanced scientific methods.

2.3.5. The Health System:

In 2010 the Sudan National Information Center NIC started work on the health system and contracted with Best-Care company, from the State of Turkey. To develop the hospital health information system HHIS. This experimental application of the hospital's management system was inaugurated at the General Omar Sawi Complex, after the installation of the system, and the training of manpower working in different sections of the complex after the activation of the system in 2016. To determine the system and assess its compliance with the different functional and non-functional requirements, a team has been formed with the participation of a number of relevant actors. Such as the national health insurance fund, the federal ministry of health, family medicine al Gazira State, in addition to major general Omar Sawi, and the E-health team at the national information center. We will talk furthermore about HHIS later in details.

2.3.6. Khartoum State Health Insurance Corporation (KSHIC):

On December 10th 2010, Khartoum State Health Insurance Corporation (KSHIC) Requested a Proposals from reputable software vendors and IT firms/companies/Houses for health insurance and resource planning software, along with related optional technical support services. This request is a major step in the implementation of a comprehensive, fully integrated KSHIC system. to supply, install and train licensed, complete integrated software package covering all the activities of the corporation and satisfying the requirements of KSHIC. The package should be capable of delivering services through all offices geographically distributed throughout Khartoum. The system should avail in a

timely manner all management information needed to the top management of the company at all levels.

2.3.6.1. Computerization of the Health Insurance System:

Is a project for the supply, installation and operation of programs, to computerize the work of the KSHIC in all aspects, and to provide services to the public customers through multiple channels of communication, in addition to the traditional channels, through the branches of offices and pharmacies and service centers in the state of Khartoum, so that these channels are linked to each other in a unified computerized system, the insurance operations are integrated and provide the required information on time and effortlessly.

2.3.7. Telemedicine and E-Learning in a Primary Care Setting in Sudan: The Experience of the Gezira Family Medicine Project:

The authors of this article argued that; the information and communication technology ICT gradually is used in the health care sector (e-health) to provide distance heath care or telemedicine and facilitate distance education (e-learning). Also, managing the patient's information by initiating the electronic medical record (EMR). The Gazera Family Medicine Project (GFMP) offered a master degree in family medicine with fully ICT integration in the project (study) for two years. The GFMP is a collaboration project between the ministry of health in Gazera state, Sudan and faculty of medicine, University of Al Gazera. It aims to enhance the quality health services by providing training of family doctor and improve the delivery of services at this level. Also, to break down the distance

barrier and offer high-quality care for the patients all over Al Gazera state at specialist level(Mohamed *et al.*, 2015).

On this project GFMP, they utilized and implementing the ICT in three areas, which are: 1) Telemedicine Program. 2) Electronic Medical Records EMR. 3) E-Learning.

Telemedicine is defined as the use of medical information and exchanged from one site to another through digital communication, to enhance the patient's clinical health status(Iucn *et al.*, 2006). In this study GFMP, the term Telemedicine used to describe the online interaction between the specialist doctor and the candidate enrolled in the GFMP.

In this part we will focus the light on the implementation of Telemedicine, Electronic Medical Records EMR, and E-Learning.

2.3.7.1.   Telemedicine Program implementation:

Gazera Family Medicine Project implemented Telemedicine by means of Designing two studios, one of them in Madani town and the others distributed all over the rural area setting in the health centers, the both studios equipped with computers, LCD screen, internet, and also, the used software program called OOVOO to connects the family doctor and patients from health center with the specialist doctor. OOVOO software offers the means for communication and provides for both site the capabilities for talking over the internet, show picture, and chatting as video conference settings. Also, allows the family doctor to show some clinical signs. Such as skin manifestation and ECG investigations.

2.3.7.2.   Electronic Medical Record implementation:

Family Clinic is an Electronic medical record program designed by GFMP that cope with the local needs.

2.3.7.3. E-learning implementation:

The same studios used for Telemedicine were also used for educational activities, the difference is that; instead of using OOVOO the used Cisco WebEx to connect all candidates with the lecturer. Finally, we have to mention that; a literature review in the Eastern Mediterranean region found that E-health has not yet been well studied(Al-Shorbaji, 2009).

2.4. Part Two: The Structure and Contents of Information Infrastructure in the Healthcare (including Exchange, EHR, EPR):

Nowadays, people are becoming more reliant on information and communication technology as it has invaded most of disciplines and businesses around the world, and healthcare organizations are not an exception (Kodner and Spreeuwenberg, 2002) This includes technology such as electronic health record HER and health information exchange HIE networks (Nugus *et al.*, 2010), (Nugus *et al.*, 2010), (Polanco *et al.*, 2015) and other ways to circulate the Patient information among emergency rooms (ER) within hospitals and among other hospitals, in order to share Patients' information that is needed by physicians (Govindhan *et al.*, 2018), not only to treat the immediate symptoms; but also, to have a knowledge of previous treatment and disease. This is essential to making decisions about whether to admit or discharge the patients to the hospital wards, in other words, it is offering the information for the decision makers to help the practitioners in the decision-making process. The call for action has been headed by the researchers who began to study the implementation of EHR, EPR and HIE networks

in the ER, which will result in better care for patients inside ER especially in challenging situations, where time constraints oblige physicians to make a rapid decision (Haux, 2006). For example (Ben-Assuli, Shabtai and Leshno, 2013), (Everson *et al.*, 2016) they describe the types of data that might enhance the decision making process in the emergency department ED, Also, one of their objectives is to evaluate the influences of different information components that were retrieved from electronic health record EHR and health information exchange HIE system on the physicians' decision to admit or discharge patients from ED. The authors used data from health maintenance organization HMO in Israel, which linked seven hospitals that shared secure EHR through interoperable HIE system. They employed statistical tools as a method on log-files and used the same information system HMO. They found that using EHR consisting of previous hospitalizations, chronic diseases, past vital signs, past blood pressure significantly affects the physicians' decision in a positive way, especially in critical contexts where the time factor is essential in the process of decision making. (Nugus *et al.*, 2010) They used complex adaptive systems (CAS) to understand the interconnections among the units and services in ED departments. The term interconnection is labelled as "integrated care" in the academic literature (e.g. (Kodner and Spreeuwenberg, 2002), (Hewett *et al.*, 2009)(Nugus *et al.*, 2010). Also, the World Health Organization (WHO) has promoted the concept of "integrated care" to illustrate the coordination of care among professional and ED services. They undertook ethnographic studies over one year to collect data through observations, compromising 110 hours of observations, and generated up to 800 pages of field work, handwritten field work. 56 structured and semi-structured interviews were conducted

with nurses and physicians. They found that the CAS approach to be noteworthy for analyzing integrated care in the ED because the operation of classification diagnoses and discharges were mainly correlation services. However, (Detmer, 2003) argued in his article(Building the national health information infrastructure for personal health, health care services, public health, and research) that improving health in our nation requires strengthens four major domains for healthcare systems; which are: managing the personal health , delivery of the care, public healthcare and related research in health. (Detmer, 2003),(Mohammed, 2017) State many barriers results in poor quality, including the difficulties of accessing the data, information and knowledge. All those barriers and shortcoming can be excluded by the implementing of a National Health Information Infrastructure (NHII) because it offers the connectivity and knowledge management facilities. NHII is defined connectivity as "An information and communications infrastructure exists to connect users to each other, to information, and to analytical tools and to enable management and generation of knowledge" (Detmer, 2003), (Essential Hospitals Institute, 2013), (Buntin *et al.*, 2011) It is a means to computerize all the manual work and move from paper-based system to computerize assisted integrated system, which can improve the quality of health data, information and knowledge. Why should Sudan build (HIIPS)? Information infrastructure is a base tool for any information-intensive industry especially the healthcare industry, an integrated infrastructure allows the beneficiaries to share and exchange the information about the patients between hospitals. (HIIPS) should be built through collaborative efforts between public and private health organizations and investment. (Detmer, 2003) Argued that, the key enablers for information infrastructure

are: incentives, standards, privacy and security framework, and funding(Zhou, Ackerman and Zheng, 2011)(Everson, 2017). Now is the time for the Republic of Sudan to take the opportunity of the introduction of ICT and the internet facilitation. And start building the healthcare information infrastructure for the public hospitals in Sudan i.e. (Mohammed, 2017). Many researchers around the world spot the light on Electronic Health Record EHR and electronic patient record EPR, because of their importance as a major element in the process of exchange between hospitals. For example (Häyrinen, Saranto and Nykänen, 2008),(Black *et al.*, 2011) presented a reviews paper in the literature of electronic health record area, including several questions as follows: 1) how electronic health records are defined? According to the international organization for Standardization (ISO), the EHR is defined as:" a repository of patient data in digital form, stored and exchanged securely, and accessible by multiple authorized users. It contains retrospective, concurrent, and prospective information and its primary purpose are to support continuing, efficient and quality integrated health care"(Black *et al.*, 2011)(Häyrinen, Saranto and Nykänen, 2008). 2) How the structure of these records is described? The structure and content of EHR (Kuhn, 2011) are categorized into three type's which are:

A) Time-oriented electronic medical record: here the data is presented according to ordering time.

B) Problem-oriented electronic medical record: here the notes are taken according to the problem.

And C) Source-oriented record: and here the content of the record depends on the method example X-ray. 3) In what contexts EHR is used? It's used in primary and secondary and tertiary hospitals. 4) Who has access to EHR? The EHR is accessed by a number of

users in the healthcare professionals like Doctors, Laboratory Technician, Nurses, Administration staff, and Patients 5) which data components of the EHR are used and studied? There is a number of data component recorded in the EHR system where used and studied in this review paper includes referral, present complaint past, medical history, lifestyle, physical examination, diagnoses, tests e.g. laboratory and radiology, procedures, treatment, medication and discharge. 6) What is the purpose of research in this field? the purpose of these studies reviewed is to identify the success factors of implementing information system according to (DeLone and Mclean, 2003) there is six success factors are 1) Information quality, 2) System quality, 3)Information use, 4)User satisfaction, 5)Individual impact and 6) Organizational impact. This study has added to our knowledge: an overview of the types of information included in the EPR, an overview of the content of EHR. Also, the role of the nurse's information system and data produced by patients has not been taking into account and this needs more study.

In the 21st century many developed courtiers started to build their own information infrastructures system in the healthcare sector, For example, (Jha *et al.*, 2008) used a combination of literature review and interview with experts from seven industrial countries to assess the state of health information technology and determine the key factors for adoption of health information exchange HIE in seven countries: the United States (U.S.), Canada, United Kingdom (UK), Germany, Netherlands, Australia and New Zealand (NZ). In this study, they defined HIE as" the exchange of clinical data such as problem lists, clinicians' notes, or other critical medical information from one provider organization to another". According

to this definition they started collecting the relevant data by searching the literature by using terms such as "computerized records", "electronic health records", "electronic medical records" and "health information exchange" also they searched Google, Google Scholar and other search engines, and also, they contact experts in HIE in each of the seven nations. They were able to contact leading government experts overseeing the adoption of HIE. The result showed that implementing HIE between the seven industrial nation is not complete yet (the UK, Netherlands, Australia and NZ) had nearly universal use of EHR among general practitioners (each >90%) and Germany was far along (40–80%). They found that evaluation of the EHR in hospitals in the seven nations is not high-quality and the data in EHR is not reliable in acute care settings. They also found that exchange health information or clinical information remains low in each country. In conclusion, health information technology has the ability to improve health service quality and efficiency. Cross-Country health clinical information is not currently available. The insight gained from this study is that: most countries are at the beginning of implementing health information exchange or health information technology, examining different countries' HIE approaches can provide valuable insight. Some counties are achieved success with HIE in the ambulatory sector, but there is still a lack in hospitals sectors, Health information exchange between countries will prove very useful to continued progress for all countries. Many countries have started to use information technology to assure and improve patient safety (Joshua R. Vest and Gamm, 2010),(Management and Controls, 2011),(Jones *et al.*, 2014), (Dauwed *et al.*, 2018) and to improve the quality of health care services. Canada one of those countries, (Rozenblum *et al.*,

2011), (Fitzpatrick and Ellingsen, 2013a) are conducted a qualitative study to identify the success of different side of the Canadian plan and ways to enhance the adoption of electronic health records. In 2001 Canada Health Infoway detected a plan to carry out a national system of electronic exchange of health record between regional, the Infoway is a government-funded corporation that comes in with a novel model for interprovincial collaboration to establish core aspects of a national framework. They assess ten years of Canada's E-health plan by using case study to assess the E-health in Canada and to evaluate its effectiveness and efficiency and to identify the ways to increase the adoption of electronic health record in Canada. In this study, they used a case study approach and a structured interview as methods. Also, they reviewed the national report and documents and also conducted structured interview and they identified 32 potential candidates that they represent the national organization. The potential candidate was contacted using phone call and Email. Also, they used a questionnaire to collect the relevant data and to analyze this data they used the *grounded-theory* approach which is a technique used in similar studies for analyzing qualitative data. The result showed that the stakeholder's participant in the study (questionnaire) they identified national standard funding for implementing E-health in Canada. Also, the study found that patient registration and digital imaging as a significant achievement of the health plan. The study provides a recommendation for future work. However, this recommendation may not represent all the stakeholders in this study, and the researchers were not able to assess either the participants view varied across provinces or stakeholder's groups, such a difference may be relevant to understanding why some provinces were successful to adoption and implementing health

information technology. In conclusions, Canada has implemented a national plan to electronically exchange of health care record by establishing a model for successful exchange health information between provinces to allow collaboration work between hospitals and making national framework; but it is not complete yet. in future Canada looking for establishing E-health policy to guide the implementation of health information technology. To address the major strategic priority of health care reform and to make improvement in the patient safety, managing the chronic disease, sustainability of health care system and to promote for the electronic exchange of electronic health records and clinical data to address these challenges, the policies are needed to: (a) Facilitate sharing the clinical information between hospitals and clinical centers timely and health providers. (b) To make personal health records accessible. Many countries have started electronic patient record to assure and improve patient safety, to improve the quality of health care services and to reduce the readmission to the hospitals. This may result in reduces the cost of treatment for the patient and the healthcare providers. United States of America one of those countries, for example,(Vest, Joshua, Kern Lisa, Silver Michaela *et al.*, 2015) they argued that the readmission to the hospitals is common and costly in the united states of America. the cost of readmission about $17 billion each year. In addition, there is a lack of information exchange (Yaraghi, 2015) between the hospitals about the patient deceased, also the patients think that their healthcare provider has a little information about them. To solve these problems the authors, utilize health information exchange systems HIE as a solution for readmission by facilitates the access to patient clinical data and improve communication. The method was used in this study was conducted retrospective cohort

study of hospital readmissions among adult patients in the Rochester, New-York area 2009-2010. The study conducted covers 38 healthcare organization in the New-York County and region. The data were collected via the Rochester Regional Health Information Organization (RHIO) and exchanged via web-based technology. "We analyzed claims files from two health plans that ensure more than 60% of the area population. Claims data provided all patient demographics, diagnoses, and encounter information" (Joshua R Vest). The study showed that the readmission after discharge is for the same cause within 30 days. And to measure the outcome of this experiment they use HIE usage as a primary independent variable. In conclusion, this study takes a sample of 6807 discharged patients the financial saving after using HIE in the USA approximately about $605 472 annually accounting to an estimated 48 potentially avoided readmissions each year. The use of an electronic record exchange through an HIE reduces the readmission to the hospital and can save the financial cost. The use of HIE system makes the information about the patients available, complete in time and complete medication lists. Diagnoses made in the hospital recent laboratory, radiology results, laboratory and radiology tests still pending at the time of discharge that required ambulatory follow-up. This study is applied in a hospital as our study and used HIE as a solution for their problem and it is showed that using the HIE is very useful in the problem-solving. Until now in the Republic of Sudan there is no computerized system to manage the public hospital's services and there is no exchange of patient's medical information among public Sudanese hospitals. These studies showed that implementing HIE in hospitals can save a lot of money and lives. Also, accessing the patient's information from outside hospitals result on improving the care of patients in

the emergency department, For example, (Everson *et al.*, 2016),(Mohammed, 2017) argued that in the fragmented healthcare system the medical staff struggle to access the patient information from outside organizations in the emergency department, that was treated in another hospital timely and retrieve the relevant information about the patient. The main objective of this study is to assess whether the use of electronic exchange of healthcare information HIE have a positive impact on the emergency department ED. By improving the ED process and its ability to facilitate more clinician timely access and viewing the patient information from outside organizations. (Everson *et al.*, 2016) They used data from the large academic medical Centre to achieve their objectives and to access the detailed information about the patient, they were used HIE if the outside organization is implemented Epic if it's not, they have used the Fax. By 2014 they activated HIE module called Care Every-where. The results showed that there is no direct association between the data retrieved from HIE to ED, but using HIE is faster to access the patient information from the outside organization. (Downing *et al.*, 2016) was conducted the study in Northern California comprises eleven hospitals that use common electronic health record vendor (Epic Systems, USA) and it is associated HIE platform (Care Every-where). They focused on clinical summary exchange in the period of time from (2013 to 2015) to examine the relationship between electronically exchange of patient health information across health organizations hospitals. They concentrated on two keys decision, the first one is whether automatically search the patient information from other organizations without patient consent, and the second one is to require the health information exchange HIE specific patient consent. The eleven hospitals involved in this study were

used the same systems which are Epic and (Care Every-where) platform which is a standards-based network providing peer-to-peer patient matching and query-based HIE among organizations. They collected the relevant data from two sources; the first source is Self-reported data that was collected from chief medical information officers and other leaders, and the second source from eleven collaborative organizations. The result showed that nine of the eleven organization enabled patient health information exchange among hospitals during the period of study (2013-2015) without patient consent and these organizations experienced a greater increase in the volume of exchange over time by 1349%. In conclusion, the use of auto-querying without patient consent in HIE can have a significant impact on the health information exchange by increasing the exchange volume. (Everson and Adler-Milstein, 2016) Argued that there is abroad agreement that health information exchange HIE is intended for transferring electronically the patient health information across organizations to enable better and more efficient care. This study used the national data of the US hospitals to evaluate how market dominance by EHR vendors was related to hospitals' engagement in HIE in the period of time 2012 and 2013. They used national data of the US which consist of information from all hospitals in the US plus data from Colombia district. They emerged data from two sources, the first one is the American Hospital Association (AHA) and the second source is Annual Survey Health Information Technology. In conclusion: the study showed that there is a relationship between EHR and HIE, also there is a great agreement that EHR is a fundamental component for HIE. So, the results came as concerns of policy maker about the relationship of EHR vendor's dominant and their ability to facilitate or impede the diffusion of HIE. Also,

the results showed that the hospitals that used a system of dominant vendors (Epic) engaged more in HIE. conversely, the hospitals that do not use the dominants vendor's system are less engaged in the HIE. However, their study focused on the EPR vendor's dominance in the hospital's engagement in the HIE and ignored other engagement factors, such as the information came from outside hospitals and ambulatory providers. (Anderson, Baskerville and Kaul, 2017),(Mohammed, 2017), (Hinchman *et al.*, 2018) Argued that Electronic exchange of healthcare information across organizations is expected to enhance and improve the quality of care and reduce the related cost. The important element to achieve this is interoperability. Interoperability is defined as the ability of healthcare organizations to exchange health information electronically between them. The National Coordinator for Health Information Technology in the US confirmed that, but the sustained use of HIE among providers has been difficult to achieve. A number of factors play a role in that; including concerns about the security of exchanged information. The tension between the expected benefits of interoperability of health information and breaching of the patient health information. The study proposed an information security control theory to explain this tension. There was a previous study investigated the problem between sharing and protecting the health data, it was exploratory studies. The study used a qualitative research approach as a method. Also, they arranged meetings with the coordinators through the HIE's executive director to collect the relevant data for their study. Semi-structured interviews were conducted personally and over phone-call the interviews exceeded to Four Months and were recorded. Documentations are also collected, including a various version of the security policy. After that, they analyzed the collected data and

recorded interviews. By the end of this process, they identified the factors that impose tension between sharing and protecting the health data that HIE has addressed through the development and implementation of HIE. The result showed that the proposed theory offers a useful framework through which to realize the information security policy. In conclusion, interoperability of the health-care information among organization and vendors becoming critical to improve the quality of the care and also, to reduce the relevant cost. However, the security of health information is vital to the success of HIE and will increase the participation of organizations and patients. Like many other people-based professions communications skills are essential to medical practice staff also. For example, (Kommers, no date), spots the light on the new interaction modes and software that capable of interpreting and recognize the facial expression, emotion and voice to be used in soft skills training in the medical field, in order to make better Doctor-patient communication. However, this is crucial for the curing process and to better treatment, so more subtle social skills are needed. The primary focus of this study is to use E-simulation for developing social skills in the medical context. Moreover, according to the recent study undertaken by European consortia to inclusion media supported social skills in the medical care this requires both Theoretical and Case-Study Framework to assist their development (Anderson, Baskerville and Kaul, 2017). Soft skills are to enhance communication exchange between medical staff and patient by using learning devices to train the soft skill. The planned Marina and top-staff projects were used for affective computing. (Picard, 1995) Has defined affective computing as the types of computer applications that deal with emotion. (Picard, 1995), (Picard) raised the awareness that emotion can interfere with

mental performance and learning. There is strong need for the communicative mode from the point of view of practical and scientific to increase the effectiveness and communication between medical staff and patient, to have positive impact among patient health and recovery, to help the patients to get realistic about what will happen to them in the future and to reduce the cost of medical instruction. According to the top-staff project, there are challenges of communicative between the medical staff and the patients' interaction, such as clinical protocol needs to be appropriately managed, the time span on communication is unpredictable and also there are a number of pedagogical issues. The overall objective of E-simulation development is to provide software or learning system for training soft skills focusing on the healthcare context (Kommers, no date). In conclusion, soft skills training is strongly recommended for the physician and nurse practitioner with particular focusing on communication and emotion management skills, because it is vital to the curing process and patient satisfaction. The use of computing in order to train people in the management of emotions in interpersonal communication through interactive simulations in a collaborative environment is an important development (Kommers, no date).

2.5. Part Three: Challenges of Information Infrastructure in Relation to Design, Implementation and Use:

Information Infrastructure has been recognized as a potential problem in the workplace that deserves serious attention. As far back as (Hanseth and Lundberg, 2001),(Fitzpatrick and Ellingsen, 2013a) have argued that healthcare is making a huge investment in information system and

Information Technology; like Picture Archiving Communication Systems (PACS) and Radiological Information Systems (RIS). In fact, to implementing such systems in hospitals has been problematic(Reddy *et al.*, 2009),(Kaye *et al.*, 2010),(Kuhn, 2011),(Everson, 2017) and where the hospital information systems are in use the benefits gained from them are low and far below what has been expected. They identify a number of challenges and problems related to hospital information systems and to deal with those problems (Shekelle and Goldzweig, 2009), (Joshua R. Vest and Gamm, 2010),(Fitzpatrick and Ellingsen, 2013b),(Yüksel, Küpçü and Özkasap, 2017) they consider it as work-oriented infrastructures. Electronic Patient Record EPR has been existed since the sixties, but are still not working well even in the developed countries, especially in the large hospitals due to the problems of *standardization*, because the standard is much needed. For both *work oriented* and the kind of *infrastructure*. The aim of this study is to get a better understanding of the design challenges associated with implementing (PACS) and (RIS) systems. Bearing in mind that, the complexity of interdependency between the technology and medical practice in increase by the existence of new medical technology and new illness. To reach their aims they used ethnography studies, which was becoming widely used in the information system (IS) and Computer Support Cooperative work (CSCW) fields. When using this research approach the focus is on investigations and understandings of actual work practice in their particular contexts. Several research methods used also on this study for data collection including, workplace video recording, structured interviews, unstructured interviews, observations and an integration, social interaction, more than 40 hours of video documentation, 45 hours of observations and 22 interviews of 1 1/2 hour each were conducted, some participants were interviewed several times.(Fitzpatrick and Ellingsen, 2013a) found that there are

major challenges for the design of information infrastructure including the following: 1) *Standards*: The standard means that, in the network that linked to another network the operation must operate smoothly and in a convergent and aligned way, and share the same communication protocol. This means that; the designing infrastructure required defining *standards protocol* including communication protocol and coordination artefacts. 2) Momentum and Irreversibility: The larger number of actors in the workplace within the larger number of components is more important for standard. On other hands, when implementing the standard in larger networks makes it harder to change the networks, because the networks are linked with the same sharing standards. 3) Installed base cultivation and gateways: An approach to manage the change of large networks must take the existing network and the installed base as its starting point (Hanseth and Lundberg, 2001). According to (Hanseth and Lundberg, 2001) the design of hospital information system has a lot to learn from the development of classical infrastructure. They are also argued that defining a shared standard for exchange the medical information is a strategy for building work-oriented infrastructures that have proved to be very problematic. As we pointed above there is a challenge related to the design of information infrastructure. (Bardram and Bossen, 2005) had studied the coordination and cooperative and they pointed challenges of designing related to collaborative work by discussing the relationship between information and representation, using Ethnographic study as a method. One of the authors conducted ethnographic fieldwork at the ward over a period of two months, 28 days of five to six hours of fieldwork observation was carried out. Notes were taken by the hand and written out in prose interviews lasting 1 hour each with nurses (8), and physicians (2) were made. And from their analysis of the hospital wards found that there is a number of design issue this issues includes

decoupling information and representation, linking and blending the digital and physical world Linkage, bringing the 'Object of Work' back to the real world and privacy issues (Bardram and Bossen, 2005) access and sharing data is issue across various technical platforms, institutions, disciplines and across long periods of time. (Axelsson and S. Axelsson, 2006) ,(Procter *et al.*, 2006) Explored other barriers related to the system design included the complexity of using the system. They conducted a systematic review of the literature to identify and assess interventions of information and communication technology on the processes of communication, and associated patient outcomes within hospital settings. They reviewed the types of interventions that have been implemented in hospitals settings, to improve clinical communication. They found 18 studies that examined several types of interventions including alphanumeric paging systems, hands-free communication devices, mobile phones, Smartphone's, task management systems and display-based systems. They found some evidence that users perceive improvements with communication interventions, given the critical nature of communication. They advocate further evaluation of information and communications technology designed to improve communication between clinician's outcome measures should include measures of patient-oriented outcomes and efficiency for clinicians. In conclusion, they used comprehensive methods such as reviewing references lists and searching for related articles to ensure articles were included in their research. Yet, the rapid developments and adoption of new information and communications technology could result in lack of time or delay in the Implementation, evaluation and publication of relevant studies as well. There may be publication bias as they restricted to peer-reviewed articles. However, given that their findings showed a general lack of high-quality evidence it is unlikely that unpublished or non-peer

reviewed articles would change these findings. (Joshua R Vest and Gamm, 2010) They spot the light on the persistent challenges and new strategies for health information exchange in the United State of America, such a challenge includes; patient safety and quality issues, when the patient is handoff among the health providers that they are failed to share the patient information. The policymaker's researchers and industry professional identify that information exchange (HIE) as a solution to these problems. The authors addressed historical problems and their subsequent lessons of (HIE) for increasing the probability of successful meaningful (HIE).

1. Community Health Management Information Systems History: The Hartford Foundation initiated community health management information systems (CHMISs) through grants to seven states and cities in 1990. However, CHMISs had two problems, the primary one is that; the lack of affordable and effective technology, CHMISs occurred before the advent of new and cheap reliable high-speed internet technology, also CHMISs had a security problem and privacy concerns (Yüksel, Küpçü and Özkasap, 2017). The second problem is that the integration between hospitals was never achieved, the lesson learned from this problem is that; the need for a clearly defined purpose and effective political support.

2. Regional Health Information Organization History:

RHIO is facilitated information exchange between providers within a geographical area to achieve more effective and efficient healthcare services. The problem of RHIOs is that; the main barrier to increasing the number of HIE and RHIOs is the lack of a sustainable business model despite the new technology, the RHIOs steel need for data integration, strong security, data storage, database for administration and provide technical support. RHIOs may require upwards of $12

Million for development and $2 to $3 Million in annual operating costs. The lesson learned from these problems is that; the technology progress doesn't solve the problem of sharing the information automatically.

3. Strategies: Obama administration official has envisioned making the healthcare services in lower price and high quality they discuss the concept of Personal Health Records PHR and they considered the PHR has appeal as eliminates the cooperative work and because of its handoff valuable information for educational directly to the patients. If the PHR application is hosted by RHIOs then there will be no doubt that all the barriers will disappear and complete vendors will participate even if the PHR is maintained by third party such as Google or Microsoft. Another strategy is to consider the PHR as public goods. In conclusion, they suggest the following strategies for continues development of HIE in US health services. Firstly, adopt and improve business model and keep those that are primarily focused on incremental cost savings to providers. Secondly, do not separate the public health benefits from healthcare benefits. Thirdly, ensure that HIE used the best and secured technology for the information exchange. Fourth, with federal government cooperation and support encourage states to be the fundamental geographical unit for HIE activities. The call for action was headed by the researchers who began to study the issues and barriers that impede the progressing of information infrastructure in healthcare. For example, (Cabitza and Simone, 2013) argued that the infrastructures phenomena have been explored by the field of science and technology studies (STS) (Cabitza and Simone, 2013) the infrastructure exists in the background it is invisible. In addition, the large-scale information infrastructure projects or the Cyber-Infrastructure aims at supporting the community digital services but this type of projects has two main associated issues. The first one:

sharing the information in the sense of public good this might lead to breaching the patient's privacy (Bardram and Bossen, 2005), (Cabitza and Simone, 2013). The second issues are the idea of sustainability of supporting research over a time. Although heterophony in Cyber-infrastructure development is a major issue related to the system access, information exchange, redesign, update and maintenance of the system. Another issue rose by (Cabitza and Simone, 2013) and they considered as a design problem is that, how to build ontology (build ontology means gathering the domain knowledge and translate this knowledge to machine knowledge) and how to describe data with metadata. By the existence of the internet new issues of information, infrastructure becomes visible, noticeable issues include the issue of data and resource sharing, issues of a database query, community standards and data spaces, domain knowledge repository and ontology's (Cabitza and Simone, 2013). Since 1960 the healthcare field and its organizations have been seeking for the establishment of integration information infrastructure with multiple objectives and aims. For instance, to reduce the redundant of data, seamless integration of artefacts' to increase the efficiency and effectiveness of care. (Bossen and Markussen, 2010) They analyzed the infrastructure in healthcare using ethnography studies and combined methods by including observation, semi-structured interview, and documents as a method to generate the study data. They described the challenges of evolving information infrastructure and found that standardization and integration are the major and central challenges. Also they found new form of errors emerge by Appling Electronic Medication Module EMM including transmission errors, and sometimes clinician uses each other's login's information such as; the use-name and pass-word (Bardram and Bossen, 2005) (Marcu, Dey and Kiesler, 2016) argued that it is very hard to implement a new technology in the healthcare settings diverse

and locally located. They point to several ways in which new technology results in purposed and unintended organizational consequences. In short, designing implementing and using technology involves complex socio-technical challenges and the CSCW field has contributed to mapping out the complexities of coordinating daily activities and documentation practices among health-care staff. However, the healthcare encompasses many of professional groups and services this added complexity to the coordination. However, (Da Cunha, Moura and Analide, 2013) argued that the starting point for this special issue on CSCW and dependable healthcare systems is the recognition of dependability. The authors of this study have two main goals. Firstly, they present an overview of the development of health-related research in CSCW distinguishing the major themes and approaches and summarizing insights from this research about the practical work of healthcare, health ICT Policies and agendas, and technology support for collaborative care work. Secondly, they step back to critically reflect on the practical effects of the research for real systems. In conclusion; they found that most of the contributions could be categorized as *workplace studies* and that the majority of design prototypes are focused on smaller scale interactions. Although, most studies do offer implications for design. However, despite significant investments and efforts getting this right has proved to be a challenging task. The causes of the problems are complex and varied. Although, many software products have been built and acquired from heterogeneous sources during a long period of time, and the systems have differences in implementation technologies and architectures. Generally, CSCW has strongly focused on the intertwined agendas of understanding cooperative work and designing tools to support that work. The value of CSCW in healthcare studies is that they contributed to a rich understanding of the subtle situated practices in the delivery of

healthcare. However, these studies resulted respectively in the design and deployment of a new planning system. They argued that moving to Electronic Patient Record (EPR) in hospitals settings is one of the reported advantages of the (EPR) is the opportunity to capture data in more structured formats and to support standardized clinical workflows. However, there is a problem of the information that doesn't fit in the formal electronic record. They argued that one of the key contributions of CSCW research into healthcare is the attention drawn. Expanding contexts of healthcare work poses challenges for integration and standardization and larger-scale vendor driven initiatives. Care is also expanding out of clinical settings into people's homes, bringing yet further challenges. However, expanding contexts can also refer to the expanding scale of ICT implementations. They argued that workplace studies have made a major contribution to the field of CSCW, drawing attention to subtle practices that enable effective collaboration CSCW problem (Services and Information, 2013). Self-evidently, society's dependence on computer-based systems continues to increase while the systems themselves embracing humans(Services and Information, 2013), computers and engineered systems become ever more complex. Workplace studies typically focus on a single setting making it difficult to assess the generalizability of the findings. The lesson of all these studies is that organizations are (in part) information processors. People, routines, forms, and classification systems are as integral to information handling as computers, Ethernet cables, and web protocols (Cabitza and Simone, 2013).

2.6. Analytical and Methodological Approaches:

2.6.1.　　Methods for Part-One:

Ethnography Study (Marcu, Dey and Kiesler, 2016),(Fitzpatrick and Ellingsen, 2013b) an interviews and observations, surveys. On this study the researchers did an observation study and an interview with the relevant actors those will be involved in the future work and also, they observed the emergency response in the Republic of Sudan in order to get an idea of the present state, of the emergency response to implementing electronic exchange of healthcare information among public Sudanese hospitals.

2.6.2.　　Methods for Part-Two:

Having done that, we formulate a thesis of key challenges, and we did Personas concerning those involved in the emergency response professional as well, as doctors and registration employees and laboratory technician. Then we did a scenario for the new map of (HIIPS) and we did a Mock-up for the screen of the Electronic Exchange of Healthcare Information EEHI among Hospitals.
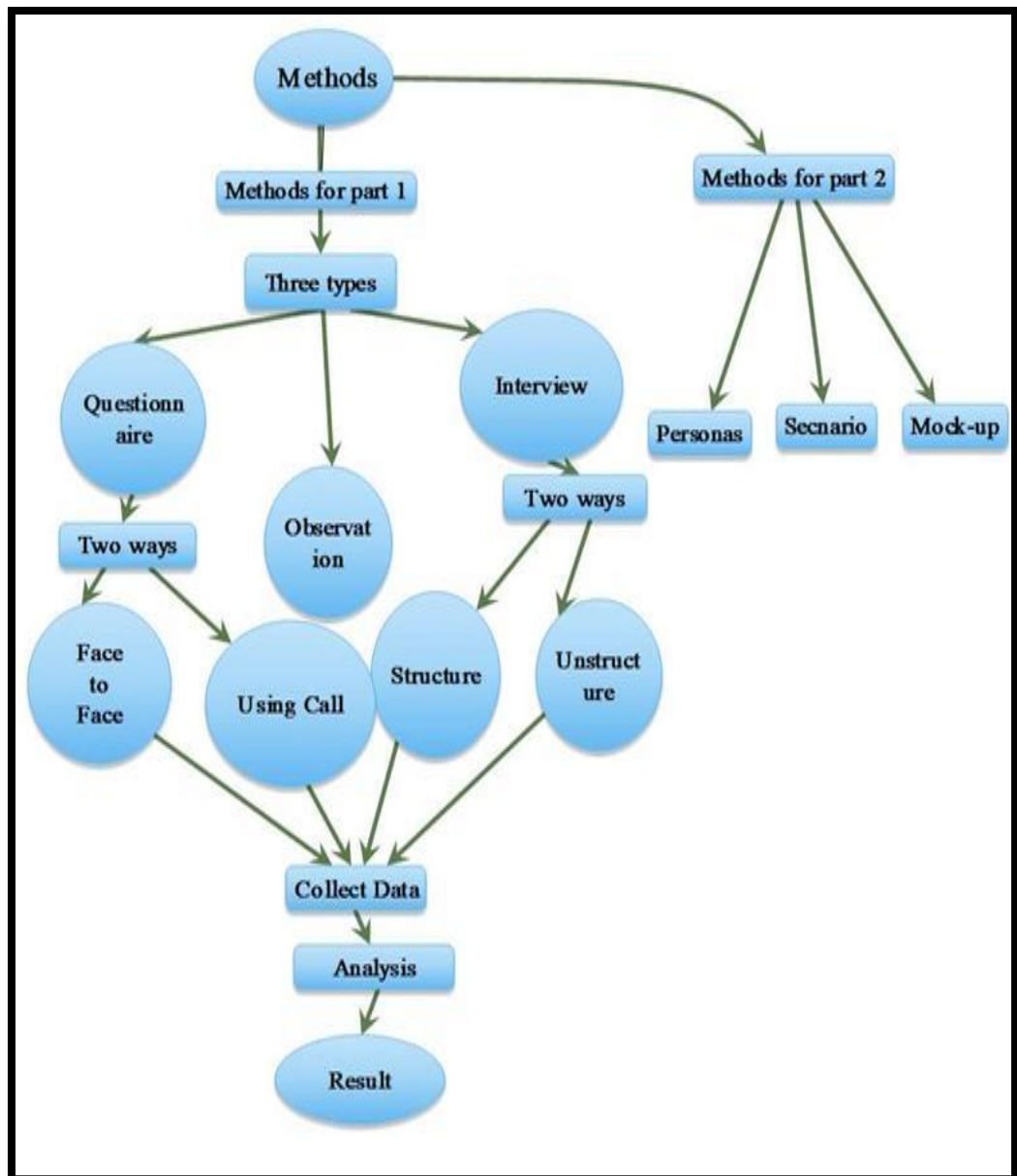
Figure 3: Research Methods

2.7. Access to the Fieldwork Settings:

In term of access to the fieldworks setting, we contacted relevant actors in the field of healthcare and the Ministry of Health in the Republic of Sudan. Some of the actors are hospital managers, doctors, nurses and finally technician, all those actors are aware of our intention and are currently awaiting more information for further scheduling.

2.8. Ethical Considerations:

All ethical considerations will be in accordance with the existing guidelines of the Sudan University of Science and Technology. This includes ensuring the quality and Integrity of our study in seeking informed consent and respecting the confidentiality and anonymity among our interlocutors.

2.9. Findings and Discussions:

The previous research says that; (HIE) can increase the effectiveness, efficiency and quality of the healthcare services. And it can provide bits of help for the medical staff and improve the medical process. Now a day's, the adoption of (HIE) is increasing and (HIE) is diffusion around the world. However, previous studies say that the implementation of (HIE) is not completed yet in any country in the world. Although, there are a number of countries they have started the adoption of (HIE), compared to the situation in the Republic of Sudan which is an African country, and it is classified in the area of the developing country, the work of implementing (HIE) has not started before this study. The purpose of this study is to fill the gap in the literature of (HIE) in the Republic of Sudan and to design a plan and "Framework" for the adoption and implementation of electronic exchange of healthcare information among public Sudanese hospitals EEHI.

- Challenges:

The study found that one of the Challenges that will face the adoption of HIIPS in the Republic of Sudan is that: some people think sharing the patient information between hospitals it will lead to privacy breaching of the patient's information. But on the other hand, it is

necessary to share the patient information between among because it can save patient's lives.

The ethnography study based on observation firstly in the Republic of Sudan showed that; the medical staff are agreed it is difficult to find the patient's medical record for two reasons: the first one is that it is difficult to search about the patient in the manual system. and the second reasons is that: some patients do not have had a patient record at all, and this is an opportunity for our new proposed project HIIPS, because its main purpose is to make the patient information timely accessed, available and secured.

Bearing in mind that, the loss of medical records leads to medical errors. On other hands, HIIPS will make it easiest for the medical staff to retrieve the information about the patient from computerizing database quicker, and take the right decision in the right time. The challenges will be how to convince the Sudanese government to support and adopting HIIPS to improve the healthcare services and increase its efficiency and effectiveness and also reduce the cognitive load from the medical staff.

2.10.   Summary

In our conclusion, computer-based patient records and the systems in which they function are becoming an essential technology for healthcare(Wu *et al.*, 2012) (Lammers, Adler-milstein and Kocher, 2014),(Everson, Kocher and Adler-Milstein, 2017) because the information management challenges faced by healthcare professionals are increasing daily. It is important to understand the potential influence that Healthcare Information Infrastructure for Public Sudanese Hospitals (HIIPS) can have on medical staff daily activities and work. Many studies indicate that the quality of

healthcare information exchange HIE systems including attributes such as effectiveness and control and reliability provide complete and accurate information about patients, for medical staff. It seems that using (HIE) may potentially help the Administrators, Doctor and Laboratory Technician to identify and eliminate ineffective activities involved in the patient process, and support medical staff' daily practice. By providing complete essential data to support optimal patient care. As we mentioned, this study aims to build Healthcare Information Infrastructure for Public hospitals in Sudan HIIPS. For these reasons, we made a systematic review in the literature using keywords for search. Such as "healthcare information infrastructure", "electronic patient record", "electronic health record" and "healthcare information exchange" and "Federal Ministry of Health library, Sudan", As well as what was published in Arabic to find an answer for our research questions. Also, we used ethnographic study in two parts, for part-one we used questionnaire, interview, observations, and investigations, note-taking and recording interview. On part-two we used the design methods including Personas, scenarios, Mock-up prototype and Framework. Also, we will use ethnographic studies in future work as the main method to achieve the study objectives.

CHAPTER THREE

ANALYSIS OF THE CURRENT SITUATION OF PUBLIC HOSPITALS

3. Analysis of the Current Situation of a Hospital's Departments:

3.1. Introduction:

The development of the modern healthcare system in Sudan dates back to 1899 when it was being handed over by the army. Some hospitals were built and smallpox vaccinated Programs are running. The medical department was established in Northern Sudan in 1904, where the southern regions remained under military rule. In 1905 the Central Health Council was established to protect public and therapeutic health. In 1924 the Sudanese Medical Services was established and managed by a director responsible for all health services, including military medical services('Strengthening Primary Health Care in Sudan Through a Family Health Approach Policy Options', 2016). In 1949 the Ministry of Health was founded (WHO, 2006). Nowadays 2018 according to the World Health Organization, Sudanese government spending on health is 9% below their recommendation level. The biggest problems facing Sudan in this health- care crisis is the lack of resources and services and the poor working environment in the healthcare profession.

3.2. Definition of Analysis:

Analysis means understanding what we are dealing with. Before we can design a solution, we need to be clear about the relevant entities, their properties and their inter-relationships. We also need to be able to verify our understanding. This can involve customers and end users since they are likely to be subject-matter experts. The analysis is about discovering what the system is going to handle, rather than deciding how to do the handling. We need to decompose a complex set of

requirements into the essential elements and relationships, on which we will base our solution on. The analysis is our first opportunity to get to grips with modelling the real world as objects.

3.2.1. There are two inputs to analysis:

3.2.1.1.　　The Business Requirements:

Contains descriptions of the manual and automated workflows of our business context (see figure 15), described using business-oriented versions of actors, use cases, objects, the glossary and, optionally, communication diagrams.

3.2.1.2.　　The System Requirements Model:

Contains an external view of the system, described as system-oriented versions of actors, use cases and use case diagrams, user interface sketches, an enhanced glossary and nonfunctional requirements.

3.3.　Definition of Actors:

An actor is a person playing some role within the business (as you might expect from the name), or a department, or a separate software system. The first thing we need to do is to identify the business actors.

3.4. Definition of Use-Case Diagram:

A use case is a static description of some way, in which a system or a business is used, by its customers, its users or by other systems. A use case diagram shows how system use cases are related to each other and how the users can get at them. Each bubble on a use-case diagram represents a use-case and each stick person represents a user.

3.5. Identifying Business Actors:

3.5.1. The Registration office Actor:

An employee at one of the hospital's departments who helps patients to register, in order to meet the Doctor.

3.5.2. The Practitioner or Doctor Actor:

A person who is responsible for determining what type of test to be performed for the patient and determine the type of drug (s) if necessary.

3.5.3. The Lab Technician Actor:

A person who is responsible to perform the Test (s) required by the doctor (s).

3.5.4. The Patient Actor:

A person he or she has something wrong in his/her body and looking for one of the hospital or clinical services.

3.5.5. MS. Office program Actor:

Microsoft Word (or simply Word) is a word processor developed by Microsoft. It was first released on October 25, 1983 under the name Multi-Tool Word for Xenix systems. A simple program that contains the patient's records.

3.6. Identifying the Business Use-Case in detailed:

This part of the study is dedicated to the description of the current situation of the healthcare environment and workflows.

3.6.1. Business Use Case one the Registration Office BC1, Current Situation:

1- Each patient must be registered at the administration office.

2- The administration office employee generates a requisition slip, and hand it over to the patient in order to get into the doctor.

3- Each patient consults to one doctor, and each doctor may have many or no patient at all.

4 - Each patient may require one or more test(s) and each test refer to only one patient.

5- Each patient may have zero or many tests at the individual lab and each test refer to only one patient.

4- Later each patient is sent to the administration office and each administration office is monitored by one or more clerk.

3.6.2. Business Use-Case two the Doctor BC2, Current Situation:

1-When the patient gets himself registered in the administration office, then he is allowed to meet the doctor.

2- When the doctor diagnoses his disease, then he will direct him to get a test or a set of tests to be performed at the laboratory.

3- Finally when the disease is diagnosed, and the result of the test is issued, then the doctor can prescribe the drug for the patient.

3.6.3. Business Use-Case three the lab technician BC3, Current Situation:

1- When the lab technician received the requesting slip from the patient.

2- He/ she will take a blood sample or any other sample to be tested.

3- The test of the blood sample can be done by Microbiology Lab Technician or Histopathology Lab Technician or Cytopathology Lab Technician using lab equipment and diagnoses the disease.

3.6.4. Business Use Case Four Patient BC4, Current Situation:

1- Get registered in the registration office.
2- Then the registration office employee will direct him to the doctor, to check him and write down what is necessary for the test (s) to be performing.
3- Take the requisition slip from the doctor and go to the individual lab technician.
4- lab technician takes a sample of blood or other, to determine the decease.

3.7. Illustrating the Use Cases Diagram on a Communication Diagram:

3.7.1. Administration office (Bc1) Communication Diagram:

This figure shows how the administration office employee can communicate with the existing system.
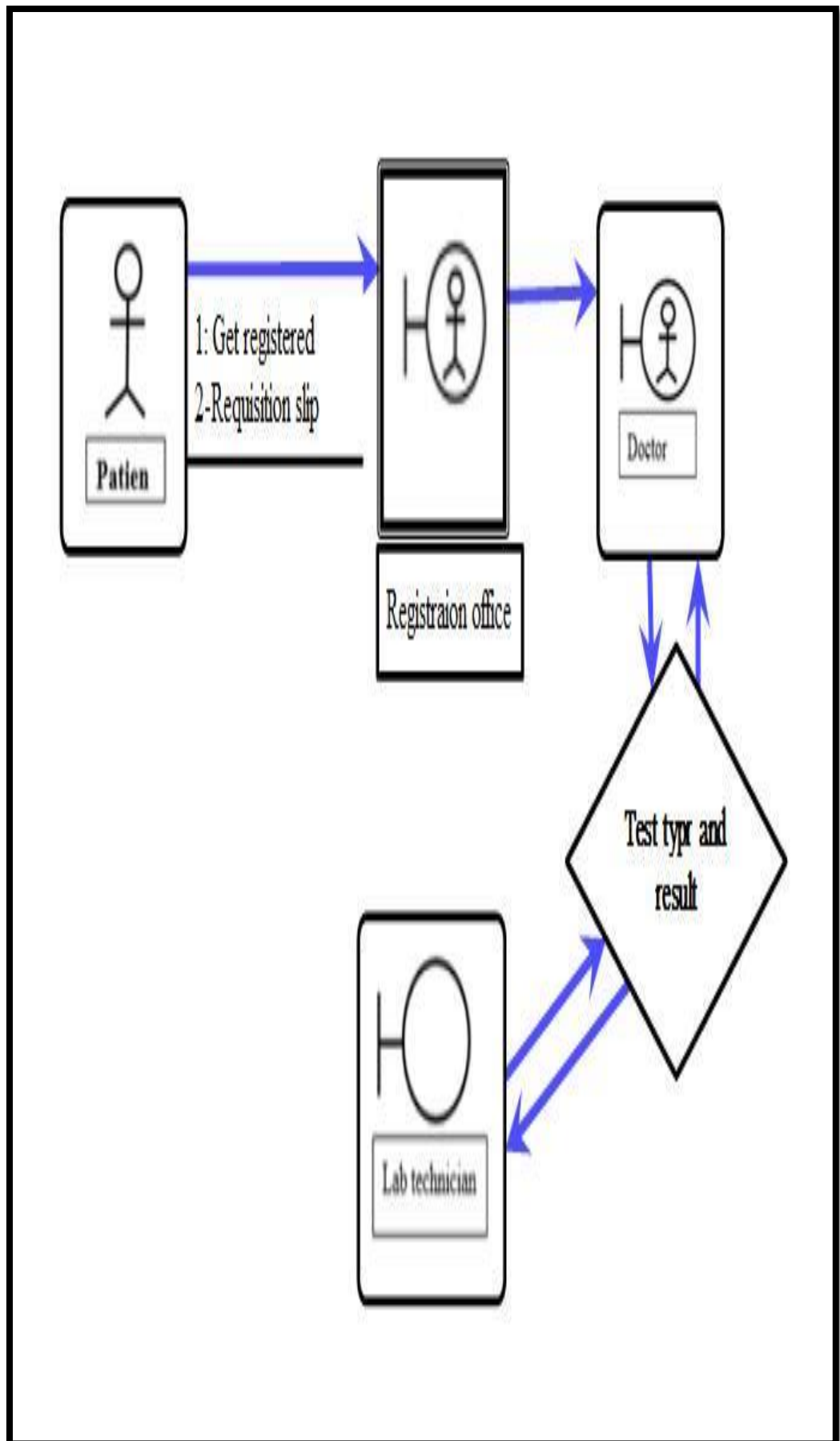
Figure 4 The Admin Communication Diagram

3.7.2. The Doctors (BC2) Communication Diagram:

The following figure shows how the Doctors can communicate with the existing system.
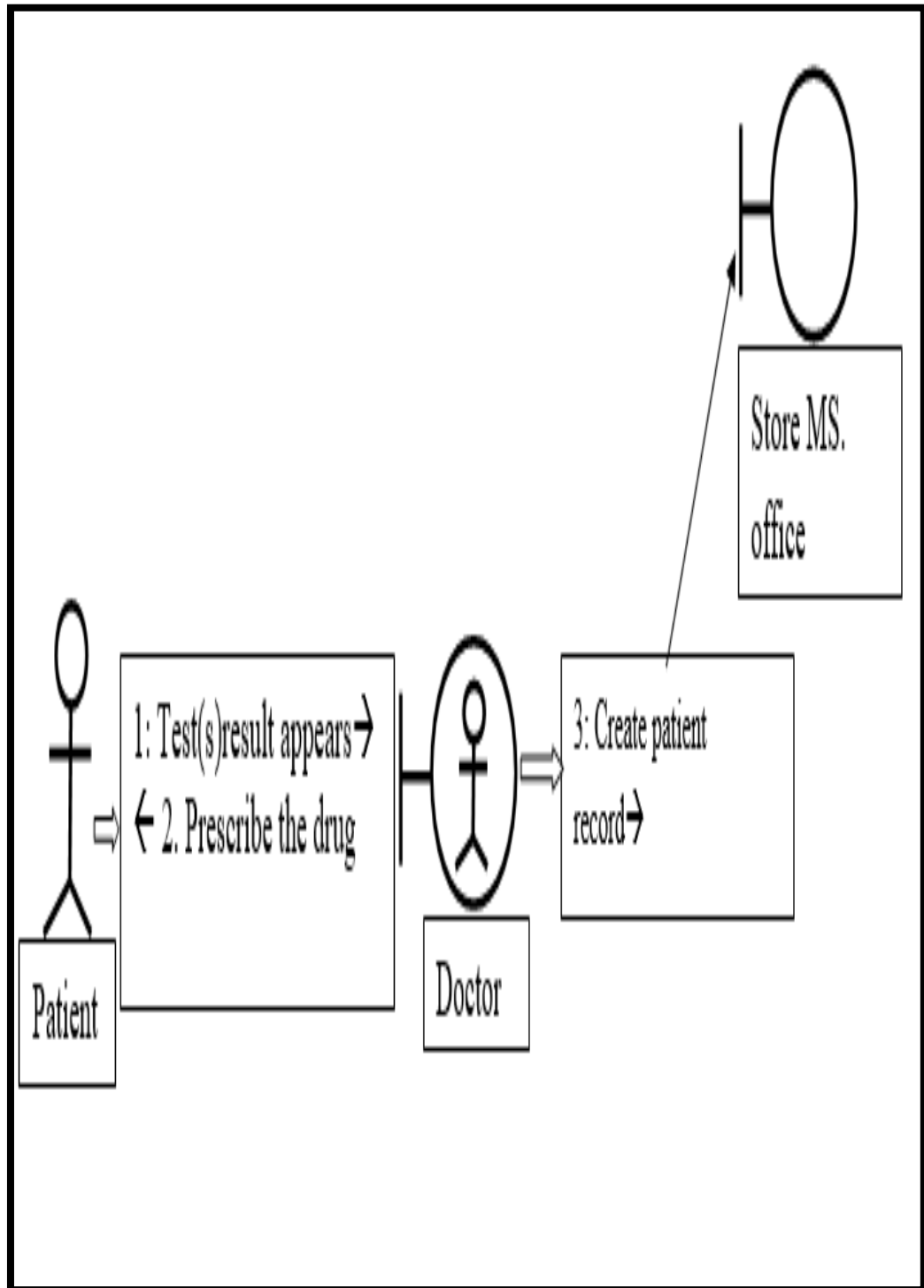
Figure 5 Doctor Communication Diagram

3.7.3. Lab Technician (BS3) Communication Diagram:

The following figure shows how the Lab Technician can communicate with the existing system.
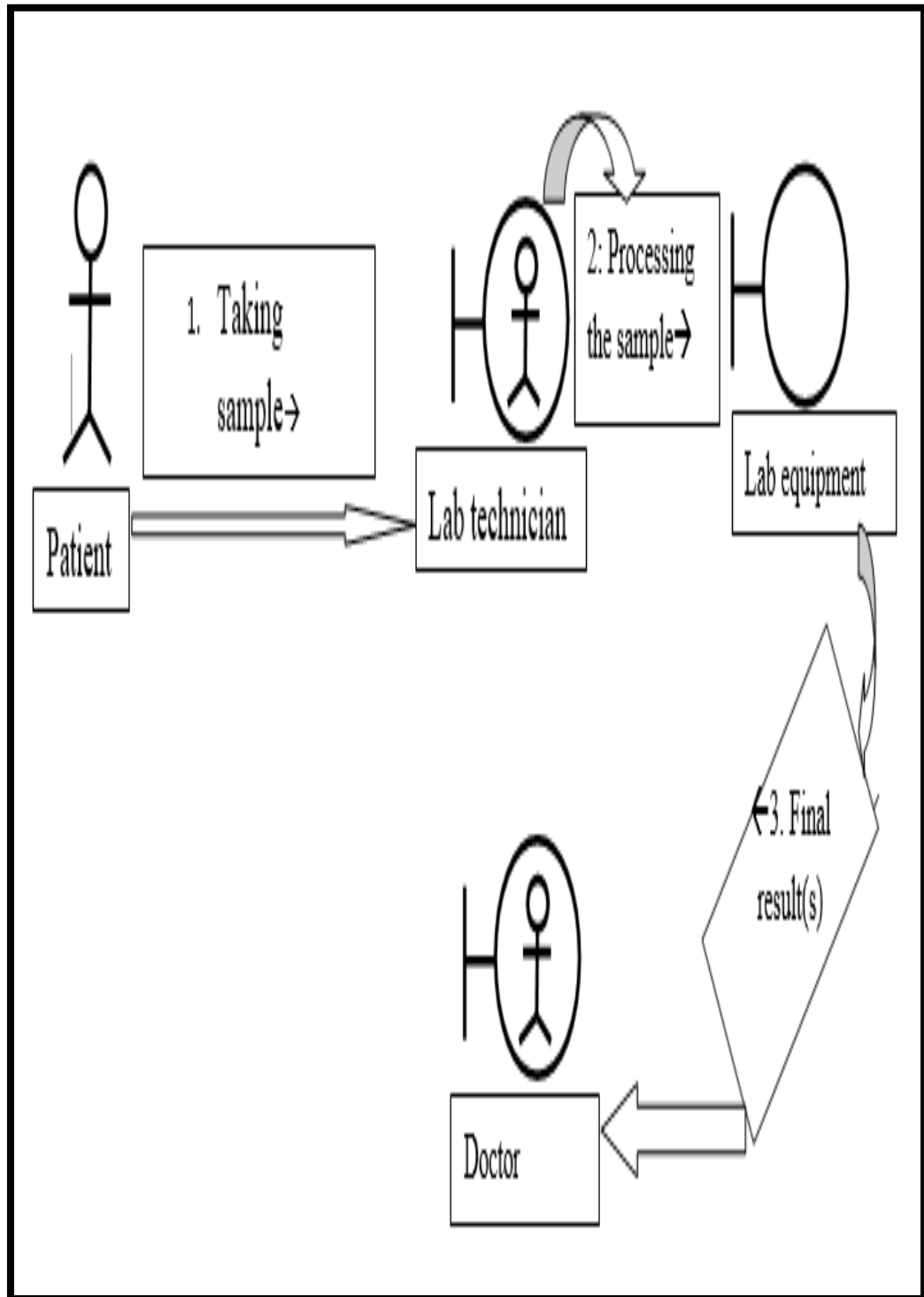
Figure 6 Lab Technician Communication Diagram

3.7.4.   The Patient (BC4) Communication Diagram:

The following figure shows how the Patient can communicate with the existing system.
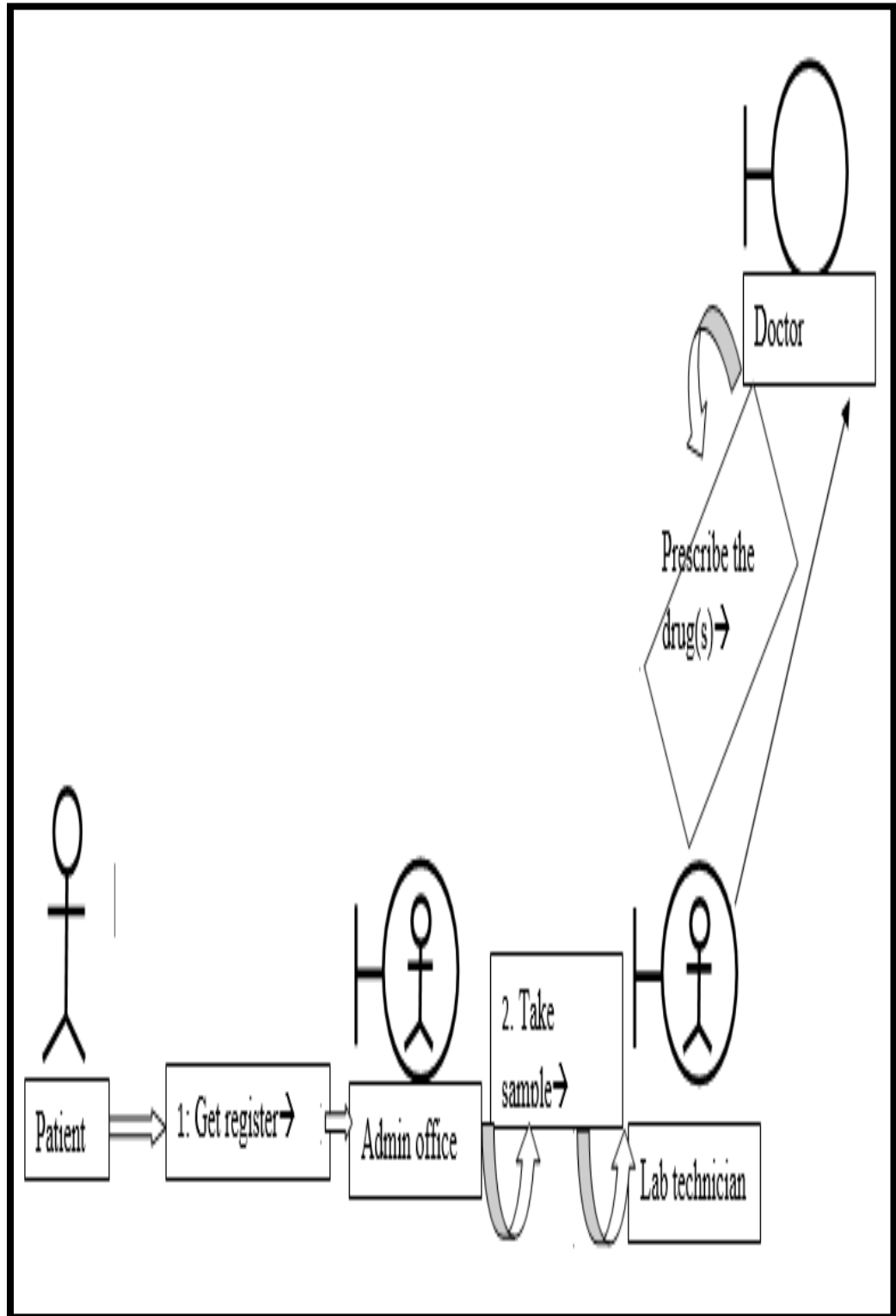
Figure 7 Patient Communication Diagram

3.8. Summary of the challenges and problems in the current situation at the hospital department:

- Most of the activities of the Sudanese Public Hospitals, whether administrative, financial or clinical, are totally manual.
- Access to the local health services at primary health care level in Sudan is very low.

CHAPTER FOUR

A FRAMEWORK FOR THE EXCHANGE OF HEALTHCARE INFORMATION AMONG PUBLIC HOSPITALS

4. Introduction to Design:

In the design phase, we work out how to solve the current problems regarding the existing healthcare systems, in order to improve the current situation, and developing a novel framework, that allows the patient's information to be an exchange and circulate among hospitals smoothly. In other words, we plan, based on experience, estimation and intuition, about what software we will write and how we will deploy it. System design breaks the system down into logical subsystems (processes) and physical subsystems (Computers and networks), decides how machines will communicate, and chooses the right technologies for the job, and so on. During the design phase, we make certain technology choices (for example, programming languages, protocols and database management systems). We must decide how much impact we want these choices to have on our design.

4.1. The system requirements model or Developer Perspective:

This section deals with the basic business process on which the system is based upon.

4.1.1. Identifying the System Actors:

Health information exchange and infrastructure system Actors (HIE):

4.1.1.1. Administration office.

4.1.1.2. Beneficiary

4.1.1.3. Patient:

a person he/she suffers from a deceased and looking for one of our hospital services.

4.2. Identifying the System Use Cases:

4.2.1. System Use-Cases list:

Sc1: Patient Register.

Sc2: Configure patient record: add, edit and delete patient record

Sc3: Configure patient status record: add, edit and delete patient result(s)

Sc4: Configure user record: add, edit and delete user record

Sc5: Generates Reports.

Sc6: Generates Reports on Patient Details.

Sc7: Lab Tech Enters Tests Results.

Sc8: Admin. Off Enters Lab Tests for Patient.

Sc9: Change user privileges: add, delete, update user privileges.

Sc10: Browse patient record, search and Browse patient record

Sc11: Browse patient results, search and Browse patient result(s)

Sc12: Browse user, search and Browse user name.

Sc13: User log on.

Sc14: User logs off.

Sc15: Change user name & password.

4.3. The use cases details:

4.3.1. Sc1: Patient Register.

1-   Patient register in the registration office.

2-   Patient gets small paper consists of National No and name.

4.3.2.   Sc2: Configure patient record:

add, edit and delete patient record (specialize by sc10, extend sc13)

1-precondition log-on.

2- Search & Browse for patient (include Sc10)

3- Configure patient.

Post-conditions: alteration message Abnormal Paths:

a1. If not found add new Patient.

a2. If found edit or delete.

4.3.3.   Configure patient status record:

 Add, edit and delete patient result(s) (specialize by sc10, extend sc13).

 1- Precondition log-on.

 2- Search & Browse for patient result(s) (include Sc10)

a.   Configure patient result(s).

 Post-conditions: alteration message Abnormal Paths:

 A1- if not found test(s) is pending:

A2- if found generate report about the patient result(s)

4.3.4. Sc4: Configure user record:

add, edit and delete user record (specialize by sc12, extend sc13)

1- Precondition log-on.

2- Search & Browse for user record.

3- Add or delete user record.

4.3.5. Sc5: Generates Report (specialize by sc10, 12, extend sc13)

1- Precondition log-on.

2- Search & Browse for patient result(s)

 3- Generate report about patient result(s).

4.3.6. Sc6: Generates Reports on Patient Details:

 1- Precondition log-on.

 2- Admin office Search & Browse for patient details.

 3- Generate a report about Patient Details.

4.3.7. Sc7: Lab Technician Enter the Tests Results (specialize by sc8, sc10, extend sc13)

 1- Precondition log on

 2- Search & Browse for the patient record.

3- Enter the Tests Results into the patient record.

4.3.8. Sc8: Admin Office Enter the Lab Tests for Patient:

(specialize by, sc sc10, extend sc13)

      1- Precondition log on

      2- Search & Browse for the patient record.

      3- Enter lab tests for the patient.

4.3.9. Sc9: change user privileges:

Add, delete, update user privileges (specialize by sc12, extend by14)

      1- Precondition log-on.

      2- Change user privileges.

      Post-conditions: alteration message.

4.3.10. Sc10: Browse patient record:

search and Browse patient record (specialize by sc2, include sc1, extend by14)

      1- Preconditions: log on.

      2- Enter key search.

      3- Search or browse

      Post-conditions: system has displayed details of the selected patient.

4.3.11. : Browse patient results:

Search and Browse patient result(s) (specialize by sc1, extend by14)

1- Preconditions: log on.

2- Enter key search.

3- Search or browse patient result(s).

Post-conditions: system has displayed result(s) of the selected patient.

4.3.12. Sc12: Browse User:

search and Browse user name.

1- Preconditions: log on.

2- Enter key search.

3. Search or browse the user name.

Post-conditions: the system has displayed details of the selected user.

4.3.13. Sc13: User log on:

(extended by Sc1, Sc2, Sc3, Sc4, Sc6, Sc6, Sc7, Sc8, Sc9, Sc10, Sc11, Sc12)

Preconditions: beneficiary has obtained a password from their office.

1. Beneficiary enters their user name.

2. Beneficiary enters their password.

3. Beneficiary elects to log-on.

5. Extended by Sc1, Sc2, Sc3, Sc4, Sc6, Sc6, Sc7, Sc8, Sc9, Sc10, Sc11, Sc1213).

Post-conditions: beneficiary is logged on. Abnormal Paths:

A1. If the beneficiary user name /password combination is incorrect, system informs beneficiary that one of the two is incorrect (for security, they're not told which one).

A2. If the beneficiary user name /password combination is correct, but the beneficiary is already logged on and they have not elected to steal, the system informs beneficiary.

### 4.3.14.	Sc14: User log-off: (extends Sc13)

Preconditions: log on. Post-conditions: none

### 4.3.15.	Sc15: Change User Name & Password:

1- Preconditions: log on.

2- Change user name / password

1. Post-conditions: alteration message.

4.4. Specialize Actors:

4.4.1. Health information exchange (HIE):

4.4.2. Patient.

4.4.3. Administration office.

4.4.4. Beneficiary

4.5. Use Cases Diagrams:

4.5.1.   Administration office Use-case diagram:

Figure (8) shows how the Administration office employee can be communicated with our new system.
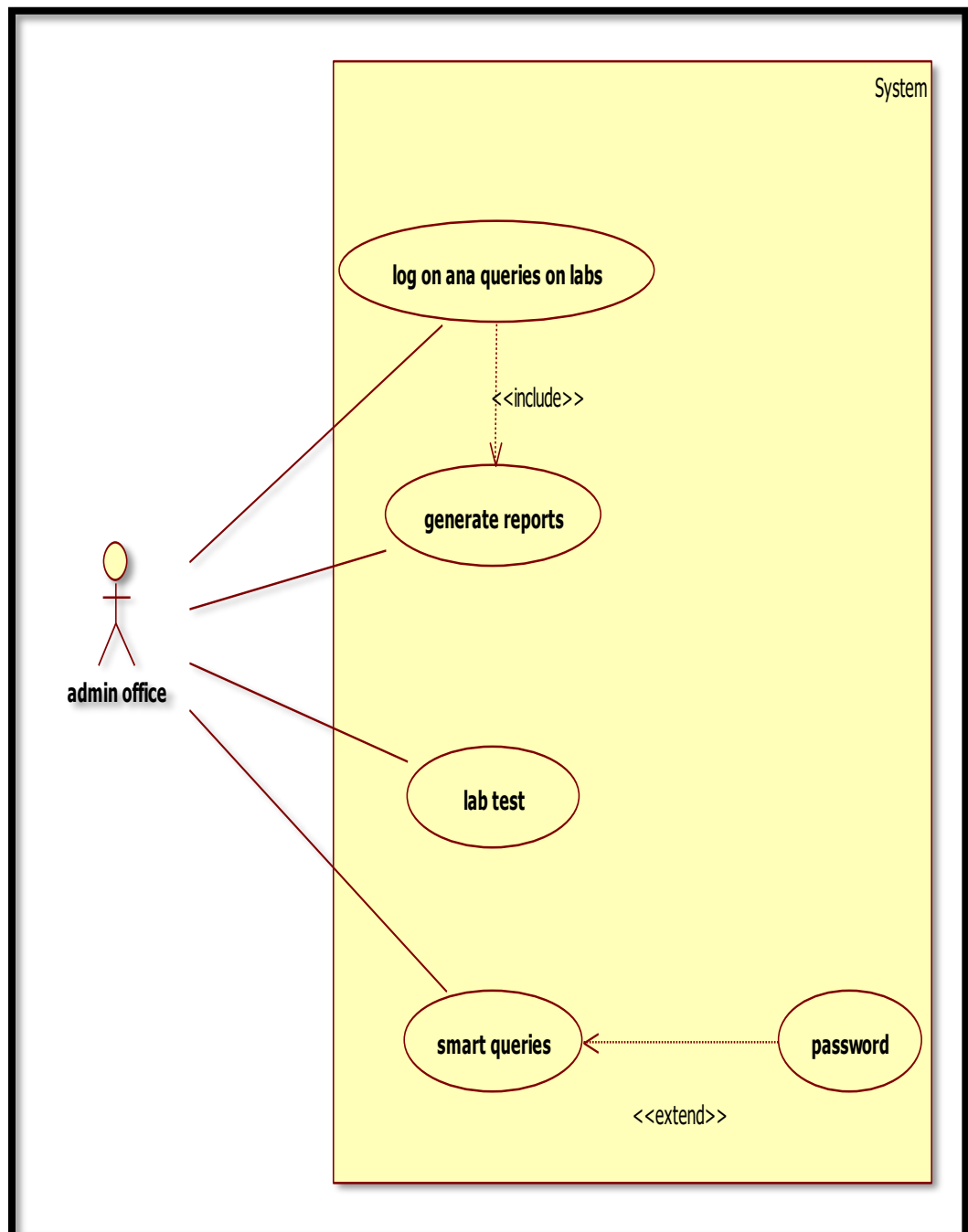
Figure 8 Administration office use-case diagram

4.5.2. Doctor Use-case diagram:

Figure (9) shows how the Doctor(s) can be communicated with our new system.
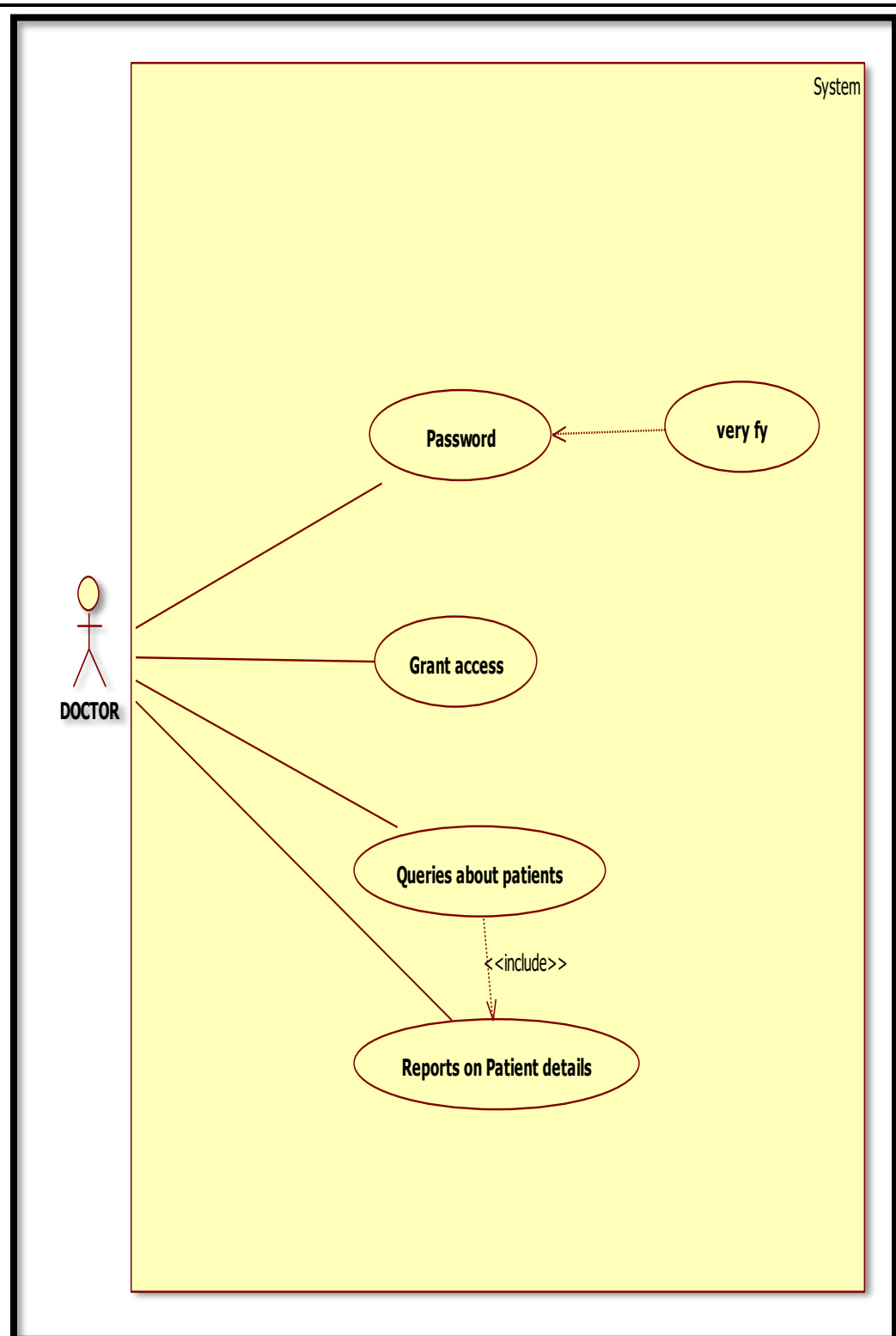
Figure 9 Doctor Use-case diagram

4.5.3.   Lab technician use case diagram:

Figure (10) shows how Lab technician can be communicate with our new system.
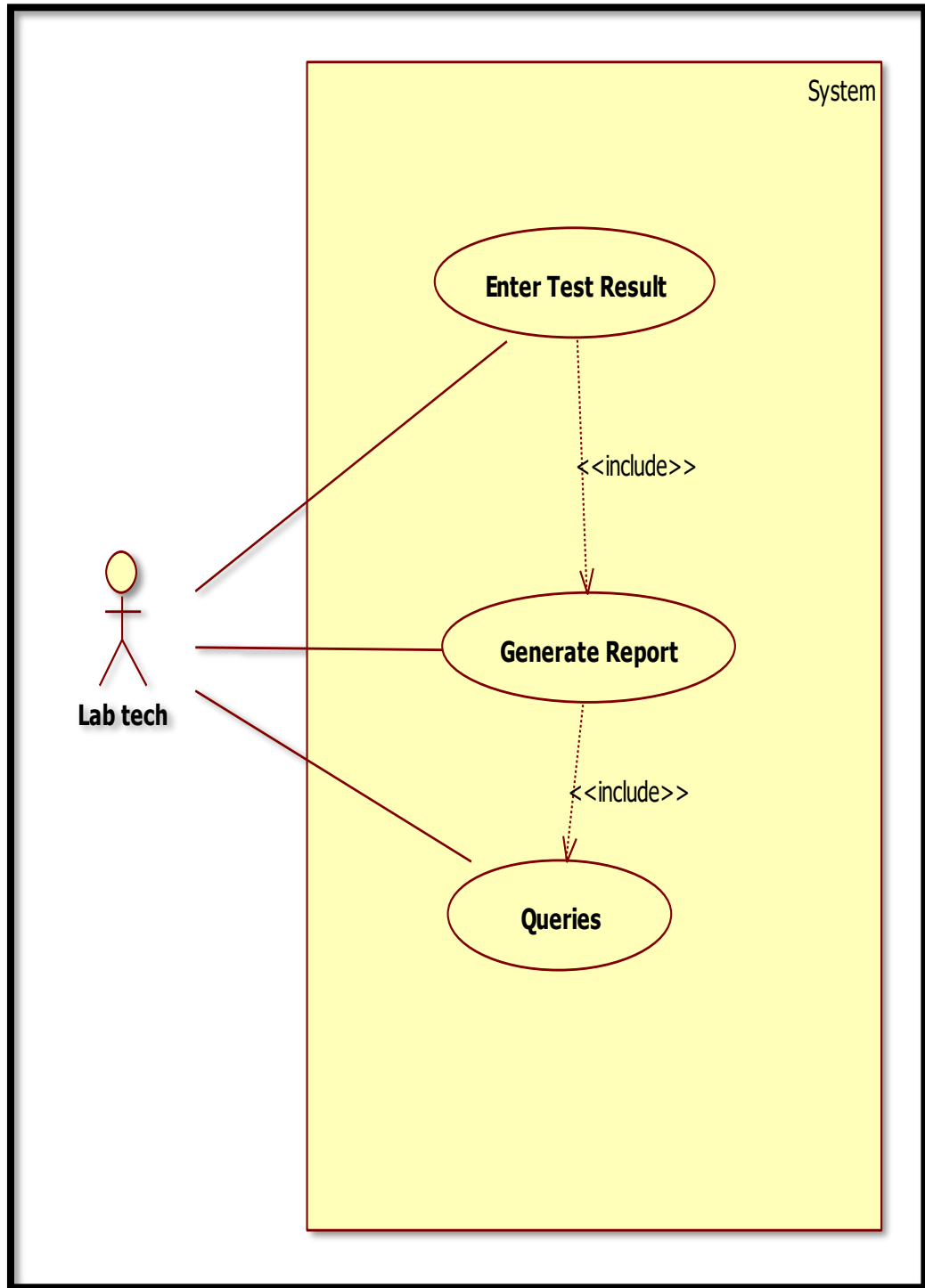
Figure 10 Technician use case diagram

4.5.4.   The Patient Use-Case Diagram:

Figure (11) shows how the patient can be communicated with our new system.
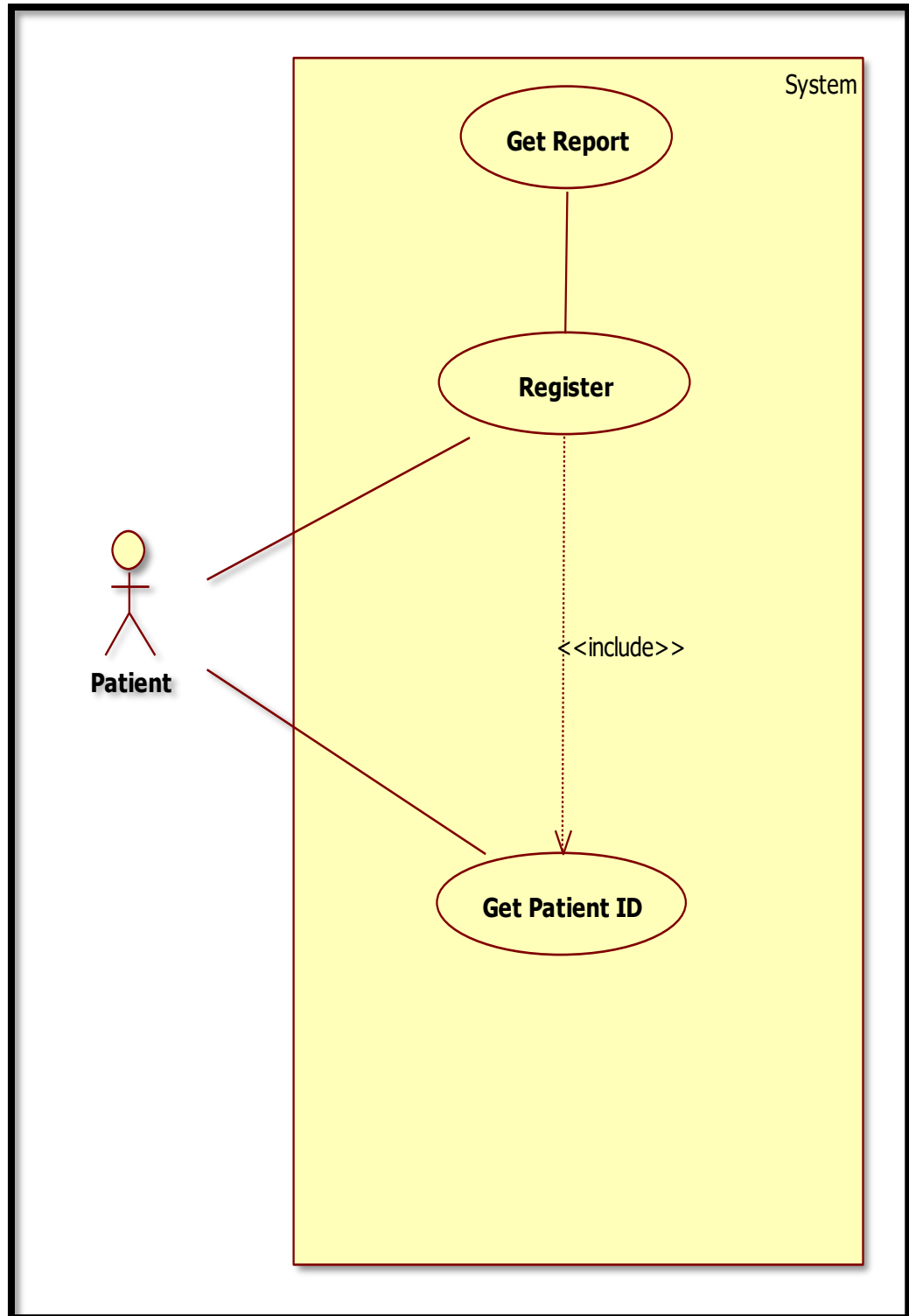
Figure 11 Patient use case

4.5.5.　　Use case diagram from the developer perspective:

Figure (12) This use case diagram shows how all the actors can be communicated with our new system.
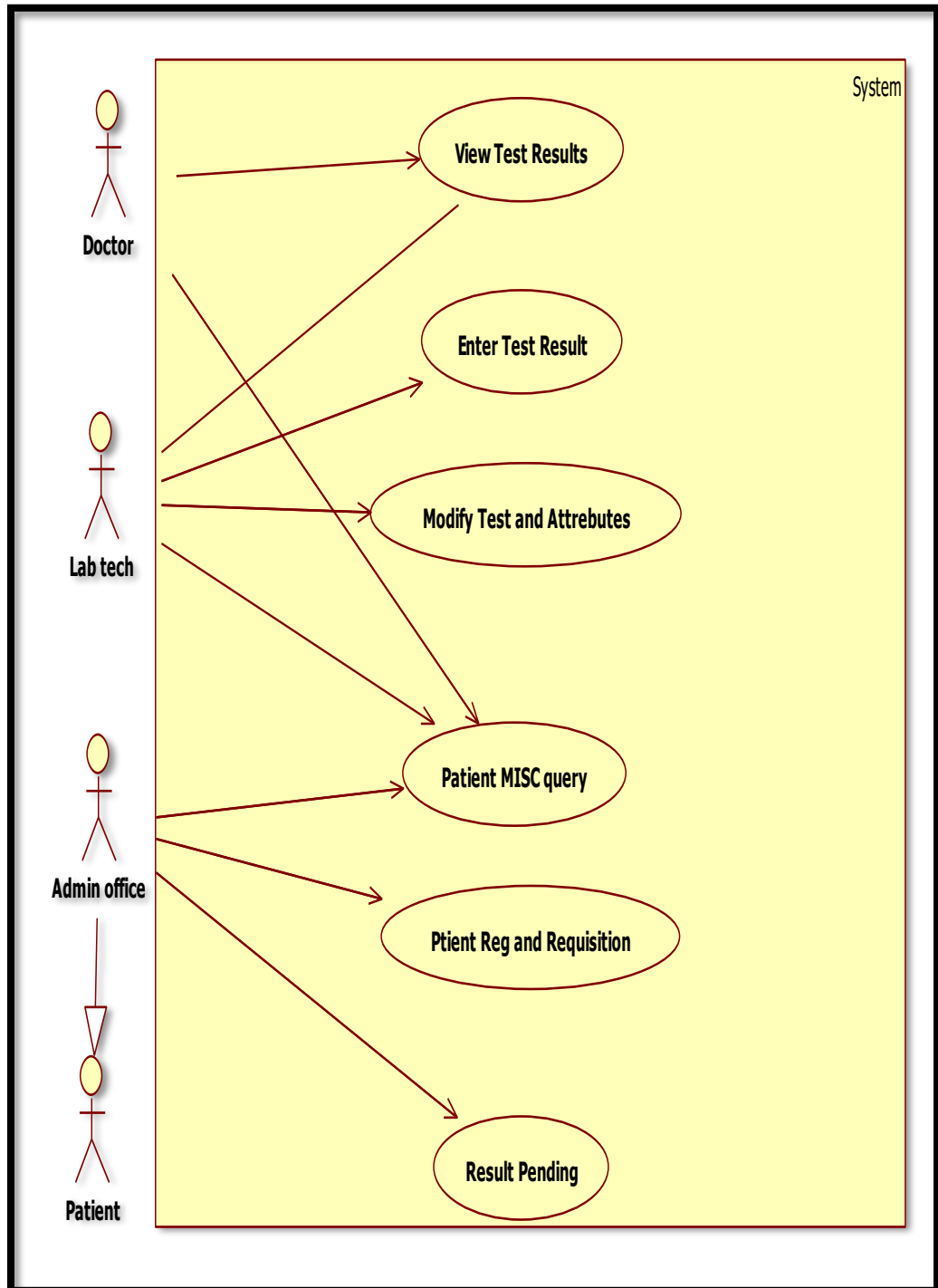
Figure 12 Use case diagram from developer perspective

4.6. Drawing Classes and Objects Diagrams:

4.6.1. The Class Diagram:
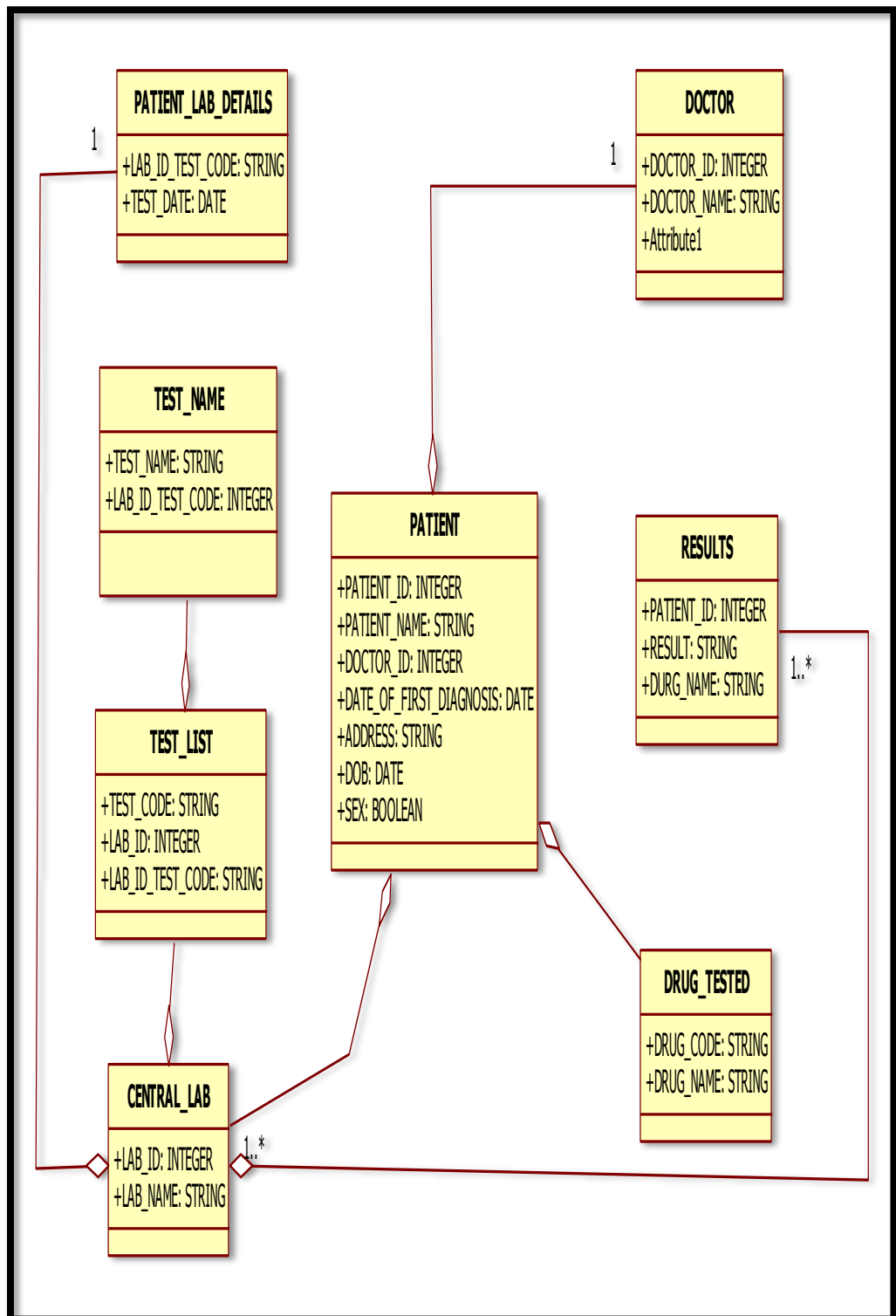
Figure 13 The Class Diagram

4.6.2.   The Attributes Figure:

PATIENT

+PATIENT_ID: INTEGER
+PATIENT_NAME: STRING
+DOCTOR_ID: INTEGER
+DATE_OF_FIRST_DIAGNOSIS: DATE
+ADDRESS: STRING
+DOB: DATE
+SEX: BOOLEAN

+add_patent()
+delete()
+search()

TEST_NAME

+TEST_NAME: STRING
+LAB_ID_TEST_CODE: INTEGER

+add()
+delete()
+search()

PATIENT_LAB_DETAILS

+LAB_ID_TEST_CODE: STRING
+TEST_DATE: DATE

+add()
+delete()
+search()

TEST_LIST

+TEST_CODE: STRING
+LAB_ID: INTEGER
+LAB_ID_TEST_CODE: STRING

RESULTS

+PATIENT_ID: INTEGER
+RESULT: STRING
+DURG_NAME: STRING
+search( )

DOCTOR

+DOCTOR_ID: INTEGER
+DOCTOR_NAME: STRING
+Attribute1

+search()
+add()
+search()

CENTRAL_LAB

+LAB_ID: INTEGER
+LAB_NAME: STRING

DRUG_TESTED

+DRUG_CODE: STRING
+DRUG_NAME: STRING

System

Figure 14 The Attributes Figure

4.7. EEHI among public Hospitals Proposed Solution:

The below (Figure 15) Ethnography studies illustrate that many Sudanese public hospitals using either small program or manual system in their work, to manage the patient's information. Unfortunately, these leads to a problem including 1) Poor communication among healthcare staff 2) Poor admin for the clinical data 3) increases the time consuming 4) probability of losing the patients information due to inconsistency regarding the manual systems. 5) And finally, waiting in the queue.

To solve the above-mentioned problems, we proposed a solution that required the following methods: 1) Observations 2) questionnaire: two types a) face to face questionnaire b) using phone call questionnaire. 3) Interview: two types a) unstructured Interview b) structured Interview 4) voice recording 5) making notes, (see Figure 16). All these methods were used in our study to collect the relevant data. After that, we analyzed this data and use the results in the design concept of healthcare information exchange HIE solution. First, we design the system Mock-UP based on the collected data.
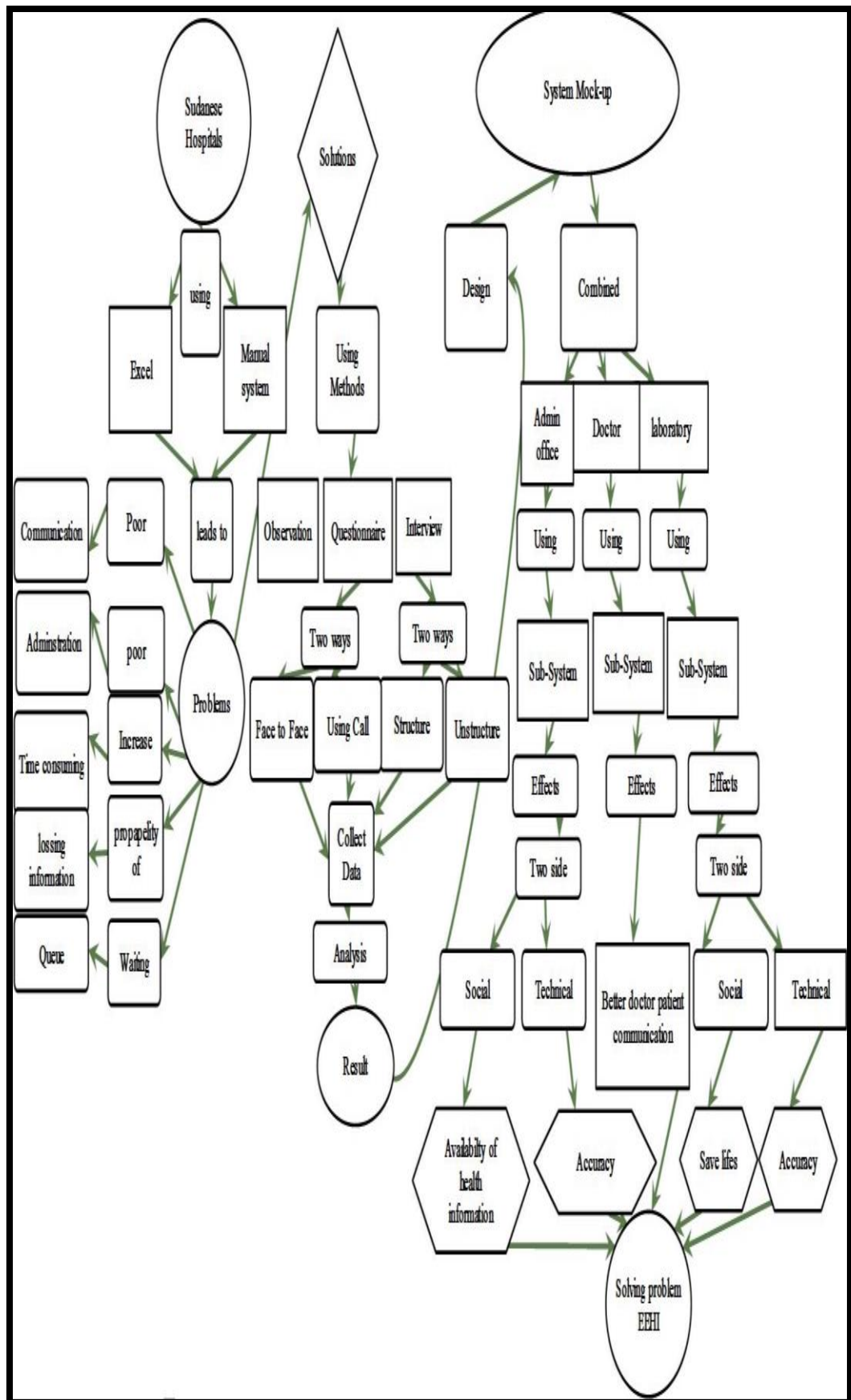
Figure 15 Ethnography studies

4.7.1.   The Mock-UP:

The Mock-UP is defined as a model or replica of a machine or structure, used for instructional or experimental purposes, see (Figure 16). Which is combined of three Sub-System they are:

4.7.2. Administration office Sub-system:

Which is dedicated for the administration office employees to collect the patient's personal information such as Name, Age, Address, Date of Birth, Data of first diagnoses and so on, and manage and store them in the EEHI Database, this sub-system has two effects a) social effects by means of the availability of the patient's information and b) Technical effects by means of accuracy and healthcare information circulation.

4.7.3. The Doctor Sub-system:

This sub-system is dedicated for the doctors to enter the type of test after diagnosing the symptoms, that it should be in the laboratory, the Doctor sub-system uses data that migrated from the administration office sub-system including all the patient's personal information. This sub-system has two effects: a) in-term of Social effects increases the Doctor-Patient communication and b) Technical effects involve the accuracy of information and healthcare information circulation.
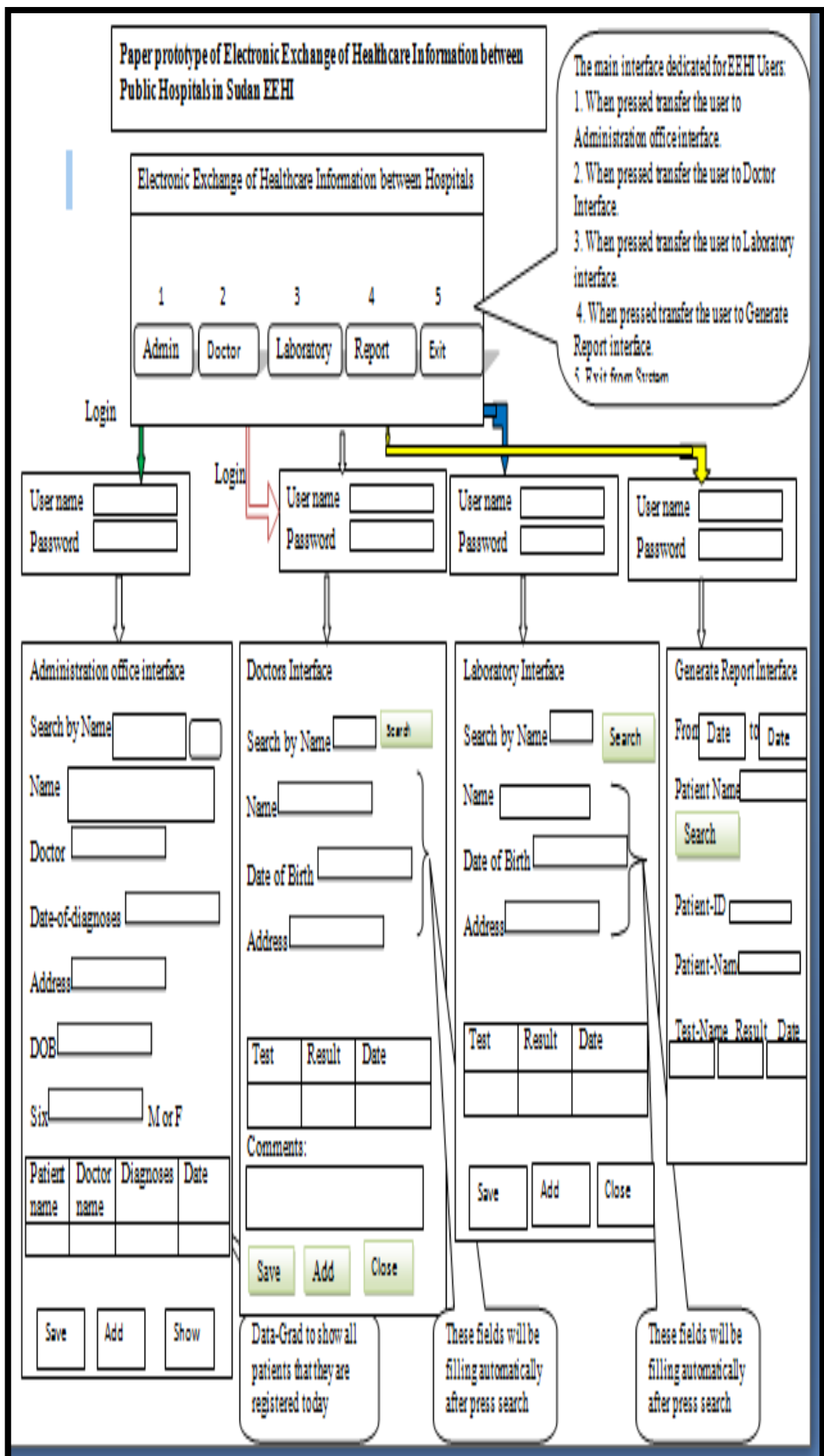
Figure 16 System Mock-Up

83

4.7.4. Finally, The Laboratory Sub-system:

Which is assigned for the laboratory technicians to enter the Result of test that specified by the Doctor, Also, the laboratory sub-system uses the patient personal information that comes from two sub-systems the Administration and the Doctor sub-systems. This sub-system has two effects first a) Social effects: save patient lives and b) technical effects: the accuracy of the results in-term of delivery and healthcare information circulation. All these methods were used in our study to produce a novel solution for implementing Healthcare information exchange in the Republic of Sudan especially in the public hospitals (our study domain). Also, there are extra methods were used in our study in the advance chapters; such as a Framework, A model and Prototype.

4.8. Structure Design "Data, Algorithms and User-Interface?":

4.8.1. The Scenario of EEHI:

In this scenario, we will describe a design concept, called EEHI, for Electronically Exchange of Healthcare Information among public Hospitals in Sudan. The concept EEHI is a proposed Healthcare Information exchange System, that will be set in the public hospitals in Khartoum, Sudan. Initially, after that, it will be generalized to the the whole Sudanese public hospital and integrate them together, with the Ministry of Healthcare in the Republic of Sudan. In order to make the information about the patients available and timely accessed, and make some sort of Electronically Exchange of Patient Health Record (PHR) among public Sudanese hospitals. The concept EEHI consists of three sub-systems, the Doctor Sub-system, the Administration or

Registrar office Sub-system, and the laboratory Sub-system. The EEHI is secured by user name and password that identifying each user for the EEHI system uniquely according to its authorizations and to the sub-systems privileges, to control the access. Now, we will be turned to describe the user's scenario, the proposed system has four users those who can interact with EEHI system, which are 1) The Doctors, 2) the Administration office employees, 3) the laboratory technician and 4) the patient.

Imagine that the patient comes to AUW-HC suffering from some disease, the Administration office employee he/she will collect the patient's personal information. Such as patient's National No, the patient's Name, the patient's Age, the patient's Address or patient's demographic area, the patient's Date-of-Birth, the patient's Gender, Status, Date-of-first-Diagnoses. Then he/she will submit this information in our proposed EEHI database, in the ministry of Healthcare Server, in the Republic of Sudan. This information automatically will migrate to the Doctor sub-system, by means of interoperability, the Administration office employee he/she also can generate a report about the patient history of disease, and see the test result, and the bending test, from the electronic patient record EPR that created and exists in our EEHI database, if the patient had visited or was treated in AUW-HC before. When the information about the patient arrives at the Doctor Sub-system, The Doctor can view the patient information by means of interoperability and making search about the patient, either by its National No its Name and he/she will diagnose the type of decease(s) and its related test(s) to be taken in the laboratory and submit his/her work in EEHI database. After submitting, the information automatically will migrate to the laboratory Sub-system. Also, by means of interoperability. then the laboratory technician will be able to view the doctor diagnoses and

can perform the test(s) specified by doctor and submit its work in EEHI database, after all these procedures and processes the information about the patient will be available in the whole Sub-systems, and other Sudanese public hospitals those engaged with the EEHI , after that any of our users can generate a report about the patient history of decease by searching the patient in our EEHI database using its User-name and Password. This scenario is essential for all our coming work in this study because it describing most of the processes.

4.8.2. The Data:

In this scenario, we will describe the flow of the data for our proposed scheme. The data comes from four sources, starting from login interface, in this stage the EEHI system required from the user to enter its User-id, User-type, User-name and password, that they are assigned for him/her previously, by our database administrator to make our database more secure, the second source is Administration office Sub-system interface, in this stage the Administration office employee he/she is required to collects the patient's personal information. Such as Full name, National No, sex, Age, Address, Date-of-first-diagnosis and enter it to EEHI system database. The third source is the Doctor Sub-system interface; the data required to be entered by the doctor are the type of test and the drugs. The last source is laboratory Sub-system interface, in this stage, the Lab Technician is required to enter the test result into EEHI system. We will describe below the type of data for each interface in an organized manner using tables.

4.8.3. The System Database Tables:

The tables that store the EEHI System information and data are summarized in table 4.1.

Table 4. 1 Database Tables

Table	Purpose
Users	Store the Users, user name and password
Patients	Store the patient's information
Doctors	Store the doctor's information
Results	Store the results of tests
Tests	Store the test information

4.8.3.1. The Users Table:

This table is designed for the security purpose to hold the user's information, we have three types of users in our proposed system which they are: 1) The Doctor, 2) The admin, 3) The lab Technician. Each of the users has a user name and password, when the user enters his/her User-ID and User-Password through the login interface this User-ID and User-Password will be compared with the existing User-name and User-password in the Users Table, if it is matching the user will be logged in to the system else the user does not have the authority to enter to our system.

Table 4. 2 Users Tables:

Field	Type	Null
USERID	Integer	No
USERNAME	Varchar (40)	No
USERTYPE	Varchar (20)	No
USERPASS	Varchar (20)	No

4.8.3.2.   The Patients Table:

This table is designed to collect the patient's personal information; it will be filling by the administration office employee through the administration office interface.

Table 4. 3 Patients Table:

Field	Type	Null
National No	Bigint	No
Patien _Name	varchar (30)	No
DATE_OF_FIRST_DIAGNOSIS	Datetime	No
Address	varchar (40)	No
DOB	Datetime	No
Six	varchar (1)	No
Doctor name	varchar (50)	No
Diagnoses	varchar (500)	

4.8.3.3. The Doctors Table:

This table is designed to hold the doctor's information, there is a relation between the doctors' table and the patient'stable using the doctor name field because every patient is assigned to one doctor.

Table 4. 4 Doctors Table:

Field	Type	Null
Doctor _ID	varchar (8)	No
Doctor _NAME	varchar (30)	No

4.8.3.4. The Results Table:

This table is designed to store the result of the test, that will be entered by the lab technician, there is a relationship between the Results Table and Patients Table using the National No filed as Foreign-Key in the Results Table referencing to the National No in the Patients Table.

Table 4. 5 Result Table:

Field	Type	Null
National No	Bigint	Not
Result	varchar (30)	Not
Test-Name	varchar (30)	Not
DATE_OF_TEST	Datetime	Not
CURR_DATE	Datetime	Not
ID	Bigint	Not

4.8.3.5.   The Structure of Tests Table:

This table is designed to hold the test information that will be filling

be the database administration.

Table 4. 6 Test Table:

Field	Type	Null
Test-id	Int	No
Test name	varchar (50)	No
National No	Bigint	No

4.9. The Proposed Scheme Algorithm:

The Electronic Exchange of Healthcare Information system as shown in (Figure 17 below) consist of three Sub-systems, each of them does its own work. But, in the end, they are overlapping and integrating to make our system work in an efficient way, by allowing the integration of date and circulated, for this reason we designed one Algorithm combined of three Algorithm from the left you will find the Administration office Sub-system Algorithm, in the Centre the Doctor Sub-system Algorithm, and finally in the right you will find the laboratory Sub-system Algorithm.
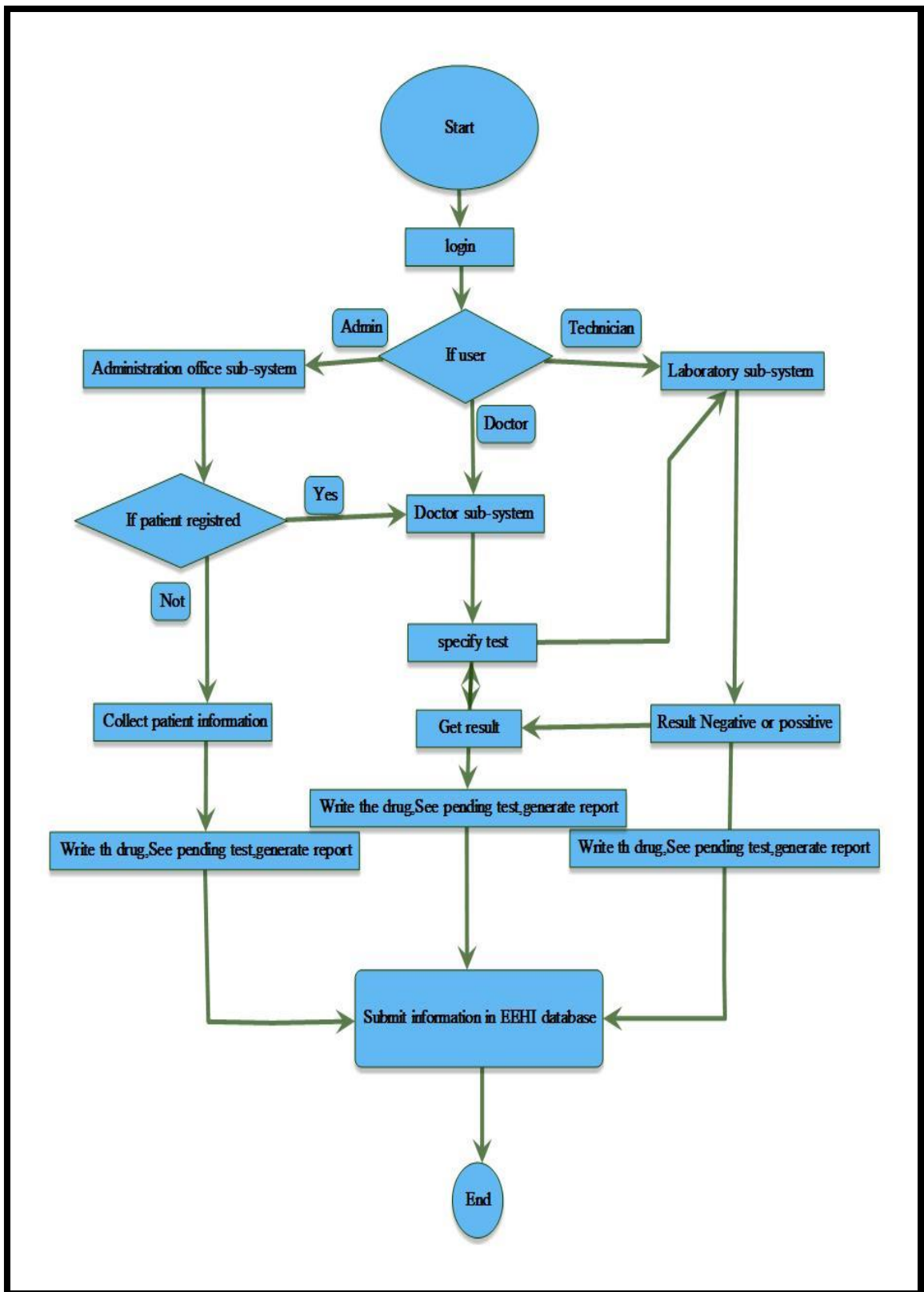
Figure 17 EEHI Algorithm

4.10. The User-Interfaces:

Our application system consists of several interfaces designed with Visual Studio. Net. The first interface we designed is the Main interface Figure (18) for our system; which consists of five bottoms. The first Bottom is the Administration office Interface Figure (20), the second bottom is the Doctor interface Figure (21), the third Bottom is laboratory interface Figure (22), and the forth Bottom is generating report interface figure (23), finally the last Bottom is close, it does not transfer you to an interface, and if you click any of this Bottom as shown in figure (20). You will be transferred to another interface, which is the login interface for all users, any user is required and compulsory to enter his/her user name and password as showing in Figure (19).

4.10.1.   The Main Interface:

This is the first interface in our system is called the main because it's the entrance for all interfaces.

Figure 18 The Main Interface

4.10.2.   Login Interface:

If your user name and password is correct then you will be allowed

to enter our EEHI database system.
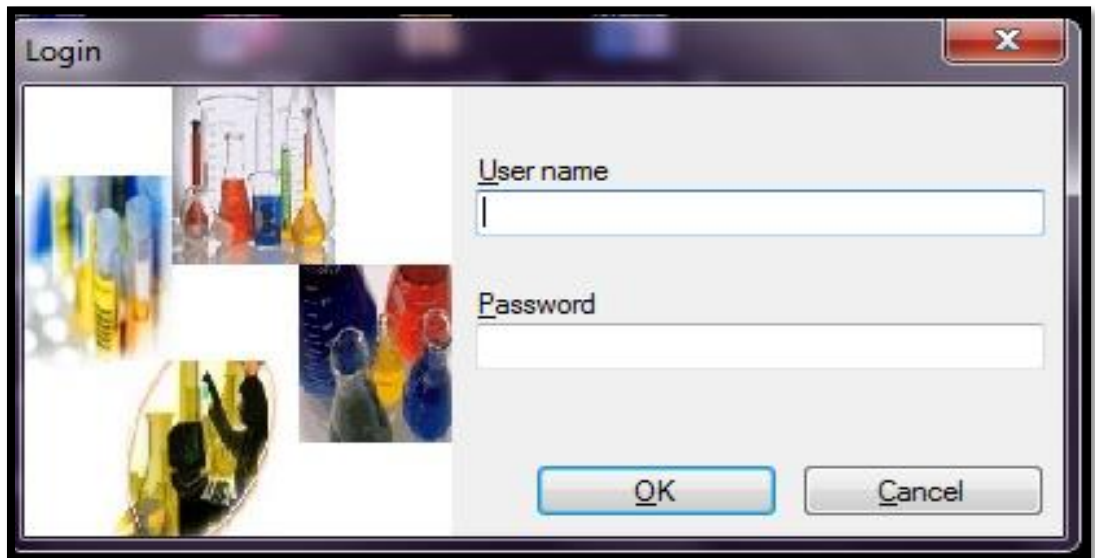
Figure 19 logon

4.10.3.   Administration Office Interface:

It is designed to be used by the administration office employees only,

in order to collect the patient's information and store it into our

database, to be fed for all other sub-systems, and to help the doctors in

the decision-making process. If the patient had visited our hospital

before, we called Registered. So, the administration office employee

will enter its Name or National No and click the search bottom to see

its information, then assigned the available doctor for him, if it is not

registered the administration office employee should filling this

interface.

Figure 20 Administration office Interface

4.10.4. The Doctor Interface:

Figure 21, the Doctor Interface; this interface is designed to be used by the Doctors only, the first step here, the doctor should enter the Name, or Patient id in the search box, then click search, after that the Patient information will appear in its interface, and after that should press New TEST Bottom, to select the type of test and Save the information. After this step, the type of test specified by the Doctor will appear for the lab technician.

Figure 21 The Doctor Interface

4.10.5.　The Laboratory Interface:

This interface is dedicated to lab technicians, to enter the result of test, specified by the doctor. The test result will be appearing automatically for the Doctor, after that the Doctor will be able to specify appropriate drugs for the Patient.
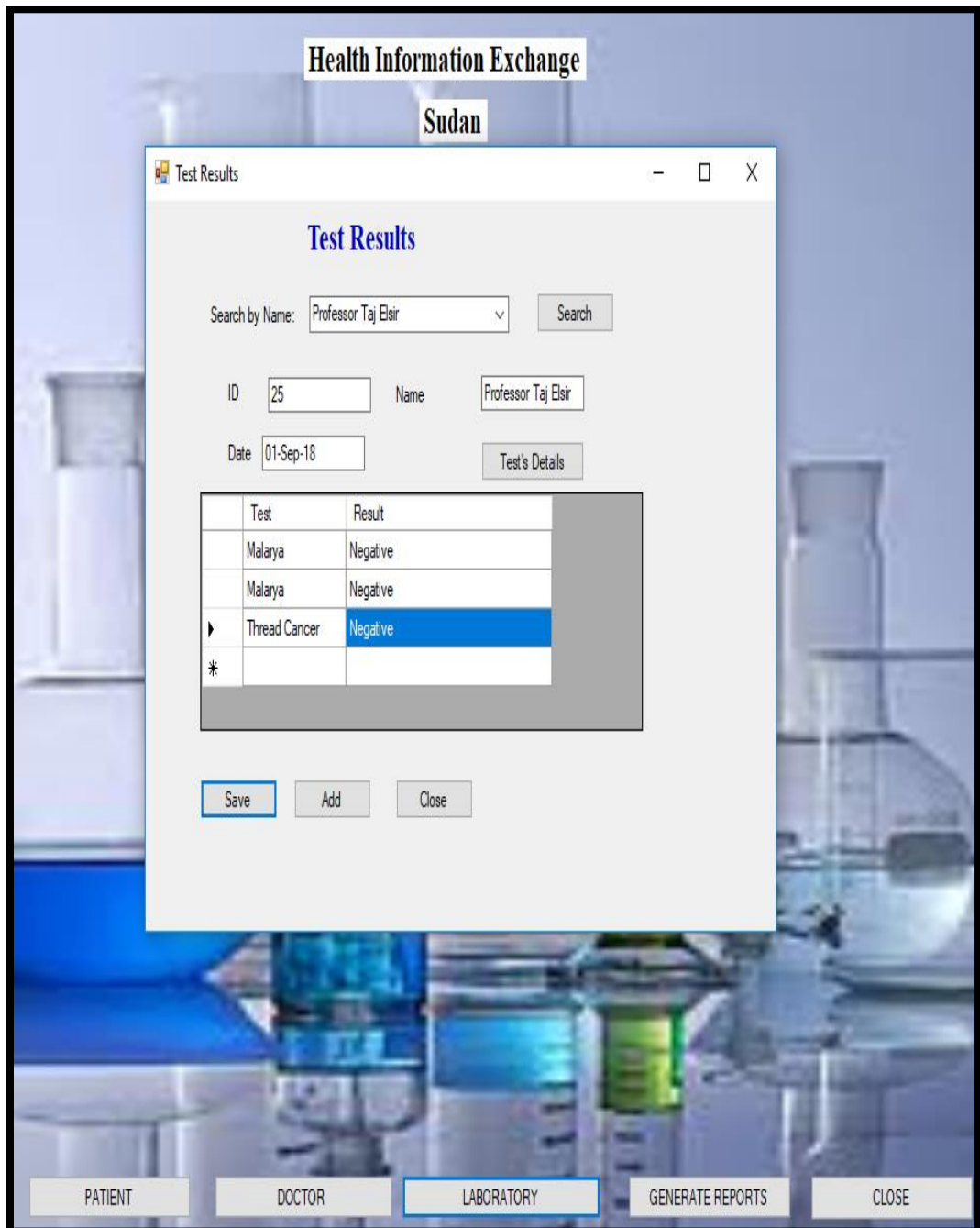
Figure 22 The Laboratory Interface:

4.10.6.   Generate EPR Interface:

This interface can be used by all our users to generate a report about the patient history of decease.

Figure 23 Generate EPR Interface.

4.10.7.   Generate EPRs Interface:

This interface can be used by all our users to generate a report about all patients.
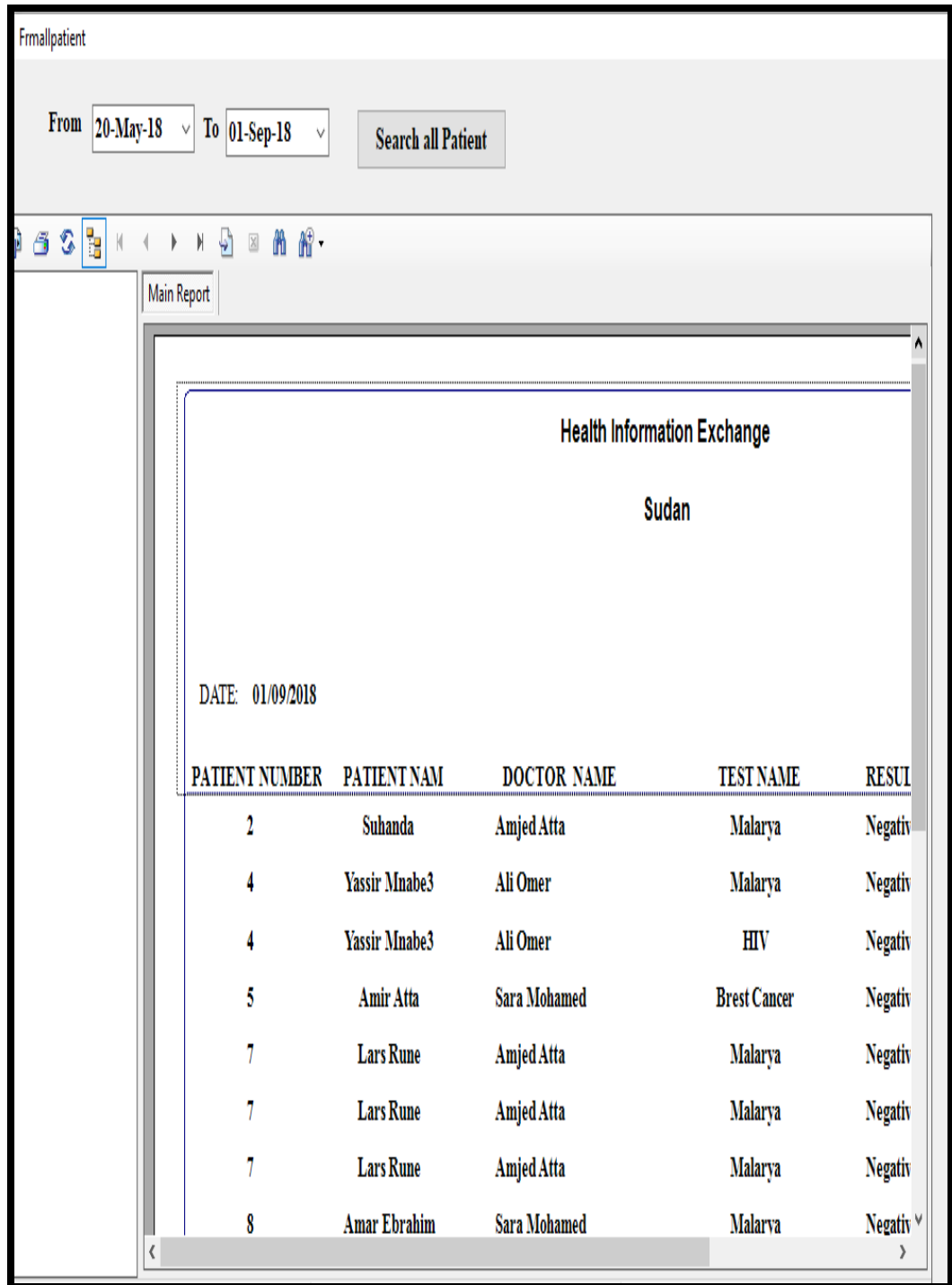
Figure 24 ERPs for all Patients.

4.11. The system processes:

The major system processes, or backbone processes, are three processes, these processes are powering the system operations and controls the overall system services. those processes are:

4.11.1.   The Search Process:

This process is designed by the following code:

```
Private Sub search_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles search.Click
    If cobname.Text = "" Then
      MsgBox("The search Location is empty!", MsgBoxStyle.Information)
    Else
      Dim conn As New OleDbConnection(constr)
      Dim cmd As New OleDbCommand("select * from PATIENT where
PATIENT_NAME='" & cobname.Text & "'", conn)
      Dim ds As New DataSet
      Dim da As New OleDbDataAdapter(cmd)
      da.Fill(ds)
      If ds.Tables(0).Rows.Count = 0 Then
        MsgBox("Datanot found")
      Else
        txtid.Text = ds.Tables(0).Rows(0)("PATIENT_ID")
        txtaddress.Text = ds.Tables(0).Rows(0)("ADDRESS")
        txtdate.Text =
       ds.Tables(0).Rows(0)("DATE_OF_FIRST_DIAGNOSIS")
        txtdob.Text = ds.Tables(0).Rows(0)("DOB")
        txtname.Text = ds.Tables(0).Rows(0)("PATIENT_NAME")
        cmbdoc.Text = ds.Tables(0).Rows(0)("DOCTOR_name")
        cmbsex.Text = ds.Tables(0).Rows(0)("SEX")
      End If
    End If
  End Sub
```

4.11.2.   The Save Process.

This process is designed by the following code:

```
Private Sub funsave()
    autoid()
    n = Val(m) + 1
    txtid.Text = n

    Dim cmds As New OleDbCommand("select * from PATIENT where PATIENT_ID ='" &
txtid.Text & "'", conn)
    Dim ds As New DataSet
    Dim da As New OleDbDataAdapter(cmds)
    da.Fill(ds)
    If ds.Tables(0).Rows.Count = 0 Then
    Dim cmd As New OleDbCommand("insert into
PATIENT(PATIENT_ID,PATIENT_NAME,DOCTOR_name,DATE_OF_FIRST_DIAGNOSI
S,ADDRESS,DOB,SEX) values (?,?,?,?,?,?,?)", conn)
        cmd.Parameters.AddWithValue("@PATIENT_ID", OleDbType.Numeric).Value =
txtid.Text
        cmd.Parameters.AddWithValue("@PATIENT_NAME", OleDbType.VarChar).Value =
txtname.Text.ToString
        cmd.Parameters.AddWithValue("@DOCTOR_name", OleDbType.VarChar).Value =
cmbdoc.Text.ToString
        cmd.Parameters.AddWithValue("@DATE_OF_FIRST_DIAGNOSIS",
OleDbType.VarChar).Value = txtdate.Text
        cmd.Parameters.AddWithValue("@ADDRESS", OleDbType.VarChar).Value =
txtaddress.Text
        cmd.Parameters.AddWithValue("@DOB", OleDbType.VarChar).Value = txtdob.Text
        cmd.Parameters.AddWithValue("@SEX", OleDbType.VarChar).Value = cmbsex.Text
        conn.Open()
        cmd.ExecuteNonQuery()
        conn.Close()
        MsgBox("Data Saved Successfuly", MsgBoxStyle.Information)
        txtid.Clear()
    Else
        MsgBox("PATIENT ID is Found", MsgBoxStyle.Information)
    End If
End Sub
```

4.11.3. Filling the Data-Grid Process:

This process is designed by the following code:

```vb
Private Sub review()


    Try
        Dim con As New OleDbConnection(constr)

        Dim adapter As New OleDbDataAdapter("select PATIENT_NAME ,
DOCTOR_name , convert(varchar,DATE_OF_FIRST_DIAGNOSIS,103) , ADDRESS ,
convert(varchar,DOB,103), SEX from PATIENT where
DATE_OF_FIRST_DIAGNOSIS='" & txtdate.Text & "'", con)

        Dim ds As New DataSet
        con.Open()
        adapter.Fill(ds, "patient")
        Me.DataGridView1.Columns(0).HeaderText = "PATIENT NAME"
        Me.DataGridView1.Columns(0).Width = 200
        Me.DataGridView1.Columns(1).HeaderText = "DOCTOR NAME"
        Me.DataGridView1.Columns(1).Width = 200
        Me.DataGridView1.Columns(2).HeaderText = "FIRST DIAGNOSIS DATE"
        Me.DataGridView1.Columns(2).Width = 100
        Me.DataGridView1.Columns(3).HeaderText = "ADDRESS"
        Me.DataGridView1.Columns(3).Width = 300
        Me.DataGridView1.Columns(4).HeaderText = "DATE OF BIRTH"
        Me.DataGridView1.Columns(4).Width = 100
        Me.DataGridView1.Columns(5).HeaderText = "SEX"
        Me.DataGridView1.Columns(5).Width = 20
        For i As Integer = 0 To ds.Tables("PATIENT").Rows.Count - 1
            DataGridView1.Rows.Add()
            DataGridView1.Item(0, i).Value = ds.Tables(0).Rows(i).Item(0).ToString
            DataGridView1.Item(1, i).Value = ds.Tables(0).Rows(i).Item(1).ToString
            DataGridView1.Item(2, i).Value = ds.Tables(0).Rows(i).Item(2).ToString
            DataGridView1.Item(3, i).Value = ds.Tables(0).Rows(i).Item(3).ToString
            DataGridView1.Item(4, i).Value = ds.Tables(0).Rows(i).Item(4).ToString
            DataGridView1.Item(5, i).Value = ds.Tables(0).Rows(i).Item(5).ToString

        Next
        con.Close()
    Catch ex As Exception
        MsgBox(ex.Message)
    End Try
```

4.12. The Metaphor Design "External Behavior and Context?

4.12.1. A list of alternative appearances of my program to be made:

1. Using Manual System.
2. Using Traditional Computerize System using a spreadsheet.
3. Integrated Hospital System (IHS) using a centralized database.
4. Electronic Exchange of Healthcare Information (EEHI) among Hospitals.
5. Electronic Patient Record (EPR).

4.12.2. The following are the sorted list of alternatives from "adequate" to "non-adequate".

1. Electronic Exchange of Healthcare Information (EEHI) among Hospitals.
2. Integrated Hospital System (IHS) using a centralized database.
3. Electronic Patient Record (EPR).
4. Using Traditional Computerize System, a spreadsheet.
5. Using Manual System.

4.12.3. The five most attractive or adequate ones, and how each of them is likely to behave to the user.

4.12.4. Electronic Exchange of Healthcare Information (EEHI) among Hospitals:

The systems collect information about the patient's disease, through an Information System, from one public hospital and make it available in the whole public hospitals in Sudan. This allows Doctors which are one

of our users, to share the information about patient(s), and help them in decision making. This kind of scheme can save the patient's life's in the critical situation, and also it will not consume time to see the history of   patent   disease.
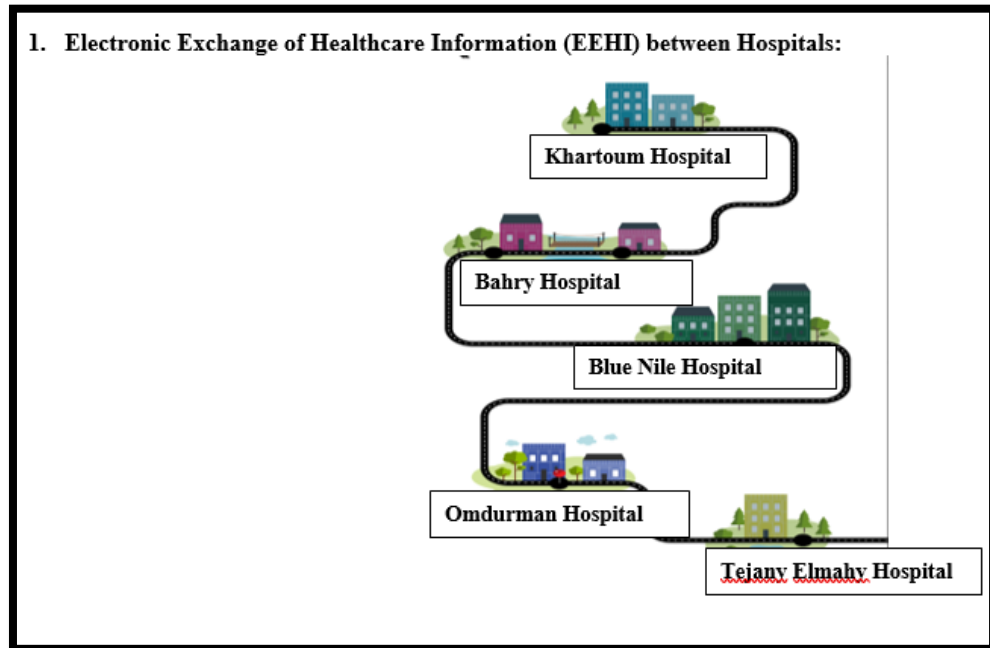
Figure 25 EEHI

4.12.5.   Integrated Hospital System (IHS) using centralize database.

Computerizing all the manual works and store the patient information using the centralize Data-Base Management System (DBMS), that collect the patient's information from the whole hospital units in the same database. This information also can be shared by all hospital units; the limitation is that it needs strong security policy also, the patient information cannot be exchanged with other hospitals.

4.12.6.   Electronic Patient Record (EPR).

It's a record of an individual's lifetime health Information, For the users of Electronic Patient Record is easy to update and transfer. It's used to documents:

Figure 26 EPR

Patient interaction with the health system.

Record of test and, appointment. Signs and symptoms of the disease.

Medications.

4.12.7. Using Traditional Computerize System based on spreadsheet.

Using a spreadsheet to organize the work
Have a lot of advantages for example:

Figure 27 Simple Application

- The model can be saved and backed up.

- Quicker and cheaper.

- the model can be shared between different

people in different locations. And easy to use. But, also have a limitation and weakness example: it's not designed for collaborative work, and incapable of supporting decision making.

4.12.8. Using Manual System.

Using traditional paper records which it also has

Much weakness such as delay in searching, more

Susceptible to damage and loss.

Figure 28 Manual System

4.12.9.   The three systems that seems to be the most effective one is:

4.12.9.1.   Electronic Exchange of Healthcare Information (EEHI) among Hospitals.

4.12.9.2.   Integrated Hospital System (HIS) using a centralize databased.

4.12.9.3.   Electronic Patient Record (EPR).

And the most effective one is the Electronic Exchange of Healthcare Information (EEHI) among Hospitals. Because, all other alternatives adequate have vulnerabilities and weaknesses, as mentioned above.

4.13. A scenario for defending the study choice:

As mentioned above all the alternatives adequate have vulnerabilities and weaknesses, we will demonstrate the vulnerabilities or weaknesses for each of them briefly in the following:

Consider that our chosen is (HIS) and imagine that; the system is functioning in one of the Sudanese public hospitals, Say its Khartoum Teaching Hospital. We knew that; the HIS collects the information about the patient from different hospital-units exists in the same hospital, and allows users to share the information about the patient, and store them in a central database. This kind of system requires a strong security policy to control access to the patient's information. Control access is vulnerability and weaknesses

compared to our proposed scheme EEHI, also patient Information cannot be sharing out of the hospital unit, this is also considered as a disadvantage of HIS.

In the same scenario above consider our chosen is EPR:

We knew that; the EPR transform the patient information from Manual System or from traditional papers into computerized system, for the patient long life's health record, so it's like a repository for the patient personal information, and patient healthcare information. One of its weaknesses is that; the information cannot be shared between hospitals and incapable of supporting decision making.

Using a spreadsheet or manual systems they are excluded from this comparison as competitors because their weaknesses and vulnerabilities are known.

Know, consider we chosen EEHI, and imagine that the system is functioning in Khartoum Teaching Hospital (KTH) and Omdurman Teaching Hospital (OTH) which they are public Sudanese hospitals. And they are linked together through EEHI system, with the Ministry of Healthcare in the Republic of Sudan, and imagine that some people come to (OTH) carrying someone in comma, let's say his name is Amgad, And the Doctor found his identity card in his pocket, so the Doctor use EEHI System and made search about Amgad, he found that; he is visited OTH and have a record consists of his disease history and he is a diabetic. In this scenario Electronic Exchange of Healthcare Information among Hospitals save's Amgad life. We argue that EEHI is the most adequate system to be implemented in the public Sudanese hospitals, and have many societal effects. For example, it can improve the doctor-patient communication, and make the

information about the patient available, and it's secure. Also, we showed there are weaknesses and vulnerabilities of all other adequate alternatives.

4.14.   Conclusion:

Our EEHI system is composed of three sub-systems, each of which performs its own tasks, within the overall system environment, and the three components are integrated to make the EEHI system operational, those three components are: Administration office sub-system which has an interface connected to the EEHI system database, to enter personal information about patients. The second component is the Doctor sub-system which has an interface connected to EEHI system database to enter the patient diagnosis and specifying test(s) for a specific patient to be performed in the laboratory. The third component is Laboratory sub-system which has an interface connected to EEHI system database to enter test(s) result(s) for a specific patient which is Specified by Doctor and then send this result(s) to Doctor which uses it to write down the appropriate drugs.

CHAPTER FIVE

PRACTICE OF HEALTHCARE INFORMATION EXCHANGE

5 Practice of Healthcare Information Exchange (Case Study Alribat Hospital):

5.1   Introduction:

It is a general aim among countries, to augment the health of their populations and to increase the quality of healthcare. With the advent of ICT, countries have increased funding in the healthcare area, in this study, "Practices of Healthcare Information Exchange in the Emergency Department of a Sudanese Hospital" (PHIEEDS), we argue that the use of new ICT systems and technology will improve health care services, and will increase patient satisfaction; bearing in mind that; the advantages of ICT facilitation and systems in public Sudanese hospitals have not yet been utilized. It is critical to making information available and accessible for the decision-making process. This chapter is an extension of the previous contribution to Healthcare Information Infrastructures among Public Hospitals in Sudan (Mohammed, 2017) The primary objective of this study (PHIEEDS) is to study and analyze the current situation of healthcare information infrastructure, if any, for exchanging and circulating the patient's information within and among Sudanese public hospitals. Methods: Ethnography studies for more than ten months were carried out, to understand the current practices in the Emergency Department ED involving the workaround.

Health information exchange has been developed in many countries especially in Europe (Johnson *et al.*, 2011),(Rudin *et al.*, 2014),(Annals Of, Medicine and Org, 2017). In Sudan, hospitals are divided into three healthcare providers, that can be summarized as follows public hospitals, private hospitals, and Non-governmental hospitals NGOs (Mohammed, 2017) All these hospitals are

promising beneficiaries' and essential to benefits from our study. There is a need for (PHIEEDS) in Sudan; with the overall number of Sudanese citizens, approximately more than more than thirty-eight million persons, who are potential beneficiaries of the Sudanese public hospital's services. Unfortunately, many of those hospitals, do not use a computerized system to manage the patients' requirements; it is obvious that; the current systems of public hospitals in Sudan do not meet with the reporting requests of recipient population. So, we investigated this situation at Al-Rabat University Hospital, specifically, in the Emergency Department (ED), to analyze the current situation of their work, and how the information may be exchanged to understand how the current system works.

5.2   Related Issues:

Imperfect administration of clinical data.

Lack of doctor-patient communication.

Unavailability of information concerning patients'   rights.

Queuing.

Time-consuming process.

Lack of data storage and the absence of information.

A successful Information System must be capable of maintaining institutional memory, where the information regarding beneficiary doctors or patients, are simple to access and retrieve.

Automated systems such as Electronic Exchange of Healthcare Information (EEHI) knows how to address such issues, and give advanced services for order and reporting of Hospital Information Systems (HIS) (Shapiro, Kannry and Kushniruk, 2007), (Everson *et al.*, 2016), (Downing *et al.*, 2016) and (Mohammed, 2017).

111

5.3   Investigating the Current Practice:

We start our investigation by the following Question: What are the current problems for the hospital department, in terms of handling patient information?

Several challenges are facing most of the Sudanese hospitals currently. Also, we describe and analyzed the current situation of healthcare systems, to specify the major challenges in term of handling patient information within ED and its circulation in the hospitals.

5.4   The Problem with the Current Practice:

After that we specified these problems as follows:

1) In many Sudanese hospitals, there are no direct connection channels between the laboratory and the radiology department.

2) There is no direct link between the physicians and radiology department and the laboratory inside the ED.

3) Computerization of patient's files, yet not done.

4) There is no link between the registration office and other ED units.

5) Finally, today in Sudan, there is no guarantee that any patient will receive high-quality care for any specified disease. The aim of this study is to find solutions for the above issues; in result we did an ethnography study for this purpose, Also, to find answers to the following questions.

5.5 Important questions regarding the current practice:

1. What information is registered about the different kinds of patients, as they are classified in the registration office?

2. What type of information is used and produced by the doctors in the triage process?

3. What kind of information is sent to the other hospitals' units? (E.g. wards, surgery, ICU, laboratory, pharmacy, etc.).

4. What information is registered when patients are discharged home?

To answer these questions, two methods were used, including Ethnography studies from the field of Computer Support Cooperative Work (CSCW) among other methods such as interview, observation, and so on.

5.6 The Study Methods:

5.6.1 Methods for part one:

Ethnography studies were carried out to understand the current practices in the Emergency Department ED at AL-Rabat University Hospital (RUH) involving the workaround and the ED procedures. Also, interaction with the practitioners' in the ED deeply analyzes the environment and culture of the ED from the perspective of workers. We carried out extensive interviews with most employees in the RUHED, both structured and unstructured (Petrakaki, Klecun and Cornford, 2014) including a phone call. All accompanied by voice recording and note-taking. We also undertook observations to see the emergency response in the RUHED to get an idea of the present state of ED response to implementation of electronic exchange of healthcare information within and among hospitals.

5.6.2 Methods for part two:

We formulated a thesis of the critical challenges and we designed a Persona for multiple patients' journeys through the ED as represented in information, using new software called Mind-Maple. We also developed a Persona concerning those involved in the emergency department response, as well as the Doctors, administration office, services, triage, laboratory, and pharmacy. Then we created a scenario for the new map of healthcare information infrastructure among public hospitals(Mohammed, 2017), (AAA Mohammed and L. R. Christensen, 2018).
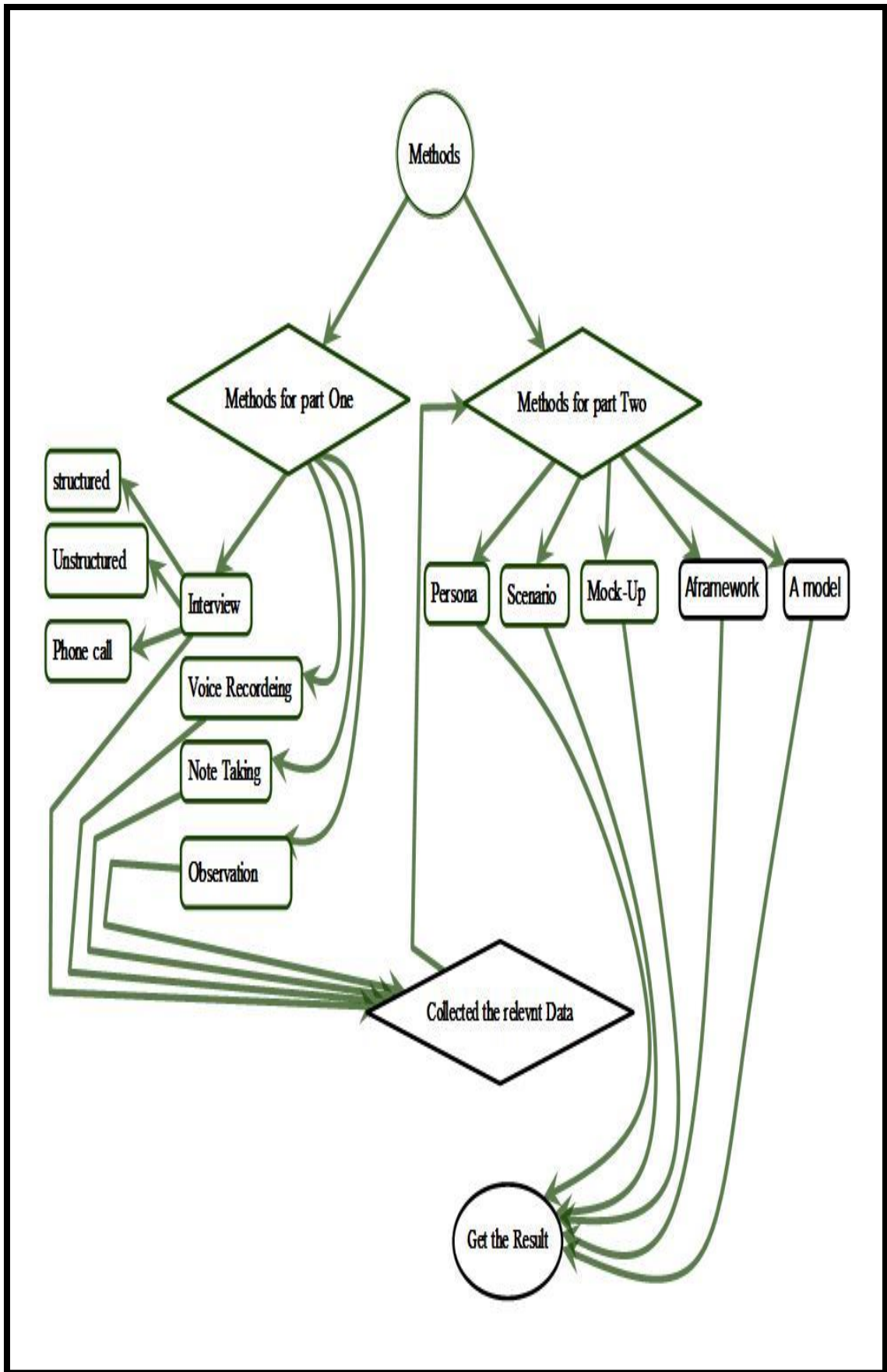
Figure 29 The Methods

5.7 Findings:

The Emergency Department ED at Al-Rabat University Hospital (RUH) receives patients from various sources. The first source is Home. The patients come directly from their home to ED. The second source is the patient transferred from another hospital in a different state. The third source is Public Car Accident; which is the patient could be a victim of a car accident. And the fourth source is that; the patient could be transferred from another special or public hospital (see figure 25). The only entrance to the hospital for all those sources is through the registration office in the ED. In the registration office, the employees classify the patients into two types: 1) type one is assigned to the police officers and their family members who have health insurance. The second one is known as the normal citizen (called investment) or those who do not have healthcare insurance.

The question that arises here is that; what information is registered about different kinds of patients as they are classified in the registration office?

The answer: The information which is registered in the registration office can be summarized as follows: Name, Age, demographic data, and contact information. All this information is recorded in the patient's "Short Stay File" which is personally devoted to every patient. The demographic data has a particular concern because it could be used to verify epidemic diseases in a specific area. The medical history of a patient is essential to see if she/he has a chronic illness; it's critical to the diagnosis process and also for prescribing suitable drugs.

5.7.1 The work environment at Alribat Hospital's Emergency Department ED:

The Emergency Department consists of 16th Rooms filled with high tech equipment plus one Trauma room, and there are more than fifty staff members who are divided as follows:

Two emergency specialists.

Seven doctors.

Twelve technicians.

 Ten nurses

Ten patient assistants.

Six laboratory technicians

Two pharmacists

Seven employees for cleaning.

5.7.2 The services offered by the emergency department are:

 Al-Rabat University Hospital (RUH) provides several   services for arrival patients in The Emergency Department which include:

1)   Radiation services:
The hospital offers many radiation treatments that involve X-Ray radiation, CT scan, MRI and ultrasound.

2)   Laboratory services:
The Laboratory provides three categories of services:

a) Blood disease.
b) Chemistry.

c) Microradiograph.

3) ECG Electrocardiograph.

4) Asthma room services.

5) Trauma room services.

 6) Dental department Services.

7) Pharmacy services.

5.8 Discussion:

This study has found that; in the Emergency Department the doctors used a triage process, in order to determine the clinical situation of the patient, because some patients need urgent care, others require attention within four hours, other patients need care within twenty-four hours, and some patients need middle (non-emergency) care. Moreover, doctors are triaging the patients into two types.

1-   **Hot cases:** this means the patient needs urgent attention or rapid intervention quickly.

2-   **Cold cases:** the patient can be listed on the waiting list for a period of time that might exceed four hours.

3-   In some instances, the patient arrives at the Emergency Department after death, in this case, the corpse will be referred to the morgue.

The next questions that arise here are what kind of information is used and produced by the doctor in the triage process?

The answer; the questions are answered by the senior manager of the RUH ED who said that "Some of the information used by the doctor in

the triage process comes from the patient's "Short Stay File" which includes the following information:

The patient's personal information; patient name, insurance card number, date, phone number, age, address, police rank or citizen, if it's not a police officer, but he/she is sponsored by a police officer who is the name of the sponsor." As far as the information produced by the doctor is concerned, it is essential that it is written down in the "Short Stay File"; the main symptoms of the patient's disease, reasons for seeking the emergency department services, and the history of the disease in connection with the main complaints. Also, the Doctors have to pay special concern to the outcomes of the Routine investigation to examine the vital signs of patients, including PR/min, SPo2, PEF, RR/min, BR, AVPU and write down the results of the routine investigation in the "Short Stay File" for every specific patient.

• Another question that remains unanswered here is that; what kind of information is sent to the other hospital units? For example, wards, surgery, ICU, laboratory, pharmacy etc. In the triage process, the doctor makes a routine investigation including the vital signs and other checks, such as kidney function test, urine examination, blood inflammation, and diabetes. In accordance with the results of this investigation, he or she divides the patients into two types; as we mentioned earlier: type one is Hot Cases or dangerous cases for those patients who need urgent intervention, grounded upon the investigation. For example, patients who suffer from heart attack, and need to be moved rapidly to the intensive care unit ICU Room; another category are those patients who have Asthma attack and need to be moved to the Asthma Room; and the patients who experience fainting or victims of road traffic accidents (RTA) who will be moved to the Recovery Room. Type two is called Cold Cases: which do not need urgent

intervention. They are categorized as a normal clinic; the patients can wait for four hours and are classified according to a specific unit of disease, such as the patient who comes with a malaria disease will be assigned to the Internal Medicine Specialist. Finally, all those patients move with Their "Short Stay File" to a specific doctor or specialist, no matter if they are Hot Cases or Cold Cases. After treatment they will be referred to:

1)   Hospital wards, 2) Or to the surgery, 3) Or to the intensive care unit ICU 4), Or to middle care unit 5) Or to Asthma Room. 6) Or to Trauma Room 7) Or to dental department and 8) Finally, discharged from the hospital to home.

The question which arises here is that; what information is registered when a patient is discharged to Home?

If the patient needs more care and followed up; she or he will stay in the hospital wards. If she or he does not need the doctor's help, the patients will not stay at Hospital, but the patient's Short Stay File will be kept in the ED registration office as a patient record for the future need. check Figure (30).
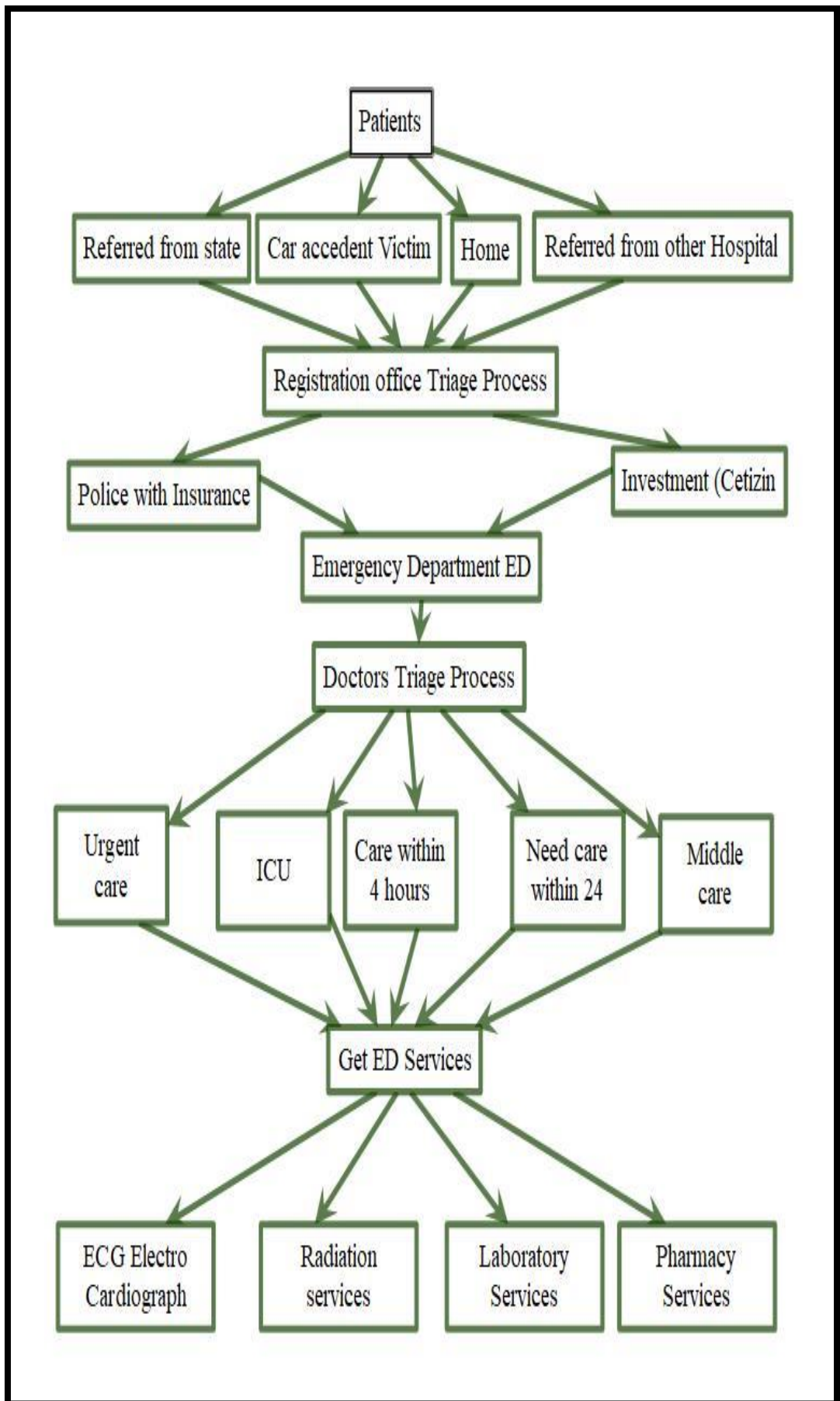
Figure 30 Patients journey through ED

5.9   How can the current situation be improved?

The current situation for the public hospital's system in Sudan can be improved, by the new design of health integrated information technology to exchange the patient's information in a convenient way. According to (Axelsson and S. B. Axelsson, 2006) integration in the public hospital's field demands an inter-organizational collaboration among all hospital units. See figure (31). Considering that; improving the health care system has become a priority for all health sector organizations and providers (Cox, Roberts and Stevens, 2002) in order to achieve the primary objectives for healthcare; which are: enhancing the quality of healthcare systems and increasing patient satisfaction.

5.10 The functions that the new information and communication technology system will offer include:

5.10.1 Security and Privacy:

User-name and password will restrict access to private patient information, and availability of patients' information for the beneficiaries and authorized people such as Doctors, lab technician, administration office employee. for security purposes.

5.10.2   Wait Time Reduction:

The proposed ICT will reduce the waiting times for all services and minimize the triage process.

5.10.3   Information:
The information about the patient will be available and accessible on time, across all hospitals' units, for instance in the laboratory and radiology units.

5.10.4 Administration:

The procedures of check-in and check-out will be easy for the administration office employees.

5.10.5 Communication:

The new ICT will build channels for Communication across the ED units, as it is an integrated system. See Figure (31).

5.10.6　A Framework for Healthcare Information Exchange:
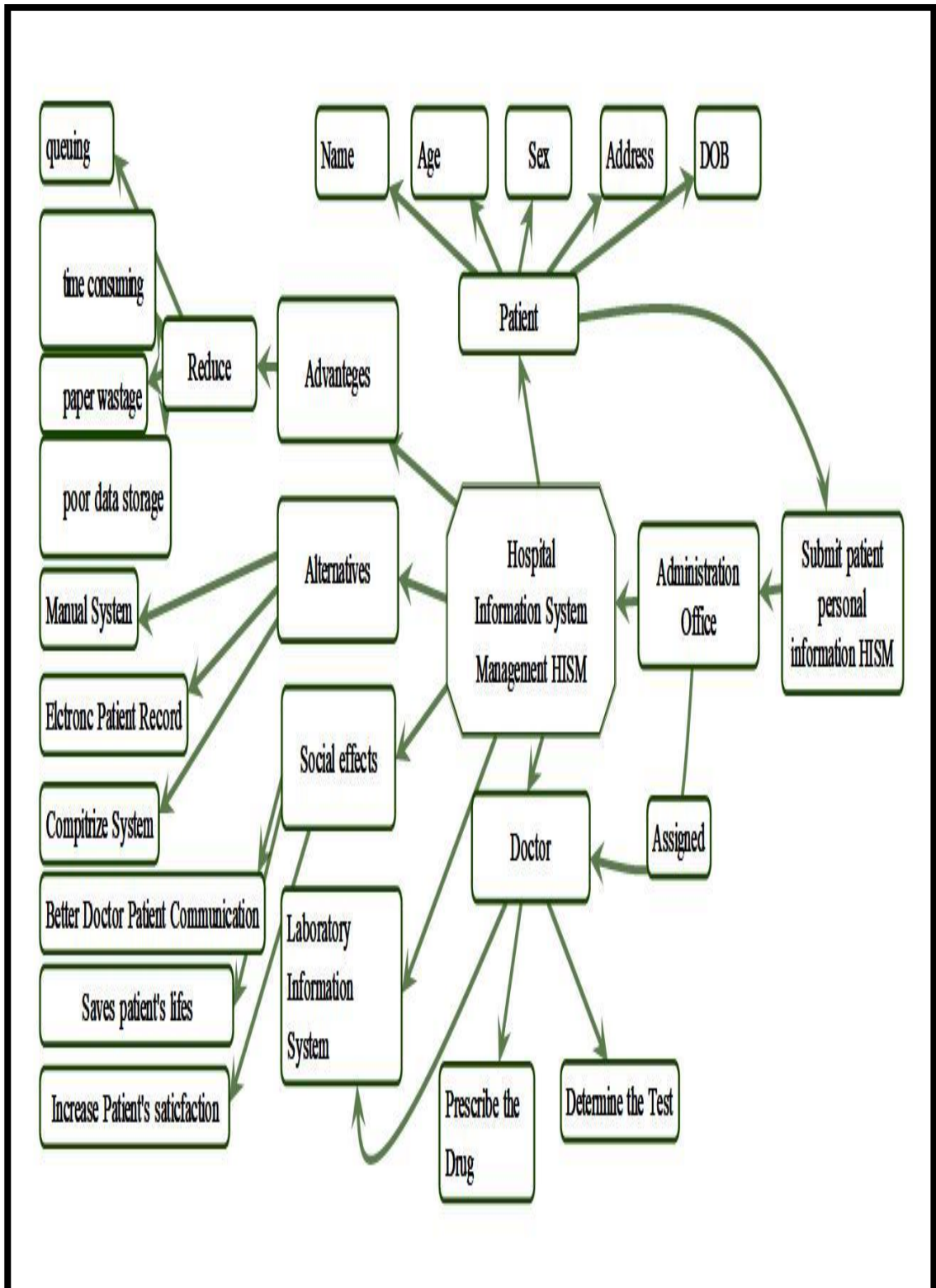
Figure 31 The Framework for Healthcare Information Exchange

5.11   Theoretical Framework for HIE:
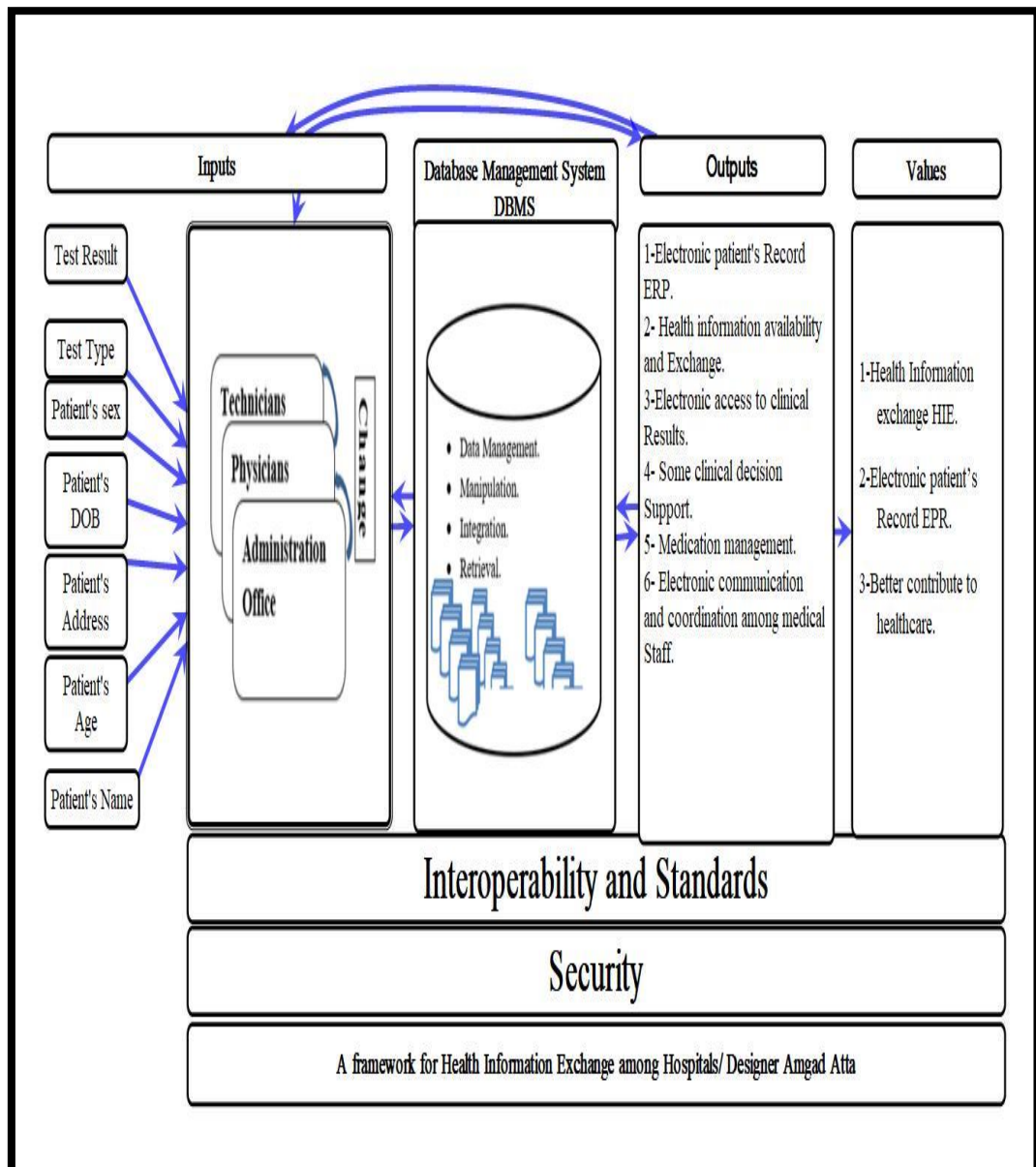
Figure 32 A New Framework for Healthcare Information Exchange

5.12 The Illustration of Framework:

The above Framework in (Figure 32) was designed to be a formative tool for healthcare information exchange HIE in the Republic of Sudan, upon areal work based on many healthcare organizations which are:

1) National Ribat Teaching Hospital or the Police Hospital.

2) Bahry Teaching Hospitals.

3) Al - Tajani Al - Mahi Hospital.

And 4) East Nile hospital.

Also, the private organizations are not an exception, we analyzed some of the private Hospitals such as:

5) Omer Sawi Hospital.

6) Alia Specialized Hospital.

7) Yestabshroon Hospital.

In addition, we analyzed two healthcare Centre which are:

8) Al Ahfad healthcare Centre and

9) Derby wounds care Centre.

5.13 The Framework combined of four main parts which are:

5.13.1 Part one, Inputs:

In this Framework the inputs are defined as the Data that should be collected or captured across the organization units, involving the patient personal information such as: Name, Age, Address, DOB, Sex, type of test, and the results, using one of the sub-systems. However, in the Input part, the Framework has three units which are 1) The administration office 2) The Doctors or physicians and 3) the laboratory technician; all these units are affected by each other changes, in term of data exchange, because there is asynchronies of data and integration. Also, this part has a function including patient's matching, data store, data exchange and privacy protection.

5.13.2 Part two, Database Management System DBMS:

This part is represented by database management software tool, which is SQL Server 2012 and it has multiple functions including:

- HIE Data management.
- Data manipulation.
- Data integration.
- Data retrieval.
- And, enabling the captured Data to be stored in a separate patient record for the future use, to be distributed across the sub-systems boundary.

- Finally, in the future we recommend that, to implement Data Warehouse and   use it to store and manage the healthcare information and patient's information rather than use Cloud Computing, because there are a number of challenges twisted with the Cloud Computing, which can be summarized as follows:

Cloud Computing Data Security:

- we have to depend on the security provided by the cloud host.
- Data protection against other applications.
- Protection against the cloud host, itself.
- A cloud is a high-value target to hackers.
- Data ownership issues.
- Moving sensitive and governmental data to the cloud.
- Performance variability.
- Lack of Quality of Service (QoS) guarantees.
- Data transfer issues.
- Financial cost.

5.13.3   Part three, the Outputs:

The expected outcomes of this Framework include:

1. A Framework for Electronic patient record EPR.
2. Healthcare information availability and exchange.
3. Electronic access to clinical data.
4. Some clinical decision supports.
5. Medication management.
6. Electronic communication and coordination among medical staff.

5.13.4   Part four, The Values:

1. Health information exchange.

2. Interoperability.

3. Electronic patient record EPR.

4. Better contribution to healthcare.

5.14 How do we achieve a Healthcare Information Exchange?

To answer this question, we designed an experiment in real life situation which can be summarized as follows:

5.14.1   The Hardware Infrastructure:

we used two computers laptops; one of them act as a Server and the one act as a client. Furthermore, used some connectivity equipment such as cables and Switch we well talk in detail about them later.

5.14.2   The Server Settings:

In the server device, we installed firstly Network operating system to be the basic platform which is Microsoft Network Operating system 2008. Secondly, we installed SQL server 2012 for Database purposes.

5.14.3   The Client Settings:

In the client computer firstly, we installed Client Tools that compatible with SQL server 2012, which is SQL Client 2012 to facilitate the access

and exchange of data, later. Secondly, we make a shortcut from our Prototype in the client interface. Thirdly, we executed the Prototype.

5.14.4   The Network Configuration:

In this phase, we connected the two devices (laptops) together in the same network using special lines (Cables) and link them to Switch device for connectivity.

In the future; we will need to connect the Public Hospitals in Sudan simultaneously, bearing in mind that; they are far away from each other using special lines, specifically Fiber-Optical lines which are provided and offered by the internet services providers companies such as NIC or other company.

5.15 Conclusion:

The use of information and communication technology will continue to dominate all businesses around the world (Coiera, 2006). The use of electronic health record (EHR) combined with HIE has been explored at the interface of primary care and hospital-based professional services. In this study, "Practices of Healthcare Information Exchange in the Emergency Department of a Sudanese Hospital", we argue that the use of new Information and Communication Technology systems will improve health care services, and will increase patient satisfaction; bearing in mind the advantages of ICT and its facilitation for computerize systems in public Sudanese hospitals have not been utilized yet. We carried out an ethnography study (Fitzpatrick and Ellingsen, 2013a), (Blomberg and Karasti, 2013) for more than ten months to

understand the situation of health information exchange in Al-Rabat Hospital ED involving structured and unstructured interviews, observations, and the collection of documents. We argue that the use of Information and Communication Technology offers powerful tools and equipment for restructuring health care organizations and its services. Finally, we are convinced that the use of the proposed Information and Communication Technology system will increase the communication channels and reduce waiting times in the Emergency Department.

CHAPTER SIX

THE RESULTS

6.1 Introduction:

The purpose of this experimental study phase is to validate the effectiveness of EEHI (Electronic Exchange of Healthcare Information among Hospitals) on Sudanese public hospitals, from the Doctor's, Administration employee's perspective and the lab technician's perspective. To investigate these phenomena, we designed a computer prototype using Visual Basic. Net for the interfaces, and SQL server 2012 for the database, and also, we observed the users when they are interacting with EEHI system prototype, and also, we used the structured and unstructured interview. And finally, we designed a questionnaire based on our research questions and our research hypothesis, and we analyzed these questionnaires using SPSS 19 to validate our work.

6.2 The Study Tools:

In the nature of the study and data to be obtained, a questionnaire was developed to measure the medical staff satisfaction from the Electronic Exchange of Healthcare Information among Hospitals EEHI, from the point of view of Doctors, Administration office employees and laboratory technicians.

6.3 The Study Society:

Our study society consists of 20 medical staff which they are, the Doctors, the Administration office employees and the laboratory technicians from thee different hospitals in three different cities, Khartoum, Bahry and Omdurman in the Republic of Sudan. the experiment showed these:

Table 6. 1: Q1. Is it necessary to share the patient's information between the hospitals?

	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	3	15.0	15.0	15.0
Disagree	2	10.0	10.0	25.0
Agree	3	15.0	15.0	40.0
Strongly Agree	12	60.0	60.0	100.0
Total	20	100.0	100.0	
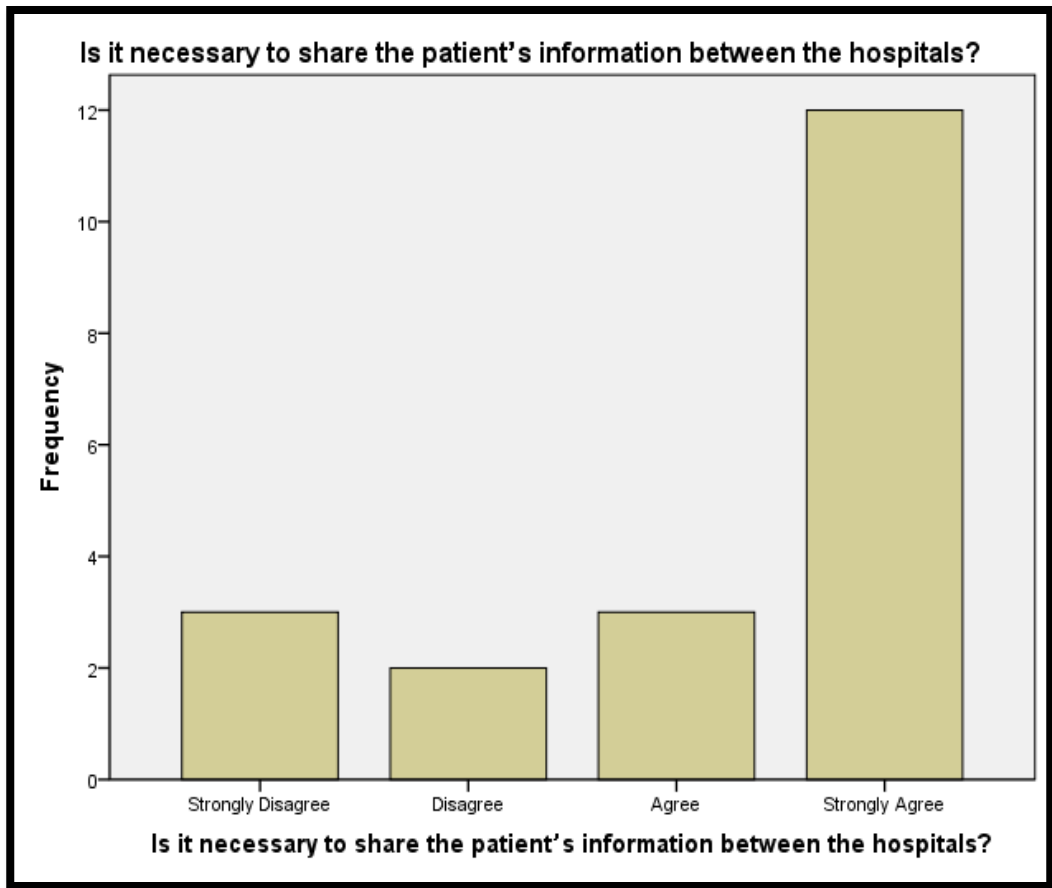
Table 6. 2: Q2. From my work experience, I meet some patients and I could not find their medical record?

	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	1	5.0	5.0	5.0
Disagree	3	15.0	15.0	20.0
Agree	11	55.0	55.0	75.0
Strongly Agree	5	25.0	25.0	100.0
Total	20	100.0	100.0	
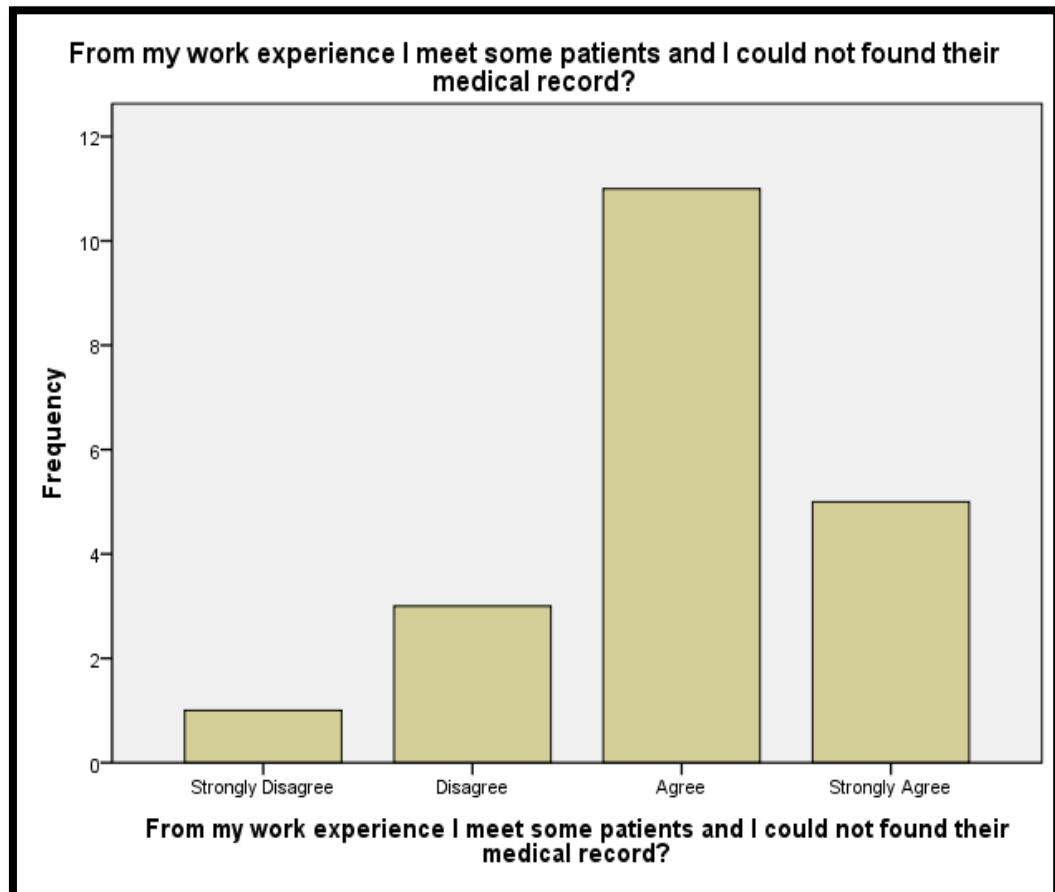
Figure 35 Result for Question 2

Table 6. 3: Q3. Some medical errors were happened due to the loss of patient medical record?

	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	1	5.0	5.0	5.0
Disagree	1	5.0	5.0	10.0
Uncertain	2	10.0	10.0	20.0
Agree	10	50.0	50.0	70.0
Strongly Agree	6	30.0	30.0	100.0
Total	20	100.0	100.0	
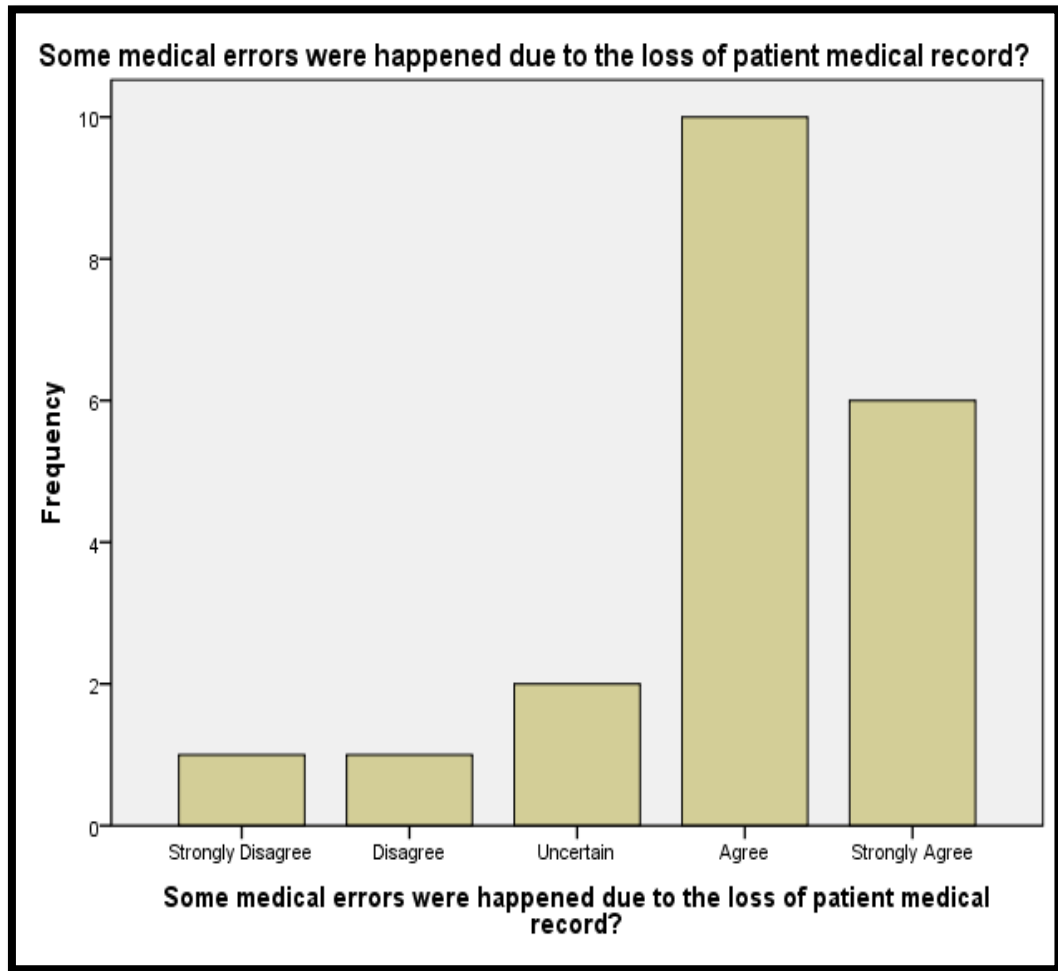
Figure 36 Result for Question 3

Table 6. 4: Q4. Find the medical record from computerize database is better and quicker than in the manual system?

	Frequency	Percent	Valid Percent	Cumulative Percent
Disagree	1	5.0	5.0	5.0
Agree	1	5.0	5.0	10.0
Strongly Agree	18	90.0	90.0	100.0
Total	20	100.0	100.0	
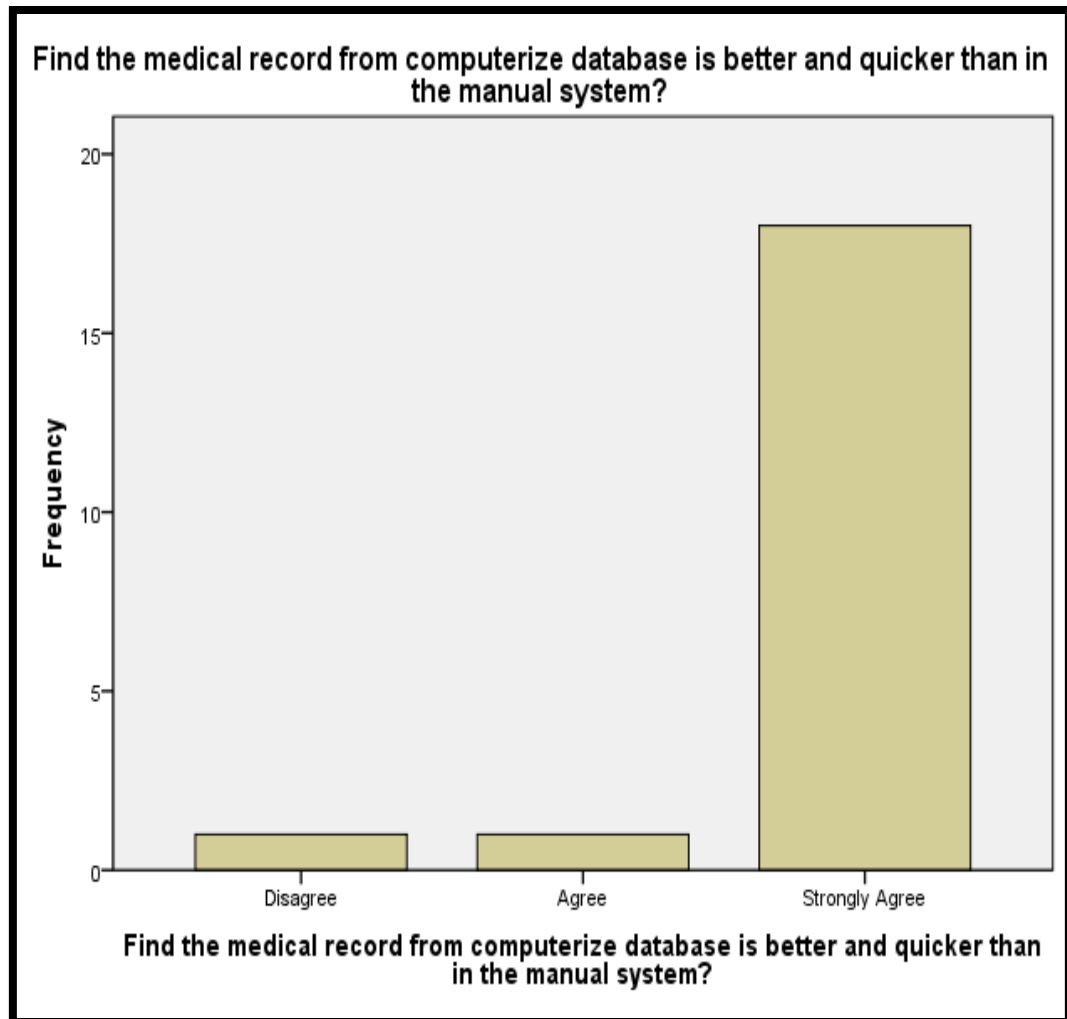
Figure 37 Result for Question 4

Table 6. 5 Q5. Using EEHI system enhanced my effectiveness on some tasks of my work.

	Frequency	Percent	Valid Percent	Cumulative Percent
Disagree	1	5.0	5.0	5.0
Uncertain	1	5.0	5.0	10.0
Agree	8	40.0	40.0	50.0
Strongly Agree	10	50.0	50.0	100.0
Total	20	100.0	100.0	
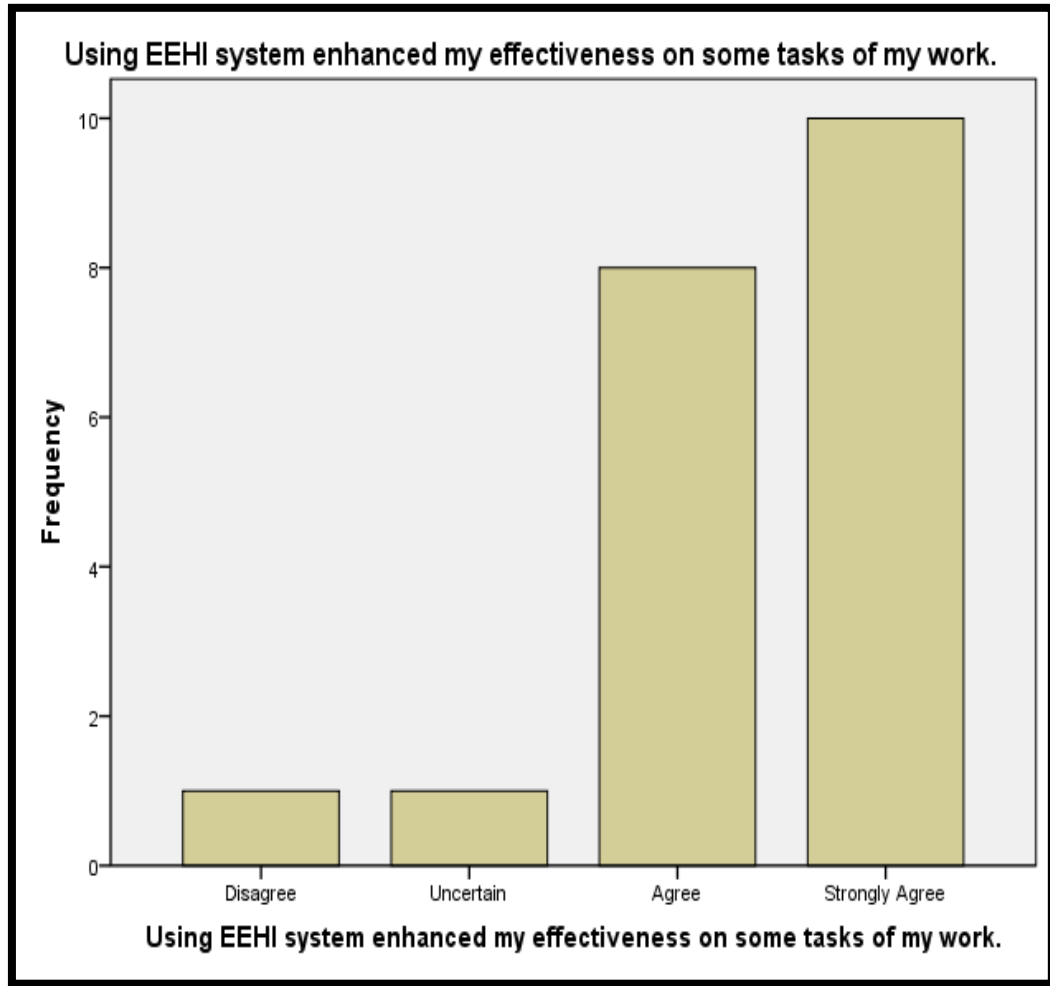
Figure 38 Result for Question 5

Table 6. 6: Q6. Sharing the patient's information between hospitals effect on the patient privacy?

	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	1	5.0	5.0	5.0
Disagree	3	15.0	15.0	20.0
Uncertain	3	15.0	15.0	35.0
Agree	8	40.0	40.0	75.0
Strongly Agree	5	25.0	25.0	100.0
Total	20	100.0	100.0	
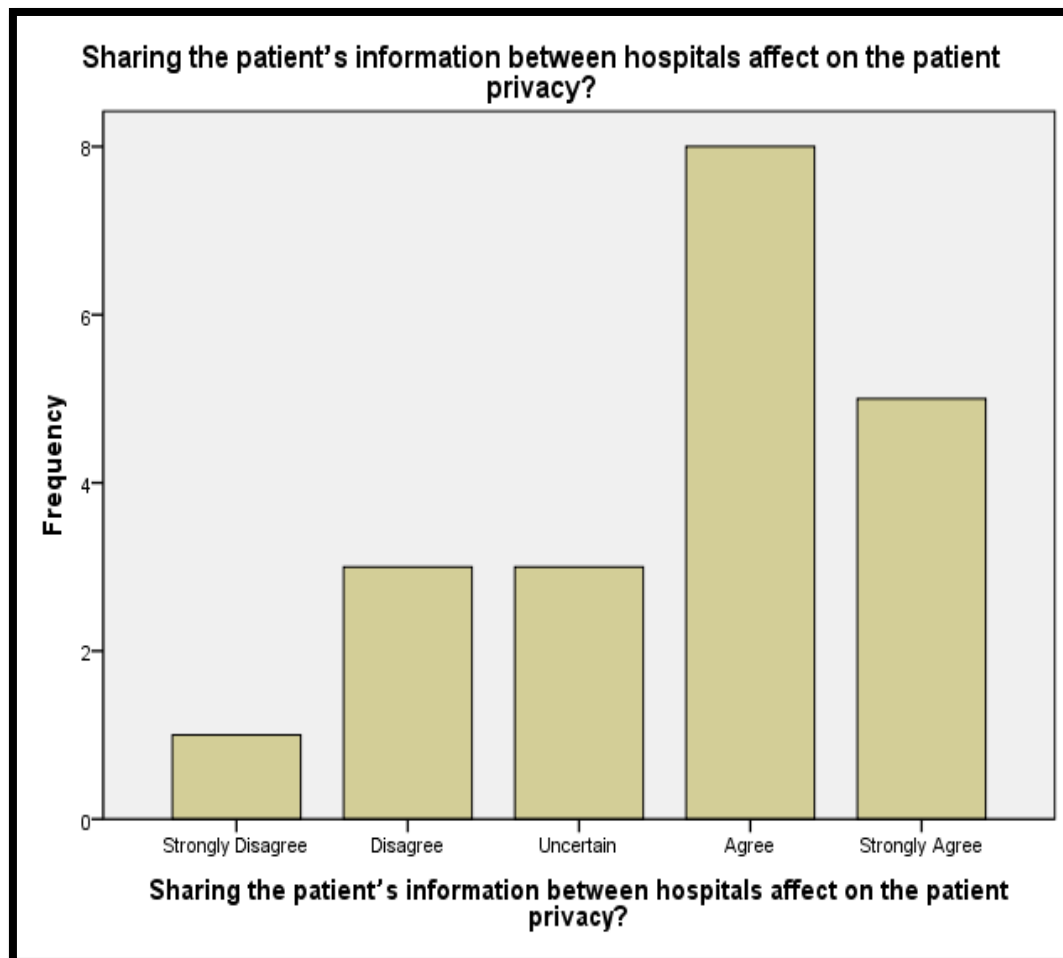
Figure 39 Result for Question 6

Table 6. 7: Q7. Sharing the patient's information between hospitals helps the
Government to analysis the medical information?

	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	1	5.0	5.0	5.0
Uncertain	1	5.0	5.0	10.0
Agree	11	55.0	55.0	65.0
Strongly Agree	7	35.0	35.0	100.0
Total	20	100.0	100.0	
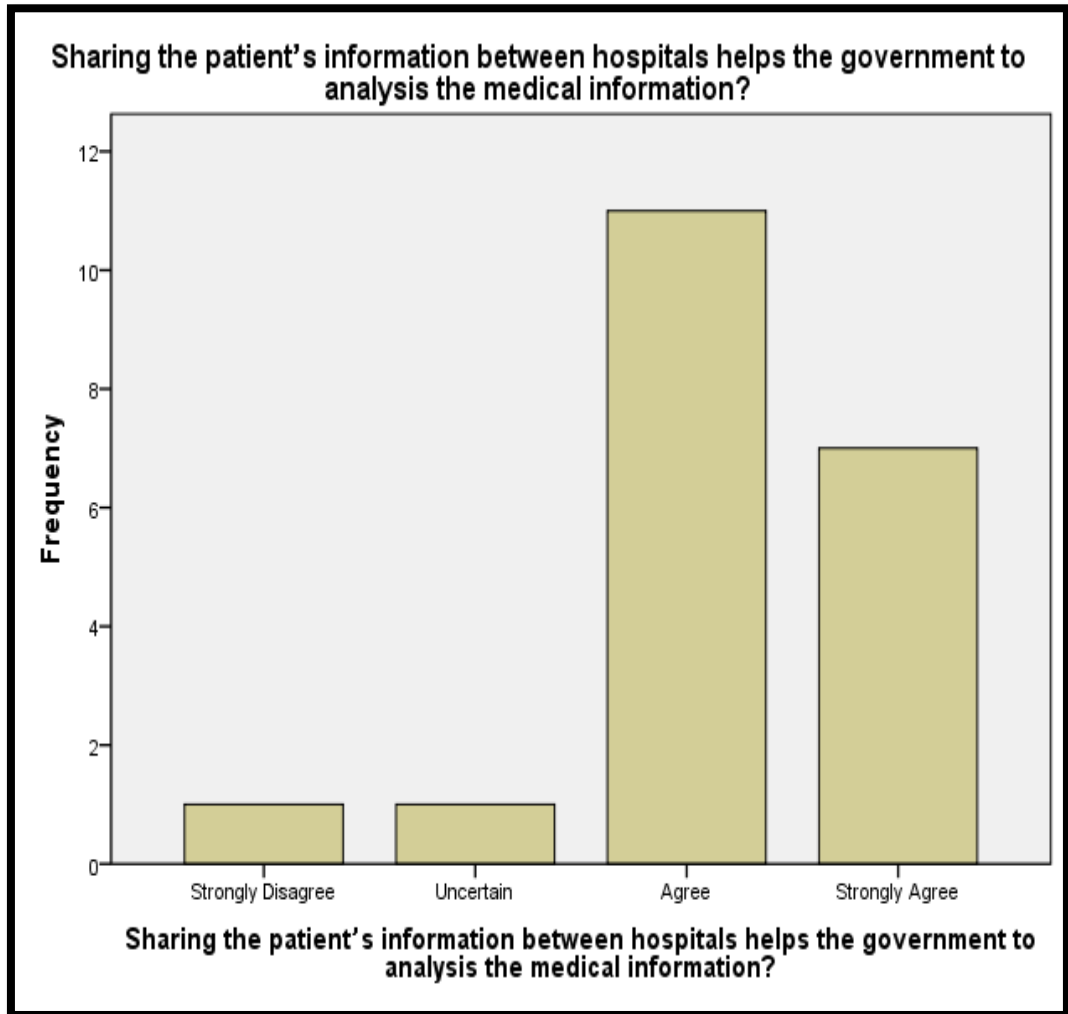
Figure 40 Result for Question 7

Table 6. 8: Q8. Sharing the patient's information between hospitals helps the government to organizing and assigning the human resources?

	Frequency	Percent	Valid Percent	Cumulative Percent
Uncertain	4	20.0	20.0	20.0
Agree	6	30.0	30.0	50.0
Strongly Agree	10	50.0	50.0	100.0
Total	20	100.0	100.0	
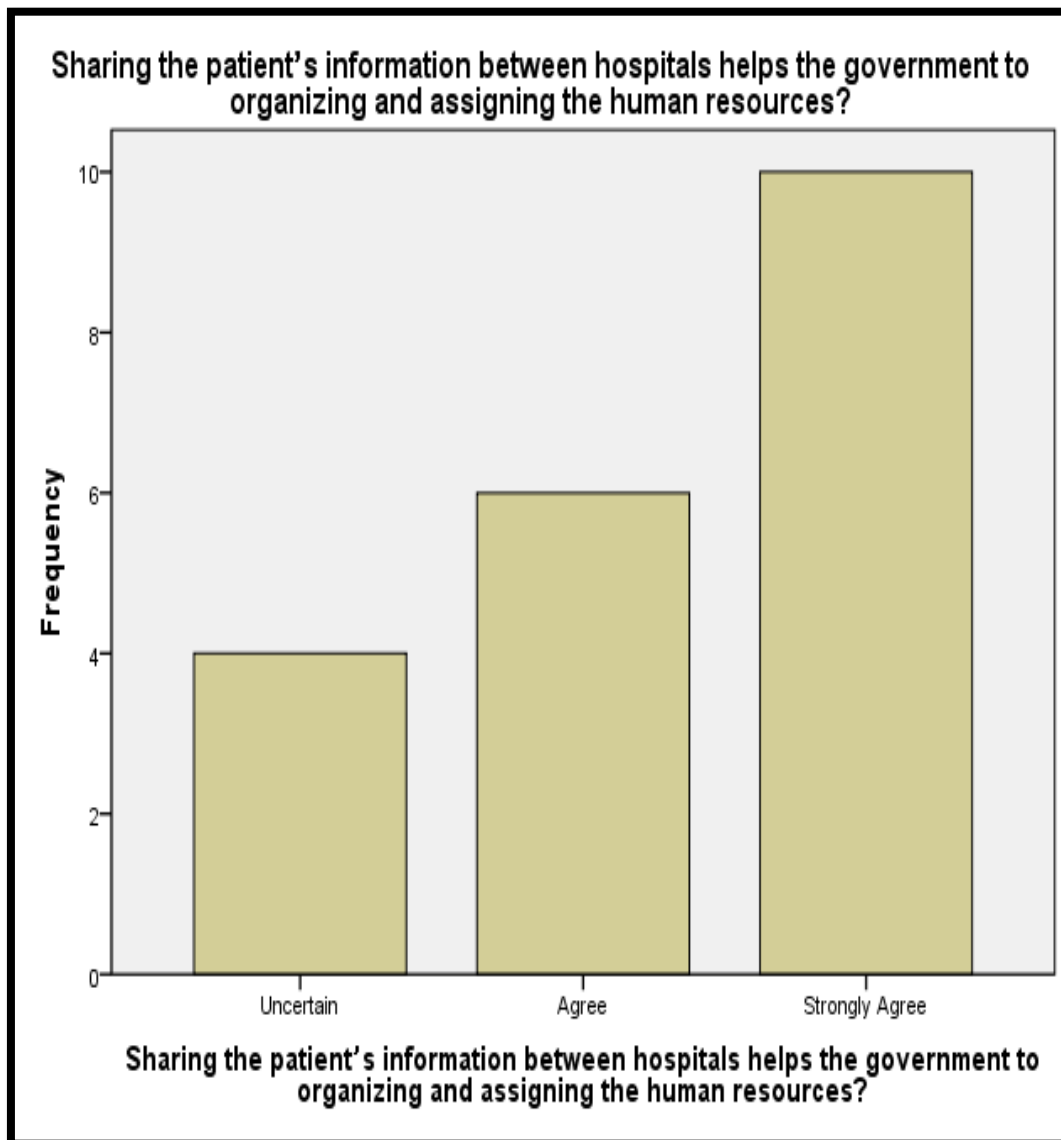
Figure 41 Result for Question 8

141

Table 6. 9: Q9. The availability of the patient information minimizes the meeting time with doctors?

	Frequency	Percent	Valid Percent	Cumulative Percent
Disagree	1	5.0	5.0	5.0
Uncertain	4	20.0	20.0	25.0
Agree	8	40.0	40.0	65.0
Strongly Agree	7	35.0	35.0	100.0
Total	20	100.0	100.0	
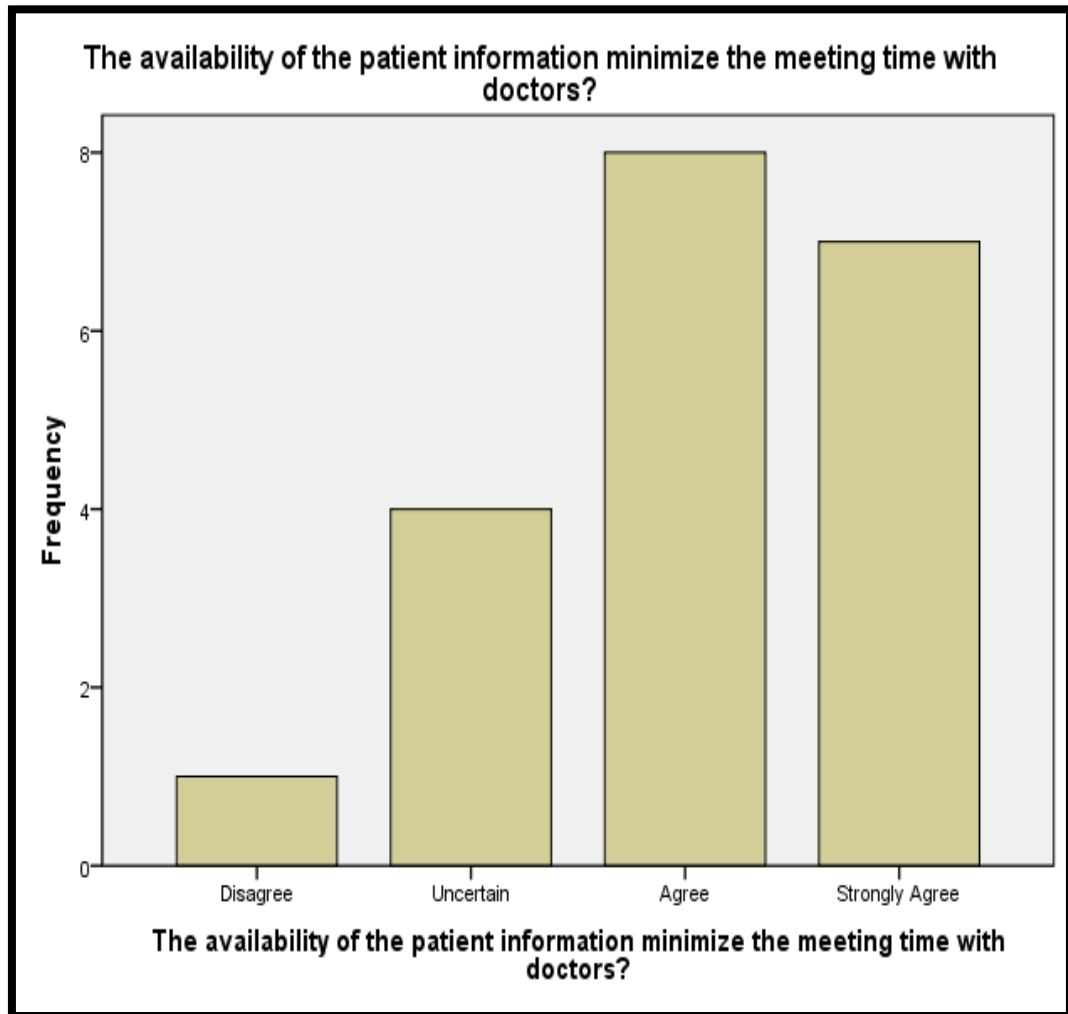
Figure 42 Result for Question 9

Table 6. 10: Q10. I think that EEHI are cumbersome to use?

	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	2	10.0	10.0	10.0
Disagree	7	35.0	35.0	45.0
Uncertain	4	20.0	20.0	65.0
Agree	7	35.0	35.0	100.0
Total	20	100.0	100.0	
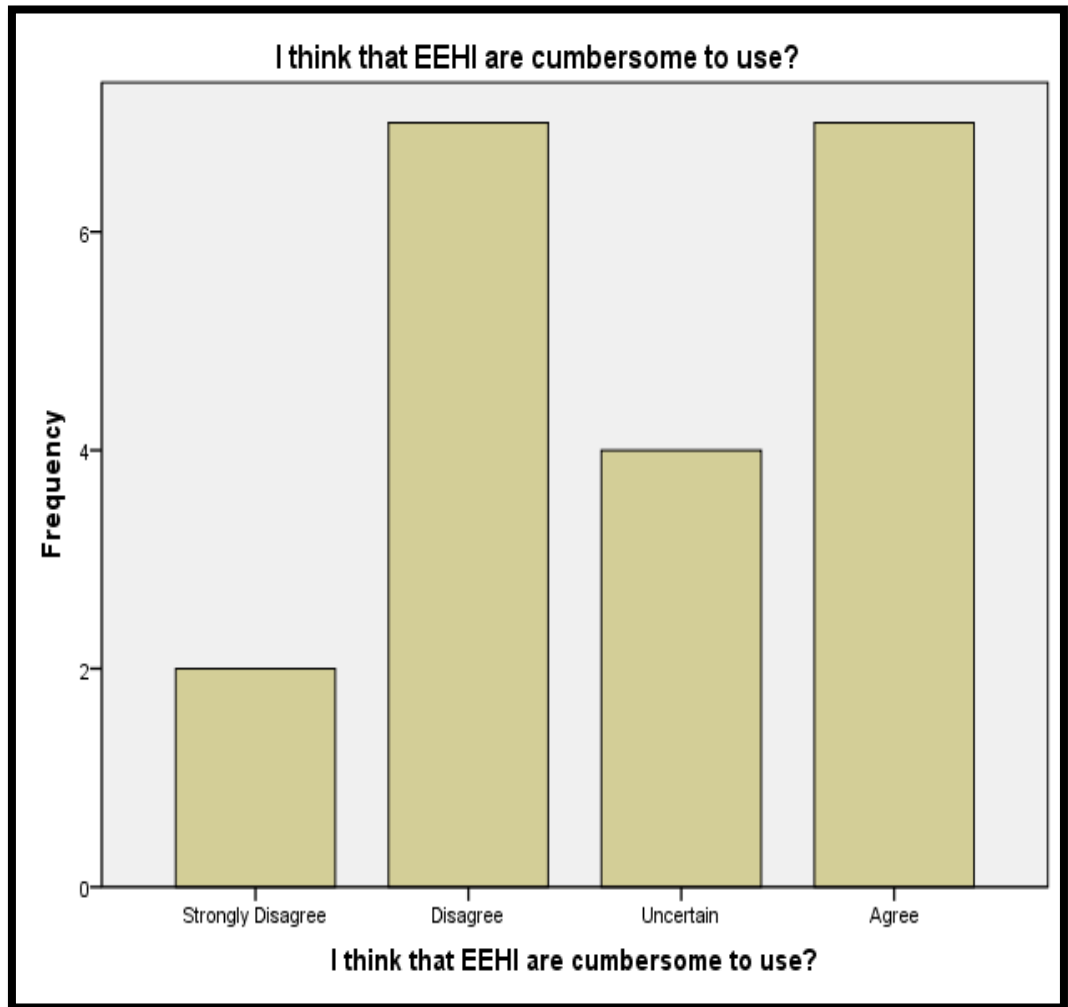
Figure 43 Result for Question 10

Table 6. 11: Q11. Using EEHI was often frustrated?

	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	5	25.0	25.0	25.0
Disagree	7	35.0	35.0	60.0
Uncertain	7	35.0	35.0	95.0
Agree	1	5.0	5.0	100.0
Total	20	100.0	100.0	
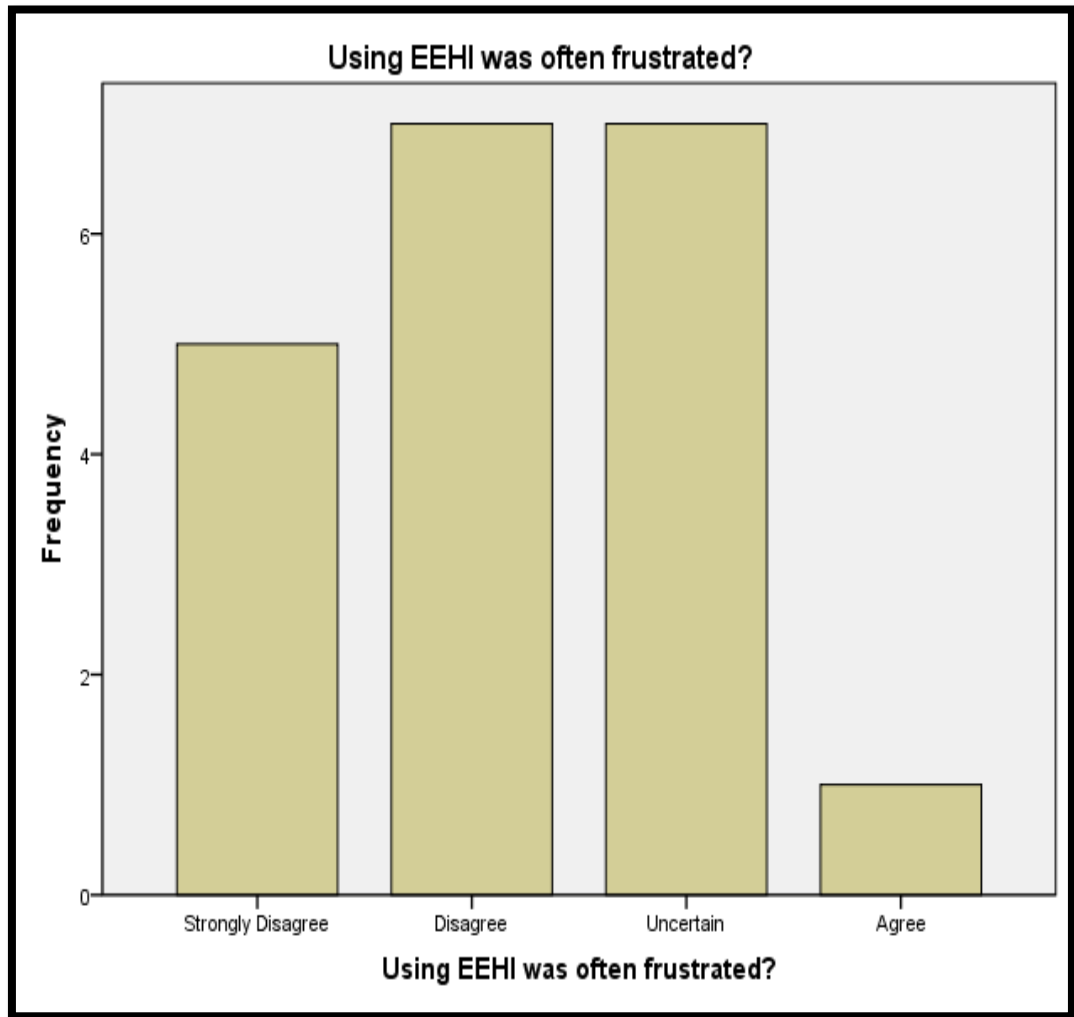
Figure 44 Result for Question 11

Table 6. 12: Q12. Using EEHI made it easier to do some tasks of my work?

	Frequency	Percent	Valid Percent	Cumulative Percent
Uncertain	1	5.0	5.0	5.0
Agree	11	55.0	55.0	60.0
Strongly Agree	8	40.0	40.0	100.0
Total	20	100.0	100.0	
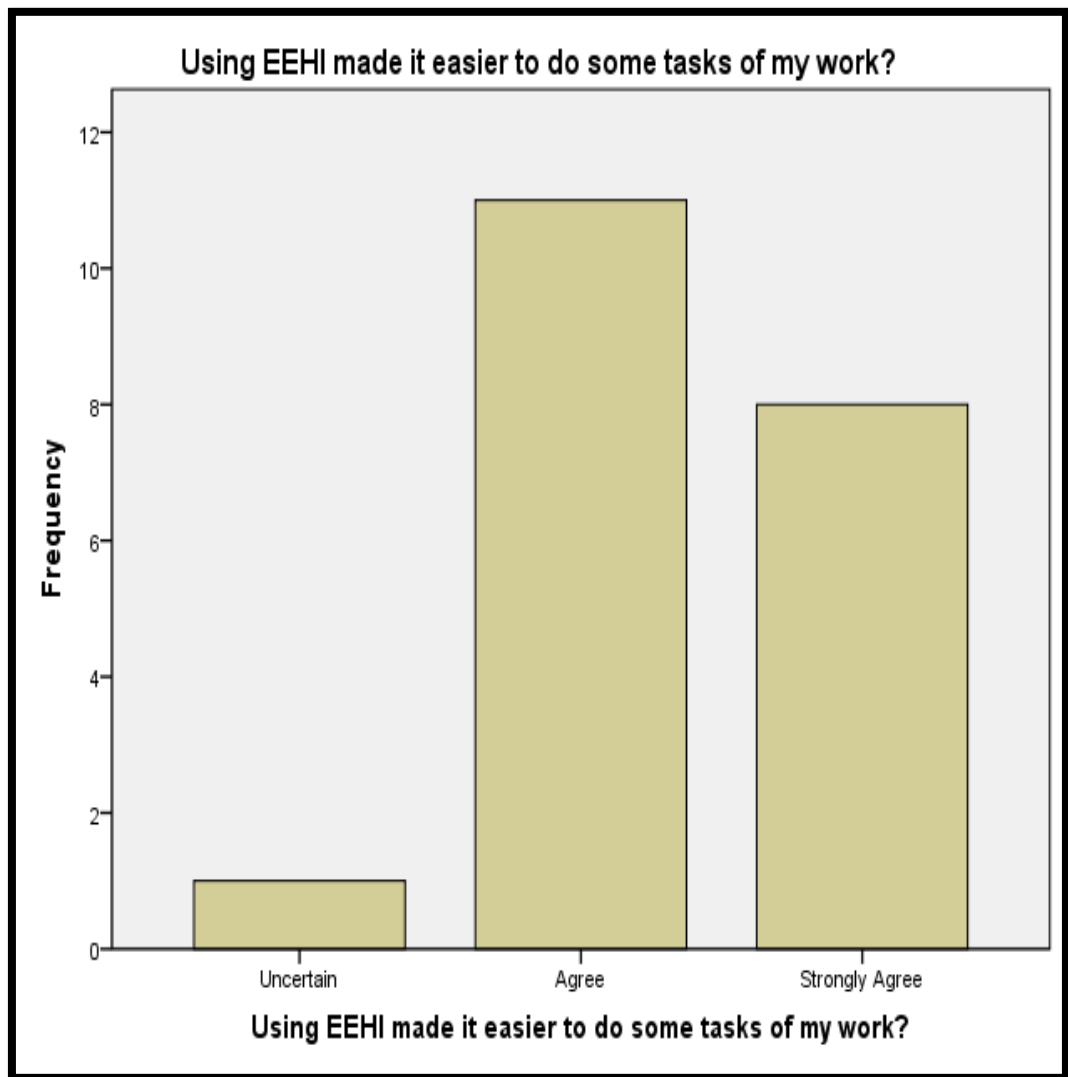
Figure 45 Result for Question 12

Table 6. 13: Q13. It was easy for me to remember how to perform tasks using EEHI?

	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	1	5.0	5.0	5.0
Disagree	1	5.0	5.0	10.0
Uncertain	2	10.0	10.0	20.0
Agree	13	65.0	65.0	85.0
Strongly Agree	3	15.0	15.0	100.0
Total	20	100.0	100.0	
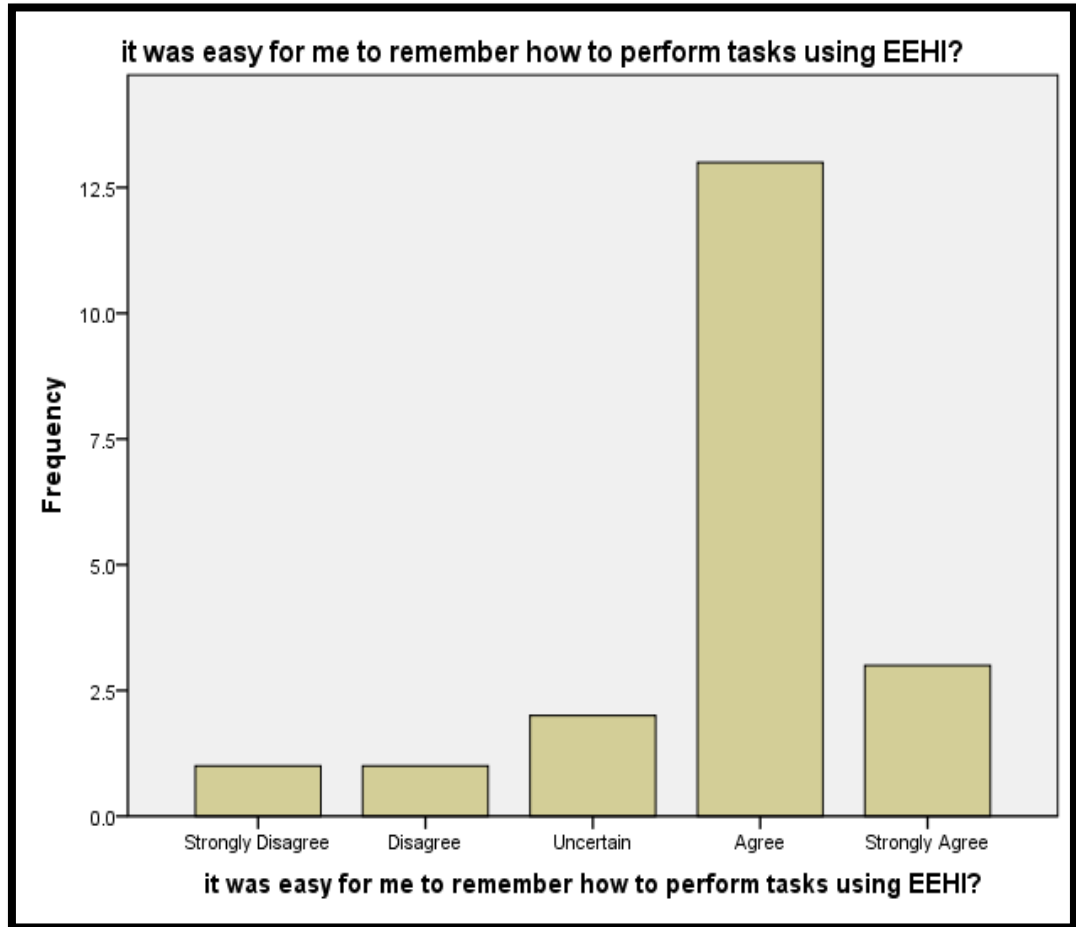
Figure 46 Result for Question 13

6.4 Use Case Validation Results usability and understandability:
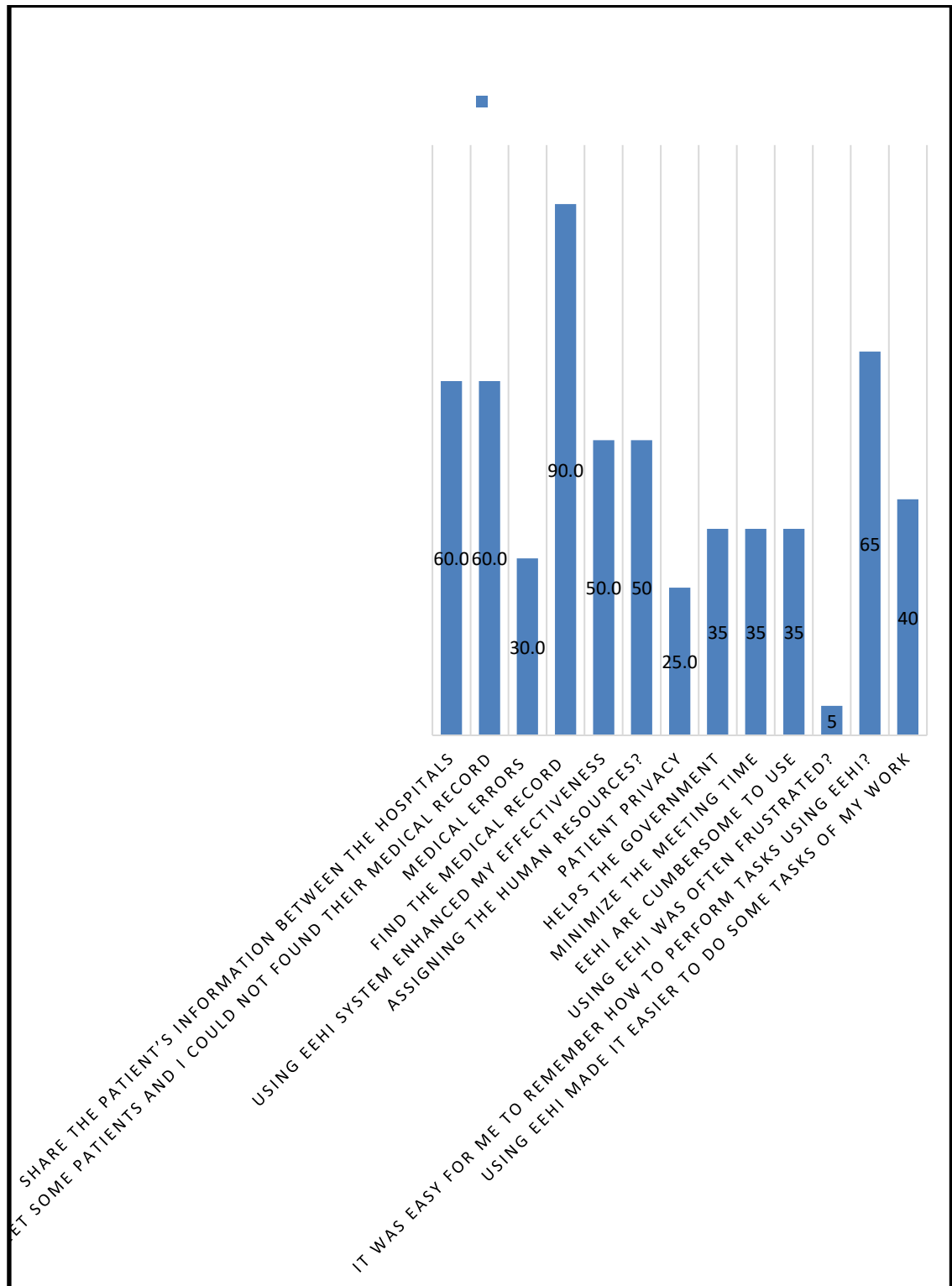
Figure 47 Case Study Validation Results

CHAPTER SEVEN

DISCUSSION

7   Discussion:

7.1   Introduction

This chapter has two main parts, part one is dedicated for the problems regarding the current situation in the Republic of Sudan, in this part, we have chosen to discuss two organization's experiments in particular because they had made huge progress in using ICT facilitation, which are:

1) The Health system which is founded by National Information Center NIC.

2) And 2) Khartoum State Health Insurance Corporation (KSHIC), Part two is dedicated to the use of case validation.

7.2   Part one the Problems with current Systems:

7.2.1 The Health System:

In 2010 the Sudan National Information Center NIC started work on the health system and contracted with Best-Care company, from the State of Turkey. To develop the Hospital health information system HHIS. This experimental application of the hospital's management system was inaugurated at the General Omar Sawi Complex.

7.2.1.1   Problems with HHIS system:

The importance of HHIS system and the necessity to be applied have been insured, to save time, effort and to save the financial costs of printing, storing and retrieving patient files, which cost a lot of money. In addition to the effort and time spent to produce reports at the level of

the health unit and at the level of the ministry and related bodies. The HHIS system right now suffering from a number of deficiencies that can be list as follows:

7.2.1.2   First, The Functional Requirements:

We observe that in the Admission Module, generating the file number automatically causes data to be duplicated if the system works on the distributed environment.

7.2.1.2.1   Polyclinic Module:

More than one option is available in the field of disease diagnosis. Sometimes a patient can come with more than one illness and the system allows only one disease to be selected during the visit.

7.2.1.2.2   Cash Desk Module:

The receipt number is not unique and unique numbers must be generated for receipts.

7.2.1.2.3   The Laboratory Module:

Check the standard forms approved in the laboratory tests since the system does not work in the laboratory section because of the lack of these forms, and only receive the examination request while the system is not allowed to enter the result of the examination.

7.2.1.3   Second, The Non-Functional Requirements:

•   There are some problems and security threats that must be addressed according to the information security department report, which conducted the security tests and prepares an integrated report.

- Some system modules only work in a particular browser, which causes the system to not be able to handle all system units with the same efficiency in a single browser.

- A system suspension occurs when dealing with the Human Resources Management Unit.

- Sometimes the system response is not done as quickly as required.

- The existing structure should be revised, so that it is preferable for many considerations, to rely on the centralized environment rather than the distributed environment.

7.2.2 Khartoum State Health Insurance Corporation (KSHIC) Health Insurance System:

7.2.3 Constraints with the Current System:

Most of the transactions in the current system are done manually, resulting in several problems, including:

1. From the point of view of the client/user, there is the problem of delays in procedures and mobility between different offices and the difficulties of paying subscriptions.

2. The complexity of the audit process.

3. Cash flow management difficulties, due to delayed claims management cycle

4. Misuse of the service.

5. Non-accurate reports resulting from the manual documentation cycle.

6. From the perspective of the service provider, there is the problem

of delay in the disbursement of receivables from the Commission.

7. **The Data Center:**

The technical committee of the project decided to remove the data centre and be hosted in one of the telecommunication company because it is the choice now in the information world for its many benefits. Including: reducing cost and ensure a safe operating environment. So, they decided to host the project in the national information Center NIC and make it web-based, the project now links more than ten government Centre with the health insurance system.

7.3 Part Two the Use Case Validation:

7.3.1 Introduction:

In this study phase, we designed a questionnaire to Validate the Prototype and to find out the medical staff opinions about proposed application EEHI. The questionnaire consists of thirteen questions each one with five choices which they are (Strongly agree, Agree, Uncertain, Disagree, strongly disagree), after that we distributed our questionnaire among twenty of the medical staff, in three different hospitals in different cities, and we made analysis for each question alone, using SPSS 19 analysis as shown in the tables and figures in chapter six the Result.

7.3.2 Question One:

The result showed that; a large percentage of the medical staff 75% thinks that; it is necessary to share the patient information between hospitals because it can save patient's life's, but other medical staff

which they are represented 25% think it will lead to Privacy breaching of the patient's information.

7.3.3 Question Two:

The result showed that; a large percentage of the medical staff which they represented 80% agree that it is difficult to find the patient's medical record for two reasons the first one is that it's difficult to search about patient in the manual system, the second reasons is they have not patient record at all. But other medical staff which they are represented 2% think it is easy to find the medical record in the manual system but it takes time to find it.

7.3.4 Question Thee:

The result showed that large percentage of the medical staff, which they represented 80% think that; the loss of medical records leads medical errors, and others think it is not, some of them they are uncertain because they are not yet faced a situation like this.

7.3.5 Question Four:

The result showed that; large percentage of the medical staff, which they represented 95% think that retrieving the information about the patient from computerizing database is better and quicker, but others think it is not, and when we investigated them, we found that they have a problem of using the computer, they are illiteracy in computer.

7.3.6 Question Five:

The result showed that large percentage of the medical staff which they represented 90% think that; using EEHI can enhance their job

effectiveness, because it reduces the cognitive load, but one of the medical staffs, he is a doctor think that; it is better for him to work without computerizing system, because he thinks, it will be difficult for him to learn how to use a computerized system in his age, he is 65 years old.

7.3.7 Question six:

The result showed that; a large percentage of the medical staff which they represented 65% thinks that; sharing the patient information effects on the patients privacy, because it can lead to privacy breaching, but some of the medical staff which they represented 20% think it does not effect on the patient's privacy and it can save the patient life, others which they represented 15% they are uncertain or in other words they are confused for two reasons: the first one is the that; the availability of the information may help the doctors to diagnose the patient deceased. And the second reason is that; if the patient has a deceased that brings shame like HIV and he does not want anyone to know about it.

7.3.8 Question Seven:

The result showed that; a large percentage of the medical staff, which they represented 90% they agree, sharing the information can help the government to analyze the medical information, but one of the medical staffs disagree, because he does not trust of Republic of Sudan government, he said it is a corrupt government.

7.3.9 Question Eight:

The result showed that; a large percentage of the medical staff, which they represented 80% they agree sharing the patient information helps

the government to organize and assigning the required human resource, especially when there is an epidemic of a disease. But other medical staff which they are represented 20% they are uncertain because do not trust in Sudan government.

7.3.10   Question Nine:

The result showed that; a large percentage of the medical staff which they are represented 75% they are agreeing on the availability of the patient information will minimize the meeting time with the doctor, but one of the doctors thinks that; it is not. Other doctors which they are represented 20% they are uncertain because they have a doubt that the internet is weak.

7.3.11   Question Ten:

In this question the respond of the participants is closer to each other, 45% of the medical staff think that using EEHI between hospitals is not cumbersome to use. Others they founded cumbersome to use the reason is that most of them they used to use handwritten and paper and they do not have time to learn how to use the proposed application EEHI, others they are uncertain and they are afraid to lose their job when the EEHI system is working because they are computer literacy.

7.3.12   Question Eleven:

The result showed that; a large percentage of the medical staff which they are represented 60% they are disagreeing on that EEHI is frustrating, and 35% they are not certain if the EEHI is frustrating or not.

7.3.13 Question Twelve:

The result showed that a large percentage of the medical staff which they are represented 95% they agree using EEHI will make it easier to do some tasks of their work. But one of the medical staff uncertain and when we investigated him more, he said: because he thinks the manual system is better for my job as a doctor.

7.3.14 Question Thirteen:

The result showed that; a large percentage of the medical staff which they are represented 80% they agree it is easy to remember how to perform a task using EEHI, but some of them they disagree with percentage 10% because they think itis complicated and others with 10%, they are uncertain without reasons.

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CHAPTER EIGHT

CONCLUSION

8   Conclusion:

In our conclusion, we think Computer-based patient records and the systems in which they function are becoming an essential technology for healthcare because the information management challenges faced by health care professionals are increasing daily. It is important to understand the potential influence that an electronic exchange of healthcare information EEHI among public Sudanese hospitals can have on medical staff daily activities and work. The findings of this study indicate that the quality of an EEHI, including attributes such as effectiveness and control and reliability, provide complete and accurate information about patients for medical staff. We proved that an EEHI helped Administrators, Doctors and laboratory technician to identify and eliminate ineffective activities involved in the patient process and supported medical staff' daily practice by providing complete, essential data to support optimal patient care.

Our work comes up with a novel scheme that is trusted, faster and more efficient than another one, less queuing, less time consuming, quick retrieval of data, less paper wastage, rich data storage and eliminate the loss of information, and enhance the overall healthcare work.

8.1   The outcome of this study involves:

1.   A novel framework for health information exchange.

2.   A model from this framework for health information exchange.

3.   The future plan is to link the HIIPS with the National No. Also, enabling the Doctors to follow-up Their patient by means of smart tools such as a smart sensor.

8.2   The recommendations and future work:

1.   Avoid the problem of repeating the data, by linking the registration to the National No of the patient and retrieving the basic information of the patient from the civil registry database, with the possibility to enter the number or part thereof, read the national card automatically or read the citizen's fingerprint and then retrieve its data from the national registry database.

2.   Enables integration with the databases of health insurance providers to ensure card validity and retrieval of the ceilings and packages for the subscriber.

3.   If the system is implemented in the Republic of Sudan nationwide in a government's hospitals, the system must be connected to E15-System so that a receipt or a visit ticket will not be issued except by E15 receipt.

4.   Introducing the Video Conference Unit to provide distance consultation and transfer lectures and operations for educational purposes.

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10 Appendixes:

10.1 List of Publications, Journal papers:

1 - AAA Mohammed (2017) 'A Review of HIIPS : Healthcare Information Infrastructures among Public Hospitals (Case Study Sudan)', *International Journal of Computer Science Trends and Technology (IJCST)*, 5(4), pp. 104–112.

2- AAA Mohammed and L. R. Christensen, "Practices of Healthcare Information Exchange in the Emergency Department of a Sudanese Hospital," Int. J. Comput. Sci. Trends Technol., vol. 6, no. 3, pp. 171–177, 2018.

3- AAA Mohammed and L. R. Christensen, "A Review Of 28 Years of Health Information Exchange Research: Achievements, Challenges and Future Work," Int. J. Comput. Sci. Trends Technol., vol. 6, no. 3, pp. 178–187, 2018.

10.2 A Survey Questionnaire:

Please circle the most appropriate number of each statement

Which correspond most closely to your desired response?

N0	Relative advantage	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	Is it necessary to share the patient's information among the hospitals?	1	2	3	4	5
2	From my work experience I meet some patients and I could not find their medical record?	1	2	3	4	5
3	Some medical errors were happened due to the loss of patient medical record?	1	2	3	4	5
4	Find the medical record from computerize database is quicker than in the manual system?	1	2	3	4	5
5	Using EEHI system enhanced my effectiveness on some tasks of my work.	1	2	3	4	5
6	Sharing the patient's information among hospitals effect on the patient privacy?	1	2	3	4	5
7	Sharing the patient's information among hospitals helps the government to analyze the medical information?	1	2	3	4	5
8	Sharing the patient's information among hospitals helps the government to organizing and assigning the human resources?	1	2	3	4	5
9	The availability of the patient information minimizes the meeting time with doctors?	1	2	3	4	5
10	I think that EEHI are cumbersome to use?	1	2	3	4	5
11	Using EEHI was often frustrating	1	2	3	4	5

| 12 | Using EEHI made it easier to do some tasks of my work. | ① | ② | ③ | ④ | ⑤ |
| 13 | it was easy for me to remember how to perform tasks using EEHI | ① | ② | ③ | ④ | ⑤ |

10.3 Raw Data:

Note: The persons with the negative response they are not the same persons.

Quality	Control	quick	Performance	Effectiveness	Cumbersome	Easy	Frustrated	Get	Easier	easiest
5	5	4	5	4	2	4	2	4	4	4
5	5	5	5	5	1	5	2	4	4	4
5	5	4	5	5	1	5	5	4	4	5
4	5	5	4	4	2	3	1	4	4	4
5	5	5	5	5	1	5	5	5	5	5
4	4	5	3	3	1	3	2	5	5	5
4	5	5	4	4	1	5	1	3	4	4
5	5	5	5	5	5	5	1	4	4	5
4	5	5	4	5	2	4	2	4	4	4
5	5	4	5	4	2	4	1	3	3	4
5	5	5	5	5	1	4	1	4	5	4
5	5	5	5	4	2	3	5	4	4	3
5	4	4	5	5	1	5	2	4	4	4
5	5	5	4	3	2	3	4	3	4	4
4	4	5	5	4	3	5	2	5	5	4
4	4	5	5	4	2	5	2	5	5	5
5	5	5	5	5	2	4	4	4	4	4
5	5	5	5	5	1	5	1	5	5	5
5	5	5	5	5	1	5	1	5	5	5
5	5	5	5	5	1	5	1	5	5	5

10.4 HIE Model Implementation Codes:

10.5 The Main-Interface code:

```vbnet
Public Class Main

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button2.Click
        Login.Show()
    End Sub

    Private Sub Button9_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button9.Click
        End
    End Sub

    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs)
        CENTRAL_LAB.Show()
    End Sub

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button1.Click
        DoctLogin.Show()
    End Sub

    Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs)
        TEST_LIST.Show()
    End Sub

    Private Sub Button5_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs)
        TEST_NAME.Show()
    End Sub

    Private Sub Button6_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs)
        PATIENT_LAB_DETAILS.Show()
    End Sub

    Private Sub Button7_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs)
        DRUGS_TESTED.Show()
    End Sub

    Private Sub Button8_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button8.Click
        labtechLogin.Show()
    End Sub

    Private Sub Main_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load

    End Sub
```

```vbnet
    Private Sub Button3_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button3.Click

        LoginForm1.Show()

    End Sub

    Private Sub Label1_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Label1.Click

    End Sub

    Private Sub Label2_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Label2.Click

    End Sub
End Class
```

10.6 Login Interface Code:

```vb
Imports System.Data.OleDb
Public Class LoginForm1
    Dim group As Integer
    ' TODO: Insert code to perform custom authentication using the
provided username and password
    ' (See http://go.microsoft.com/fwlink/?LinkId=35339).
    ' The custom principal can then be attached to the current thread's
principal as follows:
    '      My.User.CurrentPrincipal = CustomPrincipal
    ' where CustomPrincipal is the IPrincipal implementation used to
perform authentication.
    ' Subsequently, My.User will return identity information encapsulated
in the CustomPrincipal object
    ' such as the username, display name, etc.
    'Dim constr As String = "Data Source=DESKTOP-
7BGN1SV\SQLEXPRESS;Initial Catalog=DB_amjed;Persist Security Info=True"
    Dim constr As String = "Provider=SQLNCLI.1;Data Source=DESKTOP-
7BGN1SV\SQLEXPRESS;Integrated Security=SSPI;Initial Catalog=DB_amjed"
    Dim conn As New OleDbConnection(constr)
    Dim da As New OleDbDataAdapter
    Dim ds As New DataSet
    Private Sub OK_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles OK.Click
        Dim cmds As New OleDbCommand("select * from users where
username='" & UsernameTextBox.Text & "' and userpass='" &
PasswordTextBox.Text & "'", conn)
        Dim ds As New DataSet
        Dim da As New OleDbDataAdapter(cmds)
        da.Fill(ds)
        If ds.Tables(0).Rows.Count = 0 Then
            MessageBox.Show("User name or Password is not Correct")
        Else
            group = ds.Tables(0).Rows(0)("userpass")
            If PasswordTextBox.Text = group Then
                Frmmain_report.Show()
                Me.Close()
            Else
                MessageBox.Show(" password incorrect")
            End If
        End If

    End Sub

    Private Sub Cancel_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Cancel.Click
        Me.Close()
    End Sub

    Private Sub LoginForm1_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load

    End Sub
End Class
```

10.7 Patient's Registration Interface code:

```vb
Imports System.Data.OleDb
Public Class Patients
    'Dim constr As String = "Data Source=AMJED-PC\SQLEXPRESS;Initial
Catalog=dr.amjed;Persist Security Info=True;User
ID=sa;Password=dr.amjed;Provider=SQLOLEDB"
    Dim constr As String = "Provider=SQLNCLI.1;Data Source=DESKTOP-
7BGN1SV\SQLEXPRESS;Integrated Security=SSPI;Initial Catalog=DB_amjed"
    Dim conn As New OleDbConnection(constr)
    Dim da As New OleDbDataAdapter
    Dim ds As New DataSet
    Private Sub doctor()
        Dim conn As New OleDbConnection(constr)
        Dim dt As New DataTable
        Try
            conn.Open()
            Dim cmd As New OleDbCommand("select DOCTOR_name  from
DOCTOR", conn)
            Dim da As New OleDbDataAdapter(cmd)
            da.Fill(dt)
            cmbdoc.DataSource = dt
            cmbdoc.DisplayMember = "DOCTOR_name"
            'Cmbmodify.ValueMember = "card_id"
            conn.Close()
            'DataGridView1.Visible = False
            cmbdoc.Text = ""
            ' GO.Focus()
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub


    Private Sub Patients_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        txtdate.Text = Date.Today()
        doctor()
        'idfill()
        filldoc()
        review()
        txtid.Text = Val(m)
    End Sub
    Dim newdate As Date
    Private Sub funsave()
        autoid()
        n = Val(m) + 1
        txtid.Text = n
        'newdate = Format(Me.txtdate.ToString, "yyyy/mm/dd")
        'newdate = Me.txtdate.Value

        Dim cmds As New OleDbCommand("select * from PATIENT where
PATIENT_ID ='" & txtid.Text & "'", conn)
        Dim ds As New DataSet
        Dim da As New OleDbDataAdapter(cmds)
        da.Fill(ds)
        If ds.Tables(0).Rows.Count = 0 Then
```

182

```vb
            Dim cmd As New OleDbCommand("insert into
PATIENT(PATIENT_ID,PATIENT_NAME,DOCTOR_name,DATE_OF_FIRST_DIAGNOSIS,ADDRE
SS,DOB,SEX) values (?,?,?,?,?,?,?)", conn)
            '  cmd.Parameters.AddWithValue("@id",
OleDbType.Numeric).Value = txtid.Text
            cmd.Parameters.AddWithValue("@PATIENT_ID",
OleDbType.Numeric).Value = txtid.Text
            cmd.Parameters.AddWithValue("@PATIENT_NAME",
OleDbType.VarChar).Value = txtname.Text.ToString
            ' cmd.Parameters.AddWithValue("@PATIENT_ID",
OleDbType.VarChar).Value = cmbdoc.SelectedIndex.ToString
            cmd.Parameters.AddWithValue("@DOCTOR_name",
OleDbType.VarChar).Value = cmbdoc.Text.ToString
            cmd.Parameters.AddWithValue("@DATE_OF_FIRST_DIAGNOSIS",
OleDbType.VarChar).Value = txtdate.Text
            cmd.Parameters.AddWithValue("@ADDRESS",
OleDbType.VarChar).Value = txtaddress.Text
            cmd.Parameters.AddWithValue("@DOB", OleDbType.VarChar).Value
= txtdob.Text
            cmd.Parameters.AddWithValue("@SEX", OleDbType.VarChar).Value
= cmbsex.Text
            conn.Open()
            cmd.ExecuteNonQuery()
            conn.Close()
            MsgBox("Data Saved Successfuly", MsgBoxStyle.Information)
            txtid.Clear()
        Else
            MsgBox("PATIENT ID is Found", MsgBoxStyle.Information)
        End If
    End Sub

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button1.Click
        txtid.Text = ""
        txtaddress.Text = ""
        txtdate.Text = ""
        txtdob.Text = ""
        txtname.Text = ""
        cmbdoc.Text = ""
        cmbsex.Text = ""
        txtname.Focus()
        'idfill()
        filldoc()
    End Sub

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button2.Click
        Me.Close()
    End Sub

    Private Sub save_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles save.Click
        funsave()
        review()
    End Sub
    Dim i As String
    Dim m As String
    Dim n As String
```

```vbnet
    'Private Sub idfill()

    '    Dim cmds As New OleDbCommand("select  PATIENT_ID from PATIENT",
conn)
    '    Dim ds As New DataSet
    '    Dim da As New OleDbDataAdapter(cmds)
    '    da.Fill(ds)

    '    If ds.Tables(0).Rows.Count = 0 Then
    '        txtid.Text = 1
    '    Else
    '        i = ds.Tables(0).Rows(0)("PATIENT_ID").ToString
    '        txtid.Text = i + 1
    '    End If
    '    ds.Clear()
    'End Sub
    Private Sub autoid()
        Dim cmds As New OleDbCommand("select  max(PATIENT_ID)  PATIENT_ID
from PATIENT", conn)
        Dim da As New OleDbDataAdapter(cmds)
        Dim ds As New DataSet
        da.Fill(ds)
        m = ds.Tables(0).Rows(0)("PATIENT_ID").ToString
    End Sub
    Private Sub filldoc()
        Dim conn As New OleDbConnection(constr)
        Dim dt As New DataTable
        Try
            conn.Open()
            Dim cmdd As New OleDbCommand("select PATIENT_Name from
PATIENT", conn)
            Dim daa As New OleDbDataAdapter(cmdd)
            daa.Fill(dt)
            cobname.DataSource = dt
            cobname.DisplayMember = "PATIENT_Name"
            conn.Close()
            cobname.Text = ""
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub

    Private Sub ComboBox1_SelectedIndexChanged(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
cobname.SelectedIndexChanged

    End Sub
    Private Sub review()


        Try
            Dim con As New OleDbConnection(constr)

            Dim adapter As New OleDbDataAdapter("select PATIENT_NAME ,
DOCTOR_name , convert(varchar,DATE_OF_FIRST_DIAGNOSIS,103) , ADDRESS ,
convert(varchar,DOB,103), SEX from PATIENT where
DATE_OF_FIRST_DIAGNOSIS='" & txtdate.Text & "'", con)
```

```vbnet
            Dim ds As New DataSet
            con.Open()
            adapter.Fill(ds, "patient")
            Me.DataGridView1.Columns(0).HeaderText = "PATIENT NAME"
            Me.DataGridView1.Columns(0).Width = 200
            Me.DataGridView1.Columns(1).HeaderText = "DOCTOR NAME"
            Me.DataGridView1.Columns(1).Width = 200
            Me.DataGridView1.Columns(2).HeaderText = "FIRST DIAGNOSIS
DATE"
            Me.DataGridView1.Columns(2).Width = 100
            Me.DataGridView1.Columns(3).HeaderText = "ADDRESS"
            Me.DataGridView1.Columns(3).Width = 300
            Me.DataGridView1.Columns(4).HeaderText = "DATE OF BIRTH"
            Me.DataGridView1.Columns(4).Width = 100
            Me.DataGridView1.Columns(5).HeaderText = "SEX"
            Me.DataGridView1.Columns(5).Width = 20
            For i As Integer = 0 To ds.Tables("PATIENT").Rows.Count - 1
                DataGridView1.Rows.Add()
                DataGridView1.Item(0, i).Value =
ds.Tables(0).Rows(i).Item(0).ToString
                DataGridView1.Item(1, i).Value =
ds.Tables(0).Rows(i).Item(1).ToString
                DataGridView1.Item(2, i).Value =
ds.Tables(0).Rows(i).Item(2).ToString
                DataGridView1.Item(3, i).Value =
ds.Tables(0).Rows(i).Item(3).ToString
                DataGridView1.Item(4, i).Value =
ds.Tables(0).Rows(i).Item(4).ToString
                DataGridView1.Item(5, i).Value =
ds.Tables(0).Rows(i).Item(5).ToString

            Next
            con.Close()
        Catch ex As Exception
            MsgBox(ex.Message)
        End Try
    End Sub
    Private Sub search_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles search.Click
        If cobname.Text = "" Then
            MsgBox("The search Location is empty!",
MsgBoxStyle.Information)
        Else
            Dim conn As New OleDbConnection(constr)
            Dim cmd As New OleDbCommand("select * from PATIENT where
PATIENT_NAME='" & cobname.Text & "'", conn)
            Dim ds As New DataSet
            Dim da As New OleDbDataAdapter(cmd)
            da.Fill(ds)
            If ds.Tables(0).Rows.Count = 0 Then
                MsgBox("Datanot found")
            Else
                txtid.Text = ds.Tables(0).Rows(0)("PATIENT_ID")
                txtaddress.Text = ds.Tables(0).Rows(0)("ADDRESS")
                txtdate.Text =
ds.Tables(0).Rows(0)("DATE_OF_FIRST_DIAGNOSIS")
                txtdob.Text = ds.Tables(0).Rows(0)("DOB")
                txtname.Text = ds.Tables(0).Rows(0)("PATIENT_NAME")
```
185

```vb
                cmbdoc.Text = ds.Tables(0).Rows(0)("DOCTOR_name")
                cmbsex.Text = ds.Tables(0).Rows(0)("SEX")
            End If
        End If
    End Sub

    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button3.Click
        review()
    End Sub

    Private Sub DateTimePicker1_ValueChanged(ByVal sender As
System.Object, ByVal e As System.EventArgs)

    End Sub


End Class
```

10.8 The Polyclinic Interface code:

```vb
Imports System.Data.OleDb

Public Class Doctors
    'Dim constr As String = "Data Source=AMJED-PC\SQLEXPRESS;Initial
Catalog=dr.amjed;Persist Security Info=True;User
ID=sa;Password=dr.amjed;Provider=SQLOLEDB"
    Dim constr As String = "Provider=SQLNCLI.1;Data Source=DESKTOP-
7BGN1SV\SQLEXPRESS;Integrated Security=SSPI;Initial Catalog=DB_amjed"
    Dim conn As New OleDbConnection(constr)
    Dim da As New OleDbDataAdapter
    Dim ds As New DataSet
    Private Sub Label4_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs)

    End Sub
    Private Sub filldoc()
        Dim conn As New OleDbConnection(constr)
        Dim dt As New DataTable
        Try
            conn.Open()
            Dim cmdd As New OleDbCommand("select PATIENT_Name from
PATIENT", conn)
            Dim daa As New OleDbDataAdapter(cmdd)
            daa.Fill(dt)
            cobname.DataSource = dt
            cobname.DisplayMember = "PATIENT_Name"
            conn.Close()
            cobname.Text = ""
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub
    Private Sub Doctors_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        filldoc()
    End Sub

    Private Sub search_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles search.Click
        If cobname.Text = "" Then
            MsgBox("The search Location is empty!",
MsgBoxStyle.Information)
        Else
            Dim conn As New OleDbConnection(constr)
            Dim cmd As New OleDbCommand("select PATIENT_ID,ADDRESS,
convert(varchar,DATE_OF_FIRST_DIAGNOSIS,103) DATE_OF_FIRST_DIAGNOSIS,
convert(varchar,DOB,103) DOB,PATIENT_NAME,PATIENT_NAME,diagnosis from
PATIENT where PATIENT_NAME='" & cobname.Text & "'", conn)
            Dim ds As New DataSet
            Dim da As New OleDbDataAdapter(cmd)
            da.Fill(ds)
            If ds.Tables(0).Rows.Count = 0 Then
                MsgBox("Datanot found")
            Else
                txtid.Text = ds.Tables(0).Rows(0)("PATIENT_ID")
```

```vbnet
                txtaddress.Text = ds.Tables(0).Rows(0)("ADDRESS")
                txtdate.Text =
ds.Tables(0).Rows(0)("DATE_OF_FIRST_DIAGNOSIS")
                'txtdate.Text =
ds.Tables(0).Rows(0)("DATE_OF_FIRST_DIAGNOSIS")
                txtdob.Text = ds.Tables(0).Rows(0)("DOB")
                txtname.Text = ds.Tables(0).Rows(0)("PATIENT_NAME")
                diagnosis.Text =
ds.Tables(0).Rows(0)("diagnosis").ToString
                'cmbdoc.Text = ds.Tables(0).Rows(0)("DOCTOR_name")
                'cmbsex.Text = ds.Tables(0).Rows(0)("SEX")
                loadgrid()
            End If
        End If
    End Sub

    Private Sub TextBox5_TextChanged(ByVal sender As System.Object, ByVal
e As System.EventArgs)

    End Sub

    Private Sub save_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles save.Click
        Dim cmd As New OleDbCommand(" select * from PATIENT where
PATIENT_ID ='" & txtid.Text & "'", conn)
        Dim ds As New DataSet
        Dim da As New OleDbDataAdapter(cmd)
        da.Fill(ds)
        If ds.Tables(0).Rows.Count = 0 Then
            MsgBox("not found", MsgBoxStyle.Information)
        Else
            Dim cmd1 As New OleDbCommand("update patient set diagnosis='"
& diagnosis.Text & "' where PATIENT_ID='" & txtid.Text & "'", conn)
            conn.Open()
            cmd1.ExecuteNonQuery()
            conn.Close()
            MsgBox("Data Saved Successfuly", MsgBoxStyle.Information)
            ds.Clear()

        End If
    End Sub

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button1.Click
        txtid.Text = ""
        txtaddress.Text = ""
        'txtdate.Text = ds.Tables(0).Rows(0)("DATE_OF_FIRST_DIAGNOSIS")
        txtdob.Text = ""
        txtname.Text = ""
        diagnosis.Text = ""
        txtname.Focus()
    End Sub

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button2.Click
        Me.Close()
    End Sub
```

```vb
    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button3.Click
        SPECIFIC_PATIENT_TEST.Show()
    End Sub
    Private Sub loadgrid()
        datagrid.Rows.Clear()
        Try
            Dim con As New OleDbConnection(constr)

            Dim adapter As New OleDbDataAdapter("select
TESTNAME,RESULT,convert(varchar,CURR_DATE,103) from RESULT2 where
PATIENT_ID='" & txtid.Text & "'", con)

            Dim ds As New DataSet
            con.Open()
            adapter.Fill(ds, "RESULT2")
            Me.datagrid.Columns(0).HeaderText = "Test"
            Me.datagrid.Columns(0).Width = 130
            Me.datagrid.Columns(1).HeaderText = "Result"
            Me.datagrid.Columns(1).Width = 250
            Me.datagrid.Columns(2).HeaderText = "Date"
            Me.datagrid.Columns(2).Width = 90
            For i As Integer = 0 To ds.Tables("RESULT2").Rows.Count - 1
                datagrid.Rows.Add()
                datagrid.Item(0, i).Value =
ds.Tables(0).Rows(i).Item(0).ToString
                datagrid.Item(1, i).Value =
ds.Tables(0).Rows(i).Item(1).ToString
                datagrid.Item(2, i).Value =
ds.Tables(0).Rows(i).Item(2).ToString


            Next
            con.Close()
        Catch ex As Exception
            MsgBox(ex.Message)
        End Try
    End Sub

    Private Sub datagrid_CellContentClick(ByVal sender As System.Object,
ByVal e As System.Windows.Forms.DataGridViewCellEventArgs) Handles
datagrid.CellContentClick

    End Sub

    Private Sub OleDbConnection1_InfoMessage(ByVal sender As
System.Object, ByVal e As System.Data.OleDb.OleDbInfoMessageEventArgs)
Handles OleDbConnection1.InfoMessage

    End Sub
      End Class
```

10.9   Laboratory Technician's Interface code:

```vbnet
Imports System.Data.OleDb
Public Class FRMRESULT
    'Dim constr As String = "Data Source=AMJED-PC\SQLEXPRESS;Initial
Catalog=dr.amjed;Persist Security Info=True;User
ID=sa;Password=dr.amjed;Provider=SQLOLEDB"
    Dim constr As String = "Provider=SQLNCLI.1;Data Source=DESKTOP-
7BGN1SV\SQLEXPRESS;Integrated Security=SSPI;Initial Catalog=DB_amjed"
    Dim conn As New OleDbConnection(constr)
    Dim da As New OleDbDataAdapter
    Dim ds As New DataSet
    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button1.Click
        datagrid.Rows.Clear()
        Try
            Dim con As New OleDbConnection(constr)

            Dim adapter As New OleDbDataAdapter("select
TESTNAME,RESULT,ID from RESULT2 where PATIENT_ID='" & txtpid.Text & "'",
con)

            Dim ds As New DataSet
            con.Open()
            adapter.Fill(ds, "RESULT2")
            Me.datagrid.Columns(0).HeaderText = "Test"
            Me.datagrid.Columns(0).Width = 100
            Me.datagrid.Columns(1).HeaderText = "Result"
            Me.datagrid.Columns(1).Width = 200
            For i As Integer = 0 To ds.Tables("RESULT2").Rows.Count - 1
                datagrid.Rows.Add()
                datagrid.Item(0, i).Value =
ds.Tables(0).Rows(i).Item(0).ToString
                datagrid.Item(1, i).Value =
ds.Tables(0).Rows(i).Item(1).ToString
                datagrid.Item(2, i).Value =
ds.Tables(0).Rows(i).Item(2).ToString

            Next
            con.Close()
        Catch ex As Exception
            MsgBox(ex.Message)
        End Try
    End Sub

    Private Sub search_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles search.Click
        If cobname.Text = "" Then
            MsgBox("The search Location is empty!",
MsgBoxStyle.Information)
        Else
            Dim conn As New OleDbConnection(constr)
            Dim cmd As New OleDbCommand("select * from PATIENT where
PATIENT_NAME='" & cobname.Text & "'", conn)
            Dim ds As New DataSet
            Dim da As New OleDbDataAdapter(cmd)
            da.Fill(ds)
```

```vbnet
            If ds.Tables(0).Rows.Count = 0 Then
                MsgBox("Datanot found")
            Else
                txtpid.Text = ds.Tables(0).Rows(0)("PATIENT_ID")
                txtpname.Text = ds.Tables(0).Rows(0)("PATIENT_NAME")
                'txtdate.Text = ds.Tables(0).Rows(0)("CURR_DATE")

            End If
        End If
    End Sub

    Private Sub FRMRESULT_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        filldoc()
        txtdate.Text = Date.Today
    End Sub
    Private Sub filldoc()
        Dim conn As New OleDbConnection(constr)
        Dim dt As New DataTable
        Try
            conn.Open()
            Dim cmdd As New OleDbCommand("select PATIENT_Name from
PATIENT", conn)
            Dim daa As New OleDbDataAdapter(cmdd)
            daa.Fill(dt)
            cobname.DataSource = dt
            cobname.DisplayMember = "PATIENT_Name"
            conn.Close()
            cobname.Text = ""
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub

    Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button4.Click
        Me.Hide()
    End Sub

    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button3.Click
        txtpid.Text = ""
        txtpname.Text = ""
        datagrid.Rows.Clear()
    End Sub

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button2.Click
        Try
            Dim con As New OleDbConnection(constr)
            Dim cmd As String = "select * from RESULT2 where
PATIENT_ID='" & txtpid.Text & "'"
            Dim adapter As New OleDbDataAdapter(cmd, con)
            Dim ds As New DataSet
            con.Open()
            adapter.Fill(ds, "RESULT2")
            For i As Integer = 0 To ds.Tables("RESULT2").Rows.Count - 1
                'MsgBox(datagrid.Item(1, i).Value)
```
191

```vb
                Dim cmds As New OleDbCommand("update RESULT2 set
RESULT='" & datagrid.Item(1, i).Value & "',date_of_test='" & txtdate.Text
& "' where PATIENT_ID='" & txtpid.Text & "' ", con)
                ' and ID='" & datagrid.Item(2, i).Value & "'
                ' cmds.Parameters.AddWithValue("@RESULT",
OleDbType.LongVarChar).Value = datagrid.Item(1, i)
                conn.Open()
                cmds.ExecuteNonQuery()
                conn.Close()
            Next
            con.Close()
            MsgBox("Data is Saved", MsgBoxStyle.Information)
            Return
        Catch ex As Exception
            MsgBox(ex.Message)
        End Try
    End Sub
End Class
```

10.10   Generate EPR for one Patient Code:

```vbnet
Imports System.Data.OleDb
Public Class FrmPatient_Report
    'Dim str As String = "Data Source=AMJED-PC\SQLEXPRESS;Initial
Catalog=dr.amjed;Persist Security Info=True;User
ID=sa;Password=dr.amjed;Provider=SQLOLEDB"
    Dim str As String = "Provider=SQLNCLI.1;Data Source=DESKTOP-
7BGN1SV\SQLEXPRESS;Integrated Security=SSPI;Initial Catalog=DB_amjed"

    Private Sub report()
        Try

            Dim connect As New OleDbConnection(Str)
            Dim ds As New DataSet
            Me.OleDbDataAdapter1.SelectCommand.CommandText = "SELECT
PATIENT.PATIENT_ID, PATIENT.PATIENT_NAME, DOCTOR.DOCTOR_NAME,
RESULT2.RESULT, RESULT2.TESTNAME,RESULT2.DATE_OF_TEST FROM  PATIENT INNER
JOIN DOCTOR ON PATIENT.DOCTOR_NAME = DOCTOR.DOCTOR_NAME INNER JOIN
RESULT2 ON PATIENT.PATIENT_ID = RESULT2.PATIENT_ID where
PATIENT.PATIENT_NAME='" & ComboBox1.Text & "' and (RESULT2.DATE_OF_TEST
between '" & ComboBox2.Text & "' and '" & ComboBox3.Text & "') "
            Me.OleDbDataAdapter1.SelectCommand.Connection = connect
            OleDbDataAdapter1.Fill(ds)
            Dim cr As New CrystalReport3
            cr.SetDataSource(ds)
            Me.CrystalReportViewer1.ReportSource = cr
            Me.CrystalReportViewer1.Refresh()
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub
    Private Sub filldoc()
        Dim connect As New OleDbConnection(Str)
        Dim dt As New DataTable
        Try
            connect.Open()
            Dim cmdd As New OleDbCommand("select distinct PATIENT_Name
from PATIENT", connect)
            Dim daa As New OleDbDataAdapter(cmdd)
            daa.Fill(dt)
            ComboBox1.DataSource = dt
            ComboBox1.DisplayMember = "PATIENT_Name"
            connect.Close()
            ComboBox1.Text = ""
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub
    Private Sub filldoc1()
        Dim connect As New OleDbConnection(str)
        Dim dt As New DataTable
        Try
            connect.Open()
            Dim cmdd As New OleDbCommand("select distinct date_of_test
from result2", connect)
            Dim daa As New OleDbDataAdapter(cmdd)
```

```vb
            daa.Fill(dt)
            ComboBox2.DataSource = dt
            ComboBox2.DisplayMember = "date_of_test"
            connect.Close()
            ComboBox2.Text = ""
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub
    Private Sub filldoc2()
        Dim connect As New OleDbConnection(str)
        Dim dt As New DataTable
        Try
            connect.Open()
            Dim cmdd As New OleDbCommand("select date_of_test from
result2", connect)
            Dim daa As New OleDbDataAdapter(cmdd)
            daa.Fill(dt)
            ComboBox3.DataSource = dt
            ComboBox3.DisplayMember = "date_of_test"
            connect.Close()
            ComboBox3.Text = ""
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub
    Private Sub FrmPatient_Report_Load(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles MyBase.Load
        filldoc()
        filldoc1()
        filldoc2()
    End Sub

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button1.Click
        report()
    End Sub

    Private Sub ComboBox1_SelectedIndexChanged(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
ComboBox1.SelectedIndexChanged

    End Sub
End Class
```

10.11   Retrieve All ERPs Records Code:

```vb
Imports System.Data.OleDb
Public Class Frmallpatient
    'Dim str As String = "Data Source=AMJED-PC\SQLEXPRESS;Initial
Catalog=dr.amjed;Persist Security Info=True;User
ID=sa;Password=dr.amjed;Provider=SQLOLEDB"
    Dim str As String = "Provider=SQLNCLI.1;Data Source=DESKTOP-
7BGN1SV\SQLEXPRESS;Integrated Security=SSPI;Initial Catalog=DB_amjed"

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button2.Click
        Try

            Dim connect As New OleDbConnection(Str)
            Dim ds As New DataSet
            Me.OleDbDataAdapter1.SelectCommand.CommandText = "SELECT
PATIENT.PATIENT_ID,  PATIENT.PATIENT_NAME, DOCTOR.DOCTOR_NAME,
RESULT2.RESULT, RESULT2.TESTNAME,
convert(varchar,RESULT2.DATE_OF_TEST,103) DATE_OF_TEST FROM  PATIENT
INNER JOIN DOCTOR ON PATIENT.DOCTOR_NAME = DOCTOR.DOCTOR_NAME INNER JOIN
RESULT2 ON PATIENT.PATIENT_ID = RESULT2.PATIENT_ID where
RESULT2.DATE_OF_TEST between '" & ComboBox2.Text & "' and '" &
ComboBox3.Text & "'  "
            Me.OleDbDataAdapter1.SelectCommand.Connection = connect
            OleDbDataAdapter1.Fill(ds)
            Dim cr As New CrystalReport4
            cr.SetDataSource(ds)
            Me.CrystalReportViewer1.ReportSource = cr
            Me.CrystalReportViewer1.Refresh()
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub
    Private Sub filldoc2()
        Dim connect As New OleDbConnection(str)
        Dim dt As New DataTable
        Try
            connect.Open()
            Dim cmdd As New OleDbCommand("select distinct date_of_test
from result2", connect)
            Dim daa As New OleDbDataAdapter(cmdd)
            daa.Fill(dt)
            ComboBox2.DataSource = dt
            ComboBox2.DisplayMember = "date_of_test"
            connect.Close()
            ComboBox2.Text = ""
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub
    Private Sub filldoc1()
        Dim connect As New OleDbConnection(str)
        Dim dt As New DataTable
        Try
            connect.Open()
```

```vb
            Dim cmdd As New OleDbCommand("select distinct date_of_test
from result2", connect)
            Dim daa As New OleDbDataAdapter(cmdd)
            daa.Fill(dt)
            ComboBox3.DataSource = dt
            ComboBox3.DisplayMember = "date_of_test"
            connect.Close()
            ComboBox3.Text = ""
        Catch ex As Exception
            MessageBox.Show(ex.ToString)
        End Try
    End Sub

    Private Sub Frmallpatient_Load(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles MyBase.Load
        filldoc1()
        filldoc2()
    End Sub
End Class
```

10.12 Letters for Data Collection:

<div dir="rtl">

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College of Computer Science and Information Technology

جمهورية السودان
جامعة السودان للعلوم و التكنولوجيا
كلية علوم الحاسوب و تقانة المعلومات

النمرة : ج س ع ت / ك ع ح ت م

التاريخ 2018/10/4م

السادة /مستشفى التجانى الماحى

،،،حفظهم الله،،،

السلام عليكم ورحمة الله وبركاته

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،،، ولكم جزيل الشكر والتقدير،،،

د. صلاح الدين الفكى الرفاعى
عميد الكلية

</div>

197

Republic of the Sudan

Sudan University of Science and Technology

College of Computer Science and Information Technology

جمهورية السودان

جامعة السودان للعلوم و التكنولوجيا

كلية علوم الحاسوب و تقانة المعلومات

النمرة : ج س ع ت / ك ع ح ت م

التاريخ 2018/10/4م

السادة /مركز الاحفاد الصحى

،،،حفظهم الله،،،

السلام عليكم ورحمة الله وبركاته

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Republic of the Sudan

Sudan University of Science and Technology

College of Computer Science and Information Technology

جمهورية السودان

جامعة السودان للعلوم و التكنولوجيا

كلية علوم الحاسوب و تقانة المعلومات

النمرة : ج س ع ت / ك ع ح ت م

التاريخ 2018/10/4م

السادة /المجلس الاعلى للأدوية والسموم (Sudan index)

،،،حفظهم الله،،،

السلام عليكم ورحمة الله وبركاته

الموضوع: طلب بيانات

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College of Computer Science and Information Technology

جمهورية السودان

جامعة السودان للعلوم و التكنولوجيا

كلية علوم الحاسوب و تقانة المعلومات

النمرة : ج س ع ت / ك ع ح ت

التاريخ: 2018/10/4م

السادة /القطاع الخاص (فضيل– المعلم — بن الهيثم)

،،،حفظه الله

السلام عليكم ورحمة الله وبركاته

الموضوع: طلب بيانات

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،،، ولكم جزيل الشكر والتقدير،،،

د. صلاح الدين الفكى الرفاعى

عميد الكلية

جمهورية السودان

جامعة السودان للعلوم و التكنولوجيا

كلية علوم الحاسوب و تقانة المعلومات

النمرة : ج س ع ت / ك ع ح ت م

السادة / التأمين الصحى الاتحادى (رحاب عيدابى)

،،،حفظه الله،،،

السلام عليكم ورحمة الله وبركاته

الموضوع: طلب بيانات

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،،، ولكم جزيل الشكر والتقدير،،،

د. صلاح الدين الفكى الرفاعى

عميد الكلية

جمهورية السودان

جامعة السودان للعلوم و التكنولوجيا

كلية علوم الحاسوب و تقانة المعلومات

النمرة : ج س ع ت / ك ع ح ت م

التاريخ: 2018/10/4م

السادة /القطاع العام عمر ساوى (النظام التركى)

،،، حفظه الله ،،،

السلام عليكم ورحمة الله وبركاته

الموضوع: طلب بيانات

نفيدكم علماً بأن الاستاذة / **أمجد عطا عبدالماجد** ، مُسجل ضمن برنامج الدكتوراه في علوم الحاسوب بجامعة السودان للعلوم و التكنولوجيا، و أنه يقوم ببحث الدكتوراة في مجال Health care Information Exchange و نسبة لما لكم من سبق في هذا المجال ، ولما لكم من خبرة علمية و عملية و إسهامات في مجال تطوير البحث في البلاد ، نرجو من سيادتكم التكرم بمساعدته بما يحتاج إليه من بيانات في المجال المطلوب وذلك لأغراض البحث العلمي.

،،، ولكم جزيل الشكر والتقدير ،،،

د. صلاح الدين الفكى الرفاعى

عميد الكلية

Republic of the Sudan

Sudan University of Science and Technology

College of Computer Science and Information Technology

جمهورية السودان

جامعة السودان للعلوم و التكنولوجيا

كلية علوم الحاسوب و تقانة المعلومات

النمرة : ج س ع ت / ك ع ح ت م

التاريخ 2018/10/4م

السادة /التأمين الصحى ولاية الخرطوم (مأمون)

،،،حفظه الله،،،

السلام عليكم ورحمة الله وبركاته

الموضوع: طلب بيانات

نفيدكم علماً بأن الاستاذة / **أمجد عطا عبدالماجد** ، مُسجل ضمن برنامج الدكتوراه في علوم الحاسوب بجامعة السودان للعلوم و التكنولوجيا، و أنه يقوم ببحث الدكتوراة في مجال Health care Information Exchange و نسبة لما لكم من سبق في هذا المجال ، ولما لكم من خبرة علمية و عملية و إسهامات في مجال تطوير البحث في البلاد ، نرجو من سيادتكم التكرم بمساعدته بما يحتاج إليه من بيانات في المجال المطلوب وذلك لأغراض البحث العلمي.

،،، ولكم جزيل الشكر والتقدير،،،

د. صلاح الدين الفكى الرفاعى

عميد الكلية

203

Republic of the Sudan

Sudan University of Science and Technology

College of Computer Science and Information Technology

جمهورية السودان

جامعة السودان للعلوم و التكنولوجيا

كلية علوم الحاسوب و تقانة المعلومات

النمرة : ج س ع ت / ك ع ح ت م

التاريخ 2018/10/4م

السادة /القطاع الخاص والحكومى (مستشفى شرق النيل)

،،، حفظه الله ،،،

السلام عليكم ورحمة الله وبركاته

الموضوع: طلب بيانات

نفيدكم علماً بأن الاستاذة / **أمجد عطا عبدالماجد** ، مُسجل ضمن برنامج الدكتوراه في علوم الحاسوب بجامعة السودان للعلوم و التكنولوجيا، و أنه يقوم ببحث الدكتوراة في مجال Health care Information Exchange و نسبة لما لكم من سبق في هذا المجال ، ولما لكم من خبرة علمية و عملية و إسهامات في مجال تطوير البحث في البلاد ، نرجو من سيادتكم التكرم بمساعدته بما يحتاج إليه من بيانات في المجال المطلوب وذلك لأغراض البحث العلمي.

،،، ولكم جزيل الشكر والتقدير ،،،

د. صلاح الدين الفكى الرفاعى

عميد الكلية

Republic of the Sudan

Sudan University of Science and Technology

College of Computer Science and Information Technology

جمهورية السودان

جامعة السودان للعلوم و التكنولوجيا

كلية علوم الحاسوب و تقانة المعلومات

النمرة : ج س ع ت / ك ع ح ت م

التاريخ 2018/10/4م

السادة /مستشفى الرباط الجامعى

،،،حفظهم الله،،،

السلام عليكم ورحمة الله وبركاته

الموضوع: طلب بيانات

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،،، ولكم جزيل الشكر والتقدير،،،

د. صلاح الدين الفكى الرفاعى

عميد الكلية

جمهورية السودان

جامعة السودان للعلوم و التكنولوجيا

كلية علوم الحاسوب و تقانة المعلومات

النمرة : ج س ع ت / ك ع ح ت م   التاريخ: 2018/09/18م

السيد /نائب المدير – المركز القومى للمعلومات (سؤدت محمود)

،،،حفظه الله،،،

السلام عليكم ورحمة الله وبركاته

الموضوع: طلب بيانات

نفيدكم علماً بأن الاستاذة / أمجد عطا عبدالماجد ، مُسجل ضمن برنامج الدكتوراه في علوم الحاسوب بجامعة السودان للعلوم و التكنولوجيا، و أنه يقوم ببحث الدكتوراة في مجال Health care Information Exchange و نسبة لما لكم من سبق في هذا المجال ، ولما لكم من خبرة علمية و عملية و إسهامات في مجال تطوير البحث في البلاد ، نرجو من سيادتكم التكرم بمساعدته بما يحتاج إليه من بيانات في المجال المطلوب وذلك لأغراض البحث العلمي.

،،، ولكم جزيل الشكر والتقدير،،،

د. صلاح الدين الفكى الرفاعى

عميد الكلية