Sudan University of Science and Technology

College of Graduate Studies

Department of Biomedical Engineering

Designing a Tele-pediatric System Based on the Internet

تصميم نظام تطبيب عن بعد للأطفال قائم علي الإنترنت

A Thesis Submitted in partial Fulfillment for the Degree of M.Sc. in Biomedical Engineering

By:

Nourelhuda Ali Yousif Mohamed

Supervisor:

Dr. Mohamed Yaqoob Ismail

May 2019

الآيـة

قال تعالي:

" اللَّهُ نُورُ السَّمَاوَاتِ وَالأَرْضِ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ الْمِصْبَاحُ فِي زُجَاجَةٍ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِن شَجَرَةٍ مُّبَارَكَةٍ زَيْتُونَةٍ لّا شَرْقِيَّةٍ وَلا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ تَمْسَسْهُ نَارٌ نُّورٌ عَلَى نُورٍ يَهْدِي اللَّهُ لِنُورِهِ مَن يَشَاء وَيَضْرِبُ اللَّهُ الأَمْثَالَ لِلنَّاسِ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيم "

صدق الله العظيم

سورة النور الآيه (35)

DEDICATION

To my source of motivation …my parents;

My strong mother and my kind father,

To my dear sisters and brother,

To my best friend ever,

To my inspiring supervisor,

To partners on the way,

During the toughest and happiest moments,

To my great, respected teachers

FOREWORD

Alhamdulillah, I'm so thankful to AALAH S.W.T for blessing me with good health, physically and mentally, the thing that enables me starts my master thesis project and finishes it.

In order for me to complete this project to its best, I'm thankful to many persons and friends. Firstly, I would like to grate my mother who supports me and always encourages me to go forward and never look back. Then I indeed grate my life partner and my best friend for her great effort encouraging me toward success. Of course, I grate my supervisor, Dr. Mohamed Yagoob Ismail who always offered support and ideas to make this project success. In addition I must grate Eng. Lamia who supported me at the beginning of this project design.

المستخلص

لقد أسهم النمو والتطور المتسارع في تكنولوجيا الإتصال عن بعد في فتح آفاق جديدة لتشخيص عدد كبير من الأمراض، والتي تهدد الحياة، وذلك للأشخاص الذين يعيشون في المناطق النائية والقرى البعيدة عن المستشفيات المركزية والتي يتوفر بها الأخصائيون.

ليست كل الأمراض تحتاج الى تشخيص بإستخدام تقنيات الإتصال. الأمراض الحرجة، والتي تهدد حياة المريض، تحتاج ان نستفيد من مزايا مجال تكنولوجيا الإتال عن بعد لإنقاذ حياة المرضى.

تمثل شريحة مرضى الأطفال عدد لا يستهان به من إجمالي عدد المرضى، والأطفال يمثلون حاضر البلد ومستقبله المشرق، لذا من الواجب علينا التركيز علي أهمية تشخيص أمراضهم وعلاجها مبكراً وفي الوقت المناسب مستخدمين الطرق والوسائل المتاحة لحمايتهم.

إن تصميم نظام تطبيب عن بعد لمراقبة مثل هذه الحالات وتشخيصها بسرعة وعلاجها بإستخدام الأدوات المتوفرة يمثل أمراً ضرورياً وحيوياً في حفظ حياة هؤلاء الأطفال وحمايتهم من المخاطر المترتبة علي عدم علاج مثل هذه الأمراض مثل الإعاقة الحركية، السمعية، والبصرية والتي قد تصل الي الموت.

صمم هذا المشروع نظام تطبيب عن بعد للأطفال قائم على الإنترنت، باستخدام صفحات الويب في كل من مواقع الإرسال والاستقبال وتوصيلها بقاعدة البيانات وربطها عن طريق شبكة الإنترنت التابعة لجامعة السودان للعلوم والتكنولوجيا لإختبار كفاءة النظام. وإذا طبق هذا النظام سيساهم في إنقاذ حياة الأطفال ورفع مستوى الرعاية الصحية الشاملة.

ABSTRACT

The outgrowth and quick development in telecommunication technologies has open new opportunities for diagnosing of many diseases, which is life threatening, for patients who are in rural areas and district far away from city, and where there is no specialists.

Not all of the diseases are to be diagnosed using telecommunication technologies. Critical and life threatening diseases, in which patient cannot wait until going to central hospital, or specialist, need to benefit from the advantages of telecommunication technologies to save patient's life.

The segment of pediatric patients represents a significant number of patients, and children representing the country's present and bright future, so we must focus on the importance of diagnosing and treating their diseases early and in a timely manner using the ways and means available to protect their lives from risks.

Designing a tele-pediatric system for monitoring of such cases can be vital and efficient is saving those babies' lives and protect them from significant risks of disability and even death that happen if their defects are not diagnosed and treated quickly.

This project had designed tele-pediatric system by designing webpages at both transmitting and receiving sites and connected to a designated database and then linked with the Sudan University of Science and Technology's Network for testing its efficiency and effectiveness. If this project is applied; it will contribute to save baby's life and raise up the overall health care.

Table of Contents:

DEDICATION ..... **I**

FOREWORD ..... **II**

ABSTRACT (ARABIC) ..... **III**

ABSTRACT (ENGLISH) ..... **IV**

TABLE OF CONTENTS: ..... **V**

LIST OF FIGURES: ..... **VII**

LIST OF TABLES: ..... **VII**

ABBREVIATIONS: ..... **X**

CHAPTER 1: INTRODUCTION AND GENERAL REVIEW **2**

1.1 Introduction: 2
1.2 Problem Statement: 3
1.3 Objectives: 3
1.3.1 Main Objective: *3*
1.3.2 Specific Objectives: *3*
1.4 Methodology: 4
1.4.1 Transmission site: (PHCs, or Tertiary Hospital) *4*
1.4.2 Receiving site: (Referral Hospital with Specialists) *5*
1.5 Thesis Layout: 6

CHAPTER 2: LITERATURE REVIEW **8**

2.1 Conducted Telemedicine Projects in the World: 8
2.1.1 The Experiment of Sub-Himalayan State of India: *8*
2.1.2 The Experiment of Sweden (Tele-Wound ™): *9*
2.1.3 The Experiment of Italy: *10*
2.1.4 The Experiment of Ireland: *10*
2.1.5 The Experiment of Bogota, Colombia: *11*
2.2 Conducted Telemedicine Projects in Developing Countries: 12
2.2.1 A Cost-Effective Portable Telemedicine Kit for Use in Developing Countries: *13*
2.2.2 A Meta-Analysis of Telemedicine Success in Africa: *14*
2.3 Conducted Telemedicine Projects in Sudan: 16
2.3.1 Gezira Family Medicine Project (GFMP): *17*
2.4 Telemedicine Applications: 18
2.4.1 Telepediatric: *18*

CHAPTER 3: THEORETICAL BACKGROUND **21**

3.1 Database Management System (DBMS): 21
3.1.1 DBMS Users: *21*
3.1.2 Types of Database: *22*
3.1.3 Database Queries: *23*
3.1.4 Tables: *23*

3.1.5 Keys: *23*
3.2 PHP Programming Language: 24
3.2.1 The Building Blocks of PHP: *24*
3.2.2 Integrating with MySQL using PHP: *24*
3.3 Hyper Text Markup Language (HTML) and Cascading Style Sheet (CSS): 26
3.4 Hospital Database Management System: 26
3.4.1 Challenges in implementing databases in health care: *26*
3.5 Telemedicine Overview: 27
3.5.1 Definition: *27*
3.5.2 Telemedicine History: *27*
3.5.3 Importance of Telemedicine: *28*
3.6 Telemedicine in Africa: 29
3.7 Telemedicine in Sudan: 29
3.7.1 Telemedicine Infrastructure in Sudan: *32*

CHAPTER 4: METHODS AND SYSTEM DESIGN 34

4.1 Methodology: 34
4.2 Proposed System Block Diagram: 35
4.3 Design and implantation: 37
4.3.1 Patient Information: *37*
4.3.2 Hospital: *39*
4.3.3 Users Registration: *39*
4.3.4 User Login: *40*
4.3.5 Signs-Symptoms and required tests: (physician) *41*
4.3.6 Patient's Tests Results: *44*
4.3.7 Sending Email Message to Specialist: *44*
4.3.8 Specialist's Site: *45*

CHAPTER 5: RESULTS AND DISCUSSIONS 49

5.1 Results: 49
5.1.1 English Webpages: *49*
5.1.1.1 System Webpage *49*
5.1.2 Arabic Webpages: *60*
5.2 Discussion: 70

CHAPTER 6: 73

CONCLOSION AND RECOMMENDATIONS 73

6.1 Conclosion: 73
6.2 Design limitations: 74
6.3 Recommendations: 75

REFERENCES: 76

APPENDIX: 79

List of Figures:

fig. 2.1What is seen by pediatric cardiologist [7] 11
fig. 2.2 General Scheme of the Telepediatric System, Using Telemedicine [8] 12
fig. 2.3 Telemedicine Kit [9] 14
fig. 3.1 DBMS users [14] 22
fig. 3.2 PHP retrieves MySQL data to produce webpage [16] 25
fig. 3.3 Rapid diffusion rate of ICT in Sudan [23] 32
Fig. 4.1 Database Design Process 35
Fig. 4.2 Transmission Webpages of the System 35
Fig. 4.3 Receiving Webpages of the System 36
fig. 4.4 System Working Mechanism 37
Fig. 4.5 Patient Table 38
Fig. 4.6 HTML Code for the Patient Admission Webpage Design 38
Fig. 4.7 PHP Script that Connect and Insert Patient Data in DB 39
Fig. 4.8 Hospital Table 39
Fig. 4.9 Users Table 40
Fig. 4.10 HTML Code for Users Registration Webpage Design 40
Fig. 4.11 HTML Code for User Login Webpage Design 41
Fig. 4.12 PHP Script for both Registration and Login Webpages of User 41
Fig. 4.13 Signs-Symptoms and Required Patient Tests Table 42
Fig. 4.14 HTML Code for Physician Webpage Design 42
Fig. 4.15 PHP Code for Physician Webpage 43
Fig. 4.16 HTML Code for the Second Physician Webpage Design 43
Fig. 4.17 PHP Code to Connect Second Physician Webpage with DB 44
Fig. 4.18 PHP Code for Displaying the Patient's Test Results 44
Fig. 4.19 HTML Code for the Email Message Webpage 45
Fig. 4.20 PHP Code for sending the Message Form to the physician 45
Fig. 4.21 HTML code for Specialist Webpage Design 46
Fig. 4.22 PHP Code to enable the Specialist to see full Patient Information 46
Fig. 4.23 Specialist Report Table in the DB 46
Fig. 5.1 System Webpage 50
Fig. 5.2 System Webpage with the Dropdown Menu for Different Users 50
Fig. 5.3 User Registration Webpage 51
Fig. 5.4 User Login Webpage 52

Fig. 5.5 Patient Admission (Registration) Webpage 52
Fig. 5.6 First Physician Webpage 53
Fig. 5.7 Displaying Basic Patient's Information Displayed to Physician 54
Fig. 5.8 Example of Basic Patient Information Appear by Selecting the Patient ID 54
Fig. 5.9 Second Physician Webpage.....55
Fig. 5.10 Displaying Patient Results.....55
Fig. 5.11 Patient's Results Displayed to the Physician 56
Fig. 5.12 Sending SMS to Specialist by the Physician.....57
Fig. 5.13 Specialist webpage 57
Fig. 5.14 Displaying the Overall Information of the Patient Transmitted by the Physician 58
Fig. 5.15 Patient's Documents Appear to the Specialist After Selecting Patient's ID 59
Fig. 5.16 Specialist Report Webpage.....59
Fig. 5.17 Example of the Specialist Report Appear to the Physician.....60
Fig. 5.18 System Webpage 60
Fig. 5.19 System Webpage with the Dropdown Menu for Different User.....61
Fig. 5.20 User Registration Webpage 61
Fig. 5.21 User Login Webpage 62
Fig. 5.22 Patient Admission (Registration) Webpage 62
Fig. 5.23 First Physician Webpage 63
Fig. 5.24 Displaying Basic Patient's Information 63
Fig. 5.25 Example of the Basic Patient Information 64
Fig. 5.26 Second Physician Webpage.....65
Fig. 5.27 Displaying Patient Results.....65
Fig. 5.28 Example of Tests Results appears to the Physician 66
Fig. 5.29 Sending Email Message to Specialist by the Physician 67
Fig. 5.30 Specialist Webpage.....67
Fig. 5.31 Displaying the Overall Information of the Patient Transmitted by the Physician 67
Fig. 5.32 Example of the Patient Documents appears to Specialist 68
Fig. 5.33 Displaying the Feedback (Report) of the Specialist.....69
Fig. 5.34 Example of Specialist's Report Send Back to Physician 69

List of Tables:

Table 2-1Telemedicine Status in African Countries [10].....15
Table 2-2 Development Stages for the GFMP [11] 18

Abbreviations:

3G	Third Generation
C.R.U.D	Create, Read, Update and Delete
CSS	Cascading Style Sheet
CT	Computerized Tomography
DB	Database
DBMS	Database Management System
ECG	Electro-Cardio-Gram
GSM	Global System for Mobile
HTML	Hyper-Text Markup Language
HTTP	Hyper-Text Transport Protocol
ICTs	Information and Communication Technologies
ID	Identification number
ISDN	Integrated Services Digital Network
MRI	Magnetic Resonance Frequency
MySQL	My Structured Query Language
NRDBMS	Non-Relational DBMS
PHCs	Primary Health Care services
PHI	Public Health Institute
PHP	Hypertext Pre-Processor
RAM	Random Access Memory
RDBMS	Relational DBMS

SMS	Short Message Services
SQL	Structured Query Language
TCP/IP	Transmission Control Protocol/Internet Protocol
US	Ultra-Sound
WHO	World Health Organization
WLAN	Wide Local Area Network
XAMPP	Cross-Platform (X), Apache (A), MySQL (M), PHP (P), and Perl (P)

CHAPTER ONE

INTRODUCTION AND GENERAL REVIEW

Chapter 1: INTRODUCTION AND GENERAL REVIEW

1.1 Introduction:

Telemedicine can be defined as "medical care and health supporting practices based on patient information derived from images transmitted from a remote site." This definition states the condition for handling telemedicine as a branch of medicine. Telemedicine have already been used to transmit standard x-ray, Computerized Tomography (CT), Magnetic Resonance Imaging (MRI) images. Also Electro-Cardio-Gram (ECG) signal has been transmitted. There are a lot of conducted projects in which imaging and its interpretation are central to the diagnosis or management of the patient.

Tele-consultation is consultation at a distance. It is an applied method used in different fields in medicine for interaction between a remote area's patient and doctor and a central specialist who assist in diagnosing and treating the patient. Tele-consultation is done over different communication technologies like Internet, Wide Local Area Network (WLAN), Integrated Services Digital Network (ISDN) and other different communication means.

Pediatric diseases such as lung diseases and congenital heart diseases are the main cause of death for children all around the world. Designing a telemedicine system to diagnose such diseases will help save those children's life.

In order to design such a system, a database; which is a collection of related data, must be created to convey the whole information about patient, such as basic information like name, gender, address, previous diseases and medications, to which insurance company they belong, the required medical tests needed and their results in order to diagnose the patient case and assign the appropriate treatment plan, the basic information about doctors involved in the telemedicine system, information about the remote and referral hospitals involved in the system and many other information.

In order to create such database; which stores data in such a way that it becomes easier to retrieve, manipulate, and produce information, a lot of tools are available.

All of the developing countries suffer from the lack of government commitment towards healthcare services and programs, limitations of communication technologies use and application, and the funding issues.

Sudan as one of the developing countries, suffer from poor health care services, and lack of specialist in many fields especially in pediatrics. Even the available pediatricians are accumulated in big cities. So pediatrics in rural and remote areas is not receiving the required dose of health care.

1.2 Problem Statement:

Because of the small number of specialist doctors (pediatricians) compared to the number of patients; pediatrics who suffers from vital and life threatening diseases - which require continuous monitoring - face difficulty in obtaining the required treatment and medication.

There is no established database system for the Sudan as a whole, which means that not all of the medical related data about the specific patient can be found at the same place.

1.3 Objectives:

There main and specific objectives needed to be achieved through conducting this project are:

1.3.1 Main Objective:

The main objective of this project is to design Telemedicine System for Pediatrics Clinic in order to serve the remote patients.

1.3.2 Specific Objectives:

1. Design a united database system for the whole Sudan country to store all pediatrics related information and enable retrieving the required information later.

2. To establish a tele-pediatric system based on the internet using specifically designed webpages at both transmitting and receiving sites.

3. To test the capability of having a consultation between a distant specialist and a physician located where the patient is.

1.4 Methodology:

To accomplish the objectives stated earlier, this project will be conducted through the following steps:

- Due to the lack of an overall Sudanese patient's database system, a database system was designed using SQL programming language with MySQL RDBMS. Tables as an infrastructure for the telemedicine system were created.
- Also general webpages regarding the system were designed, the user's registration and login, and specialized webpages at the transmitting and receiving sites using HTML and CSS programming languages to enable contact between physician at the remote healthcare center and the specialist at the referral hospital.
- These webpages were linked with the database created earlier using PHP programming language.
- XAMPP and notepad++ programs were the software programs used to create the database and the webpages codes.
- The information from the transmission site was sent to the receiving site using internet (TCP/IP protocol).
- An email message was sent to specialist notifying them by the current patient case.

1.4.1 Transmission site: (PHCs, or Tertiary Hospital)

- Two basic webpages at the transmitting site were designed. The first is for the patient admission section, to enable the receptionist to enter the basic

patient's information (i.e., patient ID, name, Gender and medical History). This data will directly link to the database system and stored there.

- The other webpage (actually two webpages for more functionality) is for the physician who is in the same place with the patient at the local (remote) hospital. These pages is designed to enable the physician to view the patient information entered at the admission section, then determine which laboratory tests and medical images will be needed for the specific patient, and letting them make their own report on the patient status and view the feedback report sent by the specialist.

- Then all of the gathered information is sent to the specialist allowing them to make their medical decision (diagnosis and treatment plan).

1.4.2 Receiving site: (Referral Hospital with Specialists)

- A webpage was designed at the receiving site to enable the specialist to view all of the patient information sent by the physician at the transmitting site. Then allowing them makes their report about the specific case and sent their feedback to the physician (medical decision about the diagnosis and treatment plan).

When the report is sent to the specialist, an email message will be sent to them notifying them by the new case.

Finally, after the system establishment, it was tested between hub (as a server) computer and peripheral one.

1.5 Thesis Layout:

Chapters of the thesis are organized as follow:

Chapter One: Introductory part and general review about the main concepts of the project.

Chapter Two: Review the literature to know about previous studies conducted in the same project area locally and internationally.

Chapter Three: know theoretical background about the project concept and project application.

Chapter Four: Methods applied to achieve the goals stated in chapter one, and System Design.

Chapter Five: Results obtained and brief discussions about these results.

Chapter Six: Concluding the project findings and what is Recommended in the future for complete pediatric telemedicine system.

CHAPTER TWO

LITERATURE REVIEW

Chapter 2: LITERATURE REVIEW

This chapter represents some of the conducted projects in telemedicine and Telepediatric and their impacts on the society. It covers international projects, projects conducted in Africa and Sudan.

2.1 Conducted Telemedicine Projects in the World:

There are a lot of telemedicine projects conducted and established word wide. These projects were developed to meet a certain need for those countries. Here some of these projects will be highlighted.

2.1.1 The Experiment of Sub-Himalayan State of India:

India geography is diverse in nature. Populations live in mountain (Himalayan mountain) cannot access basic and advanced health care services due to geographical barriers. At the present, many super specialty and sub-specialty medical disciplines have developed. The medical specialists in these areas are few and most of them are available in big cities and central hospitals. [4]

Telemedicine network was established in one of these hill states (Uttaranchal) on April, 2004by Telemedicine Resource Center, Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGIMS), Lucknow, India with funding support from Government of Uttaranchal. Then the Government of Uttaranchal took the initiative to start a pilot project using Telemedicine technology to link the PHCs, CHCs and district hospitals of the state to the Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGIMS), Lucknow, a tertiary level academic institution situated at distance of 500 km in the adjoining state of Uttar Pradesh. [4]

In 2002, a group from Telemedicine Resource Center, SGPGIMS headed by its Director gave a seminar to the Committee constituted by the Uttaranchal government consisting of senior officials from departments of health, information technology and finance chaired by the Chief Secretary of the state in order to discuss the different (medical and technical) issues related to implementing telemedicine and the expected benefits for both government and state populations from the application of telemedicine. A month later the state government request for an action plan to the project with the expected budget. All the different aspects

for establishing telemedicine were investigated like the infrastructure from hospitals to network to equipment. ISDN was selected as a desired network. A proposal had prepared by the working team. Then the state government approved the project and it was conducted. Project manpower appointed were three telemedicine technicians one Network Engineer and one Project Assistant. Installation of equipment was carried out along with integration of ISDN telecommunication media in the month of April, 2004. After that the system was tested and all the hospital staff was trained on it. [4]

2.1.2 The Experiment of Sweden (Tele-Wound ^{TM}):

The telemedicine systems are rabidly increasing over the last decades. There is an involvement and establishing for telemedicine in national health care systems. These many and different telemedicine systems creates integration, vendor lock-in and interoperability. This study discusses telemedicine system architecture which has been built as Service Oriented Architecture (SOA), that is used to solve the telemedicine problems of designing telemedicine systems are designed by the considerations of today's need of companies. [5]

The question is how the user can become sure that his telemedicine system design could not create the problems states earlier. So this study is going to produce a design model to suggest solutions to system designers work in this field. [5]

The layout of this study is to represent system architecture of telemedicine systems along with the implementation, and to raise interest of the persons who are afraid of not having the stakeholders support and fund in the field of telemedicine. [5]

This study had designed a telemedicine project under the name Tele-Wound TM application. The targeted audience of this application will be leg ulcer patients and the main purpose of this application is to serve all those patients who cannot move freely. Their pictures of infected areas will be fetched through camera (cell phone camera or digital camera) by the nurse from their location, after fetching the picture he/she will send those pictures into our application server along with little description of patient. This Web based architecture of Tele-Wound TM is utilizing telecommunication (GSM/3G) and internet technology and their major components/modules are more dependent on those technologies. This architecture is also confirming and assuring the availability of medical data from the other

resources. Special lists in the doctor’ s end would be needed with internet access and a browser so that they can help out patients from any place or city or even country for serving the patients/nations. [5]

2.1.3 The Experiment of Italy:

This project describes how the implementation of telemedicine is able to improve quality of care for rural and remote areas. The method adopted is a case study, which link the Department of Pediatric Cardiology of Brotzu, a tertiary hospital in Sardinia, located in Cagliari (Italy) and CRS4 (Center for Advanced Studies, Research and Development in Sardinia) with the aim to develop a synchronous and low cost telemedicine platform able to support physicians with the telepresence of a specialist in real time during echocardiographic evaluations. They found that this system can emerge new care models, motivating a rational and effective use of resources. After the design and test of this project it is recommended to use hub and spoke model that is supported by the tele-health adoption by national health organizations. As this study is just applied to cardiology department, it is recommended to be applicable to other medical departments. [6]

2.1.4 The Experiment of Ireland:

Several telemedicine applications have become well established in pediatric cardiology. Pediatric cardiology is suited to telemedicine because it is highly specified field of medicine with a small cadre of professionals. [7]

In order to implement this system a lot of needs were addressed. Videoconferencing equipment at both transmitting and receiving sites, PCs, cardiology equipment, network (ISDN), and personnel are the needs to conduct the project. [7]

Ultrasound(US) image was picked up using US machine, the US image was then transmitted via some telecommunication link (ISDN), in the designing, they convert this image to digitized then transmit it to cardiology department. In the receiving site there is a reverse unit which reverses the process, so the cardiologist can see the image as it is obtained. Then the cardiologist can show his/ her opinion in the images and advice the physician by what he/she can do to save the neonate. The system then was tested to measure its efficiency and effectiveness. [7]

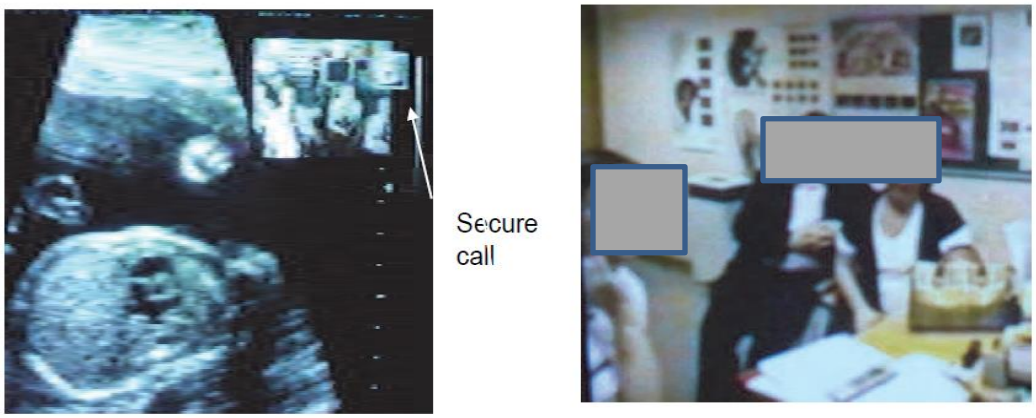


fig. 2.1What is seen by pediatric cardiologist [7]

2.1.5 The Experiment of Bogota, Colombia:

Most population in Latin America lives in large urban cities with different access to services. Even though, main hospitals provide specialized services, economically poor citizens cannot gain these services, with the pediatric patients being most affected. This paper discusses the design and implementation of low cost pediatric system, which can be applicable to primary health care hospitals through a study in Bogota´, Colombia, it is main purpose is to reduce the number of unnecessary patient transfers always referred to specialized medical services in large hospitals. [8]

In order to establish this system, it took 6 months during which there was a high rate of incidence of acute respiratory illness in children between 0-5 years. It depends on telemedicine information system "SARURO" which was developed 8 years before this study time. The system involves 9 primary care hospitals in Bogota´. The medical processes are modeled using the HL7^{+}RIM. The server used is PostgreSQL and the system developed in Java. A group of Engineers train nineteen (n=19) pediatricians in order to guarantee the system permanently. Then the rate of patient transfers after applying the system was compared with the previous records of the National Department of Colombia. Also this project has been done under the recommendation of World Health Organization (WHO). [8]

As a result of applying this system, they found that it lowers the numbers of patient transfers to higher level hospitals (specialized hospitals) by 83% and the waiting time of the patient transfers, reasonably reduction in the cost of health care in

pediatric patient, influencing 700 patients. The secondary result of applying this system which just happen by accident that the system reduced the use of antibiotics by about 17%, which was an important public health issue in Colombia at that time. [8]

This study proves that the implementation of telemedicine systems increase and improve the efficiency of public health resources, even in the large cities in Bogota´, and also accomplish the main purpose of this study which is reducing the unnecessary patient movements and referrals. Also the system application makes an optimization and appropriate use of telemedicine. [8]

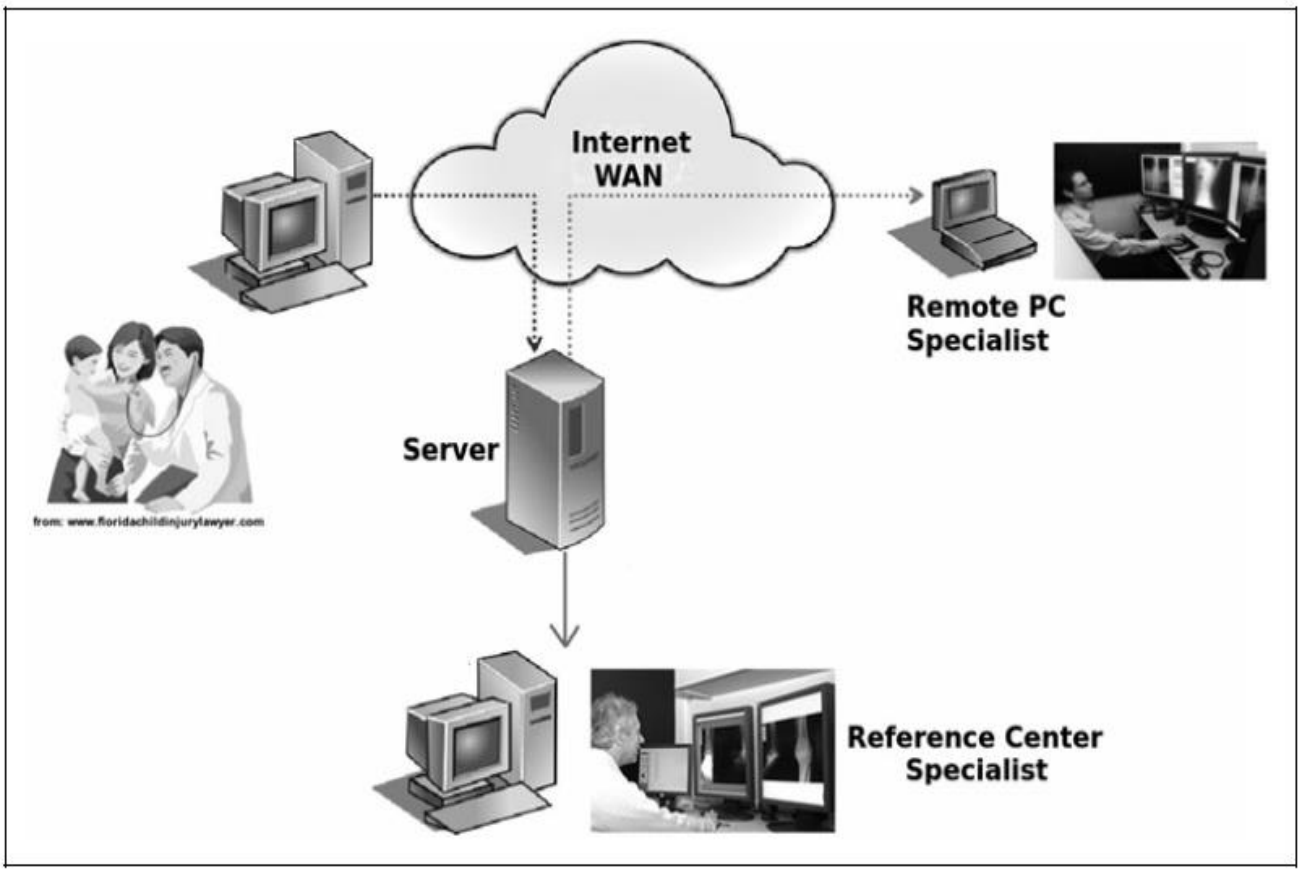


fig. 2.2 General Scheme of the Telepediatric System, Using Telemedicine [8]

2.2 Conducted Telemedicine Projects in Developing Countries:

Developing countries are those with less developed infrastructure in all aspects of life, like agriculture, health care, and industries. The experiment of those countries

with telemedicine is limited but proves the success of implementation. Here some projects which were implemented in developing countries were discussed.

2.2.1 A Cost-Effective Portable Telemedicine Kit for Use in Developing Countries:

Telemedicine is now used to overcome the actual distance between patients located in rural and remote areas and the medical specialist all around the world. The experience of developing countries with telemedicine had little or no success, because of the prohibitively expensive equipment and costs of telecommunication technology establishment. Developing countries need low-cost, practical telemedicine solutions for providing primary health care and the required access to the specialist and medical expertise when needed. This project conducts a low-cost, portable telemedicine kit to address this problem. The kit was designed as part of the Little Intelligent Communities (LINCOS) project, which is bringing satellite telecommunications, education and telemedicine services to underserved areas of Latin America and the Caribbean. This is done through the use of fabricated ISO shipping container which later forms 'Digital Area Network'. [9]

This kit was a durable housing case that enclose inside a laptop (portable computer) and peripherals like a digital stethoscope, an ECG recorder and a medical imaging system. This kit allows health practitioners in rural areas to gather patient data in different forms of audio, video, and images in an asynchronous mode then forward them over the internet to a reference specialist in a central hospital for an appropriate diagnosis. [9]

To design this kit, four aspects were considered: specification selection, integration of the preferred medical equipment, constructing the electronics and power system, and determining the software requirements. Also some of the important factors were considered during the process of design and development of the kit such as acceptable sound, image and video quality were tested and a comparison between the store-and-forward and real-time techniques of telemedicine was done. [20]
This kit was low-cost compared to the available alternatives at that time and offer multi-functions. It is not the ideal solution to all health problems, but an intermediate step toward increasing the quality of primary healthcare delivery in remote areas. This project also proves that sound, video, and medical images can be transmitted and used for diagnosis efficiently. Of course the development of such a kit for home health monitoring is possible using wireless technologies enabled from RS232 or USB equipped in home medical devices. [9]

Designing such a kit for the very far areas in Sudan, and where the health care services is almost not found, or if found is very poor will serve those people

efficiently and promote the health care practices and reduce the transfer of patient from their very far villages to the capital Khartoum to access the basic health care services. I hope that this can be target study for the Sudanese Ministry of Health in order to promote the health care practices in Sudan.

fig. 2.3 Telemedicine Kit [9]

2.2.2 A Meta-Analysis of Telemedicine Success in Africa:

It has been proved that the implementation of information technology (ICT) tools to increase the efficiency of professionalism at work is improving daily through the dynamic digital environment. Techniques such as telemedicine, tele-education, and health informatics have later been involved in the health sector to improve the access to life threatening services, like, in medical fields reducing the referral of patients, and enabling doctor to doctor consultations for the usefulness of patient. Unfortunately, studies observed great efforts and responsibility to improve the implementation of tools in the most of the countries south of the Sahara. Sub-Saharan Africa have been left behind the world in terms of development happen in west through it is natural and human resources. [10]

In this research they sought to make a meta-analysis of the success process of telemedicine and health informatics from the existing research in Africa in order to gain effective solutions to the populations who require the life-threatening health services especially in remote areas. It is not obvious that Africa is still lags behind

the development of information system, although the developed world has all the necessary infrastructure and tools to establish these services. [10]

There are technological and non-technological barriers facing the application of these services which is multidirectional. Technological challenges include lack of infrastructure to apply telemedicine projects; whereas non-technological barriers include individual and government policies that involve the ethical issues like patient information security and privacy in telemedicine, and lack of funding. However, the ethical concerns have been reported not to be specific to telemedicine but also to general medicine practice when managing distant patients as in the case of rural Africa. [10]

All the telemedicine projects in Africa hailed the internet as the communication media because of its effective transfer of information for telemedicine and tele-education. Example of projects in Sub-Saharan Africa: Fundamental of Modern Telemedicine in Africa (FOMTA) which aimed to link developing counties to European countries and uses broadband technology in Africa, Integrated Service Digital Network (ISDN), The Pan-African e-Network Project which is the biggest project for distance education and telemedicine in Africa resulting from the growing partnership between India and Africa and cover twelve African countries which include Botswana, Burundi, Cote de Ivoire, Djibouti, Egypt, Eritrea, Libya, Malawi, Mozambique, Somalia, Uganda and Zambia, and the Reseau en Africue Francophone pour la Telemedicine (RAFT)which start in Mali and has extended to 10 African French speaking countries and involved in videoconferences, tele-consultations, collaborative knowledgebase development, support for medical laboratories quality control and the evaluation of telemedicine in the rural areas via satellite connections in the context of multi-sectorial development. [10]

In the table below the telemedicine experience in many of the African regions, the sponsor who was responsible about the project and the evaluation of the success of that experiment will be discussed. [10]

Table 2-1Telemedicine Status in African Countries [10]

Country	Experience	Sponsor	Success Evaluation
Botswana	Africa tele-dermatology project	American academy of dermatology	Provides dermatology support to physician,

			dermatologists and health care workers
Congo	Links made between health center in Pointe Noire in Congo and Luigi Sacco university hospital, Milan	Interactive Tele-communication network for the world's health Services	Remote consultation and assistance to most African countries
Zambia	Medical library with partner library in university of Florida	University of Florida, America	Disseminate information to doctors in the region
Ghana	Remote sites in Ghana communicates with London school	Vodafone, and Ghana medical association	Data communication on malaria research
Uganda	Tele-pathology consultation between Mulago hospital and Fuerth hospital	Germany	Internet based consultation for primary diagnosis and second opinion
Ethiopia	Fann. St. Louis and Diorbel	The Ethiopian Government	Use of telemedicine technologies
Rwanda	Telemedicine project	Rwanda Government	provide an alternative solution to the small number of doctors, few specialists in some disciplines.
Kenya	Demagi SMS	Government of Kenya	SMS system to support effective use of Antiretroviral Therapy (ARTs)
Sudan	Telemedicine Experience by Ashrafcom	Ashrafcom	Bring together diverse groups from traditional medicine practitioners.
Sudan	Gezira Family Medicine Project (GFMP)	Ministry of Health at Gezira state, University of Gezira, Medani.	Numbers of consultations were done between the physicians for more than one year.

2.3 Conducted Telemedicine Projects in Sudan:

The conducted projects about telemedicine in Sudan are few due to the lack of government commitment towards the healthcare services in Sudan. I discuss here the project which was developed at the state of Al-Gezira which was unfortunately stooped later.

2.3.1 Gezira Family Medicine Project (GFMP):

This project was conducted in AlGezira state, Sudan.it was established with the help of ministry of health, university of AlGezira, and Japan with the vision of Accessible family doctor and specialist services for each family and mission of Presenting accessible high quality health services for all people in affordable prices, making a unique model. [11]

2.3.1.1 Project Structure:

The project is a collaboration project between the federal ministry of telecommunication and information technology and the federal ministry of health on the other partners. Other important partners include the state ministries of health, national medical specialization board, universities and training centers in addition to the health insurance fund. [11]

This project is used modern telecommunication technologies so as to reach its planned goals.

The use of modern telecommunication in the GFMP:

All family doctors are equipped with computers and free internet access. This helps in achieving the coming three important tasks:

A. Telemedicine communication with voice and picture between the family doctors and the patient on one side and the hospital specialists on the other side will spare time, effort and money for the patients.
B. The doctors will gain their training and lectures from the project datacenter through the internet.
C. The computers will be used for the patient filing system. [11]

2.3.1.2 Project Beneficiaries:

• People living in Sudan attending health centers.

• Family physicians.

• Other care providers.

• Rural areas, health centers and rural hospitals. [11]

Table 2-2 Development Stages for the GFMP [11]

Stage	2010	2011	2012	2013	2014
Campaigns, Preparations and startup					
Distance education and training					
Telemedicine (Medical consultation)					
Maturity					

2.4 Telemedicine Applications:

Telemedicine has many classes and different applications in the world. Some of those classes are: Telecardiology, Telepsychiatry, Teleaudiology, Telepathology, Teledermatology, Teledentistry, Teleaudiology, Teleophthalmology and Telepediatric.

2.4.1 Telepediatric:

Telemedicine is a technique that enhances the care of children in the world. Telemedicine was used by pediatrician and pediatric medical and surgical specialist to provide an inpatient and outpatient care, also telemedicine can be applied for emergencies and disasters, and provide health care services to rural and remote areas populations. Pediatrician can use telemedicine in many applications including: tele-education, tele-consultation, tele-practice and tele-research. Tele-education can be delivered through Continuing Medical Education (CME), while tele-consultation can be achieved by having communication link between doctors who are using a live interactive Audio-Video (AV) link,or through store-and-forward. Tele-practice is the medical home that permits have access to all medical records of patients for authorized people, and tele-research is used to recruit study of patients from community case. [12]

Telemedicine is used to increase the efficiency of pediatric care in hospitals that do not support pediatric practices. [12]

Infrastructure for telemedicine depends on either it will be used in synchronous mode (real-time telemedicine) or asynchronous mode (store-and-forward). [12]

This infrastructure includes:

1. Equipment: The equipment needed may range from dedicated turnkey videoconferencing units to software-based videoconferencing programs for computers or mobile platforms such as tablets and cell phones. An important consideration when selecting technologies for the tele-health program involves the interoperability of the technology with existing telemedicine services and technologies.
2. Connection: The quality of a telemedicine interaction depends on the connection established between the sites involved in the call. Therefore, the organization should provide adequate bandwidth to support the needs of the tele-health program goals. [12]

CHAPTER THREE

THEORETICAL BACKGROUND

Chapter 3: Theoretical Background

In order to establish a Tele-pediatric System, a Database must be created first. The database represents the mold that store the different data, information, and knowledge we want to deal with. After creating the database we can retrieve these stored data whenever we need, this process is called database query, and it is very important for us in order to get some data from the database. The next section discusses the database management system, and how to build it and how to deal with it.

3.1 Database Management System (DBMS):

"A database is a collection of data in an organized manner so that its content can easily be accessed, retrieved, managed and updated as per need. It is the think of electronic filing system". A database contains objects which are: tables, views, Indexes, Sequences, Types, packages, procedures, Functions, Triggers, Database links, Materialized view and synonyms. [13]

Database Management System (DBMS) is a software application the enable the ease of creation, update, selection, and delete of the data from the databases. [14]

3.1.1 DBMS Users:

DBMS has different user with different rights and permissions, some retrieve the data and others back it up. They can be categorized as follows:

1. **Administrators:** maintain the DBMS and responsible for administrating the DB, its usage, which uses it, creates access profiles for users, maintain security, look after DBMS resources, and other software and hardware maintenance.

2. **Designers:** they are group of people who works on designing part of the database. They decide which data to be kept and in what format. They determine the entities, relations, constraints, and views.

3. **End users:** those are the users who actually benefits from the database. [14]

fig. 3.1 DBMS users [14]

3.1.2 Types of Database:

There are several types of database management systems. Here is a list of the most common database management systems:

1. Relational database (SQL):
    - Organize data into one or more tables.
    - Each table has rows and columns.
    - A unique key identifies each row.
2. Non-Relational database (noSQL, not just SQL):

    Organize data in anything but a traditional table:
    - Key-value stores.
    - Documents (JSON, XML, etc.)
    - Graphs.
    - Flexible tables.

To create relational DB we use RDBMS which is a software application that helps us to create and maintain relational DBs, these RDBMS like: MySQL, Oracle, PostgreSQL, Maria DB …etc.

To create non-relational DB we use Non-Relational Database Management Systems (NRDBMS) which is also software programs used to help users to create

and maintain a non-relational DBs, it is like: Mango DB, Dynamo DB, Apache Cassandra, fire-base, etc.

There is no standard language for NRDBMSs, that is, most of them implement their own language for performing C.R.U.D and administration operation on the database.

The standard language for interacting with RDBMSs is Structured Query Language (SQL). It is used to:

- Perform C.R.U.D operations as well as other administrative tasks (user management, security, backup, etc.).
- Define tables and structures (tables for RDBs).
- SQL code used on one RDBMS is not always portable to another without modifications. [14]

3.1.3 Database Queries:

Queries are requests made to the database management system for specific information. As the database structure become more and more complex, it becomes more difficult to get the specific pieces of information we want. [14]

3.1.4 Tables:

A table is a collection of data that is arranged in rows and columns. The column represents a single attribute in the DB, while the row represents all the attributes for a specific entity. [14]

3.1.5 Keys:

There are different types of keys, for example:

1. Primary key: it is an attribute which uniquely defines the row in the database.
2. Foreign key: is an attribute that we can store in the database that will link us to another DB table. It forms the way that we can define relationships between tables in DB. [14]

3.2 PHP Programming Language:

PHP is a programming language used to write short as well as long scripts. It is a server-side scripting language. It is similar to JavaScript because it allows us to produce little programs (scripts) into the HTML of a webpage. These scripts control what to be displayed in the browser easier than hard HTML programming language. PHP differ from JavaScript in term of the interpretation of the webpage contents. JavaScript is interpreted by the web browser once the webpage that contains the script has been downloaded, while PHP are interpreted by the webserver before the page is even sent to the browser, and once interpreted, the output of the script is displayed on the webpage. [15]

3.2.1 The Building Blocks of PHP:

A code written in PHP is lookalike to a code written in standard C, C++, and JavaScript and C #. The code consist of a stream of statements, with each statement must be ended by semicolon operator and the code is executed line by line, that is, the result of the previous line is executed before the next line is reached. [16]

PHP contains variables (global and super-global), constants, data types (INT, VARCHAR, BLOB, TEXT, etc.), control flow statements (if, if else, switch, for, while), functions (which is used to perform a specific task), arrays (which is a collection of data from the same data type), and objects (which is used to store and organize data). [16]

PHP also contains specialized functions that are used to make the connection with the database and inform the browser to do a specific process for us. [16]

3.2.2 Integrating with MySQL using PHP:

To successfully use the PHP functions to talk to MySQL, we must have running at a location to which the web server can connect to. We must also create a user with password account and now the name of database to which we want to connect.

Example of function in PHP used to speak to MySQL database:

To make connection:

$db = mysqli_connect('localhost', 'root', '12345', 'test3ar');

Where:

$db is a variable that holds the connection.

mysqli_connect is the function used to make the connection.

localhost is the name of the host server.

root is the name of the user.

12345 is the password.

test3ar is the name of the DB.

mysqli_error (); is function used to return the error if the connection failed.

mysqli_set_charset ($db, "utf8"); // used to tell the server that the script contains Arabic texts.

mysqli_query (); is function used to do specific query in the database. [16]

By the integration of PHP and MySQL we can control what appear in our webpage. Using PHP scripts we can insert data into the database and also we can retrieve data from database. Here is a simple diagram show how PHP retrieves data from MySQL database to display on webpages. [16]

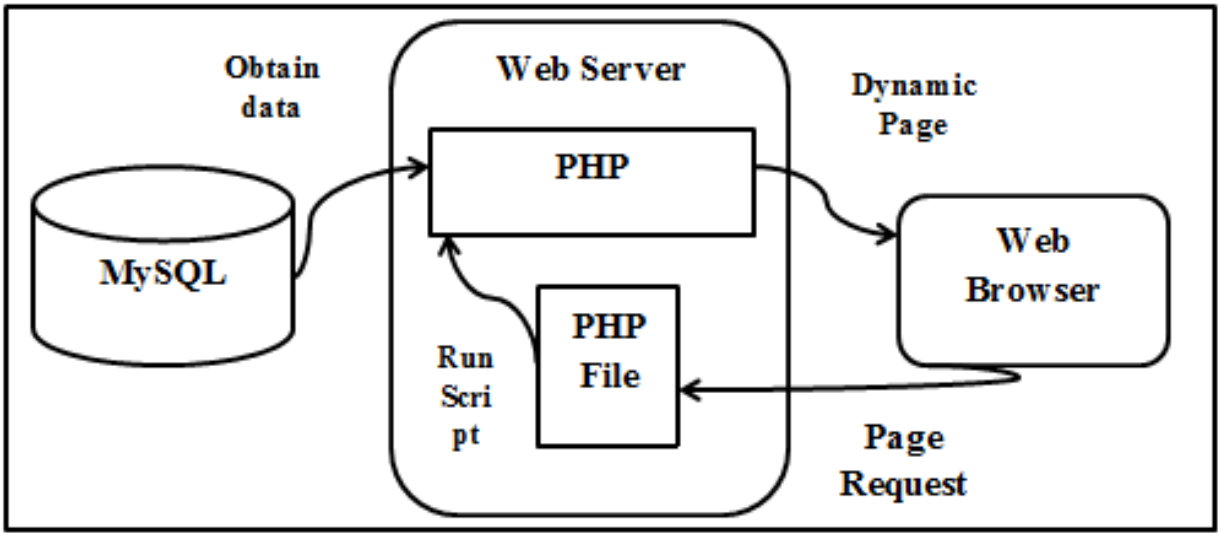


fig. 3.2 PHP retrieves MySQL data to produce webpage [16]

3.3 Hyper Text Markup Language (HTML) and Cascading Style Sheet (CSS):

HTML stands for Hyper Text Markup Language; which is a standard markup language used for creating the web pages. It describe the structure of web pages using markup, its elements are the building blocks of HTML pages and represented by tags, which label pieces of content such as "heading", "paragraph", "table", and so on, and Browsers do not display the HTML tags, but use them to render the content of the page. Using HTML we can build the general layout of the page, to make some styles on this rigid web page we use CSS and JavaScript. For example to add some colors, to control the position e use CSS. [17]

CSS stands for Cascading Style Sheet; which is used to control the style of a web document in a simple and easy way. It is a simple design language intended to simplify the process of making web pages presentable. Using CSS we can handles the look and feel part of a web page. Using CSS, you can control the color of the text, the style of fonts, the spacing between paragraphs, how columns are sized and laid out, what background images or colors are used, as well as a variety of other effects. [18]

3.4 Hospital Database Management System:

The process of storing data in hospital is traditional file systems like: Microsoft Excel, open office, and Google docs spread sheets. These traditional method share the same disadvantage which is the process of defining the data is a part of the application program, that is, in order to add new data we need to change in design and coding. Health care databases include data about patient, treatment and the previous history. This database is administered by Medical Record Administrator who manages patient records. The entities of the database can be: patients, doctors, hospitals, medicine, visit, record, etc. [13]

3.4.1 Challenges in implementing databases in health care:

A lot of challenges are facing the implementation of database software in healthcare facilities. This challenges need to be addressed in order to be solved properly. Here some of these challenges will be stated:

- Reimbursement mechanism.

- In order to meet the patient needs for services, a special database is needed.
- The clinical vocabulary is different than normal words.
- There are different department that must be included in the single health care database (e.g. radiology, laboratory, cardiology…etc.).
- We need to deal with patient data for routine, emergency and monitoring visits.[1]

Thus new technologies like-data entry- can be accomplished using: 1) Dictation & transcription 2) Free text typing 3) Forms for encoding of data 4) selection of items on menu presented on display screen. [13]

3.5 Telemedicine Overview:

This section provides an overview about telemedicine, its history, and the impact of applying telemedicine systems on the community.

3.5.1 Definition:

Up to now, there is no specific definition for telemedicine. It can be defined literally as "healing at a distance". [1]

It can also be defined as a technology which is used to overcome the distance barriers between patients in rural and remote areas and the medical specialists located in urban and large cities around the world.

Also Telemedicine has been defined as "the use of medical information exchanged from one site to another via electronic communications to improve a patient's clinical health status." [19]

3.5.2 Telemedicine History:

Until now, no one knows when telecommunications had been adopted in health care. It may be begun many centuries ago. The telegraph had early been used to transmit victim lists and medical supply during the civil war. In 1900s, and after the establishment of the telephone, physicians adopt it in their use. The use of telephone lasted to about 50 years and plays major roles in serving and feeding the heath care practices. In the First World War 1918, radio communication was

invented and in 1930s it had been used in the very far areas of Alaska and Australia to transmit and receive medical related data and information. [20]

The present systems of telemedicine were all created due to the pioneers efforts of physicians using off-the-shelf commercial equipment. One of the early uses of was established by NASA in their manned space-flight program to monitor the physiological functions (i.e. Heart Rate, Blood Pressure, temperature) for astronauts in space by a physician located in the earth. This system forms a telemetry and telecommunication system for biomedical applications. [20]

The second strong contributor to the development of telemedicine is the invention of the television in 1950. Medical personnel began to use television in clinical settings. The first video link was established in 1964 between the e Nebraska Psychiatric Institute in Omaha and the Norfolk State Hospital, 112 miles away.[20]

During this era, researchers began to prove that remote diagnosis is possible through television technology, and X-Ray images, laboratory data and other medical data can be transferred successfully. Most of the projects developed at that early time were to promote remote consultation and diagnosis using telemedicine technology. [20]

From that time, telemedicine was involved in a lot medical and clinical care applications including Anesthesia, Cardiology, Dermatology, Psychiatry, Radiology, Critical care, Oncology and many other applications like Patient education, home monitoring, and Continuing medical education. [20]

3.5.3 Importance of Telemedicine:

Patients in rural and remote areas suffer from lack of health care services. This leads them to travel from their locations to big and urban cities in order to gain diagnosis and treatment to their cases. This of course will influence the quality of their lives and its rhythm.

The travelling expenses, their no work state during travelling and the waiting as an outpatient for central or referral hospital admission and treatment of course impact the life of the patients. Those patients may be financially poor, for example just having the money for diagnosis and treatment but not for travelling. Therefore, establishing telemedicine for them will reduce expenses tipped on their

responsibilities by offering the health care services at the same place where patient's resides without needs for travelling to big cities for diagnosis and treatment.

3.6 Telemedicine in Africa:

All of the developing countries have common challenges like the lack of responsibility of the government in providing policies to nurture national e-Health programs, the limitation of tele-communication technologies, funding challenges and the responsibility of training of users and patients and, most importantly, the responsibility of stakeholders at all levels. [2]

Developing countries require the different fields of telemedicine applications that promote health care, due to small number of physicians compared to the huge number of population, when specialists (specialized physician) are not available, when patients and physicians live in remote villages need help in the delivery of health care services. Moreover, the requirements of telemedicine applications to be establish for developing countries is more costly than for developed countries. Of course, many aspects like social, organizational, and technical aspects require being addressed for effective telemedicine applications in our developing countries. [21]

3.7 Telemedicine in Sudan:

Sudan lies in the northern east sub-Saharan Africa covering 1,865,813 km² with a population of 39 million (2016), an infant mortality rate of 68 deaths per 1,000 live births, and a Life expectancy at birth: 63 years.[3]

Sudan has poorly developed systems for healthcare. With the expectations of the big cities there are few advanced health services. Even in Khartoum there are only a few examples of good institutions, and not enough to cover the needs for all citizens. A plan from 1970's aimed at provide primary health care all across the country, but it has yet to be realized, much due to lack of finance. Sudan suffer from an extreme lack of good doctors, in a country of great distances, a density of only 0.3 per 1000 inhabitants, is in particular a challenge. [3]

For pediatrics, the main causes of morbidity and mortality in Sudan are infectious and parasitic diseases such as malaria, TB, Schistosomiasis, diarrheal diseases, and malnutrition. [3]

The Evidence, which is a newsletter for the Public Health Institute (PHI), conducted to revise the eHealth in Sudan, adopted the following definition of e-Health "eHealth is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through information and communication technologies (ICTs)." [2]

The Editorial committee of the newsletter also discusses the benefits of ICTs to health care in Sudan, they conclude that the use of ICTs saves time and cost, to patients, their families and health care services and improving the quality of existing services, also it present equity in delivering of medical care, that is, patients in remote areas can get access to professional care at nearly the same time as their centrally located counterparts. And of course the second opinion and consultation improve the quality of care. This opens the chances for Continuous Education and Training for medical staff due to tele-education technologies. ICTs can be powerful tool in promoting health care services if it given the right polices organization, resources, and institutions. [2]

Also the newsletter talk about the initiatives in Sudan said that: in 2005, a Sudanese expert (Dr. Salah Mandil) made a proposal for a solution. Although there are several eHealth projects found to be running in parallel in evident, it lack from collaboration that leads to a waste of resources. [2]

Under the E-Government project, there are surveillance projects at the Epidemic unit (FMOH), human resources observatory database and eHealth projects. [2]

The challenge that faces the application of telemedicine system was found to be "the high turnover of cadre trained to operate the apparatus in the remote areas."[2]

Here are some of the words said by Dr. Salah Mandil regarding this issue "eHealth in the Sudan is a victim of unresolved managerial challenges and not technical ones." [2]

He also said "It took us many years, many proposed drafts and invitations to training courses, to convince the changing Sudan Ministry of Health officials to

demand WHO collaboration for the introduction and uses of eHealth in the Sudan health care services." [2]

Dr. Salah Mandil recommends the Ministry of Health to form the core of National Health Network, a National Health Care MIS, and a National Database of Electronic Medical Records, and if these become operational, then the introduction of National Telemedicine could begin. [2]

The doctor also sees that the limitation of resources (Financial one) led Decision Makers to go only for the installation of a Pilot National Telemedicine Network. Then the established Telemedicine Network linked the main hospital in AL-Damazeen, Kassala, Kosti, and Nyala with Khartoum Teaching Hospital. This network functioned smoothly and an actual links and tele-services and consultations were produced monthly. Unfortunately, the work slow down after about year because of staff workload and not rewarding for extra tele-services they were providing. Also this was "managerial" issue that has not been properly addressed. Latter this project was stopped. [2]

The newsletter also includes the proposed solution suggested by the Public Health Institute (PHI) which adopts the World Health Organization (WHO) speaks "the most favorable approach to the implementation of eHealth at the national level is to have a framework of strategic plans and policies which lay the foundation for development." [2]

They saw that strategic plans and policies should protect citizens, promote equity, observe cultural and linguistic issues in cyberspace, ensure interoperability and allow for capacity development so that all citizens can access eHealth solutions. [2]

The PHI also said that "The Government plays a major role in determining immediate national priorities while also working towards long-term development plan". It also stressed that design of a national policy to support the present strategy, directed towards developing eHealth in Sudan, and based on determined needs, with a sustained allocation of funds should be a main focus if the situation is to be improved. [2]

Finally, and as a conclusion, the newsletter writers stated that "The current eHealthcare system needs improved coordination and standardization, to reduce

fragmentation of care and system inefficiencies. Decision Makers are encouraged to make use of the available infrastructures and focus on providing managerial skills for personnel involved with eHealth projects. A National Policy should be designed based on strong evidence base and on scientifically defined needs. ” [2]

3.7.1 Telemedicine Infrastructure in Sudan:

Sudan has a good infrastructure and human resources regarding tele-communication. There are increase in the spreading of Information and Communication Technology (ICT) in Sudan. There is also increase in the use of ICT in Sudanese Universities. Almost all of the universities in Khartoum capital are connected to network. And of course of the computers in the universities, figure below show the rapid diffusion of ICT in Sudan. [22][23]

Also a lot of medical equipment are available that can be used in telemedicine. Almost all of the hospitals have computers along with its accessories. The staff in hospital is able to learn new technologies and use telemedicine and benefit from its advantages.

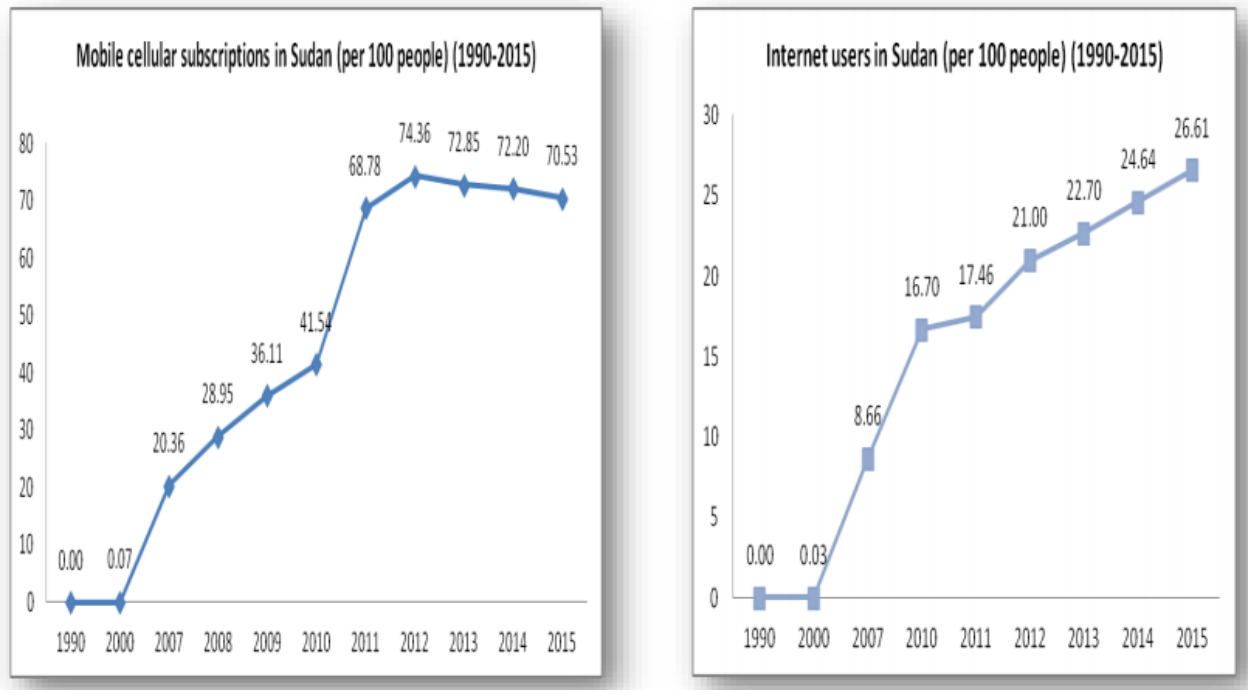


fig. 3.3 Rapid diffusion rate of ICT in Sudan [23]

CHAPTER FOUR

METHODS AND SYSTEM DESIGN

Chapter 4: METHODS AND SYSTEM DESIGN

4.1 Methodology:

In order to achieve the goals and objectives stated earlier in this research, clear steps were followed. First an appropriate database has been created using MySQL database with XAMPP open source webserver to convey the various types of data about patient, hospital, receptionist, physician, and specialists. Data about patient include: basic patient information (name, age, gender, etc.), medical data (previous diseases and medications and their insurance company, signs and symptoms and required laboratory and radiology tests and their results). Hospital information include: hospital name, where it is and their phone. Receptionist, physician and specialist data include basic information about them like name, age, address, the hospital they belongs to, etc. There were seven webpages designed to enter the various types of data about patients, their signs and symptoms, their required tests and their relevant results, physicians, specialist and pages to show the patient related information. These webpages were designed using HTML and CSS. A PHP code has been written to connect these webpages with the database to allow inserting the data into the database and also retrieving the necessary data from it. Then test data was used to test the system credibility and efficiency.

When the physician enters the full patient information, along with their report, they also send their name and phone number to enable consultation to take place between them and the specialist. To notify the specialist that a new patient is waiting for the consultation, an email message is sent from the physician.

Other programs, which were essential in order to complete this project, were used and it will be stated later in this chapter.

The suggested media selected for telemedicine was the implementation of the internet, but because it is very costly, a system was tested using two computers, one as a host server or hub, and the other as a peripheral that share the information with hub computer, this was done using Sudan University of Science and Technology's network as a bridge, using the IP of the hosting computer on another computer when both of them were connected to the internet.

4.2 Proposed System Block Diagram:

A block diagram was built to display the different steps of the research methodology.

The first block diagram show how the database was created. This block diagram shows that SQL programming language was used to make the structure of tables in the database, and then with the help of MySQL software application, the database was created.

Fig. 4.1 Database Design Process

Then a block diagram for the transmission site was built. A webpage for the patient admission was created, through which the basic patient information is to be acquired and inserted in the database. Then a physician webpage was created to enable them see the patient information, ask for the required tests, see the tests results and then write their report accordingly. And finally the overall information along with the physician report sent to the database and a notification email message is sent to the specialist alerting them that new patient is in the waiting list for consultation.

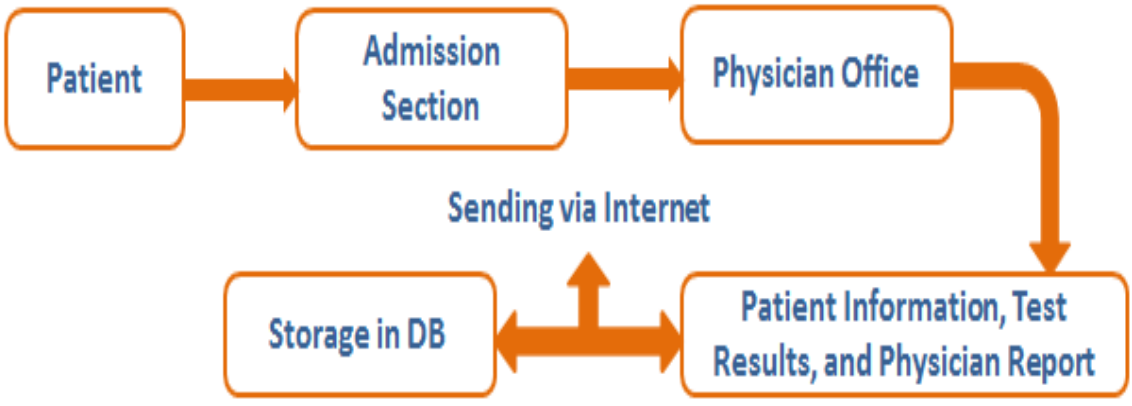


Fig. 4.2 Transmission Webpages of the System

Finally, a block diagram for the receiving site was built. After the specialist receive the message and the data from the sending site was sent, a webpage for the specialist was designed to enable them see the basic patient information, their required tests and their results, and the preliminary physician report about the patient case. If the sent data are not enough, a consultation can be take place between the physician and the specialist. Then the final report about the diagnosis and treatment of the patient case is written and sent back to the physician. A treatment plan can also be reported and sent back with the report. The transmission and receiving media is the internet using TCP/IP protocol.

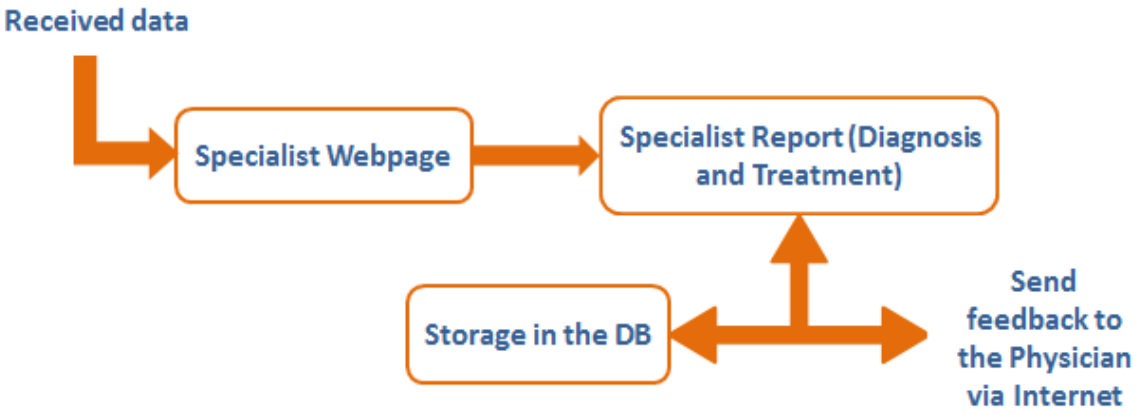


Fig. 4.3 Receiving Webpages of the System

After designing the system the mechanism of working will be like the figure below. The united database will be created. Then the receptionist through his webpage can capture all patient basic information and store it in the database. The physician then can retrieve this basic data from the database using his webpage, ask for the required tests, sees the tests results and write their initial patient's report and send all of this data to the database. The specialist then can retrieve all of the patient related information from the database using their website, look at it and write their final patient report (diagnosis and treatment plan). If the patient situation needs consultation, a conversation between the physician and the specialist can took place as the physician phone number is exist in the database.

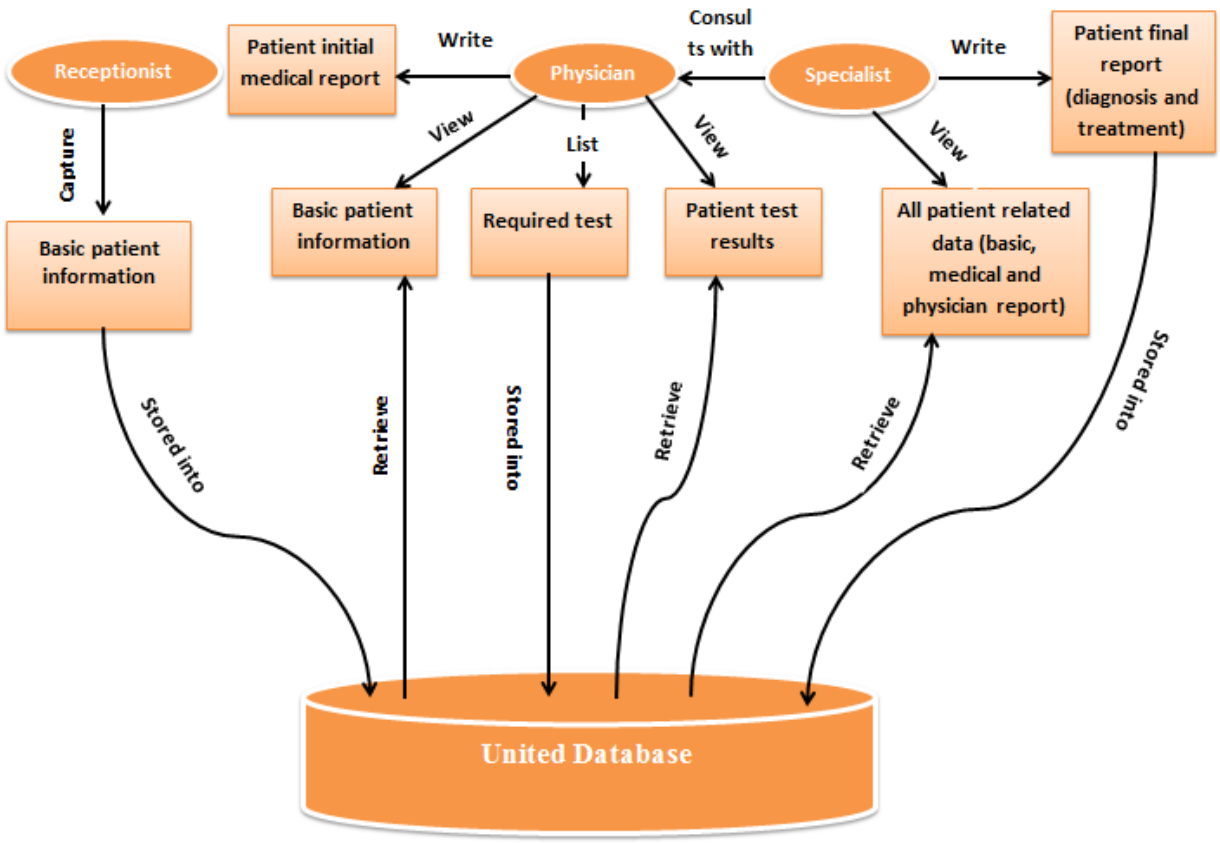


fig. 4.4 System Working Mechanism

4.3 Design and implantation:

This section includes the system design which is ordered as follows:

4.3.1 Patient Information:

First, a table has been created to convey the information about patients (Figure 4.5). This table name was patient table that includes the various fields needed to be known about the patient when they first come to admit to the hospital, like patient ID which is the primary key used for the patient table and then all of their information could be known using it and it is automatically incremented, date and time of admission which is needed to make the patient reservation, photo, hospital ID which is made to know where is this patient from, name, age which range from 1 to 16 as for pediatrics, gender, address, phone, religion, previous diseases and medications, and their insurance company. Then an HTML code with its related CSS style has been written to make a form as a webpage through which the patient information is filled by an authorized receptionist (Figure 4.6). Then a PHP script

was written to link the HTML form with the patient table in the database, this PHP script also insert the different data of the patient filled to the form into the patient table directly in the database. (Figure 4.7)

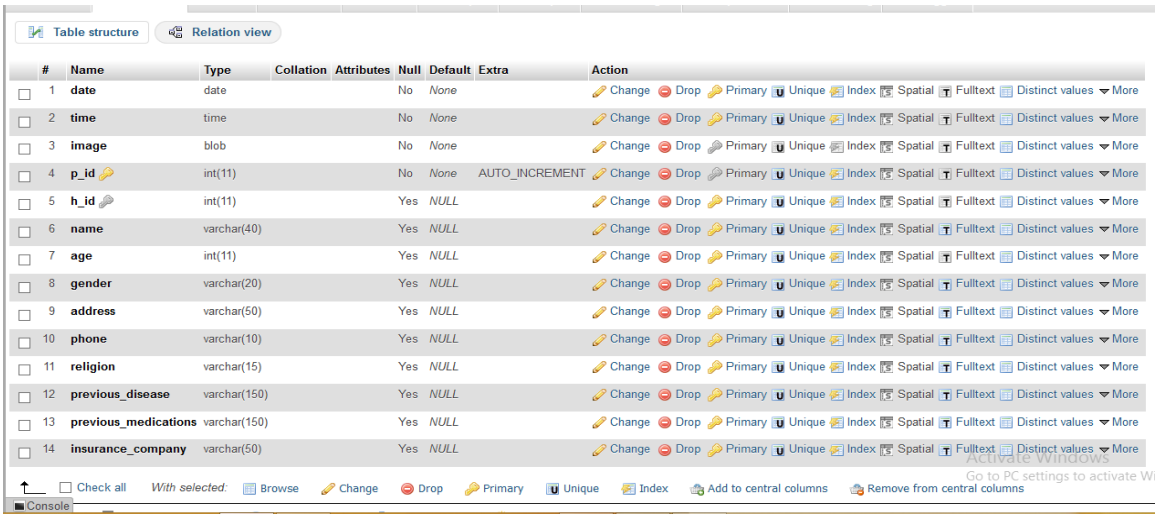


Table structure | Relation view

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	date	date			No	None		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
2	time	time			No	None		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
3	image	blob			No	None		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
4	p_id	int(11)			No	None	AUTO_INCREMENT	Change Drop Primary Unique Index Spatial Fulltext Distinct values More
5	h_id	int(11)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
6	name	varchar(40)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
7	age	int(11)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
8	gender	varchar(20)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
9	address	varchar(50)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
10	phone	varchar(10)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
11	religion	varchar(15)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
12	previous_disease	varchar(150)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
13	previous_medications	varchar(150)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values More
14	insurance_company	varchar(50)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values More

Check all | With selected: Browse Change Drop Primary Unique Index Add to central columns Remove from central columns

Console

Fig. 4.5 Patient Table

```
<div class="text">
    <div class="effects">
        <form action="patientinfo.php" method="POST" enctype="multipart/form-data">
            <input type="file" name="image"/><br />
            <label>Date</label></br>
            <input type="date" width="15"></br>
            <label>Time</label></br>
            <input type="time"></br>
            <label>H-id</label></br>
            <input type="int" name="id"></br>
            <label>Name</label></br>
            <input type="text" name="name"></br>
            <label>Age</label></br>
            <select name="age">
            <option>1</option>
            <option>2</option>
            <option>3</option>
            <option>4</option>
            <option>5</option>
            <option>6</option>
            <option>7</option>
            <option>8</option>
            <option>9</option>
            <option>10</option>
            <option>11</option>
            <option>12</option>
            <option>13</option>
            <option>14</option>
            <option>15</option>
            <option>16</option>
            </select>
            </br>
```

Fig. 4.6 HTML Code for the Patient Admission Webpage Design

```php
<?php

// connect to the database
$db = mysqli_connect('localhost', 'root', '', 'test3');

// insert patient data in the database(patient table)
if (isset($_POST['submit'])) {
  // receive all input values from the form
  $tmpname = addslashes(file_get_contents($_FILES['image']['tmp_name']));
  $id = mysqli_real_escape_string($db, $_POST['id']);
  $name = mysqli_real_escape_string($db, $_POST['name']);
  $age = mysqli_real_escape_string($db, $_POST['age']);
  $gender = mysqli_real_escape_string($db, $_POST['gender']);
  $address = mysqli_real_escape_string($db, $_POST['address']);
  $phone = mysqli_real_escape_string($db, $_POST['phone']);
  $religion = mysqli_real_escape_string($db, $_POST['religion']);
  $p_diseases = mysqli_real_escape_string($db, $_POST['pdisease']);
  $p_medications = mysqli_real_escape_string($db, $_POST['pmed']);
  $in_comp  = mysqli_real_escape_string($db, $_POST['In_company']);

```

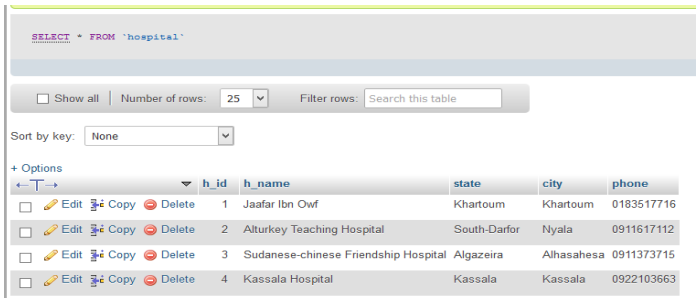
Fig. 4.7 PHP Script that Connect and Insert Patient Data in DB

4.3.2 Hospital:

A hospital table was created. This table holds basic information about the hospitals involved in the system whether it is a remote hospital, or a referral hospital. These information include the hospital ID, name, address (state and city), and phone. (Figure 4.8)

4.3.3 Users Registration:

Next, users table was created. This table was used to convey the basic information about the system users who are allowed to use the system Figure (4.9). Those uses are: Receptionist who fill the admission form for the patient, physician who determine the needed tests for the patient depending on their signs and symptoms and write a report about the patient case, specialist who diagnose the patient case and prescribe the suitable medications, this basic information include: user ID,



SELECT * FROM `hospital`

Show all | Number of rows: 25 Filter rows: Search this table

Sort by key: None

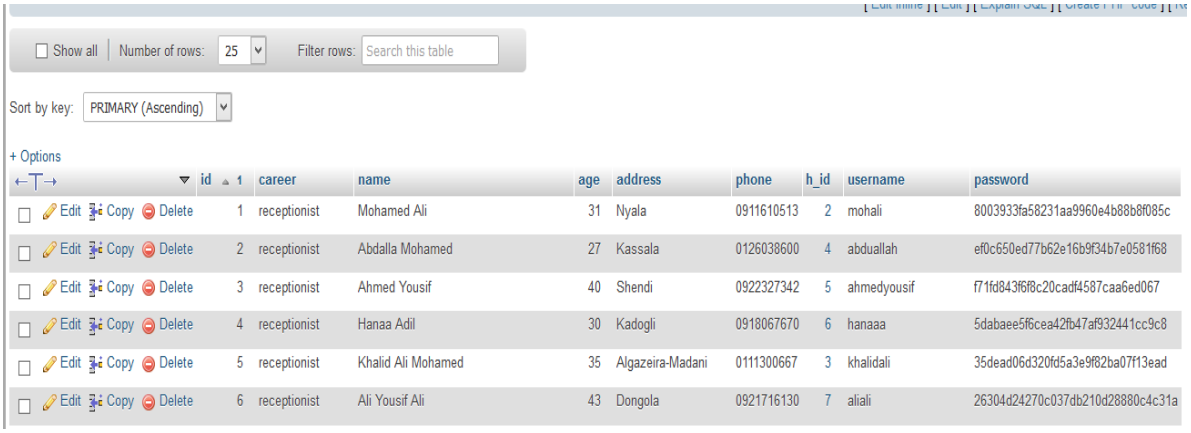
+ Options

	h_id	h_name	state	city	phone
Edit Copy Delete	1	Jaafar Ibn Owf	Khartoum	Khartoum	0183517716
Edit Copy Delete	2	Alturkey Teaching Hospital	South-Darfor	Nyala	0911617112
Edit Copy Delete	3	Sudanese-chinese Friendship Hospital	Algazeira	Alhasahesa	0911373715
Edit Copy Delete	4	Kassala Hospital	Kassala	Kassala	0922103663

Fig. 4.8 Hospital Table

career, name, age, address, phone, hospital ID, and a specified username and password. Then an HTML code with its related CSS style was written to design a webpage in order to enable those users to enter their basic data (Figure 4.10). This

code includes a way for input the data from users and then submitting these data in order to go further in the system. Then a PHP script was written to connect the HTML webpage with the users table in the database and insert these data in the users table then redirects the different users to the different webpages depending on their careers (receptionist, physician or specialist). (Figure 4.11)



Show all | Number of rows: 25 | Filter rows: Search this table

Sort by key: PRIMARY (Ascending)

+ Options

	id	career	name	age	address	phone	h_id	username	password
Edit Copy Delete	1	receptionist	Mohamed Ali	31	Nyala	0911610513	2	mohali	8003933fa58231aa9960e4b88b8f085c
Edit Copy Delete	2	receptionist	Abdalla Mohamed	27	Kassala	0126038600	4	abduallah	ef0c650ed77b62e16b9f34b7e0581f68
Edit Copy Delete	3	receptionist	Ahmed Yousif	40	Shendi	0922327342	5	ahmedyousif	f71fd843f6f8c20cadf4587caa6ed067
Edit Copy Delete	4	receptionist	Hanaa Adil	30	Kadogli	0918067670	6	hanaaa	5dabaee5f6cea42fb47af932441cc9c8
Edit Copy Delete	5	receptionist	Khalid Ali Mohamed	35	Algazeira-Madani	0111300667	3	khalidali	35dead06d320fd5a3e9f82ba07f13ead
Edit Copy Delete	6	receptionist	Ali Yousif Ali	43	Dongola	0921716130	7	aliali	26304d24270c037db210d28880c4c31a

Fig. 4.9 Users Table

```
<?php include('connect.php') ?>
<!DOCTYPE html>
<html>
<head>
    <title>Pediatric System</title>
    <link rel="stylesheet" type="text/css" href="register.css"/>
</head>

<body>
    <div class="header">
        <h1>Pediatric Telemedicine System</h1>
        <h4>Already a member? <a href="login.php">Sign in</a></h4>
        <h5><a href="system.php">Go to System Home page</a></h5>
    </div>

    <div class="container">
        <h3>Register Now</h3>

        <form method="POST" action="registeration.php">

            <div class="form_input">

                <label>Career</label>
                <input type="text" name="career" value="<?php echo $career; ?>">
                <label>Name</label>
                <input type="text" name="name" value="<?php echo $name; ?>">
                <label>Age</label>
                <input type="text" name="age" value="<?php echo $age; ?>">
                <label>Address</label>
                <input type="text" name="address" value="<?php echo $address; ?>">
                <label>Phone</label>
                <input type="text" name="phone" value="<?php echo $phone; ?>">
                <label>Hospital ID</label>
                <input type="text" name="hospital" value="<?php echo $hospital; ?>">
                <label>Username</label>
```

Fig. 4.10 HTML Code for Users Registration Webpage Design

4.3.4 User Login:

After the users had assign a specific username and a password from the registration form, they can just go to the login webpage which was written in HTML with

special CSS style in order the type just their valid username and password (Figure 4.11) to go through the system webpages, this webpage was linked to the database with the same PHP script for the registration (Figure 4.12). Receptionist can enter to the patient admission webpage, physician can go to see the patient information, know their signs and symptoms and write their reports, while specialist can come to see the whole patient information sent by the physician and then write their final report.

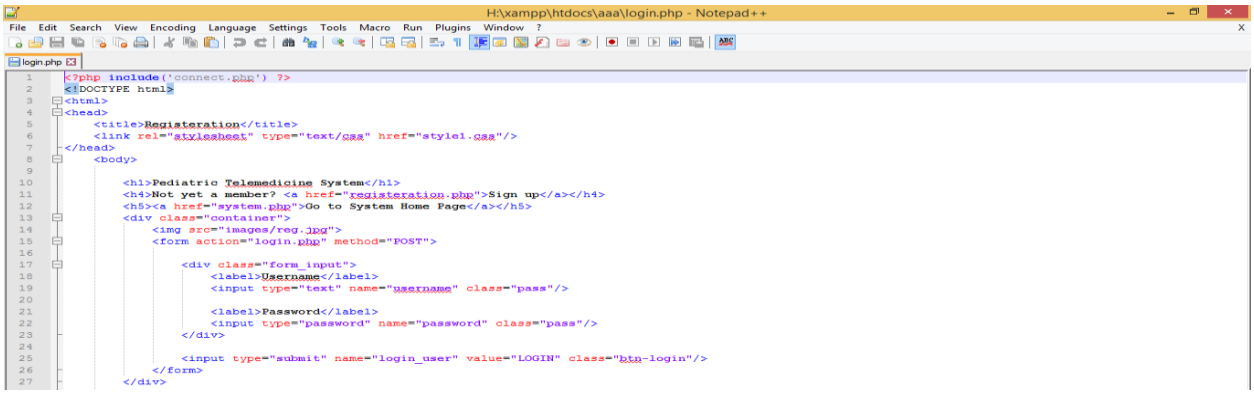


Fig. 4.11 HTML Code for User Login Webpage Design

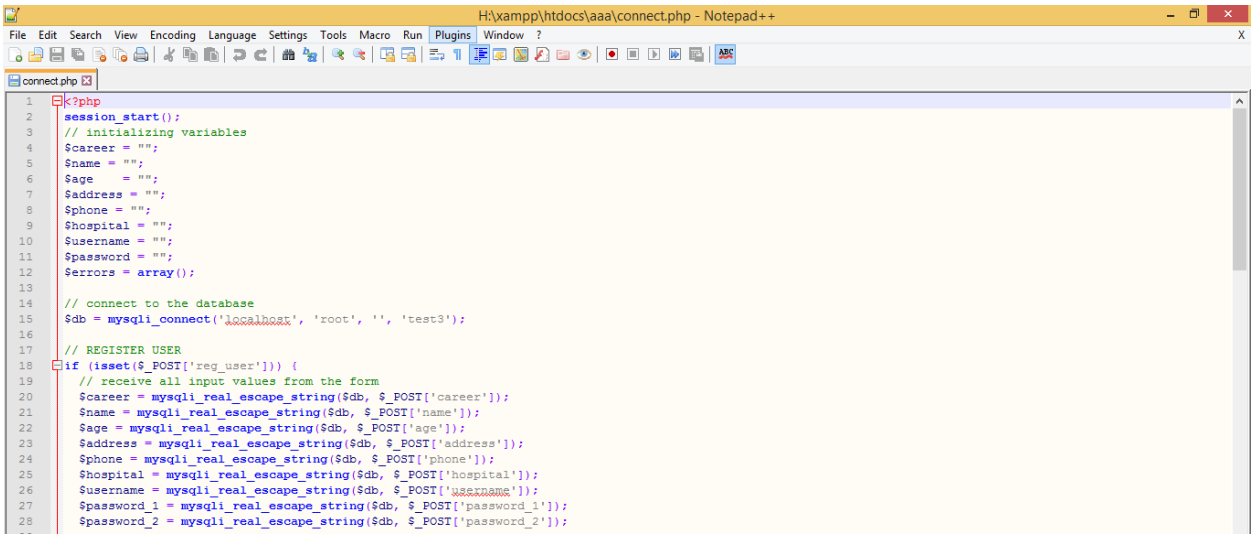


Fig. 4.12 PHP Script for both Registration and Login Webpages of User

4.3.5 Signs-Symptoms and required tests: (physician)

Then symptoms and required tests table was created. This table include important information about the signs and symptoms the patient suffer from and the laboratory and various tests requested by the physician from the patient to enable them make the diagnosis. During the creation of this table, factor like the unique

record from a unique physician to a unique patient is considered. This table includes the patient ID, physician ID, signs and symptoms of the patient, the laboratory tests, screening tests, radiological images, and electrical grams requested by the physician from the patient. (Figure 4.13)

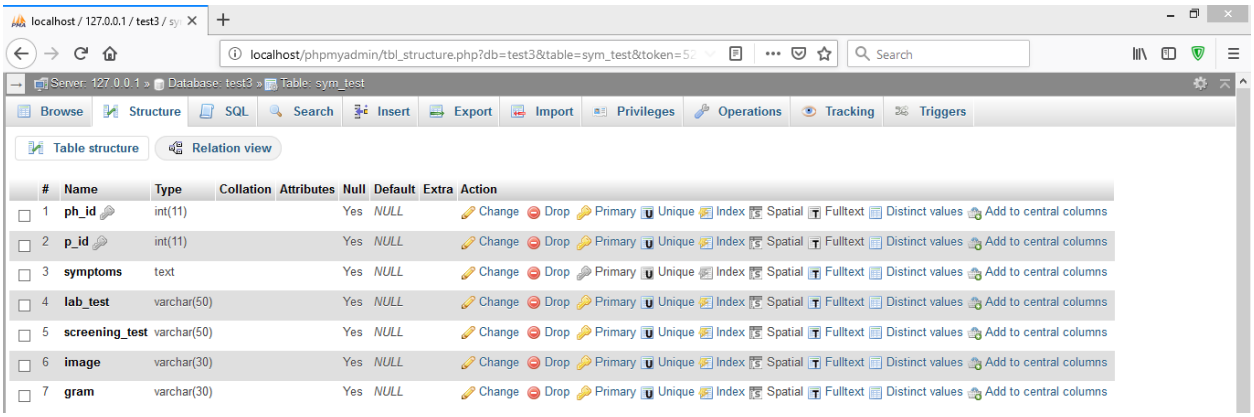


Fig. 4.13 Signs-Symptoms and Required Patient Tests Table

An HTML code with its related CSS style was written to design a webpage that let the physician to see the basic patient information entered from the admission section, note their signs and symptoms, determine which laboratory and other tests are required. (Figure 4.14)

```
<h1>Welcome Doctor</h1>
</div>
<div class="content1">
<h2>
<a href="selpatient.php">Patiet Information</a></br></br>
Ph_id: <br/><input type="text" name="phid" /><br />
P_id:  <br/><input type="text" name="pid" /> <br />
Signs and Symptoms:</br> <textarea name="symp" rows="7" cols="40"></textarea><br>
</h2>
</div>
<div class="content2">
<h2>
Laboratory Tests:</br>
<select name="tests" multiple="multiple">
<option>Blood</option>
<option>Urine</option>
</select></br>
Screening Tests:</br >
<select name="scrtests" multiple="multiple">
<option>Obesity</option>
<option>Diabetes</option>
<option>High cholesterol</option>
<option>Lead poisoning</option>
<option>Tuberculosis</option>
</select><br />
Images:</br>
```

Fig. 4.14 HTML Code for Physician Webpage Design

A PHP code was written to link this HTML webpage with the database. This code is to connect the database and insert the data there. (Figure 4.15)

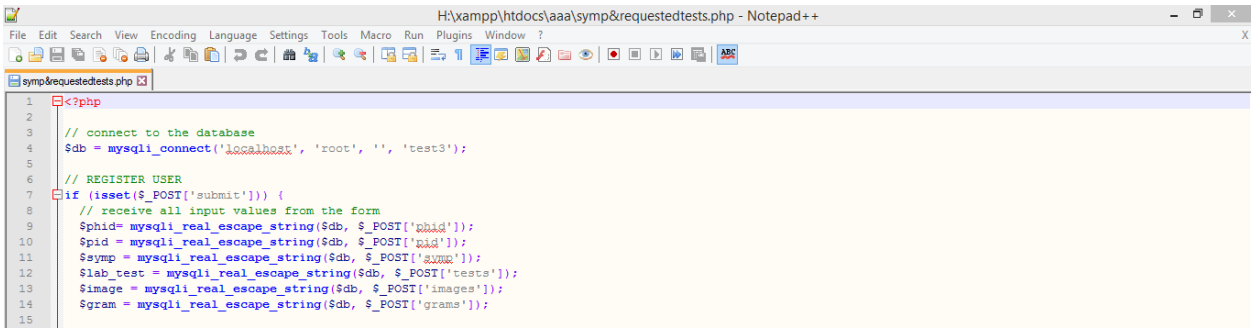


Fig. 4.15 PHP Code for Physician Webpage

Another physician webpage was designed to enable the physician to see the patient's test results, write their report about the patient case, and send an email to specialist when the patient information is sent. Finally enable them to see the report written by the specialist. (Figure 4.16)

Then a PHP script was written to connect this webpage with the database. First to enable the physician to see the patient's test result from the different departments, and then to insert the physician report in the reports table in the database, then enable them to see the specialist feedback report to make the final decision. (Figure 4.17)

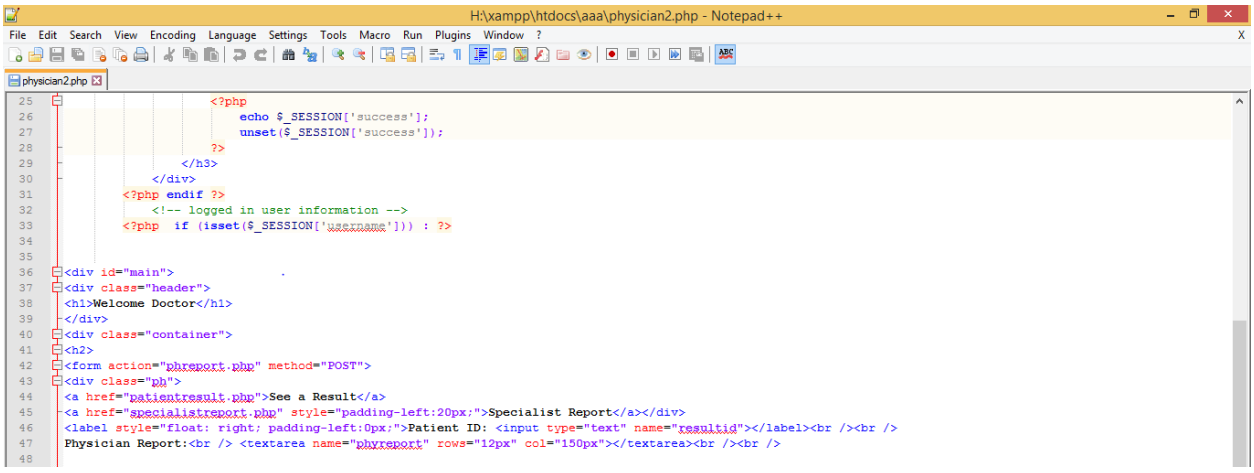


Fig. 4.16 HTML Code for the Second Physician Webpage Design

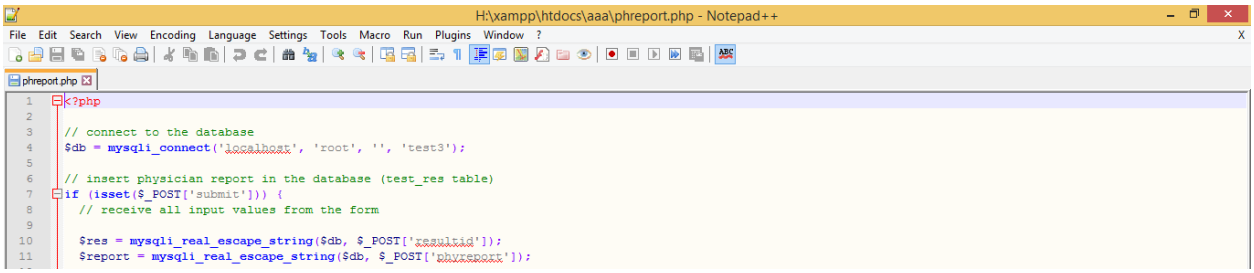


Fig. 4.17 PHP Code to Connect Second Physician Webpage with DB

4.3.6 Patient's Tests Results:

Then the tests results table which includes the results of the tests ordered by the physician was created. This table has no special webpage to insert the data from it to. This is out of the scope of the project. Instead the data is stored in the database as images and then when required by the physician, it can be retrieved from the database. (Figure 4.18)

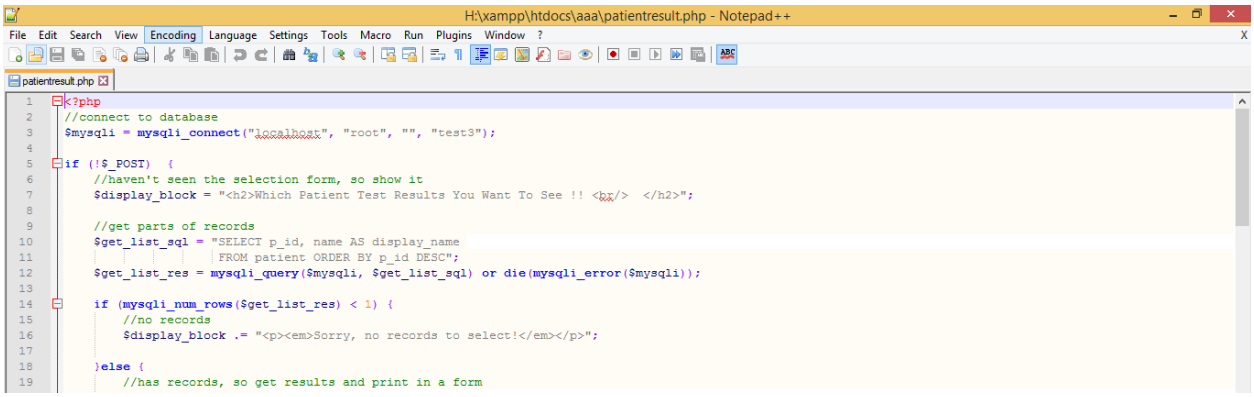


Fig. 4.18 PHP Code for Displaying the Patient's Test Results

4.3.7 Sending Email Message to Specialist:

When the physician wrote their report, all of the patient's data will be sent to the specialist, and an email message is sent to them. This message is written by the physician to notify them that there are a new patient who is waiting for their opinion about their case, and that there is a physician who need consultations A form was created that include the name, phone number, and the message to be sent. An HTML code with its related CSS style was written (Figure 4.19). Then a PHP script was written to connect the form with the database and send the message to the specified specialist. (Figure 4.20)

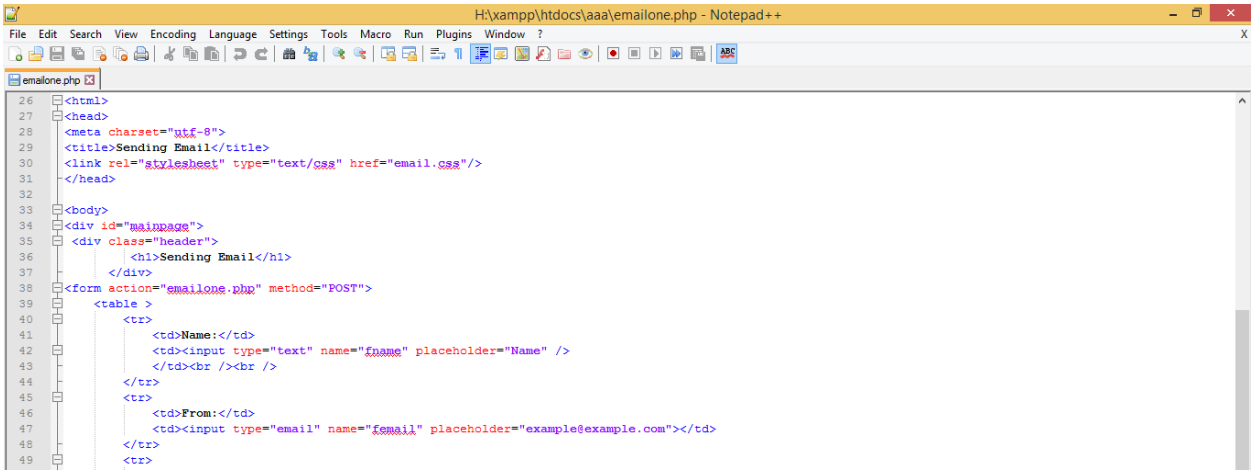


Fig. 4.19 HTML Code for the Email Message Webpage

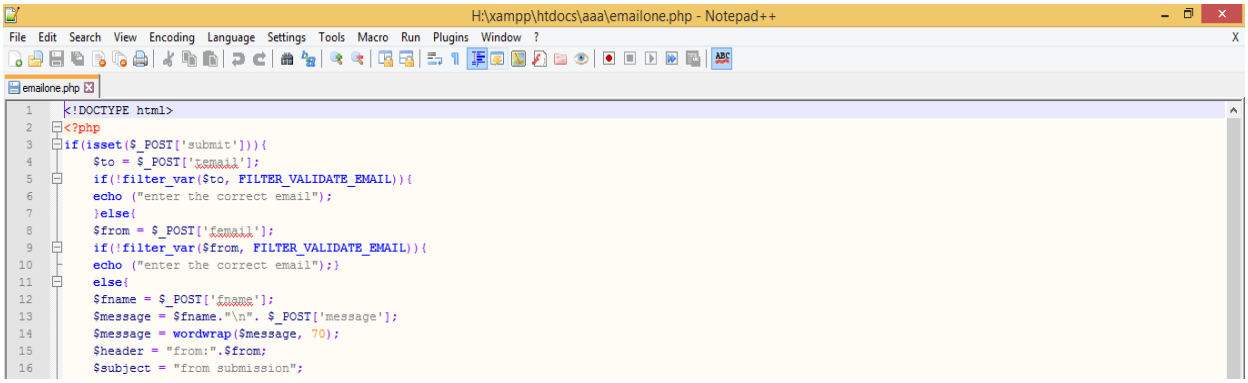


Fig. 4.20 PHP Code for sending the Message Form to the physician

4.3.8 Specialist's Site:

First, a specialist webpage was designed to enable them to see the full patient information (basic information, patient's test results, and the physician report). This is done using HTML and CSS style. (Figure 4.21)

```
<div id="mainpage">

<div id="main">

<div class="header">
<h1>Welcome Pediatrician</h1>
</div>
<form action="specreport.php" method="POST">
<div class="content">
<h2>
<div class="ph">
<a href="phyinfo.php">Physician Information</a></div>
<label>Patient ID: <input type="text" name="pid"></label><br />
<p><strong>Specialist Report</strong><textarea name="sreport" rows="9" cols="40"></textarea></p>
<input type="submit" name="submit" value="send feedback" class="btn-login">
<input type="reset" value="reset" class="btn-login">
<a href="admit.php?logout='1'">logout?</a></div>
</h2>
</div>
<?php endif ?>
```

Fig. 4.21 HTML code for Specialist Webpage Design

To enable the specialist to see the patient information, a PHP code was written. Figure (4.22)

```
H:\xampp\htdocs\aaa\phyinfo.php - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
phyinfo.php
<?php
//connect to database
$mysqli = mysqli_connect("localhost", "root", "", "test3");

if (!$_POST)  {
    //haven't seen the selection form, so show it
    $display_block = "<h2>Which Patient Documents You Want To See !! <br/>  </h2>";

    //get parts of records
    $get_list_sql = "SELECT p_id, name AS display_name
                     FROM patient ORDER BY p_id DESC";
    $get_list_res = mysqli_query($mysqli, $get_list_sql) or die(mysqli_error($mysqli));

    if (mysqli_num_rows($get_list_res) < 1) {
        //no records
        $display_block .= "<p><em>Sorry, no records to select!</em></p>";
```

Fig. 4.22 PHP Code to enable the Specialist to see full Patient Information

Then a report table (which includes the report written by the physician and specialist in addition to the patient ID) was created and then linked with the PHP code with the specialist webpage. (Figure 4.23)

Table structure Relation view

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	rep_id	int(11)			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values Add to central columns
2	ph_report	text			Yes	NULL		Change Drop Primary Unique Index Spatial Fulltext Distinct values Add to central columns

Check all With selected: Browse Change Drop Primary Unique Index Add to central columns Remove from central columns

Print view Propose table structure Track table Move columns Improve table structure

Fig. 4.23 Specialist Report Table in the DB

A waiting list was designed to display which patient is on waiting. This list displays the last five entered patient to enable the receptionist to know instantly which patient will enter the doctor office next. Once a new patient entered; automatically the fifth one is disappear from the list.

XAMPP, which is a free and open-source cross-platform web server solution stack package developed by Apache Friends consisting mainly of the Apache HTTP Server, Maria DB database, and interpreters for scripts written in the PHP and Perl programming languages, was used as a web server. It was used to develop the database, store, and select the different information stated earlier. XAMPP has been chosen because it the most known server in my country and it is easy to understand and use. First, MySQL environment was chosen, but it is locked here in my country.

Notepad++, which is a text editor and source code editor for use with Microsoft Windows program, was used to write the HTML, CSS, and PHP codes. It was preferred because it loads much faster than other editing programs text like sublime and can be edited quickly; also it can handle huge files, and the fact that it is free making it my favorite.

Firefox has been used as a web browser in order to test and visualize my webpages. It had been preferred because it takes small RAM space when working not like chrome and other web browsers.

The most important fact about this system that supports it is usefulness and usability that this system was designed in both Arabic and English languages. For Arabic language some function are added the HTML code, and PHP scripts. Designing the system in Arabic language is very important because it is our native language that we can understand and deal with. So this feature strengthens this project by making it capable of use in any local hospital settings and any of other countries that their native language is Arabic. The design in English is for internationality. With this feature this system can be used in the international scale in the developing countries.

CHAPTER FIVE

RESULTS AND DISCUSSIONS

Chapter 5: RESULTS AND DISCUSSIONS

5.1 Results:

Following the methodology for the system design discussed in the previous chapter, English webpages and another Arabic webpages were designed.

5.1.1 English Webpages:

These webpages allow the user to go through different system webpages in English language.

5.1.1.1 System Webpage:

This webpage represent basic information about the system. It contains the project name, and an icon that let the visitor see Arabic version from the system. Then there is the main menu which includes:

1. Home icon: when clicking on this icon, it directs us to general information about telemedicine, how to make the connection between the transmitting and receiving sites, the different types of telemedicine where it is real-time, or store and forward, and how to make consultation between the two sites of the connection.
2. User's icon: this icon is a dropdown list that represents the different types of the system user (Receptionist, Physician, or specialist). By clicking on any of the list item it redirect the user to the user registration webpage in order to enter their own basic information to be a valid system user.
3. About us icon: this icon redirects the system visitor to a clear definition about the system designers, the reasons why this system was created and what services this system can provide.
4. Contact icon: this icon redirects the visitor to the SUSTTECH webpage, which is a webpage related to Sudan University of Science and Technology as a reference for this system till the submission of this thesis.
5. Help icon: by clicking this icon, the visitor can know what are the server and technical problems that they can faces, and how they can fixes them by themselves or contacts the system designer for help.

Also the webpage contains a brief definition about the system and a copyright section. The figures below show the system webpage and the user's dropdown menu screenshots that was designed. (Figures 5.1, 5.2)

Fig. 5.1 System Webpage

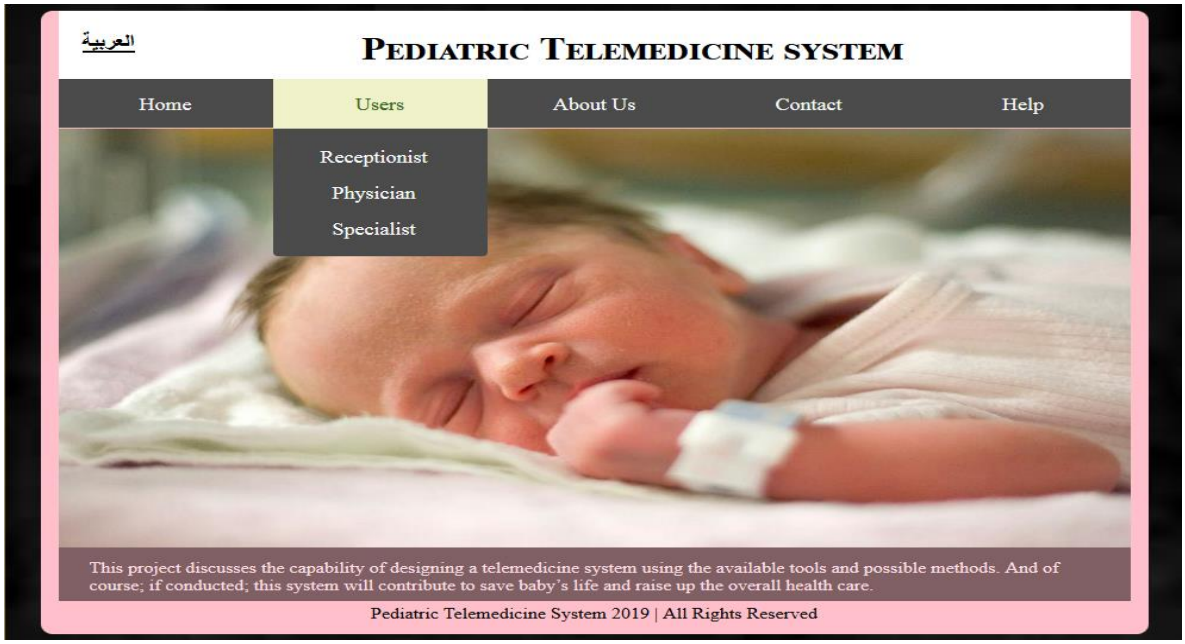


Fig. 5.2 System Webpage with the Dropdown Menu for Different Users

5.1.1.2 User Registration Webpage:

This webpage was designed to enable the user to enter their basic information and make an account in order to be an authorized user. (Figure 5.3)

From this webpage the user can go back to the system webpage by clicking the link in the upper left corner. If the user is a new member, they must register their information first, otherwise, they can just sign in by clicking the link located in the upper right corner. This link redirects the user to the login webpage which will be discussed later.

Fig. 5.3 User Registration Webpage

This webpage allow the user to enter their career (receptionist, physician, or specialist), name, age, address, valid phone number, the ID the hospital they belongs to, then they must a usernae and a password that they can remember. By pressing the login button these entered data are directly stored in the database in the user table, and at the same time, and according to the specified career, the user is redirected to the approperiate webpage. The receptionist will be directed to patient admission webpage, the physician to the physician's webpage and the specialist to the specialist's webpage. This details about this process will be discussed later. The reset button is used for reetting the input fields for correction.

5.1.1.3 User Login Webpage:

This webpage allow the user who had already registered to the system before to just enter their valid username and password to go throgh the system. If the user is redirected to this webpage without registeration, they can just click the link located on the upper right corner to go back to user registeration webpage. The user can also use the upper left corner's link to go back to the system webpage. (Figure 4.5)

Fig. 5.4 User Login Webpage

5.1.1.4 Patient Admmission (Registeration):

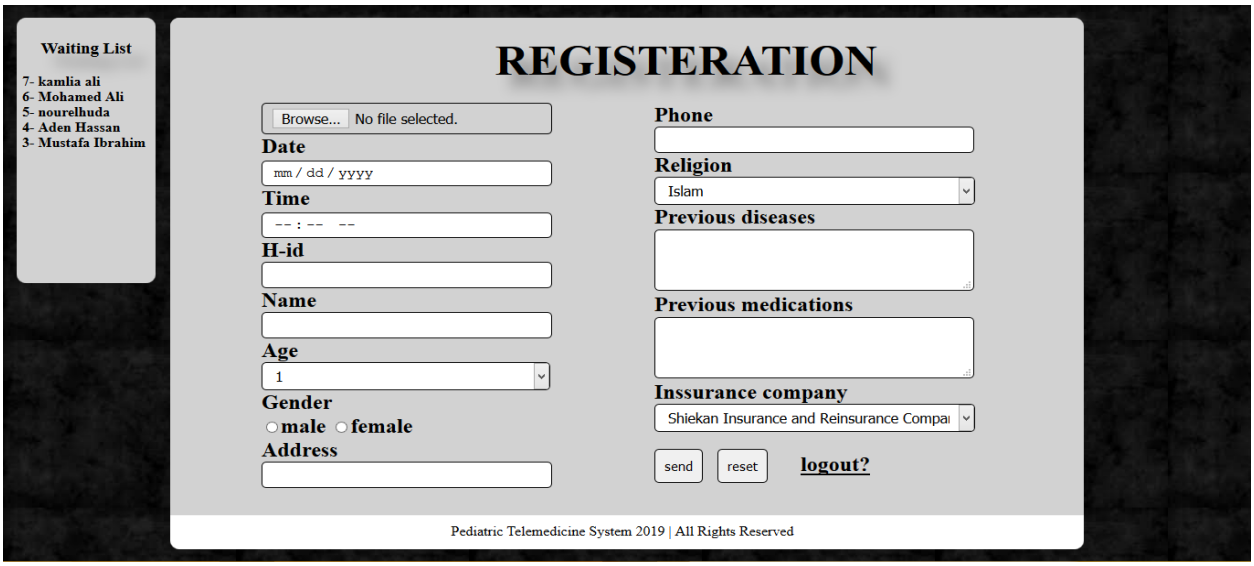


Fig. 5.5 Patient Admission (Registration) Webpage

If an authorized receptionist had login to the system, they will be redirected to this page. (Figure 5.5) The receptionist is responsible for entering all of the patient relevant information. First they must capture the patient's photo, then they can import it to the admission webpage by clicking the browse button, select the photo and press the Enter key. The date and time will be automatically setted to the current date and time and they need not to be entered. Then the receptionit need to enter the hospital id, patient's name, age, gender, address, phone, religion, previous diseases and medication, and the inssurance company that the patients belongs to. If the receptionist need to correct most of the data they enter, they can just click the reset button. By clicking the send button and after filling all of the fields, the patient data will bee send to the database and stored there for future use. If the receptionist finish their work, they can logout from the syatem by clicking the logout link at the end of the page, they will be redirected the user login webpage discussed eaarlier.a waitng list represnting which patient is next to see the doctor is displayed on the left.

5.1.1.5 Physician Webpages:

For an authorized physician who login to the system, the webpage redirection will be towards this page (Figure 5.6). From this page, they can come to look at the basic patient information entered from the admission section just by clicking the patient information link located at the top left corner of the webpage. The webpage in figure **5.7** will appear. The physician need to select the ID of the upcoming patient to know their full information. This ID is ordered descending, that is, the last patient entered will be the first one appear. As stated earlier in the methodology chapter, it is important to know which physician order which tests to which patient. So the physician ID as well as the Patient ID are required fields in this page.

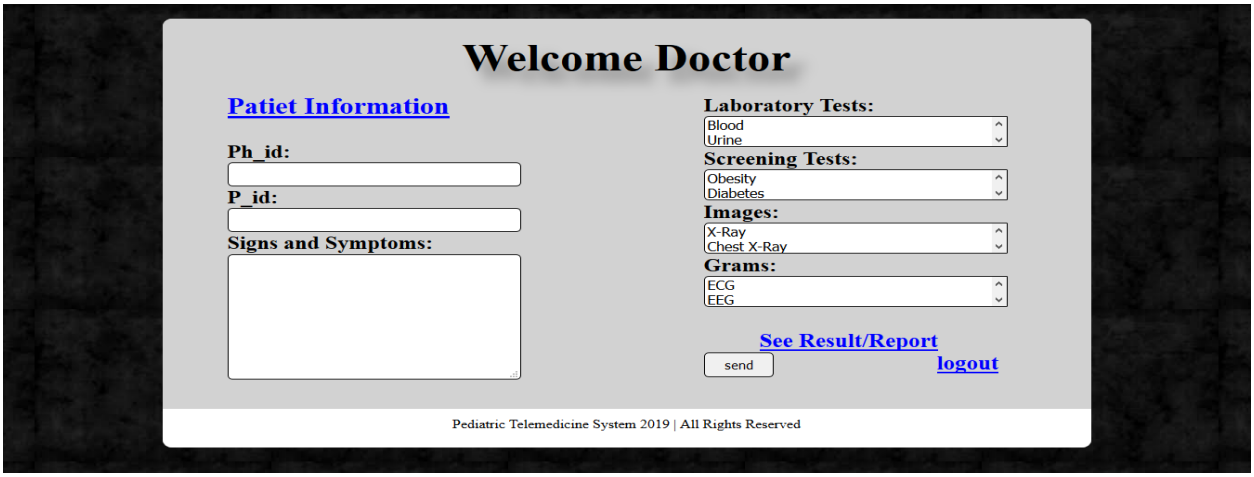


Fig. 5.6 First Physician Webpage

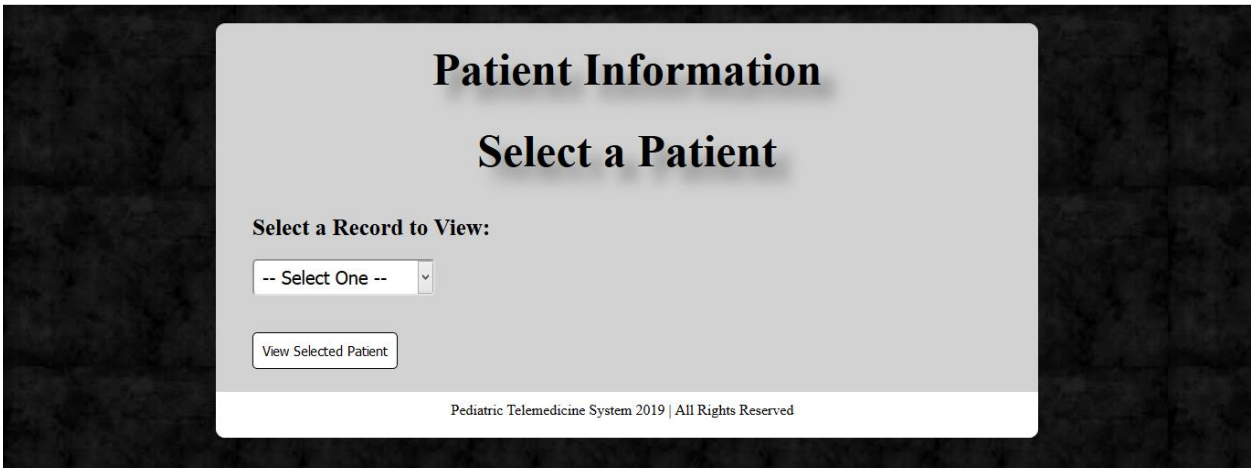


Fig. 5.7 Displaying Basic Patient's Information Displayed to Physician

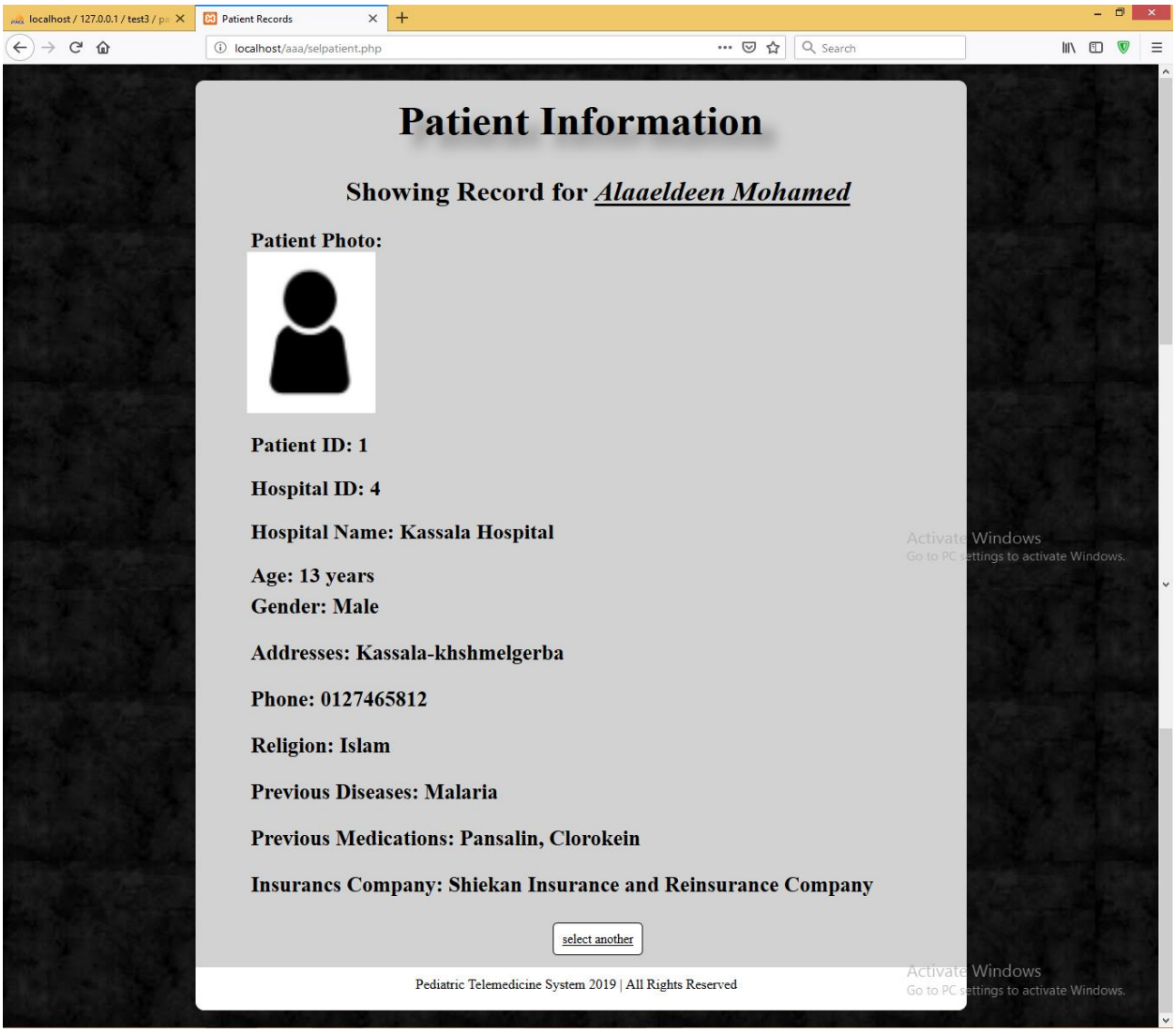


Fig. 5.8 Example of Basic Patient Information Appear by Selecting the Patient ID

In order to diagnose the patient situation, their signes and symptoms, laboratory, screening, radioloical, and electrical grams tests are required to be ordered by the pysician. By clicking the send button, all of the entered data will be stored in the database. For looking at the patient's tests results, or the specialist feed back report, the physician need to click on the see result/report link in the button at the center of the left side of of the physician webpage. The physician will be redirected to the physician's second webpage shown in figure **5.9** below. They can then logout using the logout link at the bottom right corner

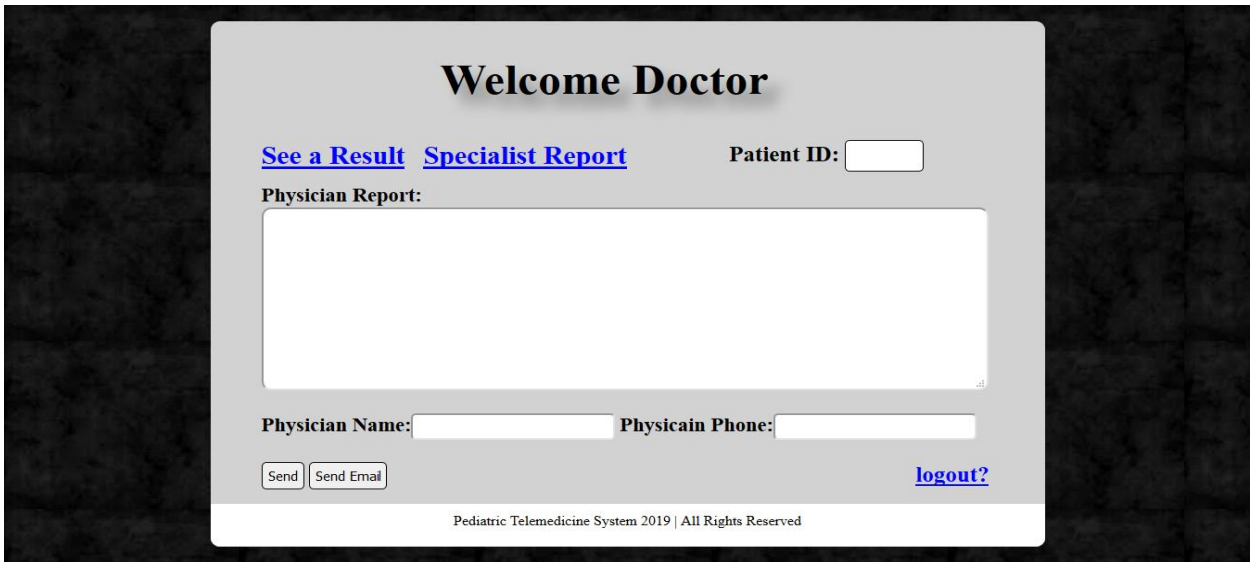


Fig. 5.9 Second Physician Webpage

This second physician's webpage allow them to look to patient's result by clicking the see a result link in the top left corner of the webpage. By clicking this link, physician will be redirected to the patient's results webpage (Figure 5.10). The physician need to select which patient's test results they want to see by determinig a spesific patient ID and click view selected results button.

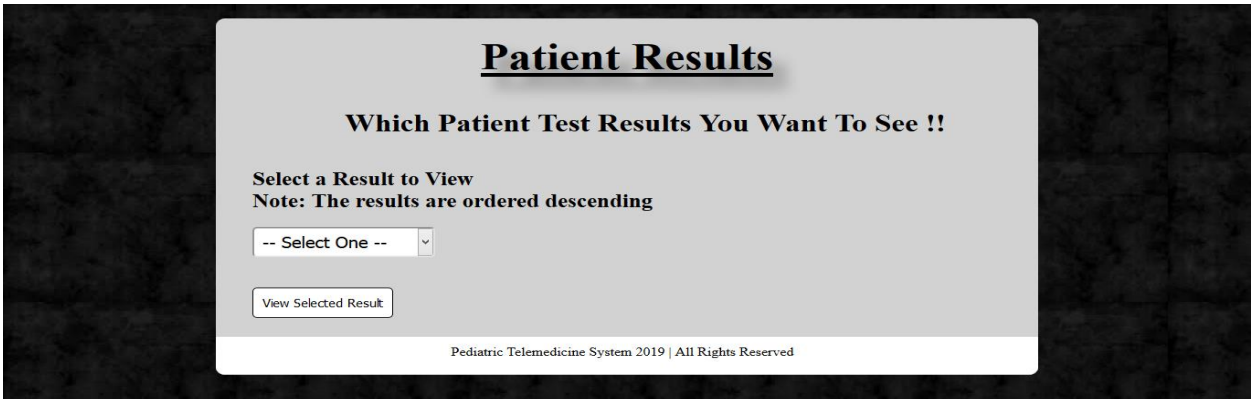


Fig. 5.10 Displaying Patient Results

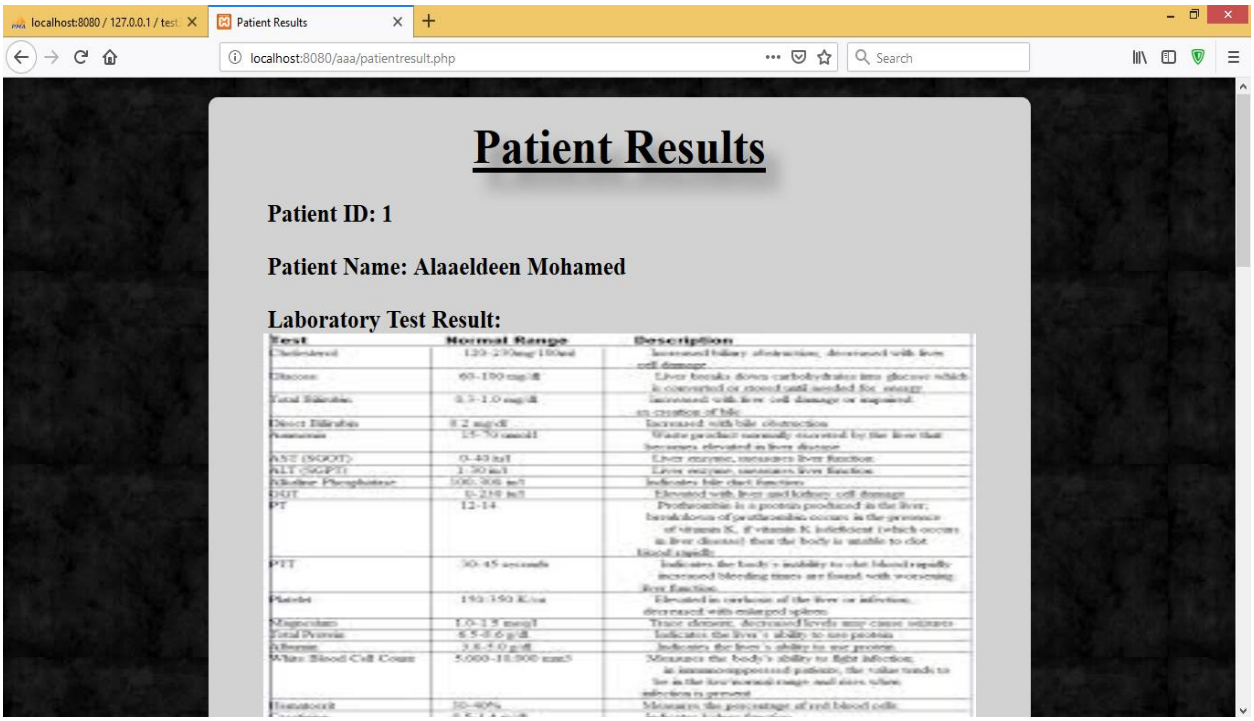


Fig. 5.11 Patient's Results Displayed to the Physician

After looking at the tests results of the patient (Figure 5.11), the physician need to write their own report about the patient status. By clicking the send button, all the data will be stored in the database. Then an email message containing the ID of the patient who we need to consult about their status is send to the specialist.

5.1.1.6 Sending Email Message Webpage:

The section was built to send an email to specialist when all of the patient's related data (basic information, medical history, requested tests and their results, and the physician report) are ready to sent. And the physician at the sending site is ready to make consultation with the specialist about the patient status.

This form (Figure 5.12) is filled by the physician, and sent.

Fig. 5.12 Sending SMS to Specialist by the Physician

All of the above webpages are considered as the transmitting site of the system.

5.1.1.7 Specialit Webpage:

Fig. 5.13 Specialist webpage

If the user login to the system as a specialist, then they will be redirested to this webpage (Figure 5.13).This webpage is considered the receiving site of the system. First the specialist can look at the full information about the patient by clicking the link in upper left corner. The below figure show the webpage that will appear (Figure 5.14).

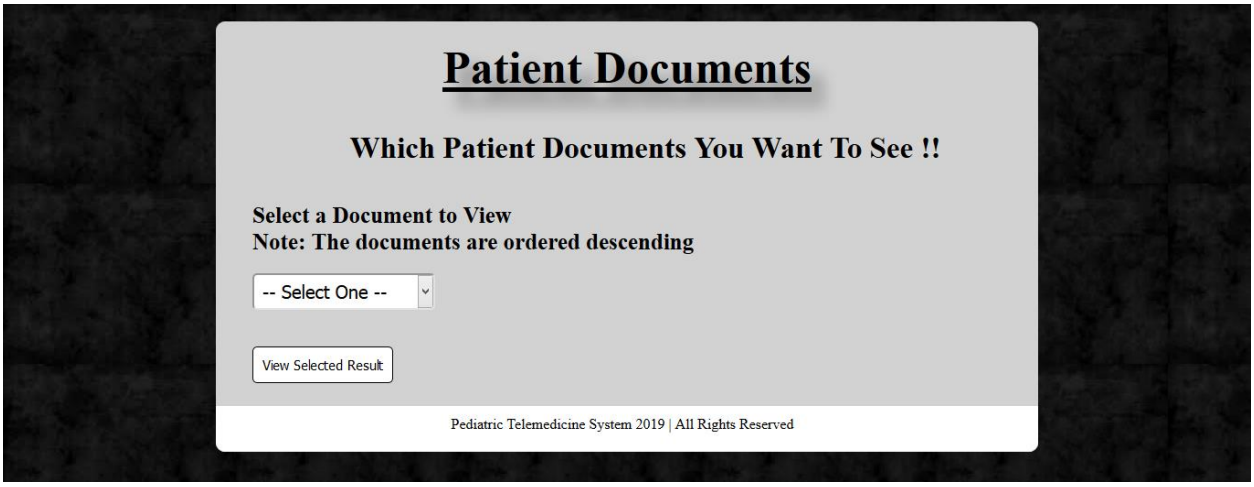


Fig. 5.14 Displaying the Overall Information of the Patient Transmitted by the Physician

Then the specialist need to select spesific patient ID to view the patient documents. This ID is in the message that the receptionist receives. The example of the selected ducuments appearance is in figure **5.15** below.

Depending on the information sent from the physician, a consultation between the physician and the specialist can take place. The physician when write their reports, at the end they must wrote their name and phone number to get contact with.

Finally the specialist can write their report about the case from the specialist webpage. And send it back to the physician. This report may be the diagnosis of the patient case, or a helping guide for the physician to assign the correct diagnosis and tratment plan for the patient.

The physician can see thee feedback report that was written by the specialist from a link in physician webpage appear in figure **5.9**. by clicking this link, the webpage in figure **5.16** will appear. Selecting the ID of the patient, physician can see the specialist report.

Figure **5.17** show an example of the reports that can be sent back by the specialist and their appearance.

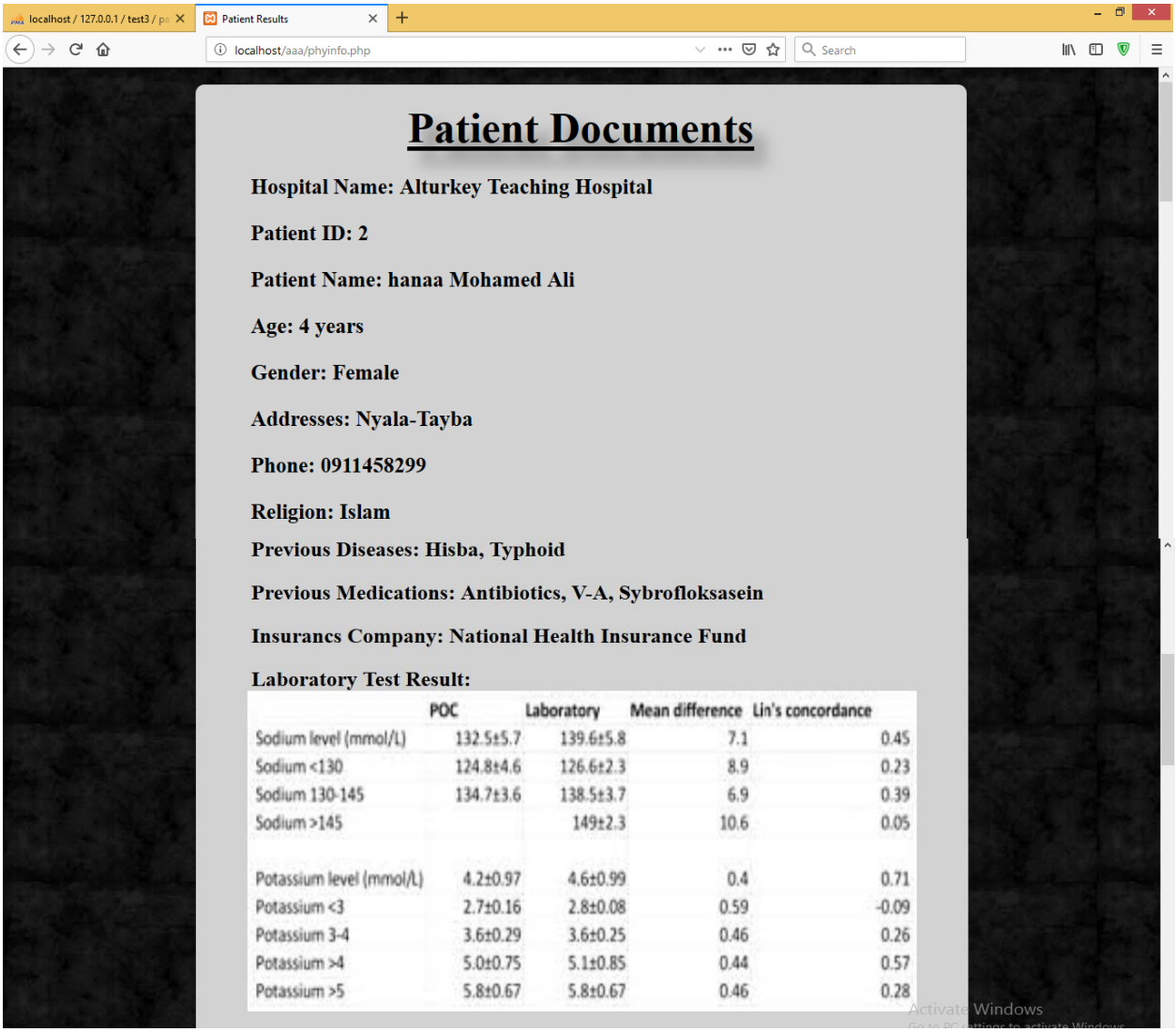


Fig. 5.15 Patient's Documents Appear to the Specialist After Selecting Patient's ID

Fig. 5.16 Specialist Report Webpage

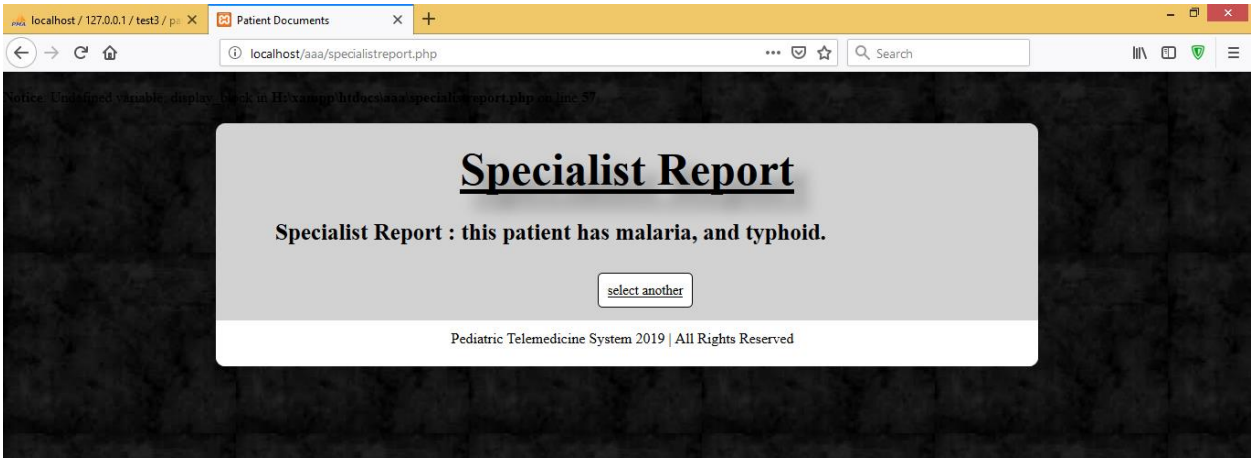


Fig. 5.17 Example of the Specialist Report Appear to the Physician

5.1.2 Arabic Webpages:

The English webpages discussed earlier in this chapter was translated into Arabic language. The same explanation is applicable here. So the following figures show the system in arabic language.

5.1.2.1 System Webpage:

Fig. 5.18 System Webpage

The system with the dropdown list of the users is shown in the following figure.

Fig. 5.19 System Webpage with the Dropdown Menu for Different User

5.1.2.2 User Registration Webpage:

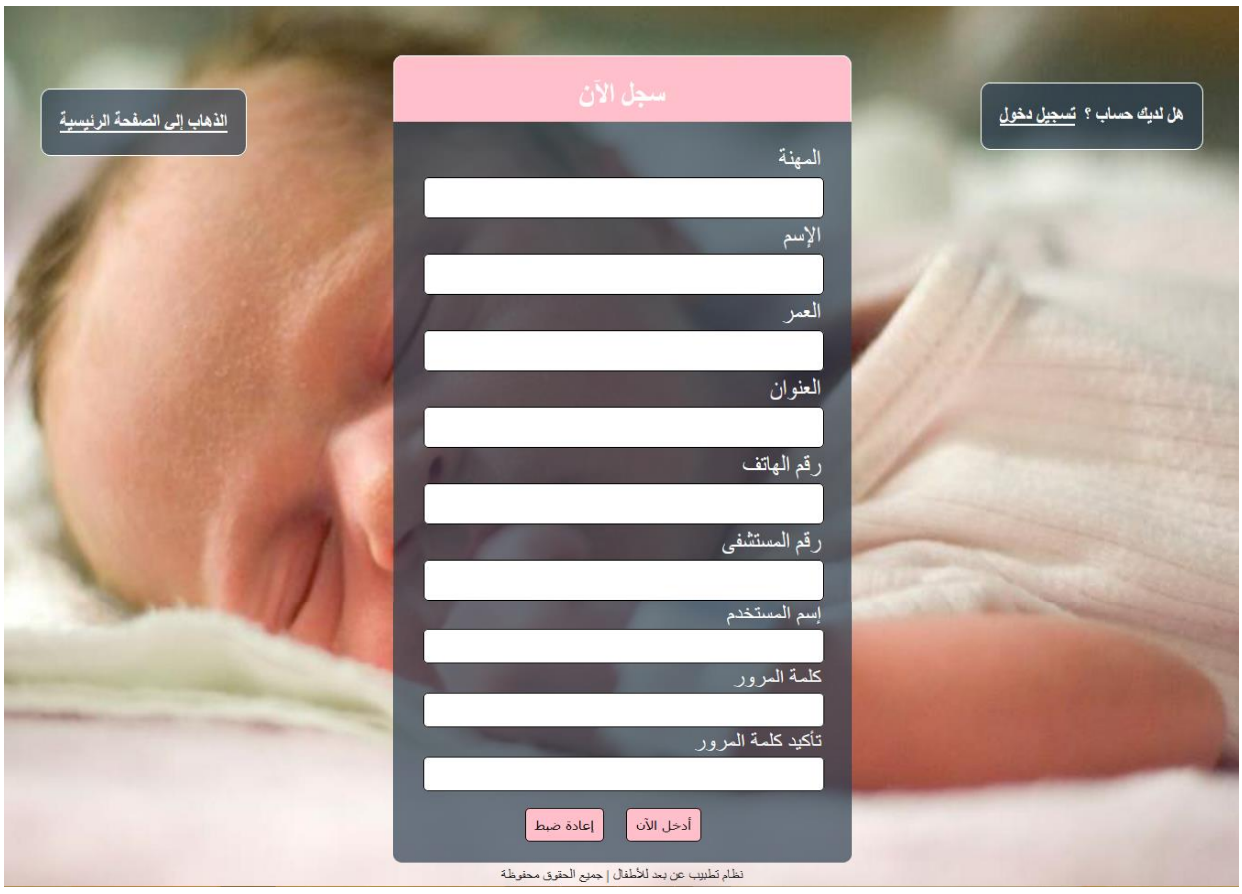


Fig. 5.20 User Registration Webpage

5.1.2.3 User Login Webpage:

Fig. 5.21 User Login Webpage

5.1.2.4 Patient Admission (Registeration):

Fig. 5.22 Patient Admission (Registration) Webpage

5.1.2.5 Physician Webpages:

Fig. 5.23 First Physician Webpage

Fig. 5.24 Displaying Basic Patient's Information

Fig. 5.25 Example of the Basic Patient Information

Fig. 5.26 Second Physician Webpage

Fig. 5.27 Displaying Patient Results

Fig. 5.28 Example of Tests Results appears to the Physician

5.1.2.6 Sending Email Message Webpage:

Fig. 5.29 Sending Email Message to Specialist by the Physician

5.1.2.7 Specialist Webpage:

Fig. 5.30 Specialist Webpage

Fig. 5.31 Displaying the Overall Information of the Patient Transmitted by the Physician

Characteristics	Total, n (%)	Medical, n (%)	Surgical, n (%)
Cultures obtained			
None	12 (31)	12 (31)	0 (0)
Sputum	13 (33)	13 (33)	0 (0)
BAL	6 (15)	5 (13)	1 (3)
Drainage	5 (13)	0 (0)	1 (3)
Chest tube	2 (5)	0 (0)	2 (5)
Blood	1 (3)	0 (0)	1 (3)
Diagnostic imaging			
Chest X-ray	4 (10)	3 (75)	1 (25)
CT	34 (87)	26 (76)	8 (24)
Chest US	1 (3)	1 (100)	0 (0)
Microbiology results			
Staphylococcus	5 (13)	4 (80)	1 (20)
MSSA	3 (60)	2 (66)	1 (33)
MRSA	2 (40)	2 (100)	0 (0)
Streptococcus	2 (5)	1 (50)	1 (50)
Peptostreptococcus	1 (3)	0 (0)	1 (100)
Fusobacterium	1 (3)	0 (0)	1 (100)
Polymicrobial	4 (10)	1 (25)	3 (75)
None identified	26 (67)	24 (92)	2 (8)

MSSA = Methicillin-sensitive Staphylococcus aureus; MRSA = Methicillin-resistant Staphylococcus aureus; CT = Computed tomography; BAL = Bronchial alveolar lavage; US = Ultrasound

Fig. 5.32 Example of the Patient Documents appears to Specialist

Fig. 5.33 Displaying the Feedback (Report) of the Specialist

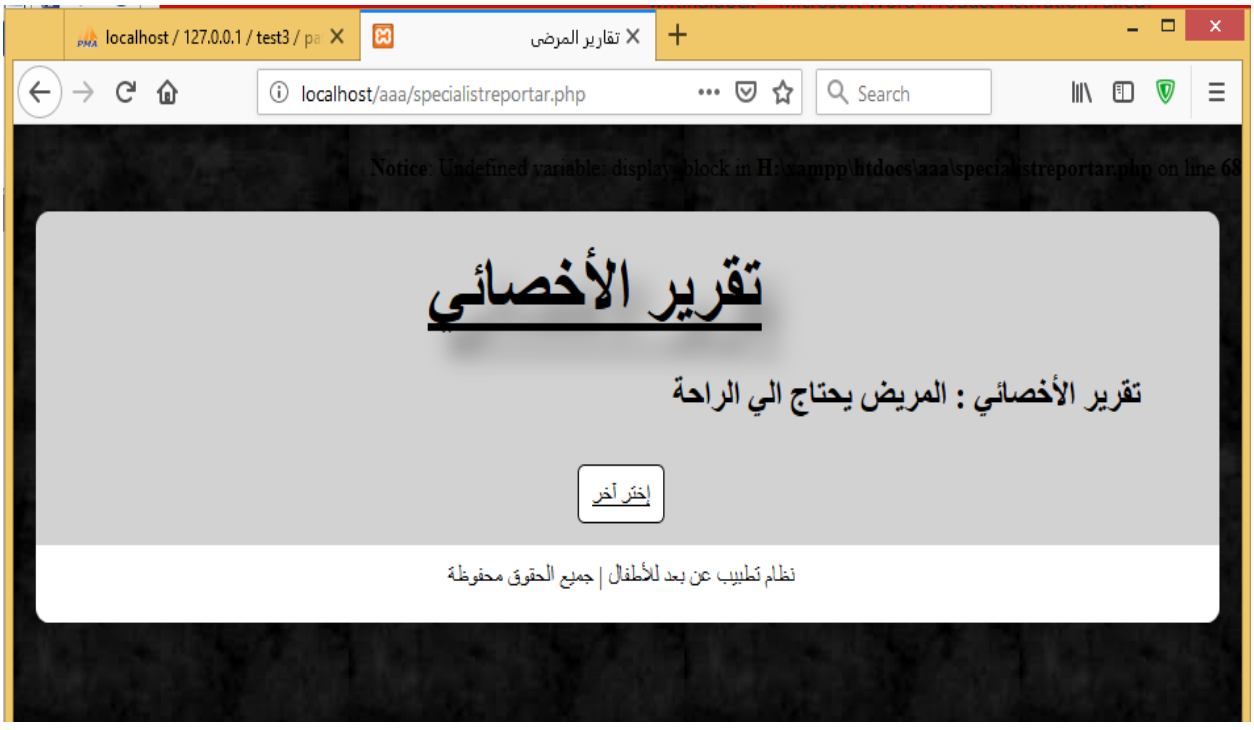


Fig. 5.34 Example of Specialist's Report Send Back to Physician

5.2 Discussion:

This project, Tele-pediatric System based on the Internet (TSBI), was conducted to support the pediatric heath care services development in Sudan. Electronic Medical Record (EMR) system was designed to enable the receptionist to enter the patient related data, and then these data is stored in the DB. EMR system allow smooth and easy way to move from paper based to electronic based records, the thing that is a goal for the e-Government project that is under developing in Sudan, As the internet users in Sudan are increasing daily, TSBI was made in the form of webpages to make it easier to utilize by the different intended system users. No other published telemedicine projects were conducted in the form of web based design, the thing that supports this project.

A lot of considerations regarding the privacy and security of the patient were addressed in this project design, including unique patient ID for each patient, through whom the whole patient related data can be accessed, also the medical practitioners (physician or specialist) whom deal with the patient case can be known from the DB. These considerations guarantee the security and canonical rights for all of the different parties using the system and the patient during faults.

Also this system was designed in both Arabic and English languages, the feature that makes it easier to deal with by Sudanese people with their various specializations. The access to the system is also easy with different windows allowing the user to navigate between the different system's webpages. Of course, to handle computers, training for the whole staff is needed, but it is easy and saves time and rights for everyone.

To establish this system (TSBI), a lot of requirements must be addressed. Central computer with large storage capacity, for storing the DB, and high speed of execution (RAM), for quick access and transfer to the data is needed. Peripheral computers are required at the different sites of the system. The system need to access the internet network. This network speed must be high. Also a staff for dealing with the system is needed. Receptionist, physician, specialist and information technology engineer are all important. Finally, this staff needs training in order to deal with the system.

Finally, this project (TSBI) had met its intended objectives by establishing a unified DB for the different pediatric patients and users, designing an EMR system, designing tele-pediatric system, testing the system between two computers, and proves its correctness.

System Cost:

Feature	Purpose	Cost
Hardware	**Hardware is required to support the other features – it includes an appropriate network.**	**303.9-425.46 for installation**
Software	**Software allows user to interact with database.**	**121.56$ per PC user**
Development	**Developers needed to put together both front and backend of system.**	**48.6$ per hour**
Maintenance	**For monthly maintenance of database**	**182.34 $ per month**
Network Installation (LAN)	**System network**	**303.9$**

CHAPTER SIX

CONCLOSION AND RECOMMENDATIONS

Chapter 6:

CONCLOSION AND RECOMMENDATIONS

6.1 Conclusion:

Telemedicine is “an information and communications technology which shows promise in improving quality and efficiency of health care”. There is increasing use of telemedicine in many countries. The most convincing evidence from the review regarding the effectiveness of telemedicine deals with tele-radiology, tele-neurosurgery, tele-psychiatry, and transmission of echocardiographic images. Promising results have also been obtained for the transmission of electro-cardiograms.

Telepediatric is the application of telemedicine for pediatric clinics in order to provide advance health care services for neonates whom live in rural and distant areas, where advance health care services, and even the primary ones, is poor. Pediatrics represents the most affected slice by the lack of the care services as they cannot resist the diseases.

This project had designed Pediatric Telemedicine System that can be used to link a remote area Primary Health Care (PHC) facility with a referral pediatric hospital using the internet. It was designed as webpages which enable the different system users to access the system. Clear steps were followed to conduct this project. First, a database was created to convey the whole information about patient (basic and medical information), and users (receptionist, physician, and specialist). Second, webpages were designed to enable users to interact with the system; also the navigation between the various system webpages is accomplished. Finally, the webpages were linked to the database to allow both insertion and selection of the data there in order to save the different user’s rights.

MySQL software application was used to create the database because of its security, as it enables user to define a specific username and password to the database. XAMPP server was chosen as a system server because of its simplicity of use and the availability of the source. HTML, CSS, and PHP are the programming languages that were implemented to design the pages and link them

to the database. Notepad++ was used as a text editor for writing codes, and Mozilla Firefox was the browser used to display the webpages. Those two software application were chosen due to their simplicity and their lower RAM consumption.

As a result, a webpages were designed starting from the system webpage which is the main page that introduce the user the system through a menu located at the top of the page, then through a series of connected webpages related the system, where each of them was designed for certain purpose.

Using the Sudan University of Science and Technology (SUST) network, one computer was used as central computer, while another one was used to share the connection of the central one using its IP address when both of them were connected to the network. Using this, the system was tested for privacy, security, efficiency and effectiveness.

The most important fact about this project is that, it was designed in both Arabic and English languages to ease its use by different users; also the ease of navigation between the different system's webpages is another feature distinguishing the system. Finally, as the system is web based, the Information and Communication Technology infrastructure in Sudan is well established, and the number of the internet users all around the world and in Sudan is increasing every day, this system ids valuable and can be applied wherever needed if the required equipment were available.

6.2 Design limitations:

Due to the weakness of the telecommunication technologies (Internet); this system cannot be established between rural or distant areas and central hospital. So it can be applicable between central hospital and other hospitals in the same town. Also the installation cost of the system is big.

6.3 Recommendations:

Even though the intented objectives of this project were achived, these objectives form some of the overall objectives needs to be achived in order to establish an overall pediatric telemedicine system that can serve all of the neonates all around the country. To do so, a lot of recommendations will be ststed here, which if followed we can enhance the use of telemedicine to promote both primary and advanced health care services.

These recommendations' are:

It is recommended to add critical webpages to this system, such as a webpage for the Laboratory department, Radiology Department, Emergency and other hospital departments.

It is recommended to transfer this system from web based form into smart phone's application, which is easier to download and use.

It recommended that certain rules and regulation can be created to be applied to this system for more security and more saving for user's rights.

It is recommended that Ministry of Health, Sudan, pay slight attention to telemedicine projects conducted in SUST and other universities for much benefit from those projects features.

REFERENCES:

[1] Organization, W.H., 2010. Telemedicine definition. survey. Geneva: World Health Organization World Health Organization.

[2] Ahmed, D.E.E., 2011. Revisiting eHealth in Sudan. newsletter. Khartoum: The Evidence newsletter Ministry of Health, Sudan.

[3] Organization, W.H., 2019. health care services in Sudan. survey. Geneva: World Health Organization World Health Organization.

[4] Others, L.K.a., 2004. Design and Implementation of Telemedicine Network in SubHimalayan state of India. Scientific Paper. Ahmedabad: ResearchGate Online Telemedicine Research Institute.

[5] Others, D.H.a., 2009. A System Design for a Telemedicine health care system. In A.S.&.M. Misbahuddin, ed. Wireless Networks, Information Processing and Systems. none ed. Jamshoro: Reaserch Gate. pp.295-305.

[6] Roberta Pinna, P.P.C.M.M., 2016. Excellence in healthcare: Telemedicine Project in an Italian Region. In Pinna, ed. 19th Toulon-Verona International Conference. Huelva, 2016. http://sites.les.univr.it.

[7] Frank Casey, B.M., 2011. Telemedicine in the Diagnosis and Management of Conginital Heart Diseases. In P.G. Graschew, ed. Telemedicine Techniques and Applications. none ed. Northern Ireland: InTech. pp.307-31.

[8] Romero, C.C.a.E., 2017. Design and Implementation of a Telepediatric Primary-Level and low-cost system to reduce unnecessary patient transfers. MARY ANN LIEBERT, INC., 23(TELEMEDICINE and e-HEALTH), pp.521-26.

[9]Adler, A.T.(.T., 2000. A cost-effective portable telemedicine kit for use in Developing countries. MSc. thesis. Cambridge: Massachusetts Institute of Technology Massachusetts Institute of Technology. Dept. of Mechanical Engineering. [10] Ahmed, D.E.E., 2011. Revisiting eHealth in Sudan. newsletter. Khartoum: The Evidence newsletter Ministry of Health, Sudan.

[10] Dan S Wamala1, K.A., 2013. A meta-analysis of telemedicine success in Africa. *Journal of Pathology Informatics*, none(none), pp.4-6.

[*11] Mohamed, D.K.G., 2012. Gazeira Family Medicine Project. none. Khartoum: https://www.mofa.go.jp Ministry of Health, Ministry of Health Sudan.*

[12] Tripathee, D., April 2016. Hospital Database Management System. International Journal of Computer Science and Mobile Computing, pp.71-73.

[13] Bryan L. Burke Jr, M.F.R.W.H.M.F., 2018. Telemedicine: Pediatric Applications. PEDIATRICS, 136(1), pp.293-308.

[14] Mike Dane from Giraffe Academy, SQL – Full course for beginners (2018), added Available at https://www.youtube.com/watch?v=HXV3zeQKqGY

[15] Yank, K., 2003. Build Your Own DatabaseDriven Website using PHP &MySQL. second edition ed. Australia: SitePoint Pty. Ltd.

[16] Meloni, J.C., 2007. PHP, MySQL, and Apache All in One. Third Edition ed. Indianapolis, Indiana, USA: SAMS, Teach yourself.

[17] Data, R., 1999. w3schools. [Online] (online) Available at: https://www.w3schools.com [Accessed 01 December 2018].

[18] Mohtashim, 2014. tutorialspoint. [Online] (online) Available at: https://www.tutorialspoint.com [Accessed 03 September 2018].

[19] Association, A.T., 2014. americantelemed. [Online] (online) Available at: http://www.americantelemed.org/learn/whatis-telemedicine [Accessed 14 september 2018].

[20] Zundel, K.M., 1996. Telemedicine: history, applications, and impact on librarianship. Bull Med Libr Assoc, 81(1), pp.71-79.

[21] Pozzi, G., 2016. *Telemedicine for Developing Countries. A Survey and Some Design Issues.* survey. Milano: Pubmed.gov National Center for Biotechnology Information (NCBI).

[22] Nour, P.S.S.O.M., 2017. Information and Communication Technology in Sudan. educational. Khartoum: http://www.karl-wohlmuth.de Khartoum University.

[23]Adler, A.T.(.T., 2000. A cost-effective portable telemedicine kit for use in Developing countries. MSc. thesis. Cambridge: Massachusetts Institute of Technology Massachusetts Institute of Technology. Dept. of Mechanical Engineering.

[24] Dan S Wamala1, K.A., 2013. A meta-analysis of telemedicine success in Africa. Journal of Pathology Informatics, none(none), pp.4-6.

[25] Jeff Atwood, J.S., 2008. stackoverflow. [Online] (none) Available at: http://www.stackoverflow.com [Accessed 12 December 2018].

APPENDIX:

Database Code

Creating the db:

```
CREATE DATABASE  test3;
```

Creating tables inside the db:

1. **Patient table:**

```
CREATE TABLE patient (
date DATE NOT NULL,
time TIME NOT NULL,
p_id INT NOT NULL PRIMARY KEY AUTO_INCREMENT,
h_id INT,
name VARCHAR (40),
age INT,
gender VARCHAR (20),
address VARCHAR (50),
phone VARCHAR (10),
religion VARCHAR (15),
previous_disease VARCHAR (150),
previous_medications VARCHAR (150),
insurance_company VARCHAR (50),
FOREIGN KEY (h_id) REFERENCES hospital (h_id) ON DELETE SET NULL
 );
```

2. **Hospital table:**

```
CREATE TABLE hospital (
h_id INT NOT NULL PRIMARY KEY AUTO_INCREMENT,
h_name VARCHAR (100),
state VARCHAR (50),
city VARCHAR (50),
phone VARCHAR (10)
);
```

3. **Users table**

```
CREATE TABLE users (
id INT NOT NULL PRIMARY KEY AUTO_INCREMENT,
career VARCHAR (15),
name VARCHAR (100),
age int,
address VARCHAR (50),
phone VARCHAR (10),
h_id INT ,
username VARCHAR (50),
password VARCHAR (50),
FOREIGN KEY (h_id) REFERENCES hospital (h_id) ON DELETE SET NULL
);
```

4. **Sym_test table:**

```
CREATE TABLE sym_test (
ph_id INT,
p_id INT,
```

```
symptoms TEXT,
lab_test VARCHAR (50),
screening_test VARCHAR (50),
image VARCHAR (30),
gram VARCHAR (30),
FOREIGN KEY (ph_id) REFERENCES users (id) ON DELETE SET NULL,
FOREIGN KEY (p_id) REFERENCES patient (p_id) ON DELETE SET NULL
);
```

5. **Test_result table:**

```
CREATE TABLE test_res (
res_id INT,
lab_test_res BLOB,
scr_test_res BLOB,
im_res BLOB,
gram_res BLOB,
FOREIGN KEY (res_id) REFERENCES patient (p_id) ON DELETE SET NULL
);
```

6. **Physician Report table:**

```
CREATE TABLE reports (
rep_id INT,
ph_report TEXT,
FOREIGN KEY (rep_id) REFERENCES patient (p_id) ON DELETE SET NULL
);
```

7. **Specialist Report table:**

```
CREATE TABLE reports2 (
rep_id INT,
spec_report TEXT,
FOREIGN KEY (rep_id) REFERENCES patient (p_id) ON DELETE SET NULL
);
```