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# Web-Based medical information system

# نظام معلومات طبية قائم على الشبكة العنكبوتية

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Submitted in partial fulfillment of the requirements for the degree of Master of Science

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**2018**

# DEDICATION

I dedicate this thesis to God Almighty Allah my creator, my strong pillar, my source of inspiration, wisdom, knowledge and understanding.

I also dedicate this work to my parents, Mohammed Abdul khalig and Hayat Abdul jalil who this work wouldn't have been possible without their support, understanding and selfless giving.

To my brothers and sisters who have always stood by me, to my friends who encouraged and supported me throughout this journey.

Thank you, my appreciation for you all can never be quantified.

## ACKNOWLEDGEMENTS

My deepest gratitude goes to God who has provided all that was needed to complete this thesis and the program for which it was undertaken for. There was never lack or want. Throughout this entire study, He took care of everything that would have stopped me in my tracks and strengthened me even through my most difficult times.

I would like to express my most sincere appreciation to the faculty and staff of the Department of Biomedical engineering of Sudan University of science and technology for their support, and most notably to doctor Mohammed Yagoub for his knowledge, guidance and patience, he has been of tremendous help to me all through this project.

I am also very grateful to engineers Tariq Yaseen and Ahmed Hamad for his invaluable help with the programming.

Lastly, this research would not have been completed without the Encouragement and devotion of my family and friends I express my heart felt gratefulness for them.

# ABSTRACT

Despite the fact that electronic information systems have been around for a long time, it remains a challenge for developing countries health systems to implement their own all inclusive functioning electronic medical information system, for a number of reasons led by the high costs running such system in all healthcare settings across the country.

Even in developed countries that has already adopted the medical technology and has a number of on-practice systems, medical information systems often lack global access, an efficient interface, and effective knowledge-based tools at the point of care.

Consequently, the information needs of patients, practitioners, administrators, researchers, and policymakers often go unmet, leaving healthcare providers dissatisfied.

To address this problem, an experimental web-based medical information system was designed referred to as "Sudan University of Science and Technology Electronic Medical Information System" (SUSTEMIS) to ensure that the most vital pieces of patient clinical records are available to make informed health care decisions.

This research aims to facilitate clinical documentation, usability, global access, and decision-making processes to better address local, clinical, and psychosocial healthcare problems in underserved communities in Sudan.

SUSTEMIS was developed with a long-term vision in mind, of all the hospitals in Sudan servicing under one national healthcare information system. Where the Sudanese patient has the freedom to move between different providers without losing his medical information.

An experimental model of the web-based medical information system with an easy to navigate, intuitive computer interface was developed and evaluated.

The developed system was tested by twenty healthcare professionals through a written survey.

The evaluation results show clear measurable positive effect on user satisfaction and work flow among other things. The participants found the system overall 85 % satisfying of their needs as health care providers in comparison to having no medical information system of any form.

# المستخلص


على الرغم من أن أنظمة المعلومات الطبية الإلكترونية موجودة على الساحة الطبية منذ أمد ليس بالقصير، إلا أنها لا تزال تمثل تحديًا صارخًا للأنظمة الصحية في الدول النامية لعدد من الأسباب؛ يأتي في مقدمتها، التكاليف التشغيلية الباهظة لهذه الأنظمة في منشآت الرعاية الصحية في شتى مناطق البلد.

إن أنظمة المعلومات الطبية، حتى في تلك الدول المتطورة، التي قامت بتبني التكنلوجيا الطبية، وتطبق عددا من الأنظمة، لا تزال تفتقر للوصول العالمي، وواجهات الإدخال ذات الكفاءة العالية، والأدوات الفعالة القائمة على المعرفة في نقاط تقديم الخدمة.

لهذا السبب، فإن المعلومات التي يحتاج إليها المرضى، والممارسون الطبيون، والإداريون، والعاملون في مجالات البحث الطبي، وواضعو السياسات، لا يتم الوفاء بها غالبا؛ مما يجعل العاملين في مجال الرعاية الصحية، على وجه الخصوص، غير راضيين.

لمعالجة هذه المشكلة، فقد تم تصميم نظام تجريبي لنظام معلومات طبي إلكتروني، قائم على الإنترنت، وقد أشير إليه في هذا البحث بـــ" نظام المعلومات الطبي الإلكتروني لجامعة السودان للعلوم والتكنلوجيا" ؛ للتأكد من أن الأجزاء الأكثر أهمية من السجلات السريرية للمرضى متوفرة لأخذ القرارات الصائبة على ضوء معلومات حقيقية.

يهدف البحث لتسهيل التوثيق الطبي، وقابلية الاستخدام، و الدخول العالمي، وعمليات اتخاذ القرارات؛ ليس لمعالجة مشكلات الرعاية الصحية المحلية، في المجتمعات المحرومة في السودان فحسب، ولكن أيضا لتسهيل الوصول للمعلومات الطبية بين مختلف مقدمي الرعاية الصحية داخل القطر وعلى مستوى العالم.

تم تطوير النظام على ضوء رؤية بعيدة المدى، تغطي جميع المستشفيات في السودان ،تحت نظام صحي معلوماتي موحد، حيث يكون لكل مريض حرية الانتقال بين مختلف مقدمي الرعاية الصحية، دون المخاطرة بضياع معلوماته الطبية.

ولتحقيق هذا الهدف، تم تطوير وتقييم نموذج لنظام المعلومات الطبية قائم على الإنترنت، بواجهة إدخال حدسية وسهلة التنقل.

تم فحص النظام المنشأ من قبل عشرين من مقدمي الرعاية الصحية عن طريق استفتاء مكتوب، وقد أظهرت نتائج التقييم تأثيرًا إيجابيّا واضحًا وقابلًا للقياس على رضا المستخدم وتدفق العمل، بالإضافة لعدد من النقاط الأخرى. وقد وجد المشاركون في التقييم النظام مُرضيًّا- بشكل عام- بنسبة 85% لاحتياجاتهم الضرورية لتقديم الرعاية الصحية بالمقارنة مع عدم وجود أي وسيلة أخرى لتسجيل المعلومات الطبية.

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# LIST OF ABBREVIATIONS

SUSTEMR- Sudan University of Science and Technology Electronic Medical Record

EMR- Electronic Medical Record

EHR- Electronic Health Record

HIS- Health Information System

HIMSS- Health Information and Management Systems Society

ISO- International Organization for Standardization

MDR-TB - Multi-Drug-Resistant Tuberculosis

IT- Information Technology

PDAs - Personal Digital Assistants

UPS- Uninterruptable Power Supply

PIH- Partners in Health

WSN- utility computing and Wireless Sensor Networks

WHO- World Health Organization

SDLC- Software Development Life Cycle

PHP- Hypertext Preprocessor or Personal Home Page

HTML- Hypertext Markup Language

RBAC - Role Based Access Control

# CHAPTER ONE

# INTRODUCTION

## .1. General Overview

The healthcare system in Sudan still to this day has not fully utilized the wide potentials of healthcare technology, in most cases the patient medical information is either unavailable or inaccessible, the absence of these health information or the fact that it is not easily accessible whenever needed, can cost the healthcare system a huge fortune every year due to duplication of tests and exams or to waste.

Medical electronic records have received a great interest in the past years for their big contribution to the quality of the healthcare services.

Electronic medical records (EMRs) can be defined as ((a digital version of the traditional paper-based medical record for an individual)).

The EMR represents a medical record within a single facility, such as a doctor's office or a clinic. There are a number of different types of digitized health records that contain most of the same types of information.

The availability of EMRs can help solve a lot of healthcare most obvious issues by making available medical information in a timely and precise manner in an electronic form which makes it much easier to analyze and manage.

High cost, privacy, security and government regulations however had impeded the implementation of EMRs widely across the country, with the main reason behind its slow expansion being their high implementation and utilization costs.

The motive behind the rapid growth and the wide expansion of the use of information technology in the developed countries has been for the most part because of the belief that these systems can improve the quality of the medical care.

Quality of the medical care is the vague expression that includes everything from improving all aspects of patient care, safety, effectiveness, patient-centeredness, communication, education, timeliness, efficiency and equity.

Even in developed countries developing an EMR system is still a very complicated and challenging task, because of the sensitive process of matching between the needs of the community and the technical qualification of the system, however, developing an EMR system for the developing countries is a much harder far more complex task for the fact that requirement, local constrains, and priorities are less understood and there are not much available information from research conducted about the unique environment of each country.

Some sittings can use the same software used in the US and Europe where others call for a specific medical software for the specific region when there are very limited resources. It is therefore impossible to suggest a single EMR system that can match the needs of all environments.

All these previously mentioned has made the use of a web-based electronic medical record a much more convenient choice for the specific needs and challenges of the Sudanese healthcare system.

What distinguishes online medical records from on-premise systems (which are locally installed and hosted by the practice) is that all the information will be accessed remotely, and sometimes the interface is even accessed through an Internet browser. This has a number of advantages, which will be addressed in later chapters.

In this research the main consideration is to match the suggested system qualification and requirements to the individual needs of the healthcare system of Sudan in a way that serve the requirements of our health system bearing in mind the lack of resources, limitation and constrains of the Sudanese environment.

To address this problem, a novel EMR design was created as an experimental Project to ensure that the most vital pieces of patient EMRs are available to Make the best health care decisions for anybody in need.

A web-based EMR model was developed with an efficient, intuitive interface, which include clinical protocols centered on a patient's clinical history,

Our version, System Sudan University of science and technology electronic medical record (SUSTEMR) provides access to clinical notes and test results. It was sought to determine whether access to SUSTEMR would improve patient satisfaction, adherence, and health status.

It was hypothesized that SUSTEMR use would have an overall positive measurable effect on provider satisfaction.

## .2. Statement of Problem

In developing countries, healthcare information systems have been driven mainly by the need to report aggregate statistics for government or funding agencies.

Medical information systems that contain information on the patients' health records, appointments, laboratory tests/results, billing and insurance in one comprehensive web site are almost nonexistent.

An Investigation of Sudan case shows that it suffers from locality, missing of unified electronic medical record EMR and lack of utilizing Internet, multimedia, wireless and real-time technologies.

Other drawbacks include: Difficulty in searching and viewing up to date records for patient, doctor, hospital, and drug, since many of such records are still kept in filing cabinet. This leads to difficulty in communication, hard to manage and exchange patient data between various medical units.

The importance of the system proposed here, SUSTEMR, is centered on the premise that current EMRs lack open national access, efficient interface, and a clear definition.

Consequently, the information needs of patients, practitioners, administrators, researchers, and policymakers often go unmet. These critical barriers have a negative impact on provider and patient satisfaction, quality of life, health outcomes, clinical care workflows, and health care costs.

# 3. Objectives

## 3.1. General objectives

- Develop a web-based medical information record.
- Evaluate the accessibility and easy to use interface of the SUSTEMR

## 3.2. specific objectives

- Develop a web-based medical information record that is accessible from any device (pc, laptop, smartphone, tablets), with an intuitive, easy to use, menu driven interface.
- Evaluate the accessibility and easy to use interface of the SUSTEMR system compared to the paper-based system based on the review of multiple post-implementation system users.

# 4. Methodology

In order to achieve the research objectives which were mentioned in chapter one a serious of strategic steps were taken, the process was broken down into six different phases

- requirements analysis
    - A discussion session was held with potential users and everyone involved in the design, use or evaluation of the system, the data obtained from the discussions were analyzed to come up with the appropriate requirements and specifications of the system.
- Designing the EMR architecture and content the architecture and content were designed based on the data obtained from step one.
- Developing the software through different stages of developing and testing until the results were satisfying.
- Make EMRs accessible on a web-based system from any device;
- Choosing the hosting server, domain name, and uploading the system to the internet.
- Compile and condense an all-inclusive intuitive EMR interface onto one navigation system.
    - Designing the interface so that it is easy to use, simple, clear and navigable.
- Post implementation system evaluation.

- A survey questioner has been designed and delivered to twenty test users, the results are shown in table 1.

## 5. Thesis layout

The research will be reported the whole process and results obtained in five chapters.

Chapter one:

This chapter presents an introduction and general definitions, the problem and main objectives of the design.

Chapter two:

This chapter presents the previous research background on medical records, electronic medical records and web-based electronic medical records.

Chapter three:

This chapter explains methods used in the research to obtain the objectives mentioned in chapter one.

Chapter four:

This chapter explains the obtained results and provides a full discussion in order to clarify and express the obtained results.

Chapter five:

A general conclusion of all the previous chapters and the research findings.

# CHAPTER TWO

## LITERATURE REVIEW AND THEORETICAL BACKGROUND

Healthcare, as in any other sector, has been pressing forth towards adopting and using information technology (IT) as a tool to simplify management of patient data, healthcare and healthcare related processes.

Even though the adoption rate was relatively slow (as compared to other sectors), some countries have led the way in implementing IT in healthcare facilitating healthcare processes and data management across departments and institutions.

The adoption has been fueled with internal and external forces that include: increment in population size, increased prevalence of chronic conditions, growing complexity of science, inherent nature of complexity of health problems and healthcare processes, and necessity to have complete patient's health information at the point of care. With respect to these forces, the old way of paper based healthcare management fall short of meeting these needs. Even more, healthcare, as a data intensive enterprise, has been generating huge amounts of clinical-data as a by-product of the service it provides.

Availability and sharing of this data has been found to be essential for longitudinal patient care, public health and clinical research. With this regard, countries have now identified the application of Electronic medical record (EHR) systems as a way in addressing the demand of process simplification and effective clinical-data management.

In some countries like Sweden, Demark and New Zealand the adoption has been reported to reach higher level, and several countries (e.g. Canada, Finland, England, Sweden and United States) around the world are pressing forth towards realization of national Electronic medical information [3], while other countries including Sudan are still for most hospitals and most states lacking the registration of health information in electronic form.

To further extend the discussion on this matter a brief description of paper based medical records, electronic medical records EMRs, the challenges that face the implementation of

medical records in the developing countries, Web-based electronic medical record systems and the Key specification and characteristics of a successful web-based electronic medical record are presented in the following sections

### 2.1. Paper Medical Records

While the central idea of this project is to bring patient records out of the ink-and-paper era and into the state-of-the-art computer age, the paper based record is not all negative.

The notion that an EMR is inherently better than a paper one is weak. The content in the one is weak. The content in the record clearly has a large impact on a record's effectiveness, independent of the medium of delivery. The most vital aspect of the medical record is well defined and structured documentation. Knowing this, an efficient design has to take into Consideration the well-known, mature, structured, and clinically-oriented paper-based system that has been supporting the health care system for centuries. Nearly 2,500 years ago, Hippocrates called for the careful recording and sharing of evidence about patients and their illnesses. He developed the first known medical record in the fifth century with two goals: to 1) accurately reflect the course of disease and 2) indicate the probable cause of disease. While this charge sits at the foundation of modern medicine, large amounts of valuable health care data still go unrecorded.

These goals are still appropriate, but Electronic medical record (EMR) systems can also provide additional functionality, such as standardized structured documentation interactive alerts, interactive flow sheets, and computerized physician order entry (CPOE) systems Information systems capturing increasing amounts of health care data have ignited interest in the exciting possibilities ahead for leveraging large quantities of patient and hospital data to increase the quality of care while reducing costs . It is necessary to have a clear notion of the physical aspects of the paper record. Paper is portable and access is direct, self - contained, and practical (no power supply, network, information technology (IT) support systems, or internet access required) It is a highly familiar method of recording information (no special training needed as compared with a computer system).

Another advantage of paper is how little structuring it demands because it is unconstrained in both form and content in a relatively informal medium (e.g., a long detailed history with marginal annotations, physical exam with drawing of the affected area, lab results using special characters, and handwriting diagrams), and it can be classified as a general-purpose tool for capturing.

Despite its benefits, a paper record can only be used for one task at a time, has access constraints (e.g., lab and X-ray results or clinical notes might be in a different office), consumes space, can be physically cumbersome, is susceptible to damage and degradation over time, and is dependent on production practices that are not ecologically sound (e.g., deforestation and water pollution). Also, because its creation and modification can be very personal, it may be difficult to understand for those other than the writer (see Figure 2.1). In addition, the lack of any formal structure to guide record creation increases the possibility for errors, misunderstandings, and omissions of relevance.


HISTORY AND PHYSICAL

AGE: DATE:

TX:

C: Improved Stable Worse

1-

2-

3-

4-

HYPER:

PALPITATIONS: TREMORS: ANXIETY: WT LOSS:

HEAT INTOLER: SWEATING: WEAKNESS: HAIR LOSS:

DIARRHEA: INSOMNIA: VISION: RASH:

MENSTRUATION: OTHERS:

HYPO:

FATIGUE: DRY SKIN: COLDNESS: MUSCLE SPAS:

SLEEPINESS: CONSTIPA: VOICE CHAN: WT GAIN:

EDEMA: MENSTRUATION:

NODULE:

DATE FOUND: PAIN: DYSPHAGIA: SOB:

VOICE CHAN: HX OF RADIATION: FHX:

ALL OTHER SYSTEMS: PSFHX REVIEW:

PE: WT: HT: B/P: P: PAIN:

EYES: CONJ: EXOPHT: R L

THYROID:

LYMPH: C: SC: BRUITS:

LUNGS: HEART:

ABD: XT: PULSE: EDEMA:

NEURO: DTR,S: SKIN:

LABS: TSH: TT4: T3U: FTI: FT4: T3: FT3:

AMA: TG: TGA: CBC: LFT,S:

THYROID US:

TYHYROID UPTAKE/SCAN:

RECORDS REVIEWED:

1: 2: 3: 4:

P:

LABS: TSH: THYROID PROFILE: TT4: FT4: T3:

FT3: AMA: TG: TGA: CBC: LFT,S:

US: THY UP/SCAN: FNABX: FNABX US

RTO: WKS MOS YR

**Figure 2.1**: Example of Paper-Based Medical Record [20]

The most important motivations for creating EMRs are the drawbacks of paper-based records outlined above. In simple terms, the current EMR is the computer replacement for the paper medical record system. It provides a mechanism for capturing information during the clinical

encounter, stores it in a secure and organized fashion, and permits use of that information only by those with a clinical need.

The EMR has a number of powerful attributes that make it ideal for data capture and storage, including the enormous quantity of data that is possible to store in a small space (e.g., cloud computing), and the ease of creating copies, backups, and secure data sharing. Also, it facilitates more structured data, portability, access, availability, interoperability, and structured care around automated protocol-guided care (e.g., e-prescribing, alerts, reminders, task specific views of data, and clinical audit and outcomes assessment).

### 2.2. Electronic Medical Records (EMRs)

EMRs are used within healthcare facilities (primary, secondary and tertiary care) for effective management of patient and care related data. According to Health Information and Management Systems Society (HIMSS) and International Organization for Standardization (ISO) definition EMR is a longitudinal electronic repository of patient health information generated by one or more encounters in any care delivery setting that can be stored, securely exchanged and accessed by multiple authorized users[2,3].

It contains retrospective, concurrent and prospective information about patient (demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports). EHR automates and streamlines the clinician's workflow with primary purpose to support continuing, efficient and quality integrated health care [3].

The EHR has the ability to generate a complete record of a clinical patient encounter, as well as supporting other care-related activities directly or indirectly via interface including evidence-based decision support, quality management, and outcomes reporting [3].

In addition to these capabilities, EHR application and use has been found to reduce medical errors, health costs, and improve quality of care. The information contained in EMR is used for different functions related to decision making processes in patient care, management and in health policy. Primarily, its purpose is to set objectives and planning patient care, documenting the delivery of care and assessing the outcomes of care eventually supporting and enhancing healthcare process [4].

It also allows intra and inter-departmental communication with a potential of individual patient's data exchange, providing access to patient information to the right care-provider whenever and wherever it is needed.

Because of these qualities and capabilities, the longitudinal patient record (contained in these Electronic medical record systems) has been targeted for clinical and translational research for decades and has been used for other applications. Safran et al. defines secondary use of data as "non-direct care use of Public Health Information including but not limited to analysis, research, quality/safety measurement, public health, payment, provider certification or accreditation, and marketing and other business including strictly commercial activities" [5].

The main purpose of the medical record is: to record the facts about a patient's health with emphasis on events affecting the patient during the current admission or attendance at the health care facility, and for the continuing care of the patient when they require health care in the future.

A patient's medical record should provide accurate information on:

- Who the patient is and who provided health care;
- What, when, why and how services were provided;
- The outcome of care and treatment.

The medical record has four major sections: administrative, which includes demographic and socioeconomic data such as the name of the patient (identification), sex, date of birth, place of birth, patient's permanent address, and medical record number; legal data including a signed consent for treatment by appointed doctors and authorization for the release of information; financial data relating to the payment of fees for medical services and hospital accommodation; and clinical data on the patient whether admitted to the hospital or treated as an outpatient or an emergency patient.

### 2.3. Medical Records in Developing Countries

The regions, nations, and communities that comprise the developing world face a wide variety of health-related challenges, and the health systems that address those challenges are struggling with limited resources and capability.

Health leaders must therefore focus on maximizing the value of scarce resources and finding ways to make health systems operate as efficiently as possible. Having reliable data on the performance of different parts of the health system is the only way to devise, execute, and measure health interventions.

Successful strengthening of health systems will require relevant, timely, and accurate information on the performance of the health system itself. The goal of a health information system (HIS) is to provide that information.

Implementation of Electronic Medical Records (EMR) in the developing countries is very important, the implementation of e-health and specially EMR will help improving and enhancing healthcare in these countries.

Concerns have been expressed that the lack of infrastructure and skills in developing countries will prevent large-scale treatment of diseases such as HIV and multi-drug-resistant tuberculosis (MDR-TB). While HIV, TB and malaria are the best known, other important problems must be addressed, including maternal and infant mortality, other infectious diseases, trauma, and rising levels of hypertension, diabetes and cardiovascular disease in developing countries.

Growing use of electronic medical record (EMR) systems in Europe and the United States (US) has been driven by the belief that these systems can help to improve the quality of health care. Decision support systems, particularly for drug order entry, are becoming important tools in reducing medical errors [6]. Email is important and widely used in healthcare systems, and access to medical data including online journals is expanding.

Even in resource-rich nations, the development of EMR systems is still an uncertain and challenging task, calling for a sensitive matching of local needs to available technologies and resources.

Experience with creating EMR systems for the developing world is much scarcer; requirements, priorities and local constraints are less well understood and probably more heterogeneous. Some settings in the developing world are similar to a European or US healthcare environment and can use similar software; other environments have very limited resources.

It is impossible, therefore, to suggest a single EMR architecture and implementation that will fit all environments and needs. In this research the focus was on systems that can support health care in the very challenging impoverished environments where the vast majority of the world's population live. A handful of projects in developing countries have now met the test of actual implementation in such settings and are in day-to-day use.

There has been substantial activity and innovation in the implementation of EMRs in the last three decades, encompassing both successes and failures. Since the requirements of a successful EMR depend on the health system it serves, it is worth looking at the trends shaping health care in the developing world.

These trends will impose increasing demands on health care systems and will potentially impact health information systems and particularly EMRs by presenting new data sources and opportunities for policy formulation.

- The role of private-sector health care will continue to increase in the developing world, requiring health information systems that are informed by private practitioners, facilities, and insurers.

- Economic development will change the profile of disease challenges, in which chronic conditions increase in importance even while infectious diseases remain a threat. This will dictate the need for additional health indicators and these indicators will need to be incorporated into HIS. Pandemic risks will link developed and developing countries, necessitating disease surveillance systems that accurately track outbreaks and transmit this information internationally. This data may allow HIS to not only report on "current" health status, but also potential threats and vulnerabilities in the health care system

- Globalization will continue to drain skilled medical and IT talent away from health systems serving the poor, necessitating health information systems that enable community-based health care workers to perform more advanced point of care services and which are sustainable in extremely low resource environments.

- Urbanization will draw talent and resources away from rural environments where a disproportionate number of the poor still live. Currently, most HIS only incorporate data

collected at facilities, which leaves the needs of the rural poor, who often cannot get to a facility, under-represented in current HIS. The data collected by community-based health care workers operating in rural settings, if communicated to an HIS, will allow rural health needs to be more clearly understood

### 2.3.1. The Potential Benefits of Implementing EMR Systems in Developing Countries.

As a Summary of the benefits of EMR system in developing countries it can be out it in the following points

-Improvement in legibility of clinical notes

-Decision support for drug ordering, including allergy warnings and drug incompatibilities

-Reminders to prescribe drugs and administer vaccines

-Warnings for abnormal laboratory results

-Support for program monitoring, including reporting outcomes, budgets and supplies

-Support for clinical research

-Management of chronic diseases such as diabetes, hypertension and heart failure

### 2.3.2. Currently Available EMR Systems in Developing Countries

Even as the developed countries are leading the electronic record revolution they are struggling to adapt to the new system, and at the current time only 9% percent of hospitals in the United States have adopted electronic medical record keeping [8]. This figure is in stark contrast to the 60% of Indian Hospitals which are using electronic medical record keeping in their surgery rooms [9].

In Kenya in 2001, the Mosoriot Medical Record System [MMRS) was developed. The project name was later changed to AMRS. The system serves 60,000 patients, and runs Microsoft Access on two networked computers. These are powered by an Uninterruptable Power Supply (UPS) and backed up with a solar battery. Patients register in the system on their arrival to the clinic and travel through the clinic with a paper visit form. In comparison with the clinic before and after

the system was implemented, there were great improvements. Patients visits were 22% shorter, provider time per patient was reduced by 58%, patients spent 38% less time waiting in the clinic, clinic personnel spent 50% less time interacting with patients, 67% less time interacting with each other, and more time in personal activities..

In 1996, Partners in Health (PIH) started an open source web system in Peru that was backed by an Oracle database. The system serves 4300 patients. Physicians fill out forms, and nurses and their assistants enter medication data. The medication order entry system has shown 17.4% fewer errors than the previous paper approach.

This EMR demonstrates the strength and flexibility of a web-based approach. But, of course this requires a reliable internet connection.

In 1999, PIH began an EMR system in parts of rural Haiti. These rural areas have virtually no roads, electricity, or telephone service. This design serves 4000 patients and is the same design that was established in Peru except with an additional offline client for data entry and review. This offline component helped overcome unreliable internet communications. When the network is down, the offline component still allows data entry and case viewing. This system displays how EMR systems can overcome great challenges in remote areas with virtually no infrastructure and limited technical expertise.

Other EMR systems include a Careware system in Uganda that is a stand-alone database built with Microsoft Access and an EMR in Malawi that is a touch screen patient management information system. The downside of the system in Malawi is that it is difficult to enter free text with the use of touch screens.

Data quality and completeness are critical to the success of any information system. Achieving high standards is a particular challenge in sites with limited computer literacy and experience. It is important to design systems that are easy to use and have good instructions and training.

### 2.3.3. Expected Constrains and Challenges When Developing an EMR System In Developing Countries

#### 2.3.3.1. **Data quality and completeness**

items should be structured and coded where possible to simplify data checking and optimize reuse. This does not mean that free text must be excluded; doing so prevents the system from capturing any data that do not fit the normal pattern. Such data will either be lost or recorded in hard-to-locate paper records.

Structured data such as laboratory test results might benefit from double entry. In some projects physicians and other staff enter data directly. This has the advantage of avoiding transcription errors, and also allows order entry systems to be deployed to check for potential medical errors.

A web-based system can be helpful in this respect as user problems and data quality can often be monitored centrally. Regular conference calls to discuss technical problems and new requirements with users keep the development team in close touch. Email, instant messaging, internet video conferencing and application sharing can all be valuable in supporting users and can usually be made to work well over limited internet connections. Prompt and effective help to users is a vital factor in generating support and ensuring widespread use of an EMR system.

Low literacy contributes to inconsistent spelling of patients' names and addresses. Search tools can be used to match similar names, age, gender and address, and either merge the two records or email the details to the users for advice.

Use of patient ID cards can also be helpful in some projects. A WAN system can be valuable in enforcing a single unique identifier across sites.

#### 2.3.3.2. **Data security and confidentiality**

Views of medical data security and confidentiality vary in different developing countries. In some sites, the use of electronic databases is treated with great suspicion; in other sites staff think nothing of emailing sensitive medical data.

Patients can face serious risk if their communities discover their HIV status or other sensitive medical information. It is imperative that healthcare providers protect this information. However, it has been suggested that the very limited access to health care makes it critical to avoid barriers that might be created by excessive adherence to principles of confidentiality.

Well-run projects should use a combination of technical and human protocols as described here:

Users are required to have complex passwords and can only access the parts of the system they need.

All log-ins and viewed data are recorded and reviewed to minimize the occurrence of unauthorized access.

Using a centralized database allows the computer and data to be physically secure and backed up on a regular basis.

The capability to look up patient details securely in a web-based EMR removes the need to send patient information by non-secure email, a potential problem in many countries. Users can simply click on a link to open the web page and log in. Nevertheless, as it is difficult to abolish completely the use of non-secure clinical email (even if a better, more secure alternative system is available), organizations should consider setting up their own secure web-based email systems.

### 2.3.4. Summary Discussion about the implementation of EMR systems in developing countries

The deployment of significant numbers of EMR systems in developing countries has blunted some of the skepticism about such approaches, but real concerns and much resistance remain. The potential diversion of resources from other healthcare needs to support information systems has to be weighed against the potential to improve quality of care and efficiency of care delivery. Successful new IT applications tend to have certain beneficial capabilities that overcome uncertainties and drive forward their deployment.

At present, two examples have emerged as primary benefits for EMR systems in developing countries: the ability to get laboratory results to remote clinics in a timely fashion, and the ability to track drug supplies and expected drug usage, particularly for HIV and MDR-TB.

The use of EMR systems to reduce medical errors and improve quality of care is still in its infancy, but initial evaluations are promising despite the challenges.

Improvement of clinical management by physicians and other healthcare workers has the greatest potential to benefit patients. It also requires more sophisticated tools than just simple patient registries and could therefore take longer to demonstrate.

The development of EMR systems in the developed world over the last two decades has been dogged by problems of closed, proprietary and incompatible systems; a recent survey of US primary care physicians identified 264 different EMRs in use [10].

Unfortunately, developing countries are beginning to experience similar problems, with many projects building their own basic EMR systems. This stems from a lack of good customizable systems, lack of appropriate foreign language options in some cases, and a feeling that each project is unique.

There are clear advantages in developing custom software but the cost in time and money can be high. Once the system is operational, it needs to be supported and upgraded. Many of the core tasks in building a good EMR are common to most projects and benefit from the feedback of multiple users and developers. Because software development has a significant component of trial and error, reuse of well-tested components helps reduce technical problems, especially for complex functions like order entry.

This is particularly important in remote sites with limited access to technical support. The software should also be open-source if possible. Small projects are vulnerable to the loss of a key programmer or IT company and are likely to fail if source code is not available to other programmers.

### 2.4. Web-Based Electronic Medical Record Systems

Web-based electronic medical record system are patient medical records that can be viewed and edited online from any device through the use of internet.

By making EMRs accessible on a web-based system from any device—PC, Mac, tablet, or smartphone, each with their corresponding operating systems—there will be a substantial

simplification and expansion of the ways in which health care providers access and input clinical information. They will switch from local, restricted onsite use of paper-based medical records or EMRs to a system that takes advantage of cloud computing.

This change will allow them to input, retrieve, store, share, and access patient medical records anywhere (rural or urban settings) when needed to support clinical decision-making.

With this new service, the patient, as the owner of their personal medical record and its access code, can travel almost anywhere in the world and find a provider that can access their EMR,

There by avoiding the need to reenter demographic and medical information onto paper forms.

This represents a potentially significant savings in time and frustration, and improvement in health care quality for patients who seek medical attention while traveling or living abroad.

The application of this project clearly challenges the current EMR paradigm by shifting away from the fragmented, difficult-to-use EMR system that has been unable to provide evidence that clinical practice is more efficient than in the past. This novel proposed design counteracts the predominant health care system paradigm that prioritizes the quantity of care rather than the quality of it.

Web-Based EMR represents the cost saving health care innovation that drug companies and private insurers have failed to provide.

Web-Based EMR is patient-centered rather than system-centered, based on the promise that a standardized, easy-to-use, well-defined, and accessible EMR that integrates best evidence, provider clinical expertise, and patient choice will improve health care. It is a network of tools that recognizes the primary information in the EMR—clinical documentation—is the keystone on which the health care decision-making process is based.

Provider interaction with such an integrated system is expected to be a satisfying experience.

A system that is centered on efficiency and quality of information will be one way to reduce health care costs, as the evidence points out. In addition, this model could be generalized as a valid frame of reference for other similar populations (primary care centers aimed at providing services in limited resource settings.

### 2.4.1. Web (Cloud)-Based Electronic Medical Record System vs. Internal EMRs

When it comes to choosing the kind of EMR Software that works best for a certain practice, you can take two different routes. Either to install an internal server and run the EMR at the location, or use a cloud-based (or web-based) EMR.

Most web-based systems are hosted in secure data center- to access it, all you need is a mobile device, tablet, or computer with a web browser. A cloud-based system gives you the ability to access your system from any place at any time. Cost is lower in the beginning, but you will have monthly payments that are open-ended over time.

Cloud-based system have less hardware requirements- there's no need to purchase or maintain a server or additional hardware. Any workstation with access to the internet will do.

There's less concern for disaster recovery or data backup, and you don't have to worry as much about physical security.

One drawback is that since the hospital don't control the system through the IT department, internet outages, line failures, etc. happen, which could make it hard to access the billing or patient charts.

Server-based EMR systems give a lot more on-site advantages with a higher up-front cost. The user has to consider long-term investment, and how his practice or office will grow before investing in this type of system, but it has some advantages over a cloud-based EMR System.

The practice typically owns the software and the licenses, so they can install it on as many systems as they need without a lot of outside support. Through remote connections, they'll be able to access the EMR System whenever they need to.

There will be an increase in speed and performance for all systems since they're located onsite. This is a lot more noticeable when there are no dedicated internet connections.

### 2.4.2. The expected Cost of Implementing an internal EMR System compared to a cloud-based system

There are a few published estimates of the costs of widespread implementation of EMR systems. Samuel Wang and colleagues have provided a model for estimating the cost and return on investment for a physician office practice.

Jan Walker and colleagues have estimated the costs ($28 billion per year during a ten-year deployment, $16 billion per year thereafter) and net savings ($21.6–$77.8 billion per year, depending on the level of standardization) of a broadly adopted, interoperable EMR system [11].

The Patient Safety Institute estimated the initial cost of widespread connectivity of EMR systems (not of the EMR system itself) to be $2.5 billion [11].

Adoption costs for hospitals

Eliza san et.al mentioned that, from cost data obtained from the literature, as well as from direct discussions with providers, estimated that the cumulative cost for 90 percent of hospitals to adopt an EMR system is $98 billion if 20 percent of hospitals now have such a system.

Average yearly costs for the fifteen-year adoption period are $6.5 billion—about one-fifth of our earlier-described estimate of potential efficiency savings in hospitals.

Whereas, Typical non-personnel costs of internet access in remote sites such as rural areas in Sudan (US$); assumes electrical supply/generator and limited technical support

Satellite dish and modem $6000

2 desktop PCs $1500

1 laptop PC $1000

Network cables, power supply, and etc. $500

Annual internet charges $4.800

Total 13.800$

Excluding the cost of developing the software itself.

### 2.4.3. Over View of Existing web-based Health Systems

The utilization of modern information technology in the delivery of healthcare is to enhance the availability and reliability of improved healthcare services to patients at a reduced cost. There exists a handful of published research that uses the adoption of cloud computing as a dependent variable to explore healthcare industry characteristics that are associated with the implementation of these technologies.

Padhy, et al. [12] designed and presented the implementation of a cloud-based healthcare information system model for rural communities; this system makes use of a cloud central server that accepts virtual machines as tenants. The tenants are secure facilities that store information in different healthcare centers..

Saif, Wani, & Khan [13] proposed a system of engineering network solution for data sharing solution across healthcare providers for protecting patients' health information in an Electronic Health Record (EHR) system. This system was implemented on a role-based and signature-based delegation.

An approach based on utility computing and Wireless Sensor Networks (WSN) was proposed by Rolim, F. Koch and C. Westphall [14]. Wireless Sensor Networks (WSN) uses sensors that can be worn to gather vital indications that enable the easy collection and distribution of information to and from any mobile device. These two computing features were combined to develop a system that automates the collection, input and analyses patients' critical information through network of sensors connected to installed medical devices, which in turn deliver the records to the health center's cloud for storage, processing, and distribution..

However, all these previous researches either lack legal, security and privacy of patient's data or the system is too complex to implement. Also, the reliability and availability of the system cannot be guaranteed.

Our version, System Sudan University of science and technology electronic medical record (SUSTEMR) provides access to clinical notes and test results, and also provides a method of sending electronic messages to the clinic staff. It was sought to determine whether access to SUSTEMR would improve patient satisfaction, adherence, and health status.

### 2.4.4. Limitation Of Existing Systems And How They Can Be Solved With the Use of Our System

Although there are currently available web-based electronic medical records each one of them has its own disadvantages which makes them unreliable and need of further development the reasons are many, but the main reasons usually are:

1) The lack of definition and clarity of what is important and required in health care;

2) The lack of consistency in the practice of medicine;

3) The variety in evidence in an evidenced-based-medicine delivery model;

4) The lack of a business model that proves a return on investment for HIT;

5) Lack of standards to support interoperability across various sites, domains, and models for health care; and

6) The lack of an infrastructure enabling the necessary connectivity to support the bringing together of data about a single patient."

Overall assessment is that "For the most part, today's EMR is not even a good representation of the paper record, which is still unorganized and contains unstructured content." According to Kush et al [15], "We can travel almost anywhere in the world and find a machine that will dispense local currency, taking the money from our home account with the use of a bank card. Yet, when we go from a primary care physician to a specialist in our hometown, we must begin at square one, providing the new doctor's office with all our demographic and medical information, often by completing paper forms." Also, they pointed out "if we were traveling abroad and needed access to our health information, we would face formidable difficulties." Financial institutions in particular have for years developed and used standards for electronic exchange, but not the health care industry

This research describes the approach to how the most critical problems with conventional EMR systems were resolved with the design, implementation, and evaluation of a new EMR system

The proposed changes are aimed at contributing to the EMR of the future, which would first positively impact provider satisfaction.

The ultimate goal is higher quality of life as a result of improved health outcomes

Our proposed system SUSTEMR builds the technical capability to

1) Make EMRs accessible on a web-based system from any device;

2) Consistently include patient histories as part of standardized clinical core EMR;

3) Compile and condense an all-inclusive intuitive EMR interface onto one navigation system; and

These features will provide access to scientific knowledge and build specific needed infrastructure to better address not only local, clinical, and psychosocial primary care problems in targeted underserved communities around the globe, but transnational migration health issues based on data transfer of clinical information in primary care settings, By making EMRs accessible on a web-based system from any device—PC, Mac, tablet, or smartphone, each with their corresponding operating systems—there will be a substantial simplification and expansion of the ways in which health care providers access and input clinical information. They will switch from local, restricted onsite use of paper-based medical records or EMRs to a system that takes advantage of cloud computing.

This change will allow them to input, retrieve, store, share, and access patient medical records anywhere (rural or urban settings) when needed to support clinical decision-making.

With this new service, the patient, can travel almost anywhere in the world and find a provider that can access their EMR,

There by avoiding the need to reenter demographic and medical information onto paper forms.

This represents a potentially significant savings in time and frustration, and improvement in health care quality for patients who seek medical attention while traveling or living abroad.

The application of this project clearly challenges the current EMR paradigm by shifting away from the fragmented, difficult-to-use EMR system that has been unable to provide evidence that clinical practice is more efficient than in the past. This novel proposed design counteracts the

predominant health care system paradigm that prioritizes the quantity of care rather than the quality of it.

Web-Based EMR is patient-centered rather than system-centered, based on the promise that a standardized, easy-to-use, well-defined, and accessible EMR that integrates best evidence, provider clinical expertise, and patient choice will improve health care. It is a network of tools that recognizes the primary information in the EMR—clinical documentation—is the keystone on which the health care decision-making process is based.

Provider interaction with such an integrated system is expected to be a satisfying experience.

A system that is centered on efficiency and quality of information will be one way to reduce health care costs, as the evidence points out. In addition, this model could be generalized as a valid frame of reference for other similar populations (primary care centers aimed at providing services in limited resource settings).

## 2.5. Important Considerations When Designing a Web-Based Electronic Medical Record

Patient's medical records are generally fragmented across multiple treatment sites, posing an obstacle to clinical care, research, and public health efforts. Electronic medical records and the internet provide a technical infrastructure on which to build longitudinal medical records that can be integrated across sites of care. Choices about the structure and ownership of these records will have profound impact on the accessibility and privacy of patient information. Already, alarming trends are apparent as proprietary online medical record systems are developed and deployed. The technology promising to unify the currently disparate pieces of a patient's medical record may actually threaten the accessibility of the information and compromise patients' privacy.

In this research I propose six desirable characteristics to guide the development of online medical record systems. I describe how such systems could be developed and used clinically.

### 2.5.1. Medical information: access and privacy

No single institution can hope to encompass a patient's entire record. Ideally, it should be possible to create or assemble each patient's personal health record so that it is accessible at all

points of care within the health service and contains data from all institutions involved in that patient's care.

To guide the development of electronic medical records: first, that record systems should be designed so that they can exchange all their stored data according to public

Substantial problems arise if patients cannot trust that their medical data will be used only in the ways they intend. If patients feel that they have no control over the fate of their medical information, they might fail to disclose important medical data or even avoid seeking medical care because of concern over denial of insurance, loss of employment or housing, or stigmatization and embarrassment.

### 2.5.2. Comprehensiveness

Because care is normally provided to a patient by different doctors, nurses, pharmacists, and ancillary providers, and, with the passage of time, by different institutions in different geographical areas, each provider must be able to know what others are currently doing and what has previously been done. Outpatient records should contain, at least, problem lists, procedures, allergies, medications, immunisations, history of visits, family medical history, test results, doctors' and nursing notes, referral and discharge summaries.

The records must also span a lifetime, so that a patient's medical and treatment history is available as a baseline and for retrospective analysis.

### 2.5.3. Accessibility

Medical records may be needed on a predictable basis (as at a scheduled doctor's visit) or on the spur of the moment (as in an emergency).

They may be needed at a patient's usual place of care or far from home. They may be needed when the patient can consent to their use or when he or she is unconscious and only personal or societal policy can dictate use.

Ideally, the records would be with the patient at all times, but alternatively they should be universally available, such as on the World Wide Web. In addition, with patients' permission, these records should be accessible to and usable by researchers and public health authorities.

### 2.5.4. Interface

A wide range of user interfaces are available to allow staff to interact with systems. The interface choice Might make a significant difference to the user experience but should not tie the system to a particular data model or architecture. Ideally any interface should be usable with any data model, and most network architectures.

The choice of user interface will depend on the system and user requirements. In larger EMR systems, it is important to design and implement the user interface as a separate component. The system should provide a structured programmatic interface to transfer data to and from Different user interfaces that can be used in EMR systems.

Web pages are more widely understood and used than other interfaces and simple to deploy at a distance. They are flexible but can be more limited in functions and interactions than other forms..

Small screen size limits ease of data entry for large forms. Phone Can be used to access and enter data through a voice interface such as the Voxiva disease surveillance system in Peru [16]..

Thus, it should be possible initially to build a forms-based interface, and with minimal effort introduce a PDA interface at a later stage without having to redesign the entire system.

The user interface is also the component of the system that changes the most. User interfaces should contain minimal functionality and should be easy to change; modifying and creating new forms should be a rapid and painless process that may be delegated to junior IT staff.

### 2.5.5. Interoperability

Different computerized medical systems should be able to share records: they should be able to accept data (historical, radiological, laboratory, etc.) from multiple sources, including doctors' offices, hospital computer systems, laboratories, and patients' personal computers.

### 2.5.6. Confidentiality

Patients should have the right to decide who can examine and alter what part of their medical records.

In principle a patient might choose to allow no access to such records, though at the risk of receiving uninformed and thus inferior care. At the other extreme some might have no hesitation in making their records completely public.

For most patients, the appropriate degree of confidentiality will fall in between and will be a compromise between privacy and the desire to receive informed help from medical practitioners..

Most patients will probably also choose to provide a confidentiality "override" policy that would allow an authenticated healthcare provider in an emergency to gain access to records that he or she would not normally be able to, though at the cost of triggering an automatic audit.

### 2.5.7. Accountability

Any access to or modification of a patient's record should be recorded and visible to the patient. Thus, data and judgments entered into the record must be identifiable by their source.

Patients should be able to annotate and challenge interpretations in their records, though it is believed they should not be able to delete or alter information entered by others. Patients should also be able to see who has accessed any parts of their record, under what circumstances, and for what purpose.

Reliable authentication is essential to make this feasible. Appropriate laws can reinforce accountability built into the records system.

## 2.6. Choosing appropriate system Architecture and design

The choice of system or technology to be implemented will be influenced by medical, staffing and environmental factors.

### 2.6.1. Number and size of sites

A single large hospital will probably need to have multiple terminals for data entry and viewing: this makes a networked system the logical design.

With good local technical support and stable power, the server could be located in the facility

If the site has limited infrastructure, a web-based system is an alternative with the server off-site.

A small clinic could set up a stand-alone database system. Alternatively, an internet-based system could be deployed with local data storage to help with network outages

This design also makes sense if there are multiple sites that need to be covered, particularly if certain resources are located at a distance, such as laboratories or a common drug warehouse

### 2.6.2. Available infrastructure in sites

Servers need stable power and physical security in a relatively dry, dust-free and temperature-regulated area.

Off-site data back-up as well as a second back-up server in a different location is strongly advised.

### 2.6.3. Access to networks

Internet access allows more flexible designs with external communication of data and off-site back-up.

Pure web-based systems need reliable networks, but dial-up connections can work if the pages are designed carefully and the system is not required all the time.

### 2.6.4. Local expertise in development and technical support

A major factor in any design will be the availability and skills of local technical support staff. Managing client PCs or single Windows machines running a database is within the expertise of many countries (though viruses and security issues are very important challenges).

Servers need more expertise for setting up and backing up data; MS Windows tends to be easier for small sites to manage.

For larger installations open source software can be cheaper and more ‘future proof’, also Linux is very easy to manage and support over the internet. Good documentation and easy-to-configure systems are important.

## 2.7. Conclusions

In deciding what EMR systems to develop and deploy promising ideas are not enough: they need to be validated in the field. It is important to look closely at systems that have been successfully deployed in challenging environments, and any available evaluation data.

The introduction of IT systems to remote sites with no communication should provide good opportunities to evaluate the impact of data management and/or communications tools.

Improvements in drug supply management using medication data from EMR systems could offer the most measurable cost benefits at present; a well-managed drug supply also improves availability and quality of patient care.

In creating or choosing a new EMR, it is essential that the underlying data model is designed with a long-term vision of the functions that will need to be supported: it can be very difficult to scale from a simple flat file data model to a larger clinical system or one that can be deployed in other sites.

Furthermore, it makes little sense to recreate the same functions and tools at each site. Collaborative development between projects using an open source model (even if the underlying operating system is not open) has great potential to improve quality of software and reduce costs.

The critical challenge is to create well-designed, effective, low-cost systems by sharing resources, learning from each other's experience and evaluating our work.

Web-based medical information systems are at the start of what promises to be a rapid evolution. We are still in a position to look ahead and consider the promise and pitfalls of such systems as we design and deploy them.

# CHAPTER THREE

## METHODOLOGY

### 3. The Phases of System Development

Any software System design and development usually proceeds through several phases of software development life cycle (SDLC) that includes feasibility study (problem identification), requirement analysis (user's requirements), system design, testing, implementation and evaluation (Suwarno et al., 2004).

In order to achieve the research objectives which were mentioned in chapter one a serious of strategic steps were taken, the process was broken down into six different phases

1) Requirements analysis

2) Designing the EMR architecture and content

3) Developing the software

4) Make EMRs accessible on a web-based system from any device;

5) Compile and condense an all-inclusive intuitive EMR interface onto one navigation system.

6) Post implementation system evaluation.

the steps taken to reach each goal, will be discussed first

**Phase One: Requirements Analysis**

Various discussion sessions have been organized with potential system users from the healthcare providers (physicians, nurses, lab technicians, dentists, and pharmacists), healthcare quality specialists, hospital administrators and information technology (IT) specialist.

the basic needs and requirements that would satisfy all parties involved were able to be identified Through these discussions.

Data requirements and various parameters were identified which are essentially required to the researchers through phase wise discussions.

**Phase Two: designing the EMR architecture and content**

Designing the health record contents and structure was done on the light of the following organizations standards

The bay of plenty district health board health records protocols [17].

The world health organization (WHO) medical record manual components of a medical record [1].

Mclaren health plan, medical record standards. [18].

The content of SUSTEMR include but are not limited to:

- Patient demographics (name, mothers' name, record number, address, gender, phone number).
- Patient consent form
- Medical history including problem list.
- Family history
- Initial diagnosis
- Physical exam findings
- Medications list
- Treatment plan
- Admission note
- Discharge note
- Clinical summary
- Radiology report
- Laboratory report

**Phase Three: Developing the Software**:

This phase was broken down further to a number of smaller steps, through trial and error the system functionality was improved until it reached the final software product.

**Phase four: Make the system openly accessible on a web-based system from any device**.

A tool was created that provides a response to the needs for information exchange across institutions, platforms and borders within the medical care system.

This solution is integrated into an efficient web-based system using cloud computing.

In this setting, the provider will be able to access the EMR through any smart device, anywhere, anytime.

Patients will be empowered by the ability to access their medical record anywhere, allowing them to choose any provider anywhere for informed individualized care.

This EMR code will allow the provider to have full privileges to access, retrieve, and add information to the clinical file.

The provider, will be able to access files and input information regarding demographics, family history, personal medical history (e.g., allergies), current prescription medication, and/or over the counter supplements.

**Phase five: Compile and condense an all-inclusive, intuitive, and efficient EMR Interface into one navigation system**

An intuitive EMR interface was created that allows providers to see the whole EMR and its different domains in three top windows while navigating among the different fields and applications without losing sense of where they are (i.e., all fields and applications are within the reach of one or two clicks).

Text fields entry boxes was created for each different field of the clinical history so that providers can indicate positive and negative findings and use either structured data or free text.

The interface will allow users to easily and accurately retrieve, seek, gather, transform, organize, and manipulate pertinent information to accomplish desired tasks.

**Phase Sex: Post Implementation Evaluation**

The evaluation was carried out through a written survey questioner applied to ten test users who are potential users of such system, the details of the questioner and the results are discussed in chapter four.

The detailed system specifications and how each requirement was achieved are discussed below

### 3.1. The system architecture

An open source platform consists of LAMP ( Apache, xampp, MySQL and PHP) has been deployed with the standard web based three tier architecture to design and implement the system The system architecture designed to develop an efficient electronic medical record information system is shown in Figure 3.1.

The system architecture contains three layers namely, database, application and user interface. The database layer stores the data of the patient.

Application logic layer was used to provide the interface between user and database. The queries are implemented in this layer for inserting, modifying and accessing data. The access rights are also specified in the application logic layer.

Third layer is the user interface layer that contains the browser based platform to access the desired information from the database using a input entry form.

The general architecture of the system is shown in figure 3.1.

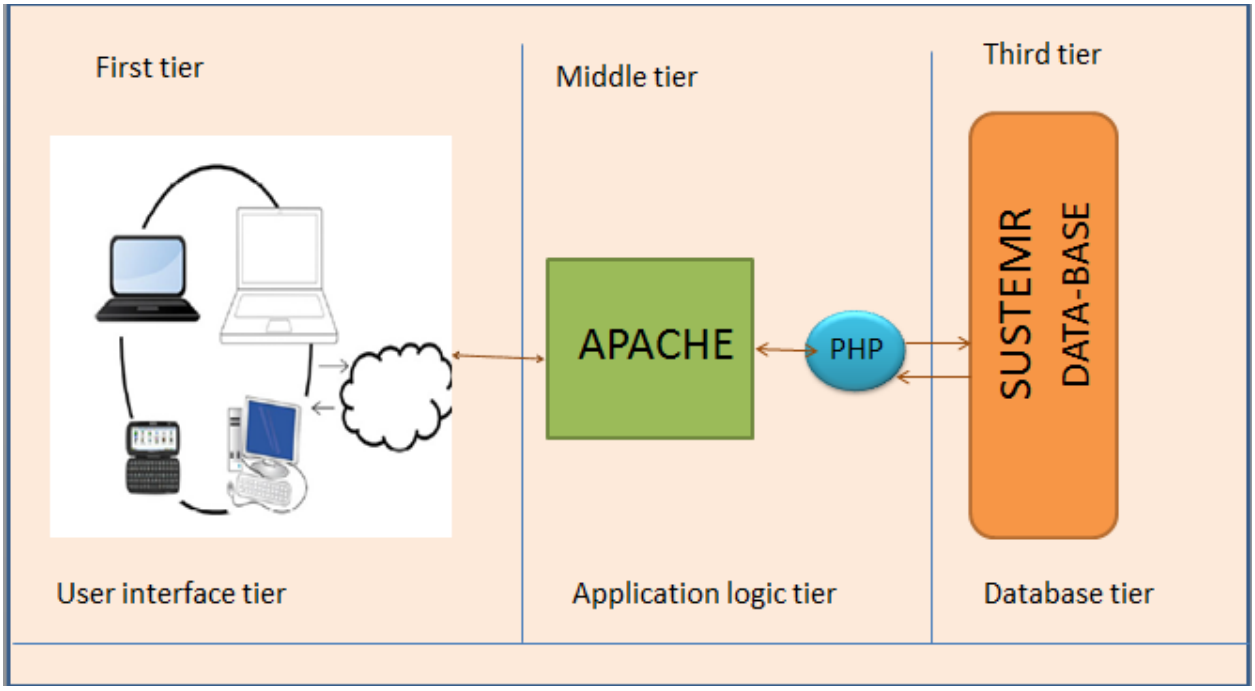


Figure 3.1: Web-Based Electronic Medical Record System Architecture.

### 3.2.Access

A tool was created to provide a response to needs for information access, exchange, and interoperability across an unlimited number of institutions, communication platforms, and political borders.

This solution was integrated into a web-based system using cloud computing, which refers to subscription based, fee for service utilization of computer hardware and software over the internet.

The model is gaining acceptance for business IT applications because it allows capacity and functionality to increase on the fly without major investment in infrastructure, personnel, or licensing fees.

Large IT investments can be converted to a series of smaller operating expenses. Cloud architectures can potentially be superior to traditional EMR designs in terms of economy, efficiency and utility.

Also, the cloud computing model can achieve acceptable privacy and security through cloud providers that specify compliance requirements, performance metrics, and liability sharing.

SUSTEMR can be accessed through any smart device (mostly desktop PCs), anywhere, anytime through internet access.

### 3.2.1. Server hosting

The hosting company maintaining the web server software and computers was selected based on the provision of reliable and low cost web services 24 hours a day, seven days a week. GoDaddy Web Hosting (http://www.godaddy.com) also provides data backup and technical servicing of the software and hardware in a large facility with state of the art equipment and staffing.

Godaddy.com is currently considered one of the best hosting services available worldwide and has received numerous web hosting awards

(https://www.newsroom.godaddy.net/newsroom/awards-and-honors/default.aspx).

### 3.2.2. Cloud computing

The concept of the "cloud" is an extension of existing computing practices, but places more content and program code in the hands of remote servers rather than the user's local computer.

In the case of SUSTEMR system, the web server is providing the storage for medical/clinical records and the principal software application (the web application software on the site's server) that manages these records for users.

### 3.2.3. Administrative management

Access to the application is via the World Wide Web. This makes the application open to patients, providers, and administrators through simple use of web browsers.

The user roles are defined as follows:

1) Patient: view clinical records and notes, but may only change certain personal information such as phone numbers and addresses;

2) Doctor: can edit diagnosis and test results and is authorized to edit clinical history or view all patients records

2) Administrator (Admin): create, edit and delete patient records, add a new hospital or doctor registration to the system or delete certain hospital or doctor accounts, and have similar control over other Patient, doctors, and hospitals accounts; manage problems that may appear in the system to modify, update, and develop the software and/or help other roles recover lost accounts or other information.

SUSTEMR site automatically sends different page data according to the user roles, access devices, and browsers.

Testing indicates that most smart devices such as iPhones and iPads are able to scale the page or arrange it in the display appropriately enough to use.

It more valuable at this point for developing applications that are targeted to run on those particular devices. So far, no device specific codes have been necessary.

At this stage monitoring indicates that SUSTEMR is working appropriately. Users have access to the electronic mail addresses of technical support as well as the project supervisor at the front page of the web site.

### 3.2.4. Privacy and security

Security and privacy of the system relies on the role based access control (RBAC) which restricts access to the network based on the user's role in the organization (patient, doctor, admin). System users are only allowed to access the information necessary to effectively perform their job.

All the role based accounts are password protected, passwords must be used to gain entry to the network, in order to authenticate the user accessing the network. Another step can be easily add to further secure the network which is Using secure socket layers (SSL) which protects user privacy on the internet by encoding the information sent back and forth from a user's browser.

Another layer of security is represented by the fact that all system access, modifications and views are audited, the moment any user log in to the system the user account, date, and time are automatically registered and any modification of the data will be viewed along the user that made the modification, thus ensuring accountability and avoiding malicious manipulation of patient's information.

## 3.3. Programming Language and software developing tools

The application for SUSTEMR was written using hypertext processor (php) programming language version 5.6.38 for server software, It is a server scripting language. It can be run under the Microsoft IIS 7 web server, at can be used in different platforms

PHP (recursive acronym for PHP: Hypertext Preprocessor or Personal Home Page) is an open-source server side scripting language. PHP scripts are used to develop the dynamic web application, where the content displayed is generated from information accessed in a database. Hypertext Markup Language (HTML) is used in conjunction with PHP to give aesthetically pleasing web interface for users.

SUSTEMR system also relies on client side software, which runs directly in a user's browser software on their local computer.

The code supports the functionality in the various pages, and is executed on demand when pages are requested from a web server.

the local server was created using Xampp , an open source platform which is getting popularity day by day because it has been made by the user and for the user without incurring any cost.

the database has been created using world's most popular open source database MySQL database for storing the data in back-end, the tables needed were created using phpMyAdmin (Graphical user interface for MySQL administration)

The Apache web server has been used for bridging the gap between database server and user in retrieving the information remotely.

For access of the system globally, it has been developed in "English and Arabic" languages.

MySQL version 5.1.56 and Apache 2.2.21 have been used for database management server and web server, respectively. PHP version 5.1.17 for server side scripting and Java script for client side scripting has been used in developing the system.

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# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.1. Results

SUSTEMR was uploaded to the internet under the domain name SUSTEMR.com and can be accessed from anywhere using any device, then it was tested by multiple Users, the goal behind it was to address the problem of the lack of a modern, EMR system with global access and comprehensive interface to efficiently collect, store, share, manage, and access patient files.

This system aimed to better address local and clinical health challenges based on systematic documentation, interoperability, and transfer of clinical information among primary care providers in targeted, underserved communities.

### 4.1.1. The Interface

Apart from the effort of building an inclusive interface with one navigation system, what remains one of the biggest challenges of achieving a highly rated web-based EMR user interface is balancing the providers' requirements with an integrated and fully functional system in the global context. Too much information and too many functions on a single screen may impede task efficiency rather than improve it. However, less information and fewer functions on a single screen require more screens and thus lead to a more complex user-interaction structure.

With the recent explosive growth of electronic medical information, the user interface design of EMRs has become a crucial issue. Many interfaces in current EMRs are barriers between users and tasks. By re-implementing these interfaces in functionally equivalent but representationally different interfaces, the barriers can be removed or minimized via direct interaction.

For SUSTEMR, the interface was constructed so that users could easily and accurately retrieve, seek, gather, encode, transform, organize, and manipulate pertinent information to accomplish desired tasks.

When the web page is launched the home page appears with a short description of the system followed by the login text fields asking for the user's email and password, when the user log in using a certain account the system automatically directs him to the corresponding role-based page whether he is an admin or a doctor, when the system is launched by the administrator, The

hospital's administrator enters his username and password in their respective columns in order to gain access into the system; it compares the details with those of the administrator in the database and the system grants access to administrator, the login interface is shown in Figure 4.1.

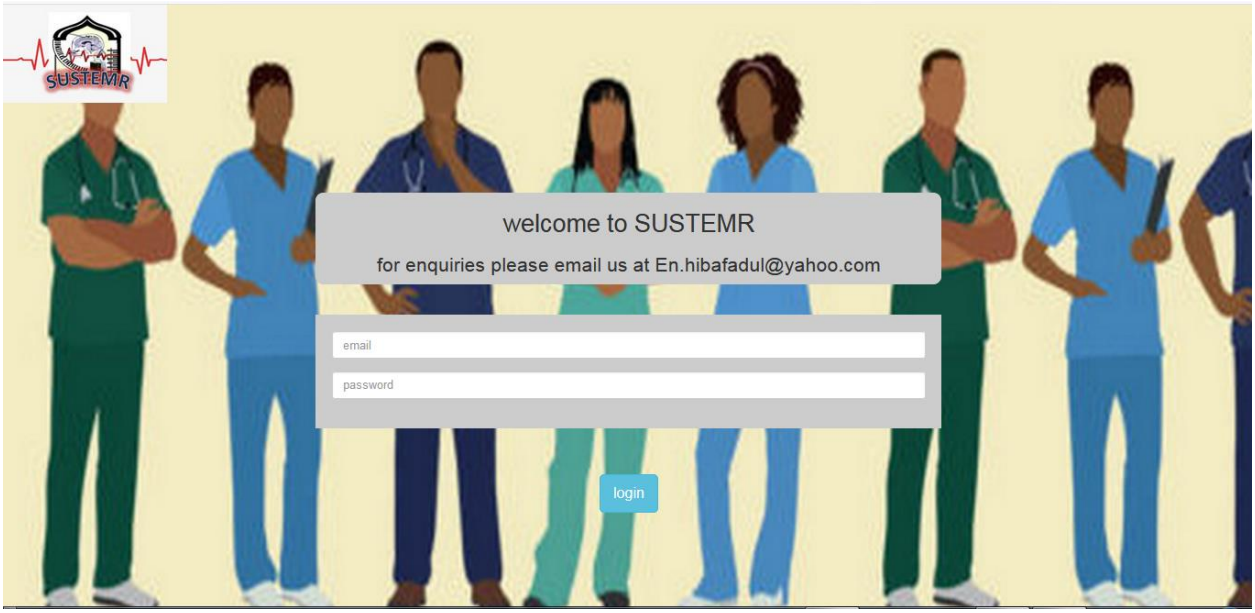



Figure 4.1: SUSTEMR Login Interface

If access is granted for an authorized user (administrator), it leads to another interface that displays the home page. As shown in figure 4.2, it has a side menu bar with the following options:

**Hospitals**: this option returns a list of all registered hospitals in the system

**Doctors**: this option view a list of all the registered doctors in the system

**Sittings**: where the user can change the system sittings and customized to his preferences.

**Sign out:** this option returns the user back to the log-in interface

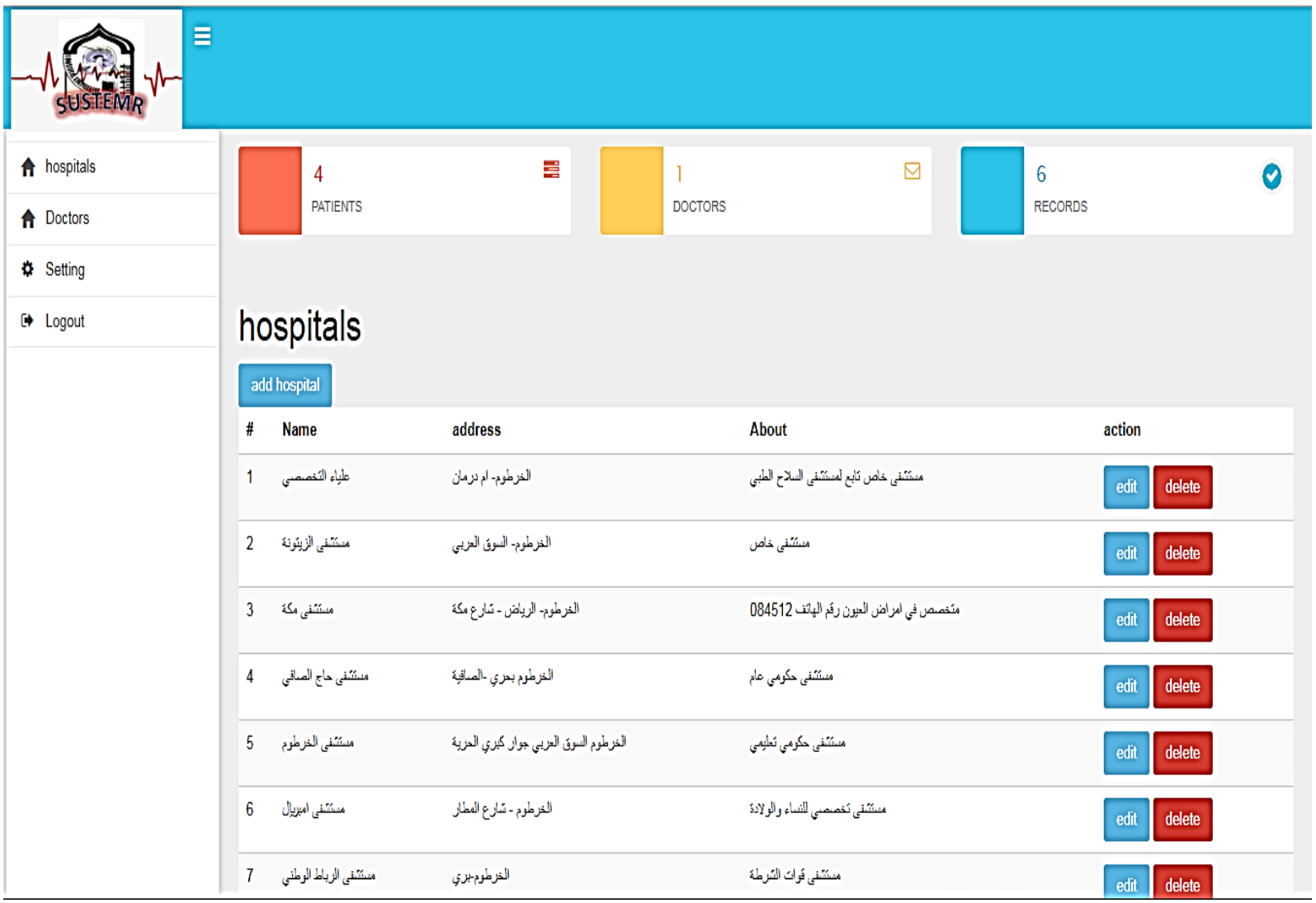



Figure 4.2: hospitals list Interface.

As shown in figure four the administrator has the option of adding a new hospital account to the network, editing existing hospital account details or deleting hospital account with all its corresponding data (doctors accounts, login information, patients registered under those doctors) of the system.

The doctors interface views a list of all the doctors in the system and the hospitals each doctor is registered under, beside their contact information.

A screenshot of the doctors' interface is shown in figure 4.3.

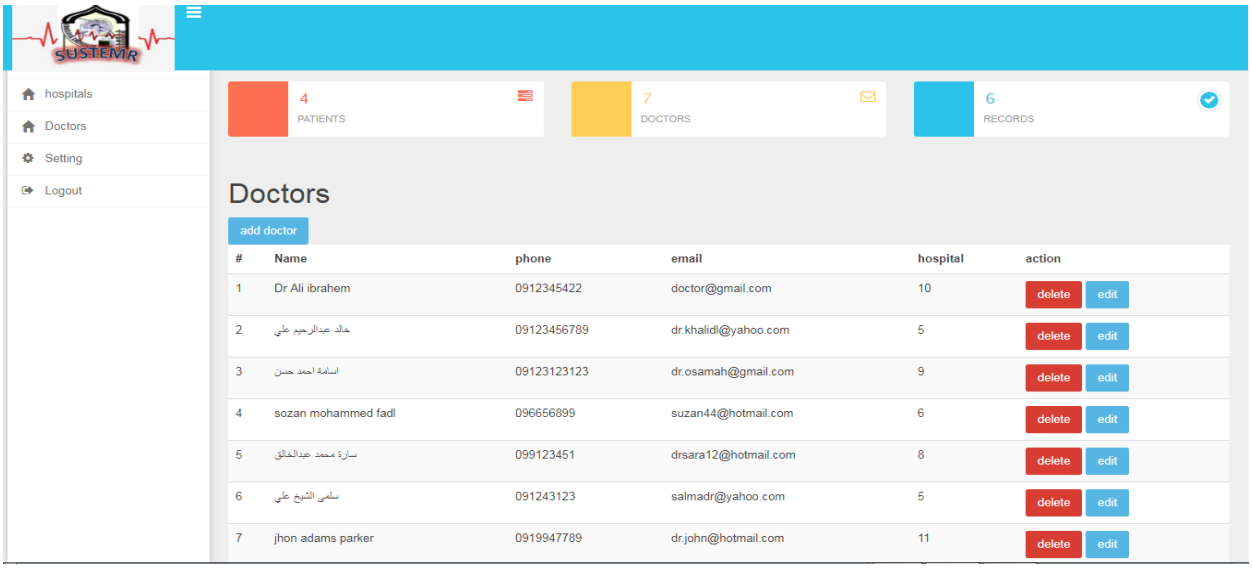



Figure 4.3. : a list of all registered doctors.

As shown in figure 4.3 the admin can delete, edit, or add a doctor account, add doctor option interface is shown in figure 4.4.

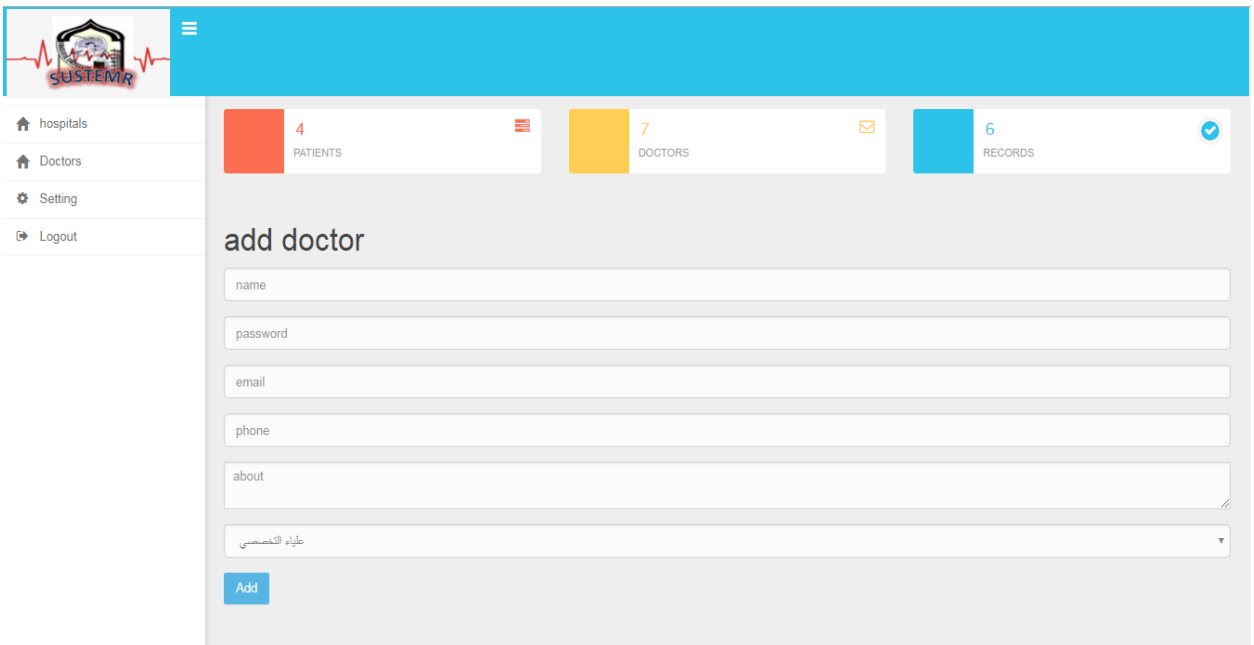



Figure 4.4. : add new doctor to the system interface.

When a new doctor is added to the system he is automatically given authorization to inter the system a new user account is created automatically so he can log in using his email and password.

When the user log in using a doctor account the doctor interface is viewed with a list of all the patients registered in the system along with their personal info (figure 4.5)

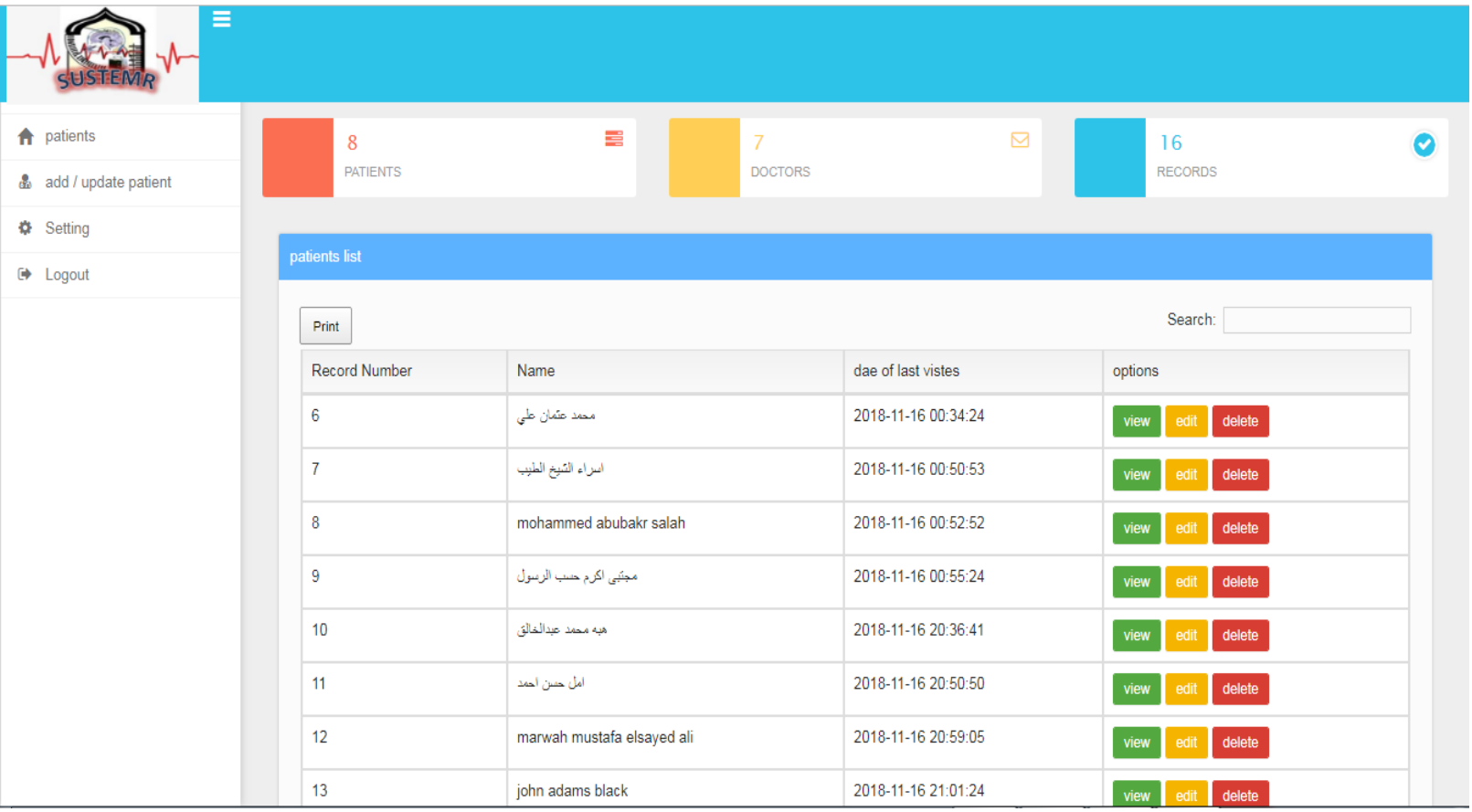



Figure 4.5.: doctor log in home page/ patients list

As you can see in figure 4.5 a search box was inserted to ease the search of a particular patient, the top bar displays a counter of the number of patients, doctors and records that are currently stored in SUSTEMR database, a side menu with four options appears in the left side of the screen with these options:

**Patients**: view a list of all the patients along with their identifiers (each patient has a unique record number that never changes which is one of the WHO main requirements of a medical record) and the date of their last visit to the doctor, to the right side of each patient there are three options that the doctor can use to view, edit or delete the record.
When the doctor chooses to view a certain patient record the patient personal information appears on the screen and in the bottom of the page appears the list of all the patient's visits to the hospital ordered from recent to last which makes much easier for the doctor to find the information he is looking for, to make the search even easier and less time consuming for busy doctors different ways in which he view the record were created , the first one is to view the full report which is more likely to be used when suspecting a previous misdiagnosis, where the other

is to view only the case summary of that visit which leads to the most important information only, this option is more likely to be used in follow-ups. (figure 4.6 ).

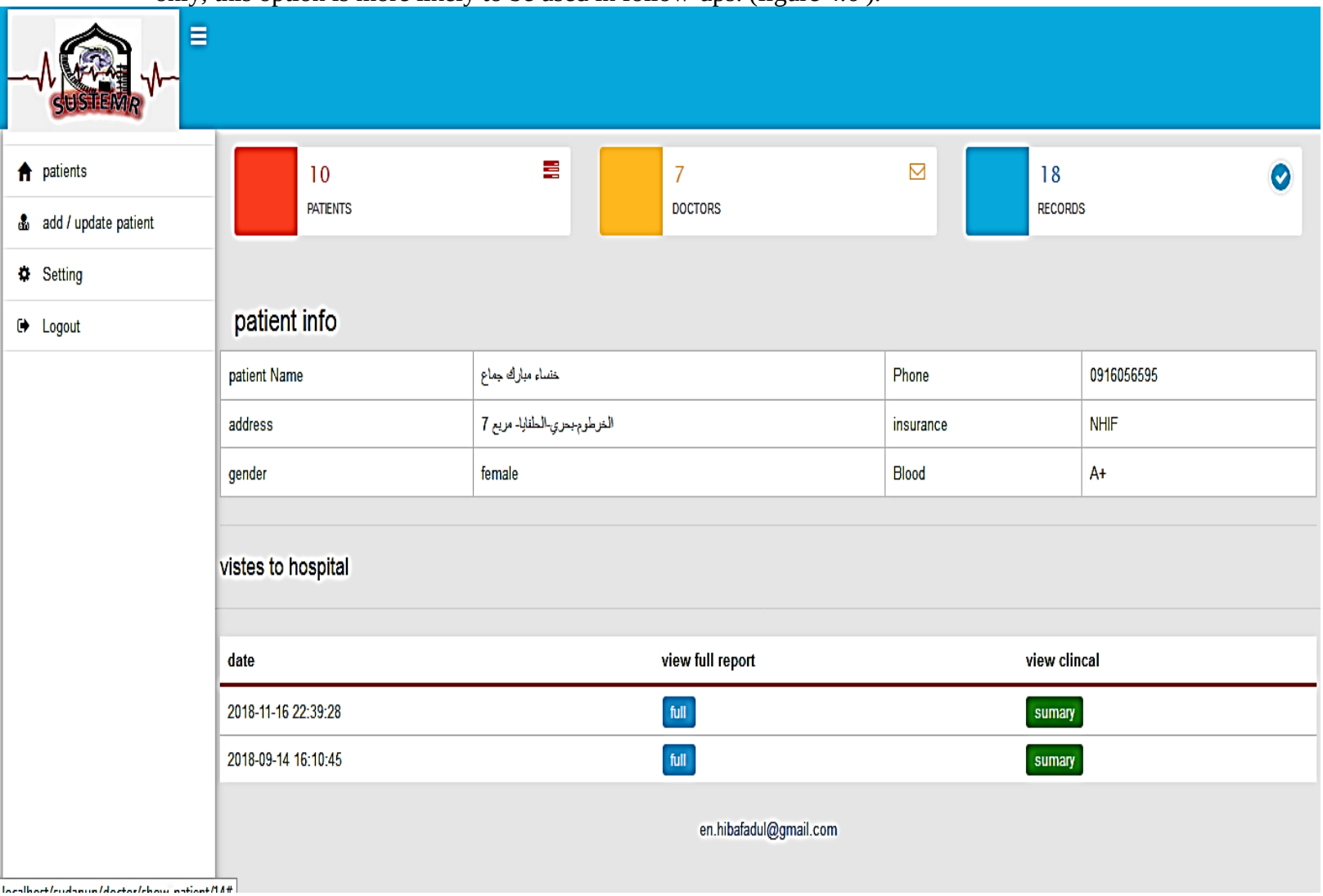



Figure 4.6.: patient record view organized in dated visits to the hospital.

A screenshot of some parts of the full report view is shown in figure 4.7, for security and accountability reasons the doctor name the attended to each visit is automatically registered, and appears first thing in the page, any changes the he make to the information appears along with date and time of modification.

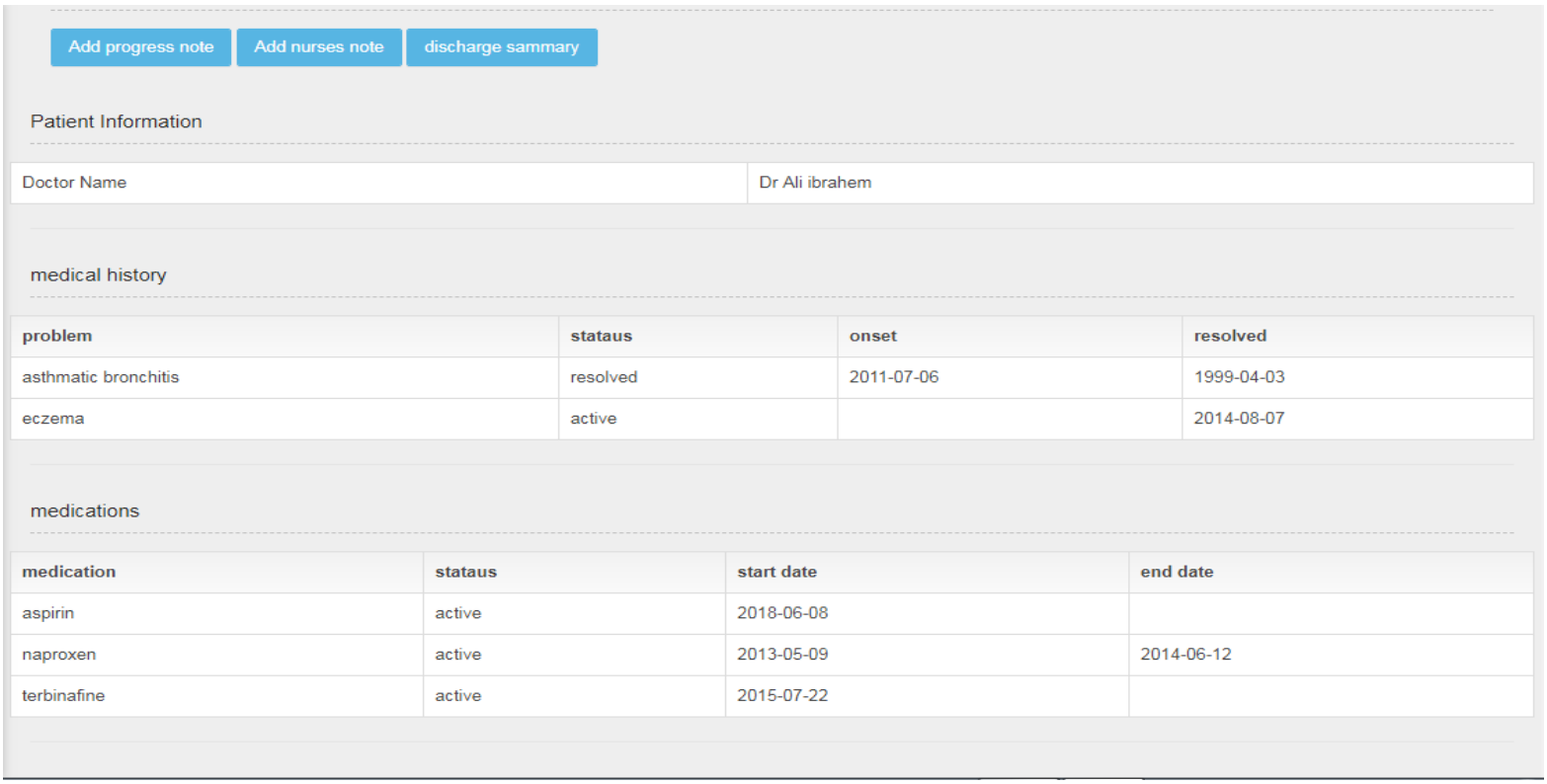



Figure 4.7. : example of some fields of the full medical visit report view.

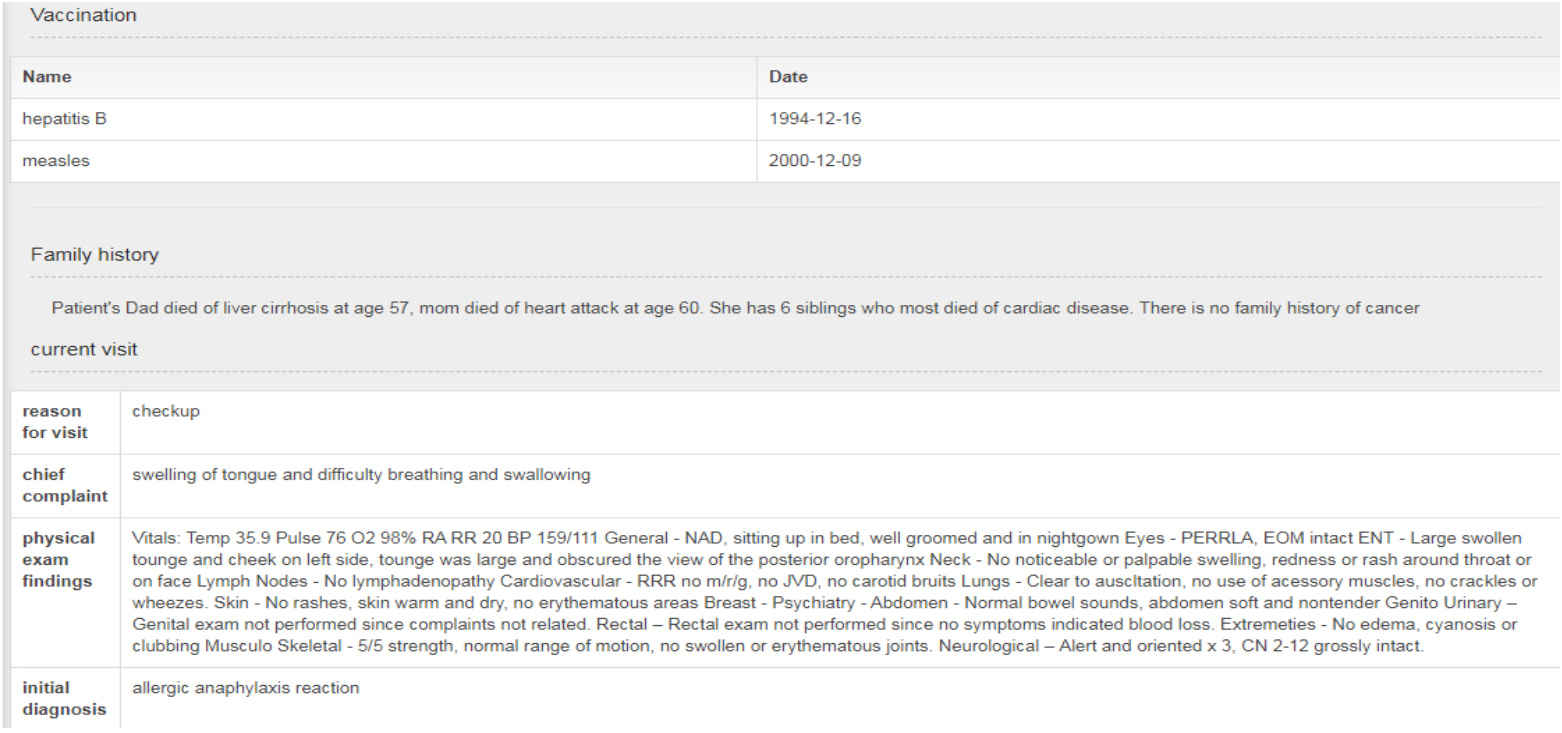



Figure 4.8. : view the information added to a patient record in a certain date.

orderd test

| test Name | result | observations |
|---|---|---|
| WBC | normal | 9.9k mcl |
| blood sodium test | normal | 140 mmol/L |

final diagnosis

Altace (ACEI) drug reaction

treatment plan

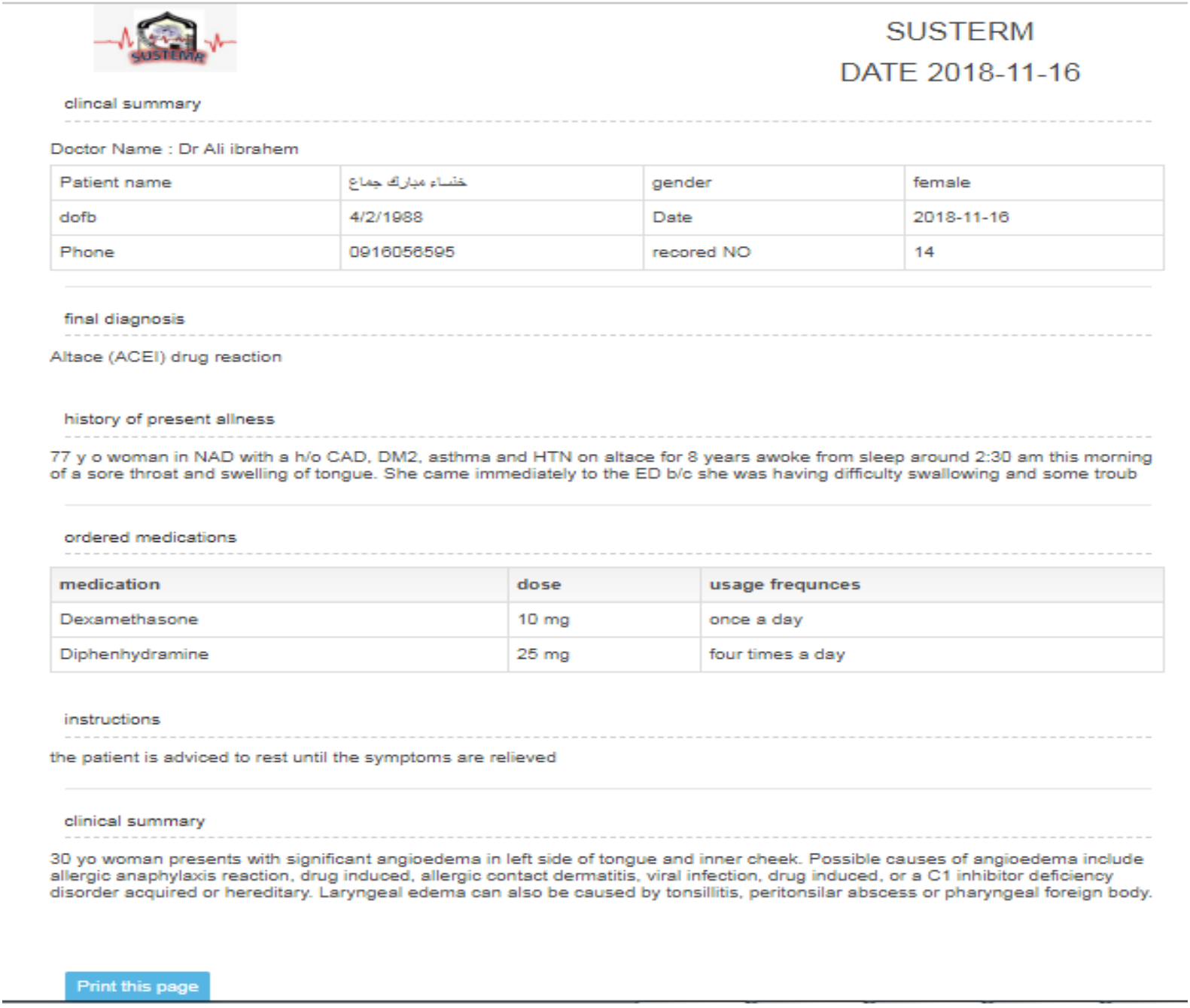
77 y o woman in NAD with a h/o CAD, DM2, asthma and HTN on altace for 8 years awoke from sleep around 2:30 am this morning of a sore throat and swelling of tongue. She came immediately to the ED b/c she was having difficulty swallowing and some troub

order medications

| medication | dose | usage frequnces |
|---|---|---|
| Dexamethasone | 10 mg | once a day |
| Diphenhydramine | 25 mg | four times a day |

Figure 4.9. : continue, patient full medical record view.

The clinical summary view is shown in figure 4.10, which represents a brief medical report or case summary of the visit including the final diagnosis, history of present illness, treatment plan, ordered medications and discharge note, SUSTEMR follow the rules and standards of WHO for clinical summary reports [1]. This option is extremely helpful when the patient needs to transfer to a different doctor, at the bottom of the page the print button, the user can print the medical report for legal or any other purposes.



SUSTERM

DATE 2018-11-16

clincal summary

Doctor Name : Dr Ali ibrahem

| | | | |
|---|---|---|---|
| Patient name | خنساء مبارك جماع | gender | female |
| dofb | 4/2/1988 | Date | 2018-11-16 |
| Phone | 0916056595 | recored NO | 14 |

final diagnosis

Altace (ACEI) drug reaction

history of present allness

77 y o woman in NAD with a h/o CAD, DM2, asthma and HTN on altace for 8 years awoke from sleep around 2:30 am this morning of a sore throat and swelling of tongue. She came immediately to the ED b/c she was having difficulty swallowing and some troub

ordered medications

| medication | dose | usage frequnces |
|---|---|---|
| Dexamethasone | 10 mg | once a day |
| Diphenhydramine | 25 mg | four times a day |

instructions

the patient is adviced to rest until the symptoms are relieved

clinical summary

30 yo woman presents with significant angioedema in left side of tongue and inner cheek. Possible causes of angioedema include allergic anaphylaxis reaction, drug induced, allergic contact dermatitis, viral infection, drug induced, or a C1 inhibitor deficiency disorder acquired or hereditary. Laryngeal edema can also be caused by tonsillitis, peritonsilar abscess or pharyngeal foreign body.

Print this page

Figure 4.10. : SUSTEMR clinical summary view.

**Add/ update patient:** the doctor can use this option to add a new patient record or update the record of an existing patient with a new findings, when the doctor enters a name and phone number SUSTEMR compares the data against the data in the database if the name and record number entered are already in the system, SUSTEMR directly update the new entered information to the existing patient record with the date it was entered on, and if no patient is registered under these information a new record number is granted to the patient and SUSEMR will open a new file for the patient.

Based on the discussions held with doctors prior to the development, the number one concern of doctors was the ease of use of the system, other concerns mentioned were the work flow and time consumed filling the record, for those reasons the interface was made as simple as possible, divided the clinical care into six different steps ordered in the same order the medical service is usually provided ,thus making the flow of information much simpler and every step is accessible with on click without the need to put too much fields in a single page and make the interface complicated and not appealing.

Figures 4.11, 4.12. 4.13, 4.14, 4.15, 4.16 , 4.17, 4.18 and 4.19 shows some of the EMR information fields that were chosen based on the bay of plenty district health board health records protocols [23].

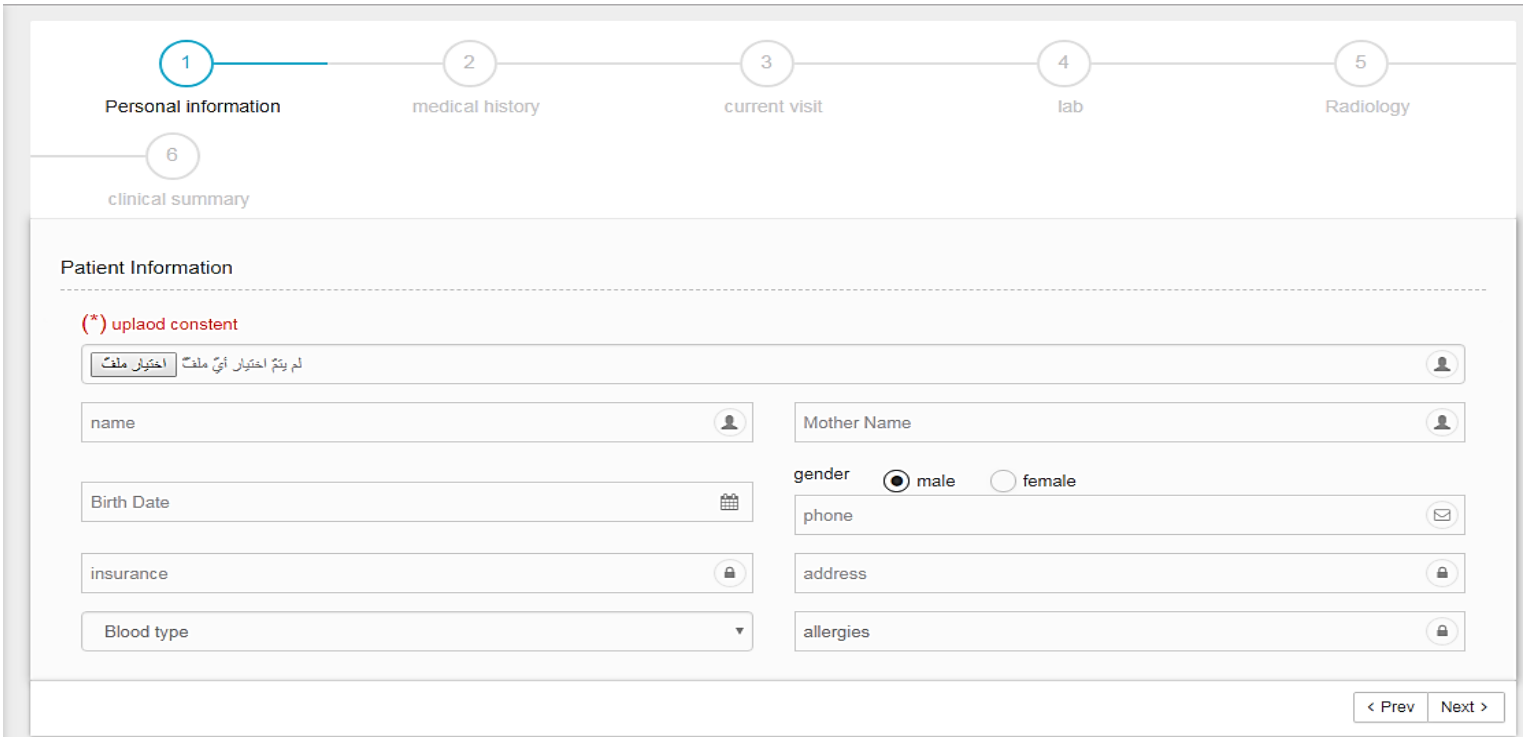



Figure 4.11.: add the patient personal information.

As you can see in figure 13, the first step of creating a new record for the patient is to enter his personal information, one of the most important rules when designing a medical record is correct identification of the patient, confusing between the records of two different patients with same name can be a high risky mistake and can sometimes be fatal, for this reason three different distinct identifiers where chosen (patient name, patient mother's name and record number).

The patient must consent to using his medical information before the doctor can create a record for him, a consent form can be created from the legal department for the patient to fill and then it can be uploaded, if the doctor did not upload the consent for any reason SUSTEMR will automatically reject the movement to step two and no other data can be entered figure 13.

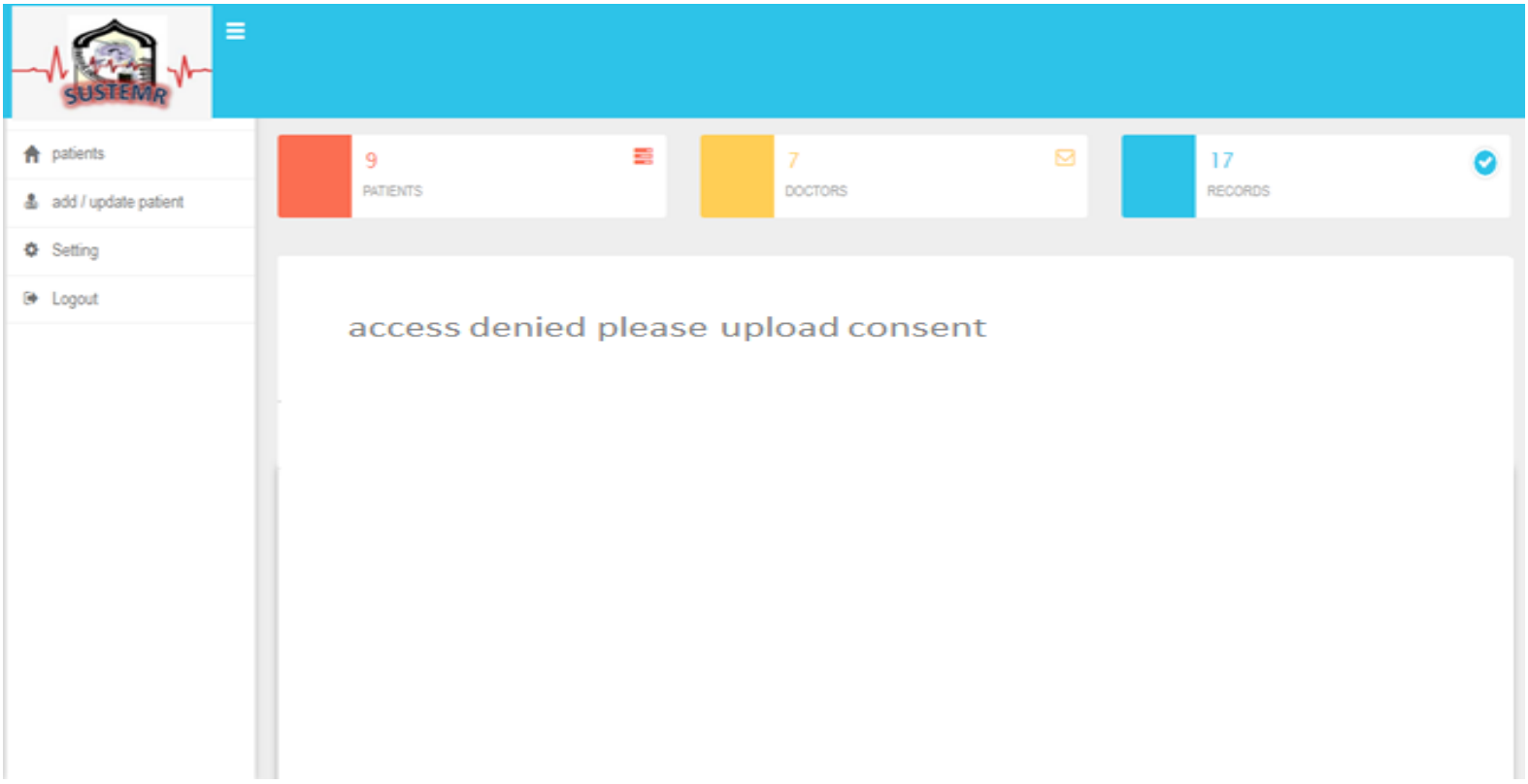



Figure 4.12. : error message when trying to upload medical information without the patient consent.

The second step is medical history of the patient is u can see in figure these information include problem list and medications list which makes the collection of data for research and medical statistics easier, it also includes vaccinations and family history data.

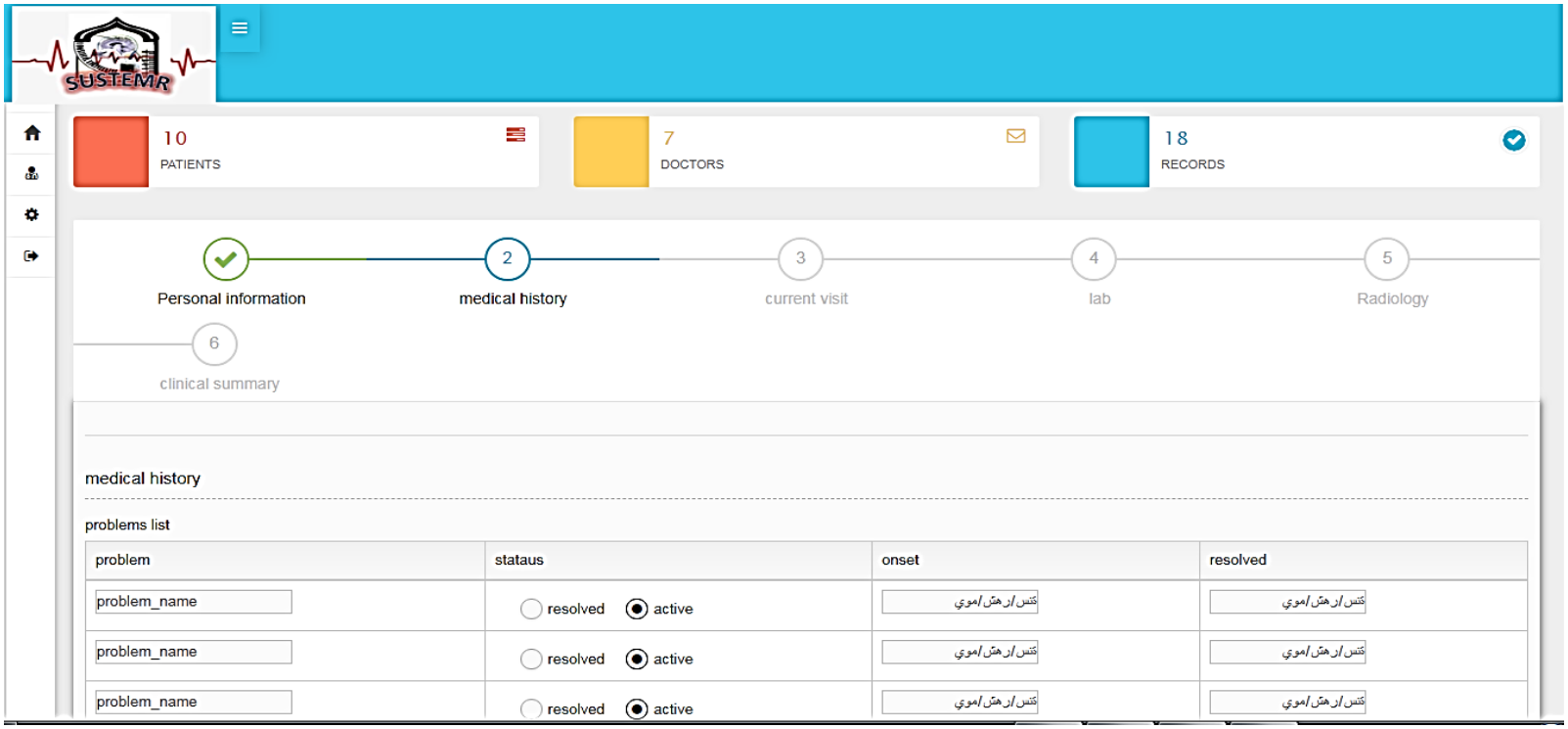



Figure 4.13. : adding the patient medical history 1.

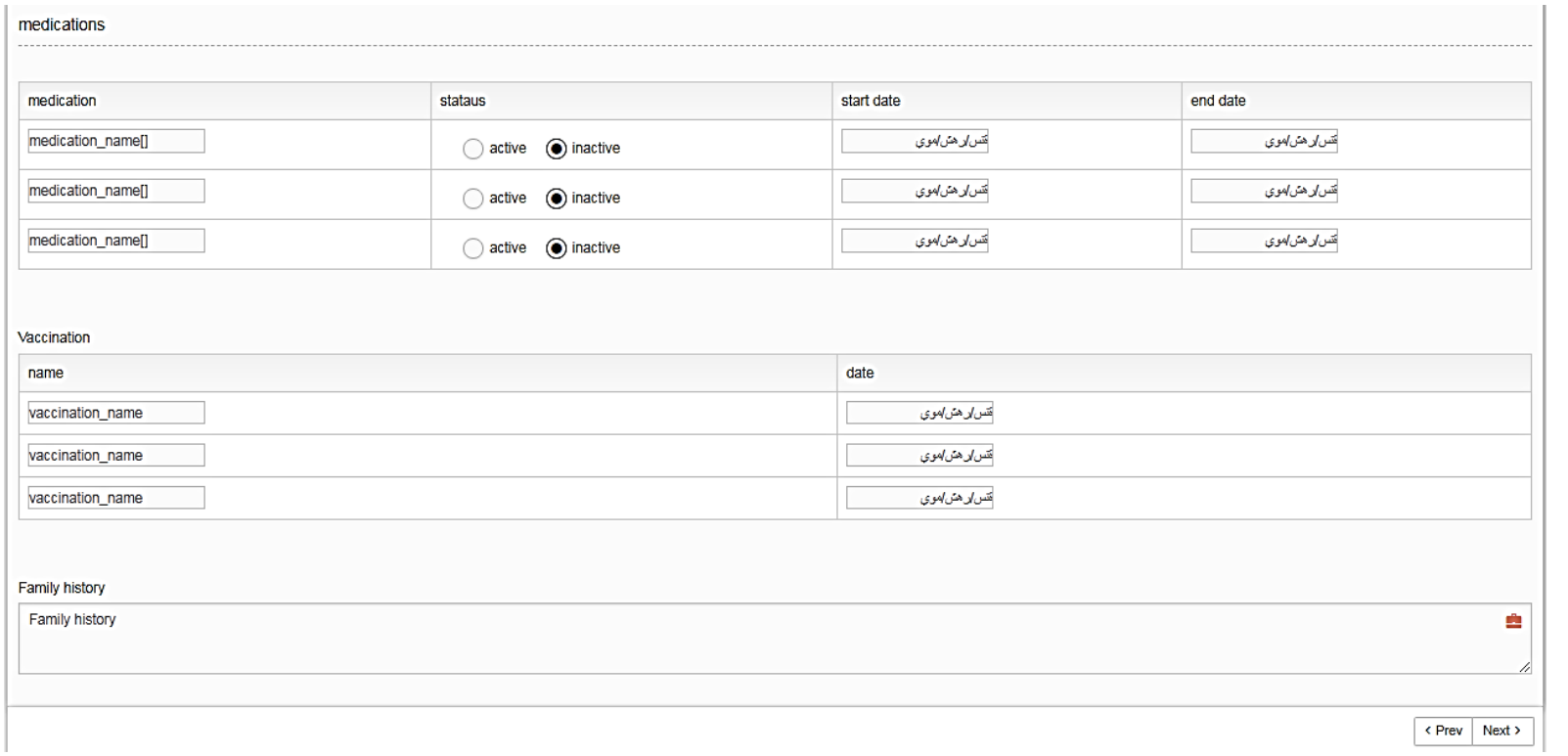



Figure 4.14. : adding the patient's medical history 2.

The next page contains the information of the patient's current visit to hospital along with initial diagnosis and ordered test to confirm the diagnosis.

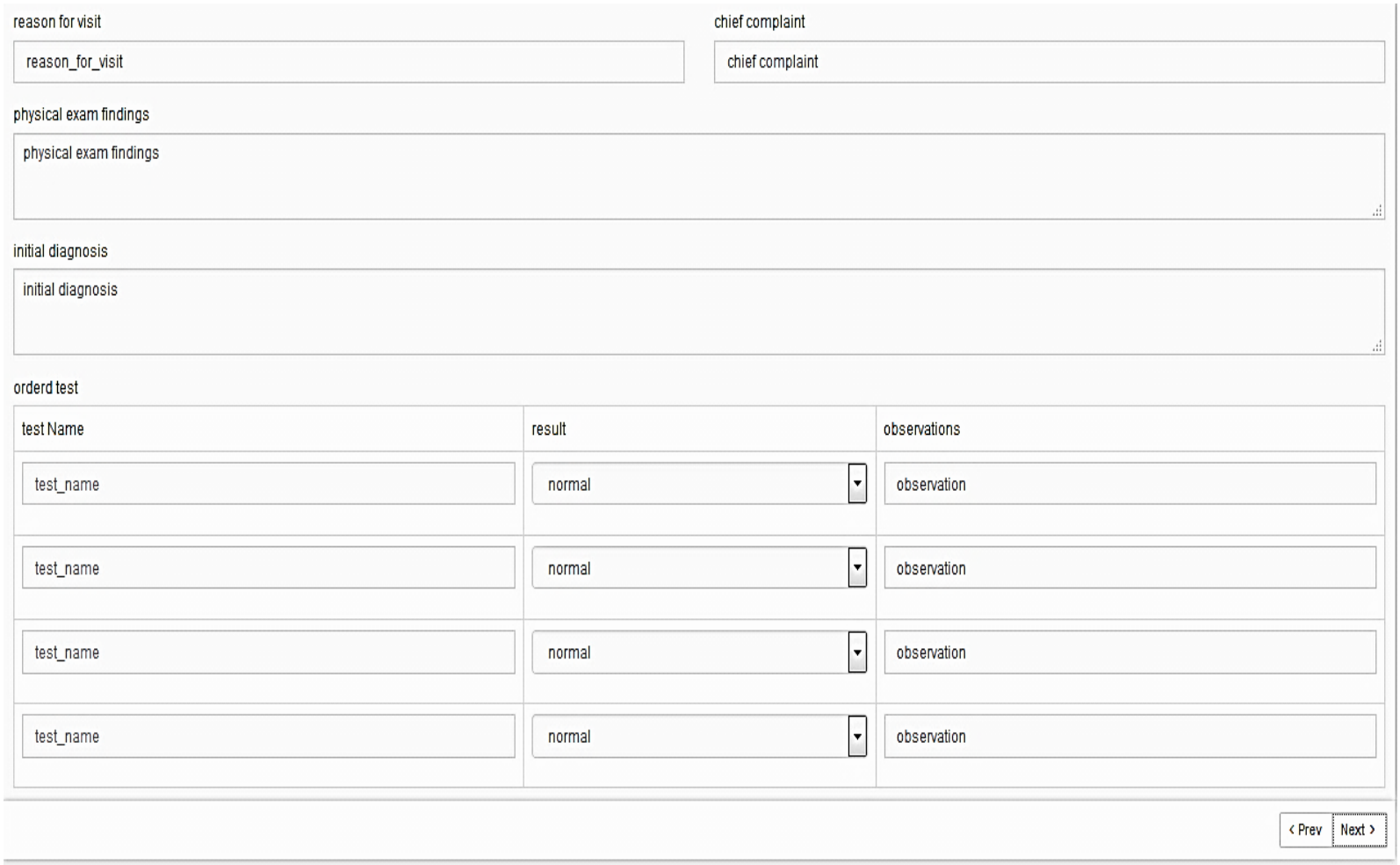



Figure 4.15. : adding information about the patient's current visit to the hospital.

The fourth step contains the laboratory information the lab technician should upload the test results and the doctor analyze it and write his comments about it. The same goes for the radiology data which is page number five.

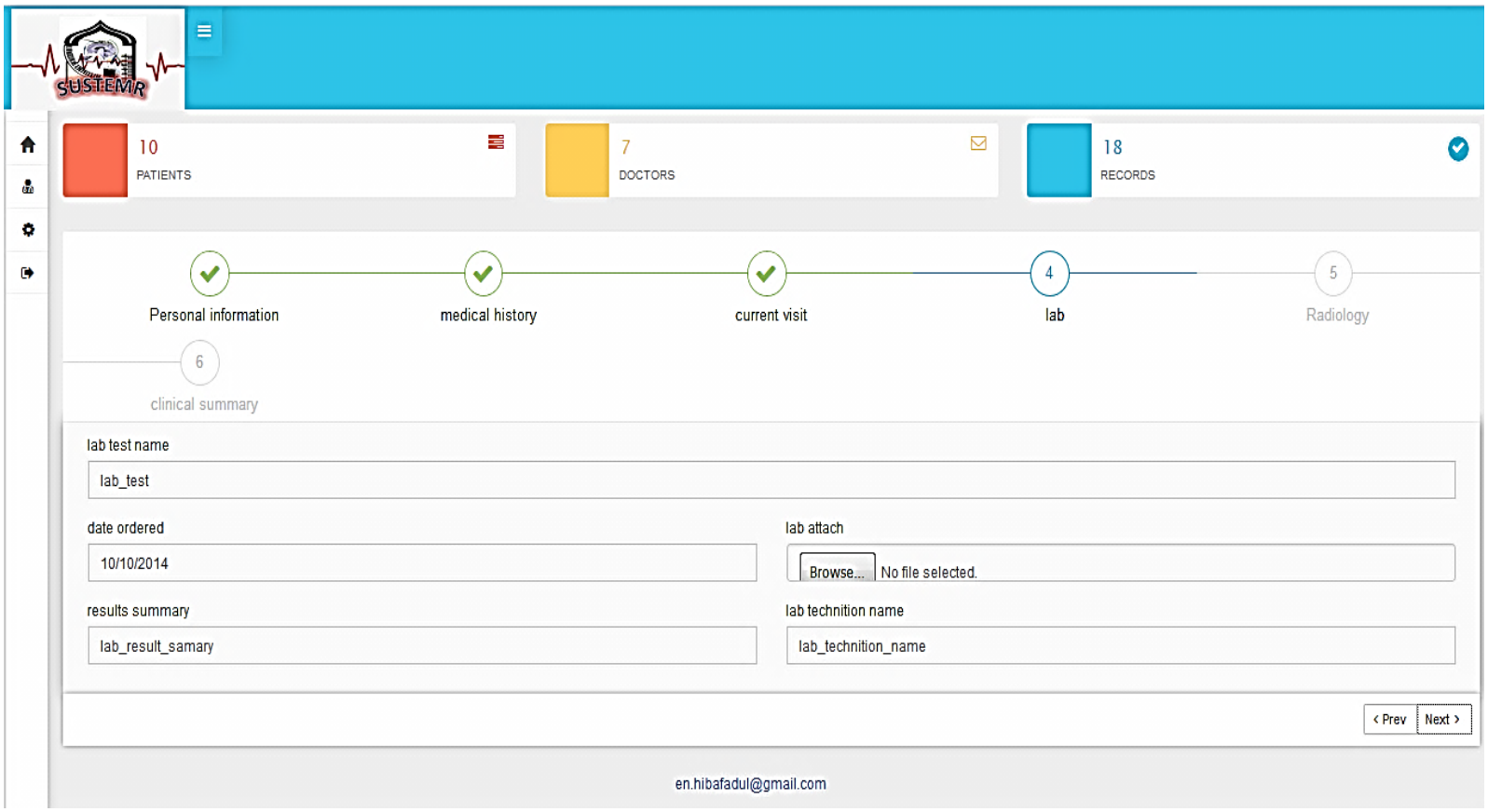



Figure 4.16.: adding laboratory information.

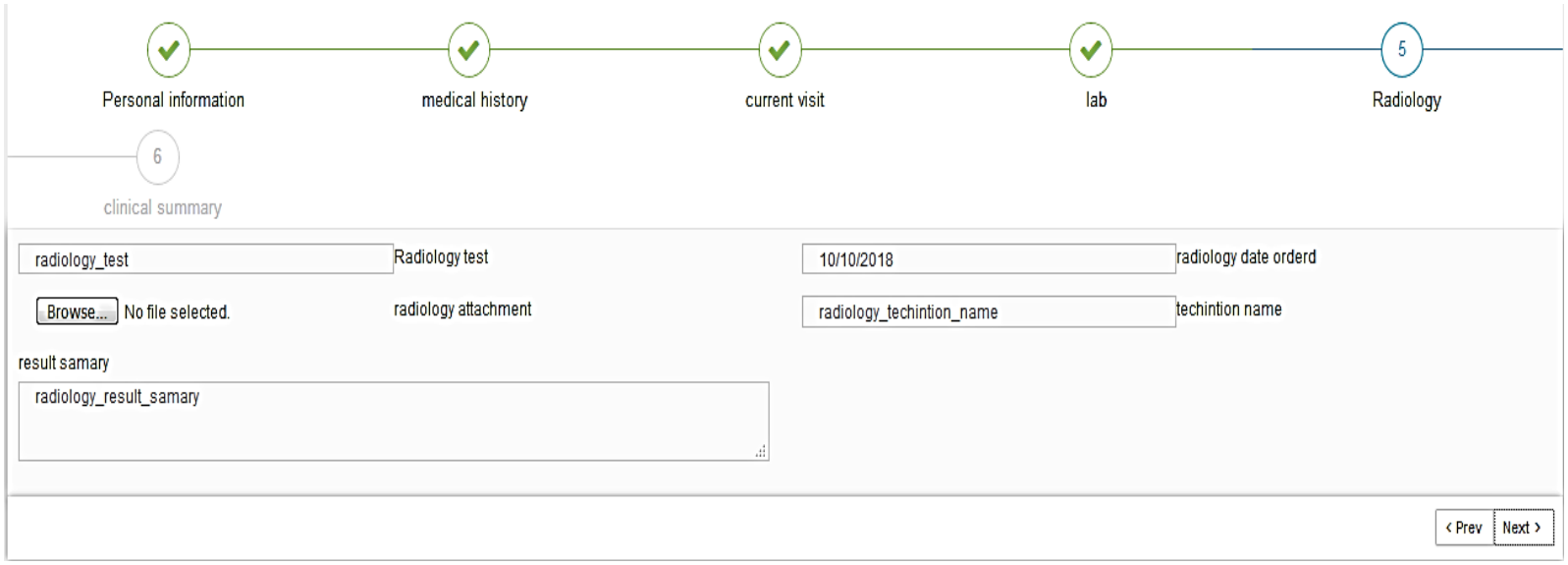



Figure 4.17. : adding radiology information.

The six and final step is the clinical visit summary with the final diagnosis, treatment plan, ordered medications list, instructions and in case the patient needs to be admitted to hospital the admission note.

It contains a link to a decision support system (DXplain) which can be further developed to infobutton.

This conclude the data entry and the doctor can submit the information and the record will be stored.

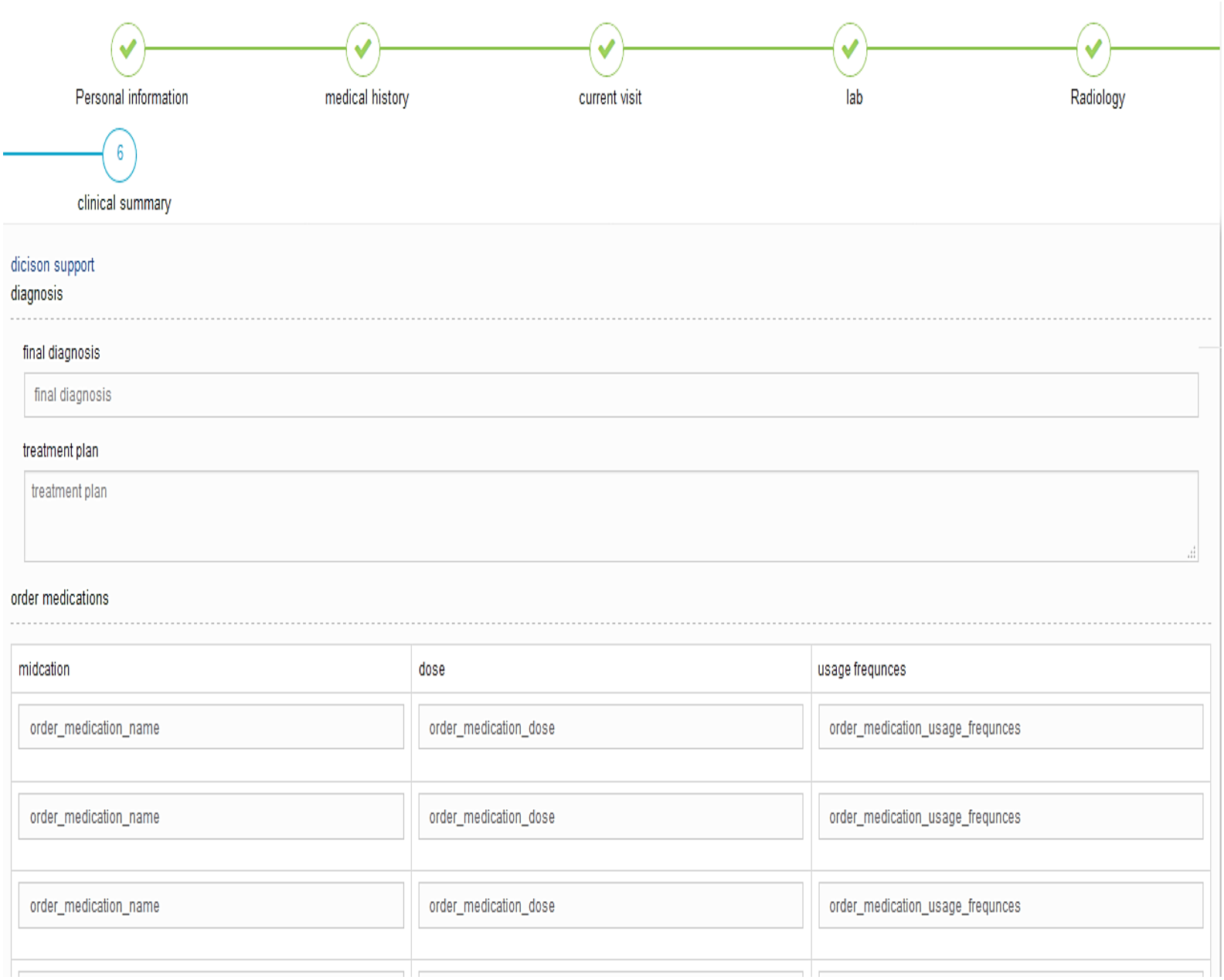



Figure 4.18. : final diagnosis/ treatment plan.

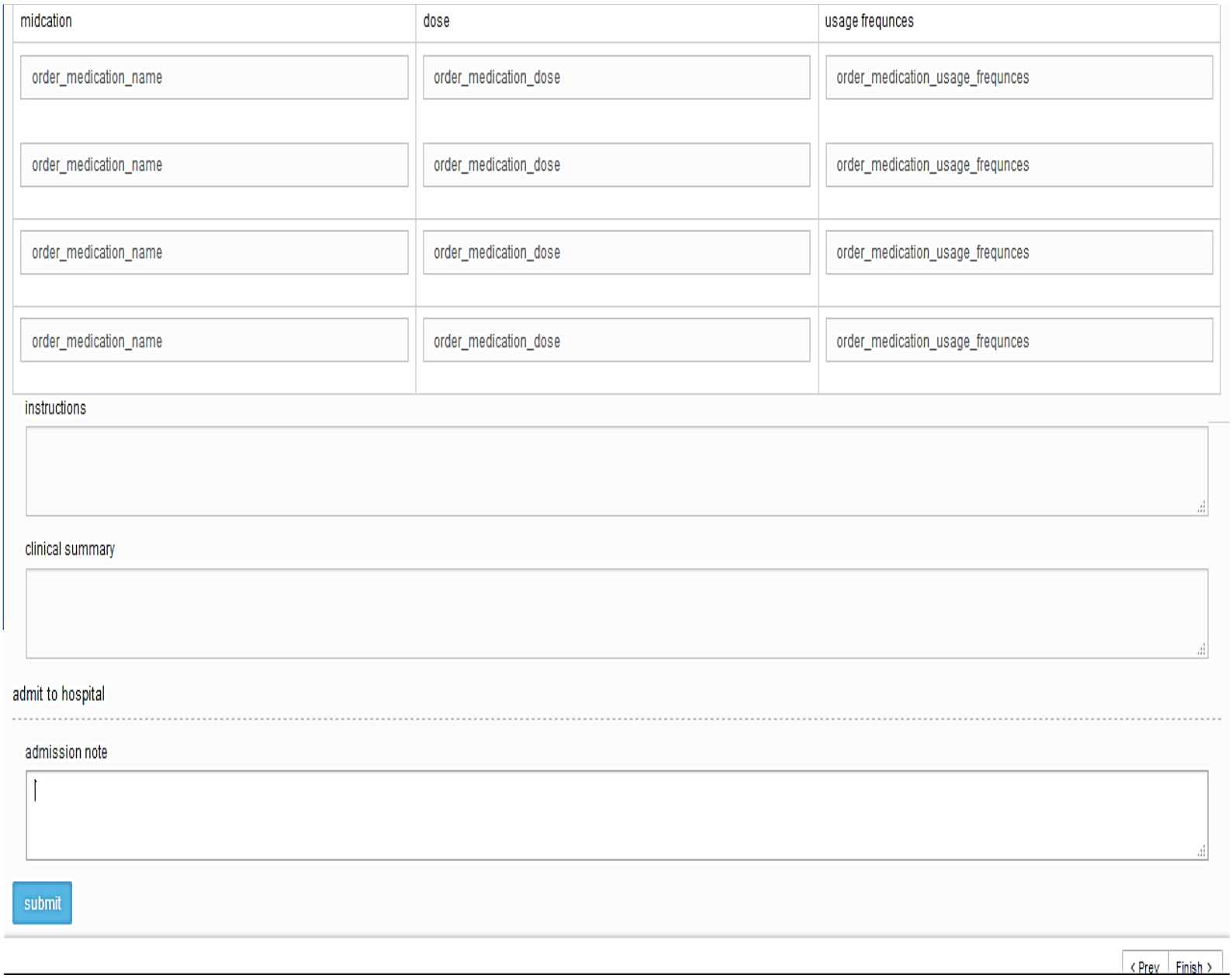



Figure 4.19. : ordered medications and clinical summary.

If the patient needs to be admitted to the hospital the doctors write the admission note, and then throughout the patient hospital stay progress notes are created figure, and the nurses can document the patient vital signs in the nurses note section figure (4.20). These notes are the automatically added to the patient record with the time and date.

When the patient is finally discharged the doctor creates a discharge note with the diagnosis, instructions and ordered medications figure (4.21).

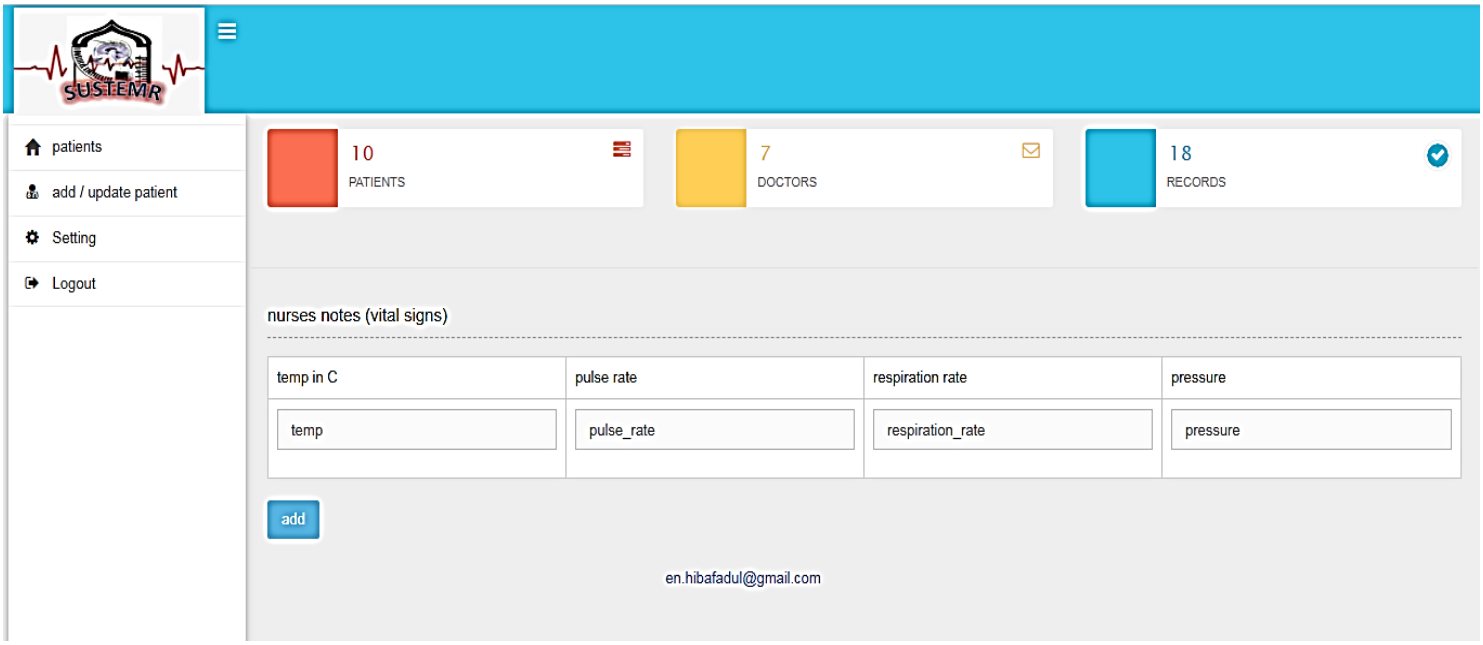



Figure 4.20. : nurses notes/ vital signs.

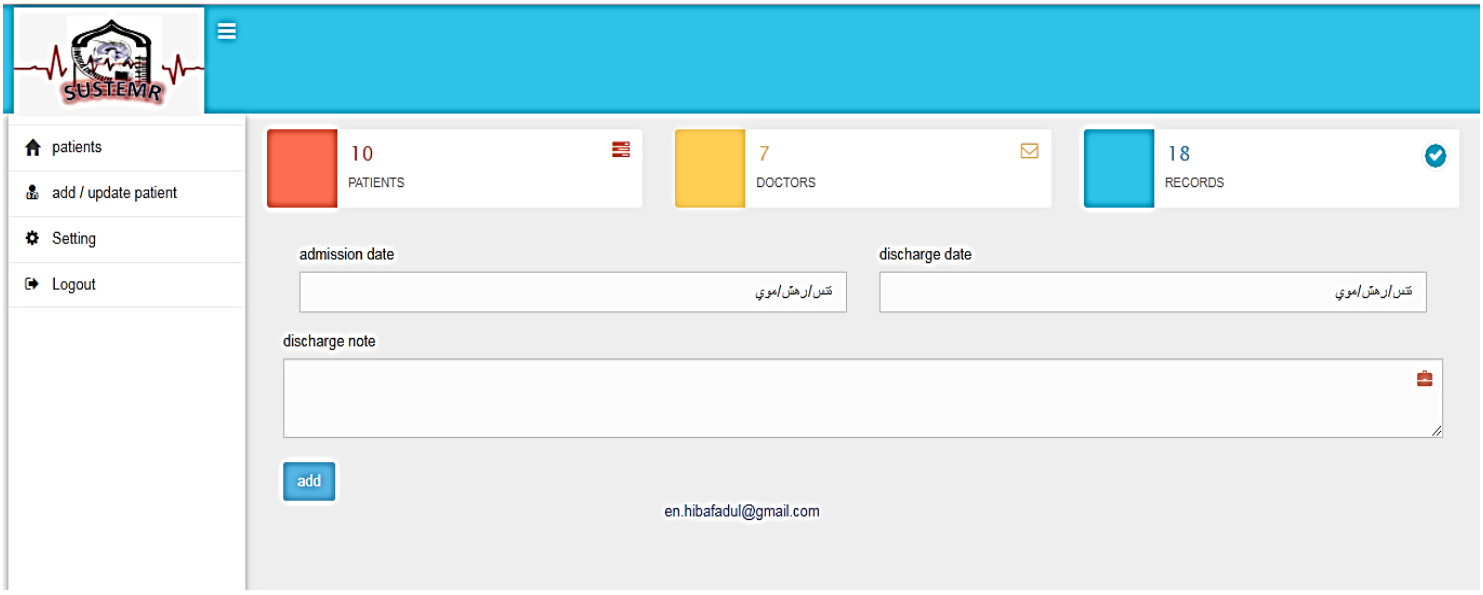



Figure 4.21. : discharge note.

**Sittings**

Here the user can change the system sittings to customize it with his preferences.

**Logout**

Takes you back to the log in page.

### 4.1.2. Suggested improvements of the system

1. Include a button for additions to patient problems: "Have a button 'add to problem list' on progress notes to facilitate updating the problem list when a new diagnosis is made.

2. Dedicate a separate interface to Arabic language so the user can have the freedom to choose either Arabic or English, which can simplify the interface and reduce complexity.

3. Add Arabic language sources of information: Have access to sources of information in Arabic to make it easier to use for the physicians who have not mastered English.

Several ideas can be developed to update ongoing future improvements:

1) Information exchange and interoperability with diverse EMRs;

2) Global expansion: make the system compatible with other countries healthcare standards and conform to global polices.

3) Integration of drug administration and medicine dosage calculators.

4) Integrating Information in the Care System project (e.g., machine learning, knowledge discovery, and data mining).

## 4.2. The Evaluation Of The System

Because of the difficulty of implementing SUSTEMR in a medical facility in Sudan, given the lack of regulations, standards, and clear laws organizing the use of medical information, the sensitivity of the medical information, the lack of registered data before the implementation to measure the improvement after using the system. And also, given the need for higher leaders involvement in the implementation and adaption of the system, all these reasons made the appropriate method for evaluation is using surveys to test the users' satisfaction with the system.

The University of Maryland QUIS version 7.0 (questionnaire for user interface satisfaction) [19] was used a frame of reference to design the user satisfaction questionnaire for SUSTEMR.

Twenty participants were chosen to test the system, all the participants are medical field professionals, males and females, whom ages are between 27 and 41 years old

Test users had the flexibility of answering a written survey. The survey consisted of 13 questions and toke 10 minutes to complete.

The answer choices were based on the Likert scale (strongly disagree \ disagree \ neutral \ agree \ strongly agree) the questions were as follows:

SUSTMER in comparison with having no form of documented patient medical records

Q1: can help me complete my Tasks

Q2: Facilitates my input of information

Q3: easy to use

Q4: safeguards patient privacy

Q5: effectively reviews patient history and problems

Q6: effectively shares patient information with other care providers

Q7: easy to learn how to use

Q8: can improve work flow

Q9: can facilitate the use of information for quality control

Q10: can help obtain information for research

Q11: is overall satisfying for my care providing needs

The design of the questioner is shared in appendix B

Table 4.1 shows a summary of the evaluation results, with the percentage of each response from the overall participants' responses to each question

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| Q1 | 0% | 30% | 5% | 65% | 19% |
| Q2 | 0% | 0% | 0% | 70% | 30% |
| Q3 | 0% | 15% | 0% | 85% | 0% |
| Q4 | 0% | 15% | 65% | 20% | 0% |
| Q5 | 0% | 30% | 30% | 40% | 0% |
| Q6 | 0% | 5% | 0% | 70% | 25% |
| Q7 | 0% | 0% | 5% | 75% | 20% |
| Q8 | 0% | 35% | 40% | 20% | 5% |
| Q9 | 0% | 20% | 5% | 45% | 0% |
| Q10 | 0% | 20% | 5% | 45% | 0% |
| Q11 | 0% | 0% | 5% | 45% | 50% |

**Table 4.1. :** summary table showing the percentage of respondents for each response of questionnaire questions

Figure 4.22 depicts the results in bar graph so it can be better understood.

After reviewing the results of table ` it can be concluded that the majority of users found the system useful and has great potentials,

The results of question one and two shows that vast majority of the participants think that SUSTEMR can help them complete their tasks, and facilitate their input of patients' information more than a paper based patient record.

The results of question three proves the ease of use of the system for average users who had no prior training on the system.

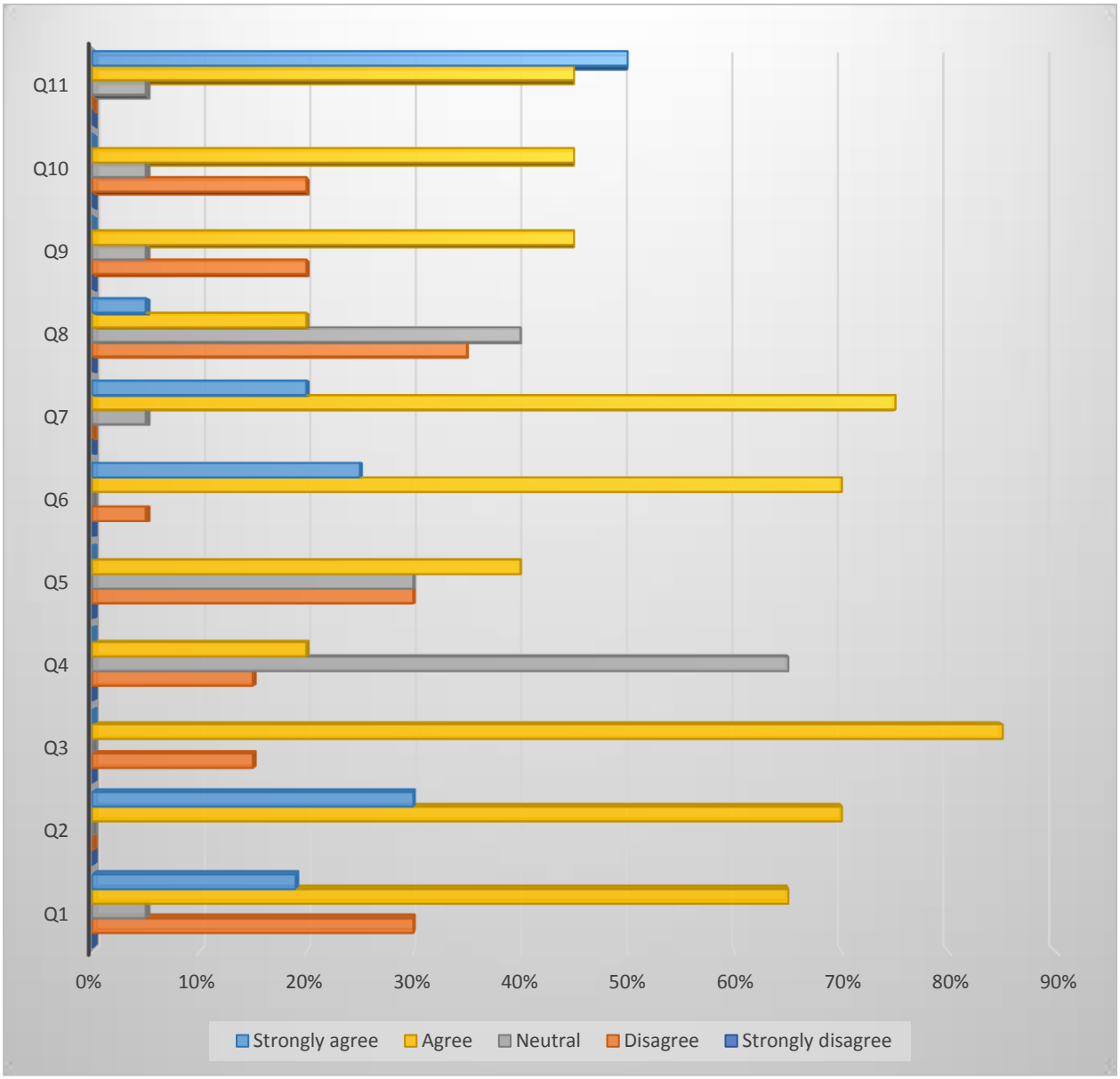



Figure 4.22. : the results of SUSTEMR evaluation

The majority of the participants remained natural regarding the security of the system for guarding patient information, which can be explained by the users' lack of information on the system design and their limited technical knowledge.

The results of question 10 and 11 were similar and inconclusive, which can be justified by the fact that the mechanism of the database mining was not explained to the users, which made them not sure about the effectiveness of the system for these purposes.

The majority of the users found the system not applicable in their environment, and they verbally expressed the difficulties that would face the system implementation and use in their medical facilities.

One of the biggest barriers was the availability of a stable network of computers and internet connection, in every clinic and ward of the hospital, which would put additional financial pressure on the administration without proving the cost effectiveness of the system.

95% of the users found SUSTEMRR overall satisfying to what information they need to give a better care to their patients. Whereas 5% remained neutral and were not confident that system in its current version can provide them with all the information they need in an easy and effective manner.

Perhaps the most revealing finding of the survey results were that the highest two level of satisfaction were for question three and seven ( ease of use and ease of learn), which is not surprising given that various clinical system designers have stated over years that "ease of use" is the single most important determinant of user satisfaction.

One of the possible explanations for the relatively high disagreement on ( help me complete my tasks) Q1(30%), is that the test users found SUSTEMR content very familiar and similar to the paper-based system previously used therefore it had no effect in increasing productivity.

None of users expressed concerns about the system speed, and they considered the system to be adequately fast to accomplish needed tasks, such as information input and retrieval.

SUSTEMR is still running in www.sustemr.com where it has proven to be stable and reliable.

SUSTEMR has achieved the intended goals initially outlined:

1-It is globally accessible on a web-based system from any smart device (PCs, Macs, tablets, and mobile phones]

2- It uses an all-inclusive ،intuitive EMR interface into one navigation system

3- It is network based (web/cloud).

4- It is intuitive ،easy to use and learn ،and does not require formal training.

This project demonstrates that despite the associated challenges, we can move from a paper system to an empowering system based on state of the art technology (e.g., cloud computing and cellular networks now widely available).

# CHAPTER FIVE

# LIMITATIONS CONCLUSION AND RECOMMENDATIONS

## 5.1. Limitations

The biggest challenge that was faced was to actually implement the system on a number of medical facilities across Sudan, Implementing a national web-based electronic medical information record will require a substantial investment in administrative and governance infrastructure along with the investment in information technology which were not available for this project.

The administrative and governance infrastructure must enable a complex oversight structure of advisory and supervisory boards and be able to address issues such as network maintenance and usage, study oversight, monitoring, access, standardization of proposals, protocols, and multi-site agreements, including data use agreements.

Issues such as security, proprietary, legal, privacy, and cost presented substantial challenge to the implementation of the system. In addition, concerns regarding risk mitigation, patient privacy came as an obstacle to developing a persuasive business case in order to convince data holders that the benefits of participation outweigh the real and potential costs of participation.

The laws regulating the use of medical information in Sudan are not clear and the policies were not made available they were not accessible either online or in the ministry of health head office in Khartoum.

## 5.2. Conclusion

SUSTEMR highlighted the importance of taken medical record out of the ink and paper era into a fully electronic web based system, and focused on the benefits of an electronic system to the quality of care, provider, and patient satisfaction.

This research focused on finding the reason behind and the appropriate mechanism to develop such system by answering the (why) and (how to) questions regarding the interface, access and

evaluation of the proposed concept. It was expected that the proposed system would have a measurable, positive effect on provider satisfaction compared with the paper-based system.

In this research, a complete, robust and efficient cloud-based EMR system has been designed and implemented. Cloud computing has been identified generally as the next big deal in computing infrastructure and it offers some benefits by allowing the use infrastructures like networks, storages, and servers, software such as application programs and platforms like operating systems and middleware services.

Adapting the cloud technology to medical record management, reduces the cost of healthcare delivery through reduce administrative bottlenecks. The convenience this kind of system will give to physicians, patients and hospital administrator especially in developing world cannot be quantified. With time, it is hoped that hospitals, health care regulatory bodies and the Health ministries in Sudan will take advantage of innovations that are becoming available through internet solutions to improve healthcare system.

The implementation of SUSTEMR in a clinical care sitting is expected to be associated with perceived overall user satisfaction in information sharing, research, access to files, continuity of care, workflow, and primary documentation capabilities.

The central idea of this research was to provide a web-based medical record system with state-of-the-art biomedical informatics applications that would improve provider satisfaction and health care for populations in Sudan with limited resources.

## 5.3. Recommendations for Future Research

Although the study offered important insights about the level of satisfaction with use of web-based EMR system compared to paper based records as expressed by the user satisfaction survey, several related critical questions remain unanswered.

One of these is how patient satisfaction is affected during clinical encounters with health care providers who use SUSTEMR.

Also, to what extent does the use of SUSTEMR in the same and similar settings impact patients' overall quality of life, specific health indicators, and health outcomes?

One important recommendation would be the coding of medical information which will ease the use of a decision support tool, and the entering of structured data.

Another recommendation would be to strengthen the security of both the system and the user.

It would be beneficial to test how the system would perform using one of the recent database management tools.

One improvement of the system is to grant access to patients to their records by adding a third role access control that opens directly the record with the number associated with the login information.

Fortunately, these enhancements have become more focused because of the study. These research initiatives should take place in parallel with the software updates and setting expansions in primary care around Sudan.

Actual implementation of SUSTEMR in multispecialty primary health clinics of varying sizes needs to be done to better understand the functionality that is most associated with high levels of satisfaction with its use.

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# APPENDIX A

## THE PROGRAMMING CODE

**Admin side**

```
defined('BASEPATH') OR exit('No direct script access allowed');
class Admin extends CI_Controller {
   public function __construct()
{
   parent::__construct();
   if (!$this->session->has_userdata('login')) {
     redirect('login');
   }
   elseif ($this->session->login->level !== "admin") {
     redirect('doctor');
   }
}
   public function index() {
      $data["page"] = "admin/index.php";
      $data['sidebar'] = 'admin/sidebar.php';
      $this->load->view('template', $data);
   }
   public function hospitals() {
      $data["title"] = "hospitals";
      $data["hospitals"] = $this->db->get("hospitals")->result();
      $data["page"] = "admin/hospitals.php";
      $data['sidebar'] = 'admin/sidebar.php';
      $this->load->view('template', $data);
   }
   public function add_hospital() {
      $data["title"] = " add new hospital";
      $data["page"] = "admin/add_hospital.php";

      $data['sidebar'] = 'admin/sidebar.php';
      $this->load->view('template', $data);
   }
   public function post_add_hospital() {
//          hospitals `name`, `address`
      $name = $_POST["name"];
      $address = $_POST["address"];
      $about = $_POST["about"];
```

```
        $this->db->insert("hospitals", ['about' => $about, 'name' => $name, 'address' => $address]);
        redirect("admin/hospitals");
    }

    public function edit_hospital($id) {
        $data["hospital"] = $this->db->get_where('hospitals', array('id' => $id))->row();

        $data["title"] = "edit hospital";
        $data["page"] = "admin/edit_hospital.php";

        $data['sidebar'] = 'admin/sidebar.php';
        $this->load->view('template', $data);
    }

    public function post_edit_hospital() {

        $name = $_POST["name"];
        $address = $_POST["address"];
        $about = $_POST["about"];
        $id = $_POST["id"];

        $this->db->where('id', $id);
        $this->db->update("hospitals", ['about' => $about, 'name' => $name, 'address' =>
$address]);
        redirect("admin/hospitals");
    }

    public function delet_hospital($id) {
        $this->db->delete('hospitals', array('id' => $id));
        redirect("admin/hospitals");
    }
    public function Doctors() {
        $data["title"] = "Doctors";
        $data["doctors"] = $this->db->get_where("users", ["level" => "doctor"])->result();
        $data["page"] = "admin/doctors.php";
        $data['sidebar'] = 'admin/sidebar.php';
        $this->load->view('template', $data);
    }
    public function add_doctor() {
```

```
//       users `id`, `name`, `password`, `email`, `level`, `created_at`
        $data["hospitals"] = $this->db->get("hospitals")->result();
        $data["title"] = " add new hospital";
        $data["page"] = "admin/add_doctor.php";
        $data['sidebar'] = 'admin/sidebar.php';
        $this->load->view('template', $data);;
    }

    public function post_add_doctor() {

        $name = $_POST["name"];
        $password = $_POST["password"];
        $email = $_POST["email"];
        $level = "doctor";
        $hospital = $_POST["hospital"];
        $phone = $_POST["phone"];
        $about = $_POST["about"];

        $data = ['about' => $about,'name' => $name, 'phone' => $phone, 'name' => $name,
'password' => $password, 'email' => $email, 'level' => $level, 'hospital' => $hospital];
        $this->db->insert("users", $data);
        redirect("admin/doctors");
    }

    public function edit_doctor($id) {
        $data["doctor"] = $this->db->get_where('users', array('id' => $id))->row();
        $data["hospitals"] = $this->db->get("hospitals")->result();
        $data["title"] = "edit doctor";
        $data["page"] = "admin/edit_doctor.php";

        $data['sidebar'] = 'admin/sidebar.php';
        $this->load->view('template', $data);
    }

    public function post_edit_doctor() {
        $name = $_POST["name"];
        $password = $_POST["password"];
        $email = $_POST["email"];
        $level                                          =                                          "docto
```

# APPENDIX B

## THE SURVEY DESIGN

**Part one: Demographic data:**

**Please complete**

1) **Age:**

20-30☐ 31-40☐ 41-50☐ 51-60 ☐ 60+☐

**2) Gender:**

Male☐ female☐

**3) Field:** _____

**Part two: User Satisfaction Questioner**

For each of the following features, please mark the rating that best describes how you think of SUSTEMR in comparison with the system used in your facility (paper-based system / no used system).

**SUSTMER in comparison with system currently in practice at my medical organization**

Q1: can help me complete my Tasks

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q2: Facilitates my input of information

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q3: easy to use

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q4: safeguards patient privacy

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q5: effectively reviews patient history and problems

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q6: effectively shares patient information with other care providers

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q7: easy to learn how to use

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q8: can improve work flow

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q9: can facilitate the use of information for quality control

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q10: can help obtain information for research

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q11: is appropriate for use in my care sittings

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree

Q12: is overall satisfying for my care providing needs

☐ Strongly disagree ☐ disagree ☐ neutral ☐ agree ☐ strongly agree