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Development of a system for electronic health record (EHR)

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DEVELOPMENT OF A SYSTEM FOR ELECTRONIC HEALTH RECORD (EHR)

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Option: Information and Communication Technology and Networks

2019 – 2020

I dedicate this modest work:
To all members of my family for their continued support and I wish them good health and long life

BRAHIMI Mohamed Meziane.

I am dedicating this modest work to God Almighty my creator, my strong pillar, my source of inspiration, He has been the source of my strength throughout this work and on His wings only have I soared.
To my familly espically my parents who gave me this celestial gift, this majestic unique experience called life i wish them long life and good health.
I also dedicate this work to all my teachers who have been supportive, to all my friends who have been with me throughout the process. I will always appreciate all what they have done.

GHADBANE Yassine

ACKNOWLEDGEMENTS

In The Name of **ALLAH**, The Most Beneficent, The Most Merciful.

All praise belongs to **ALLAH** alone, and blessings and peace be upon the final Prophet.

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Part I

GENERAL INTRODUCTION

This part contains the general introduction of our dissertation which have overview, motivation and problematic issues.

1 GENERAL INTRODUCTION

1.1 OVERVIEW

Use of Information Technology (IT) is common in all areas, including healthcare. Many healthcare organizations use IT-enabled healthcare applications for simplifying healthcare processes such as administration, managing health records across departments, and billing. On the other hand, some organizations are still struggling with conventional healthcare processes and paper-based health records. Increase in population, complemented with new and complex treatments for diseases, have increased demand for better and more efficient healthcare services globally. Due to complexity of health problems, multiple healthcare providers are involved in treatment of a patient, making healthcare process more complex. Need for complete health information of a patient such as patient's history, allergies, laboratory tests, medication, and so on at one place for his/her better care is increasing. Researchers have now realized that increased application of IT to healthcare with Electronic Health Record (EHR) is a way to deal with these issues. Hence, many countries are promoting increased use of IT in healthcare services and use of EHR for enhancing continuity of care to patients.

1.2 MOTIVATION

Because of the rapid development in the field of the internet and means of communication Almost no one on this earth that is not connected somehow to a mobile device. This makes it a very powerful tool for health-care delivery. In this context we would like to develop an electronic health record that meets all the requirements of Healthcare.

1.3 MEDICAL RECORD PROBLEMS

Medical records are one of the focal points on which the provision of health care depends among the different types of medical institutions, and its importance lies in preserving all patient information from comprehensive medical and master data for all the tests, diagnoses, treatment, follow-up reports and important medical decisions. For decades, the nature of medical records has remained constant in the form of a file or a set of papers on which handwritten, increasing the possibility of medical errors or damage to paper files. We will respond to this problem, and we will develop Electronic health record to facilitate and improve healthcare.

1.4 ORGANIZATION OF DISSERTATION

Our dissertation is divided into four parts. The first contains the general introduction of the project and we talk about overview, motivation and problematic issues. The second part contains the litterateur topics to help the reader to understand the contribution of this project. This part contains two chapters: e-health and electronic health record. While the third part will talk about design and implementation of our proposed solution. The last parts is the general conclusion and future work.

Part II

THE LITERATURE PART

Two chapters will be provided in this part to help the reader to understand our work. The chapters are the identification of information and communication technology and its impact on the practical areas of the human being, including the health field and the method of developing an electronic health record.

2

E-HEALTH

2.1 INTRODUCTION

In today's world, technology plays an important role in every industry as well as in our personal lives. Out of all of the industries that technology plays a crucial role in, healthcare is definitely one of the most important. This merger is responsible for improving and saving countless lives all around the world.[20]

2.2 E-HEALTH

In this section, we will learn about the definition of e-health and its reality in Algeria.

2.2.1 *What is the E-health*

E-health is a concept intended to be used by the health sector for communication and information technology. We can also define e-health as follows:

2.2.1.1 *Definition 1*

WHO(WORLD HEALTH ORGANISTION) defines eHealth as the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research. Clear evidence exists on the growing impact that eHealth has on the delivery of health care around the world today, and how it is making health systems more efficient and more responsive to people's needs and expectations. The Eastern Mediterranean Region includes different levels of maturity and readiness to utilize eHealth as a key enabler in the delivery of health care services. Experience shows that harnessing ICT for health requires strategic and integrated action at the national level, to make the best use of existing capacity while providing a solid foundation for investment and innovation.[6]

2.2.1.2 *Definition 2*

Electronic health (eHealth), defined as the use of information and communication technology (ICT) in healthcare, is regarded as a modern driver of universal health coverage and quality healthcare delivery A range of eHealth applications including telemedicine, electronic health records (EHRs), clinical decision support systems (CDSS), mobile health (mHealth) applications, computerised physician order entry (CPOE), electronic prescribing systems (EPS) and web-based health services (WHS), have all recorded varying levels of success in promoting access to quality health services.[22]

2.2.2 *Algerian electronic health status*

The huge population number of Algeria that exceeded 42 millions inhabitants by the end of 2018 made Algeria one of the most important largest countries in north Africa whereby the estimated number of Internet users was around 30 million, including 22 million social media users, which allows a successful implementation of the e-health in Algeria that has globally evolved due to health related sites that had exceeded 175 million applications. However, the electronic health services are not very common among the Algerian public. Moreover, this remarkable lack is not due to the developers disinterest in applications, but due to the reputation that the Algerian content holds for being deficient in most domains. Especially, in the field of health. In addition to the absence of awareness in both sides, doctors, specialists and patients regarding the benefits of this advanced technology that shortens distances and facilitates people's daily lives. The fact that content storage services are weak and development price is still high, does not make the Algerian individual uninterested in the technological evolution. In the contrary we can found around 21000 application that serve the filed of electronic health, but most of them are foreign applications that deal with traditional medicine and religion. Latest statistics in medical insurrance reveal that one doctor per

1000 inhabitants, which is quite inferior for 42 million inhabitants. Furthermore, administrators in the health sector face certain issues. Some of these issues can be solved through implementing electronic health, like the use of an application that keeps track of the patient's medical file, an application that can be digitized to schedule appointments at the doctor.[23]

2.3 INFORMATION TECHNOLOGY

Humans have been storing, retrieving, manipulating and communicating information since the Sumerians developed writing in about 3000 BC, but the term information technology in its modern sense first appeared in a 1958 article published in the Harvard Business Review; authors Harold J. Leavitt and Thomas L. Whisler commented that "the new technology does not yet have a single established name. We shall call it information technology (IT)." Their definition consists of three categories: techniques for processing, the application of statistical and mathematical methods to decision-making, and the simulation of higher-order thinking through computer programs.[18]

2.3.1 *Definition 1*

As defined by the Information Technology Association of America (ITAA), is the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware.[34]

2.3.2 *Definition 2 (Tom forester)*

Information technology in its strictest sense is the new science of collecting, storing, processing, and transmitting information.[38]

2.3.3 *Application domains*

The rapid development of new equipment and technologies, especially in the field of information systems and technologies, robotics, modern means of communication, transmission and processing of information allows them to be rapidly introduced into government administration, industrial production, transport and construction, the provision of services, that is, in all areas of life. Digitalization today serves as the main driver of economic growth and improving the quality of life of the population. Digital economy and logistics.[3]

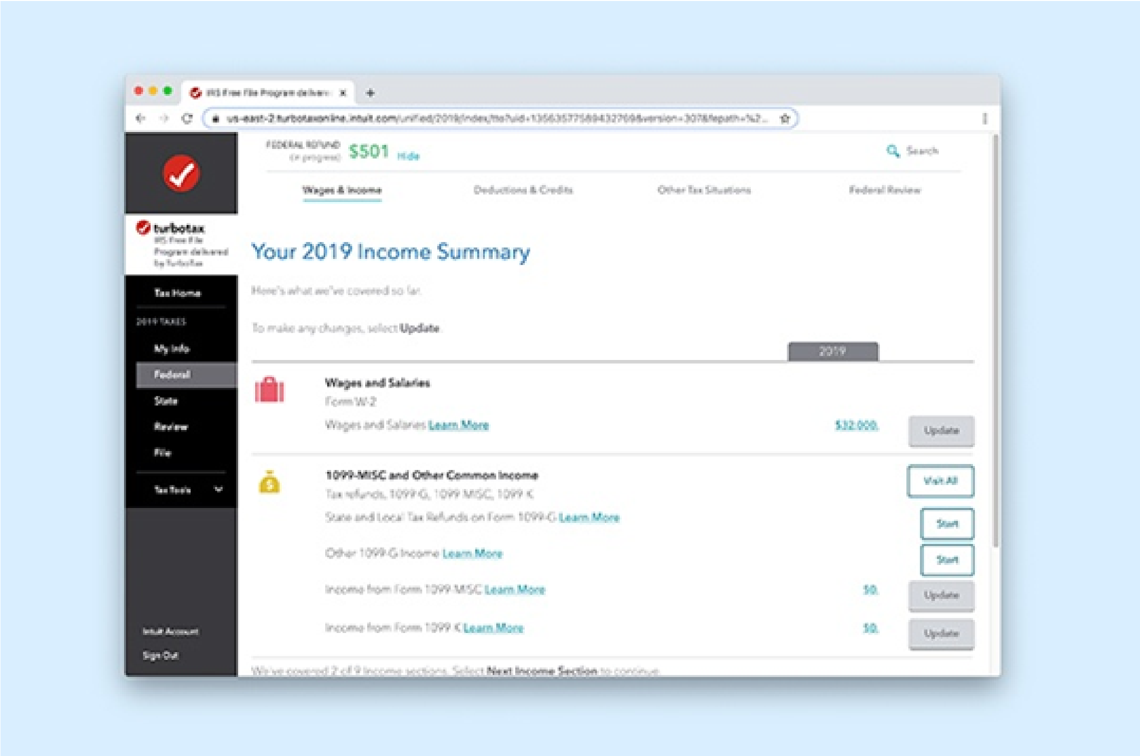
2.3.3.1 *Administration and governance*

Information technology (IT) strategies are organized and long-term approaches to connect government with citizens. Federal, state, and local governments are investing in the development of IT strategies to promote their e-government goals. E-government improves and enhances the infrastructures and services provided to the citizens.[26]

Such as :

- Electronic tax filing.
- E-government.
- Electronic voting.

Figure 1: Tax filing software (Turbo tax).



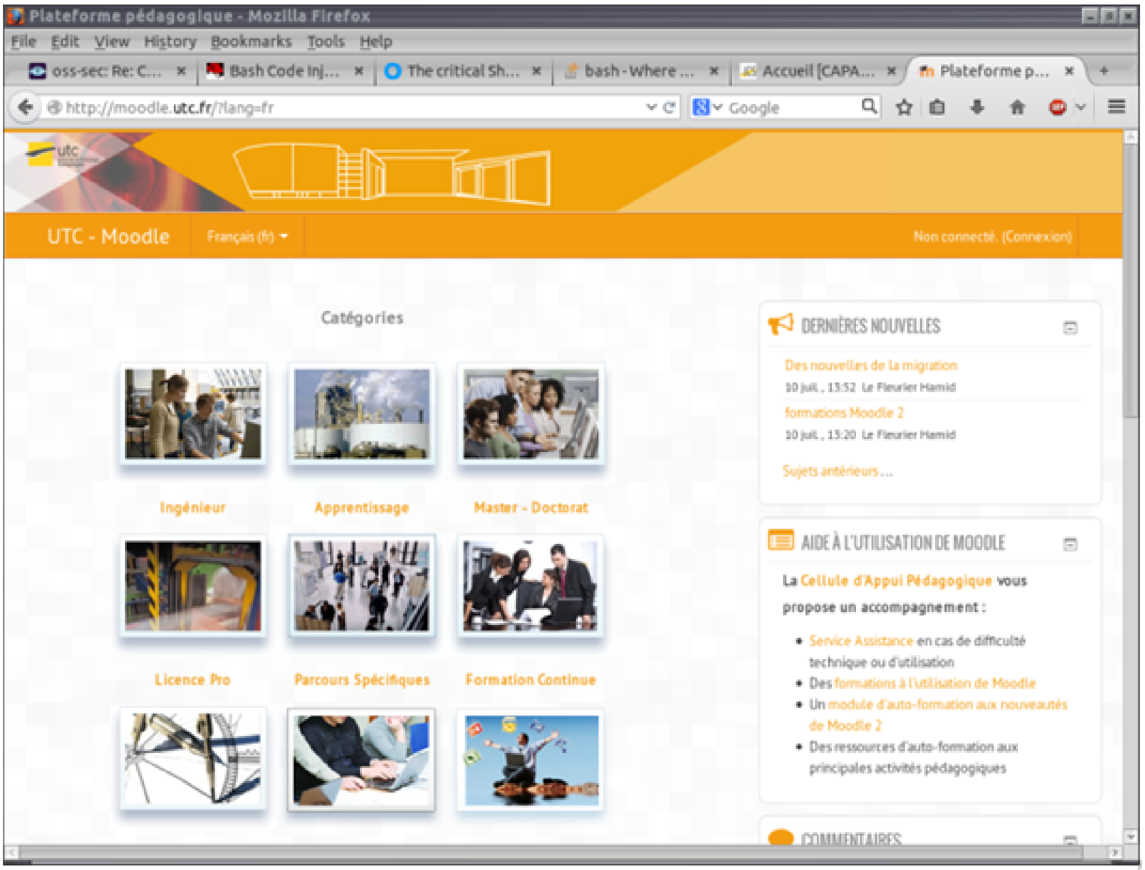
2.3.3.2 *Education*

The use of Information Technology in classroom has left behind the traditional methods of giving long boring lectures. Using IT the teachers can create interesting audio and visual presentations which will keep the students engaged and will give them a greater understanding of all the concepts. Beside this, such methodology can give rise to interactive sessions between students and teachers. Everyone likes watching animated videos. Using Information Technology the whole classroom can be digitalised thus making both teaching and process of learning much easier.[24]

Such as :

- Tadarus.
- Dokeos.
- Blackboard Inc.
- Moodle.

Figure 2: Open source learning platforme.



2.3.3.3 *Transportation*

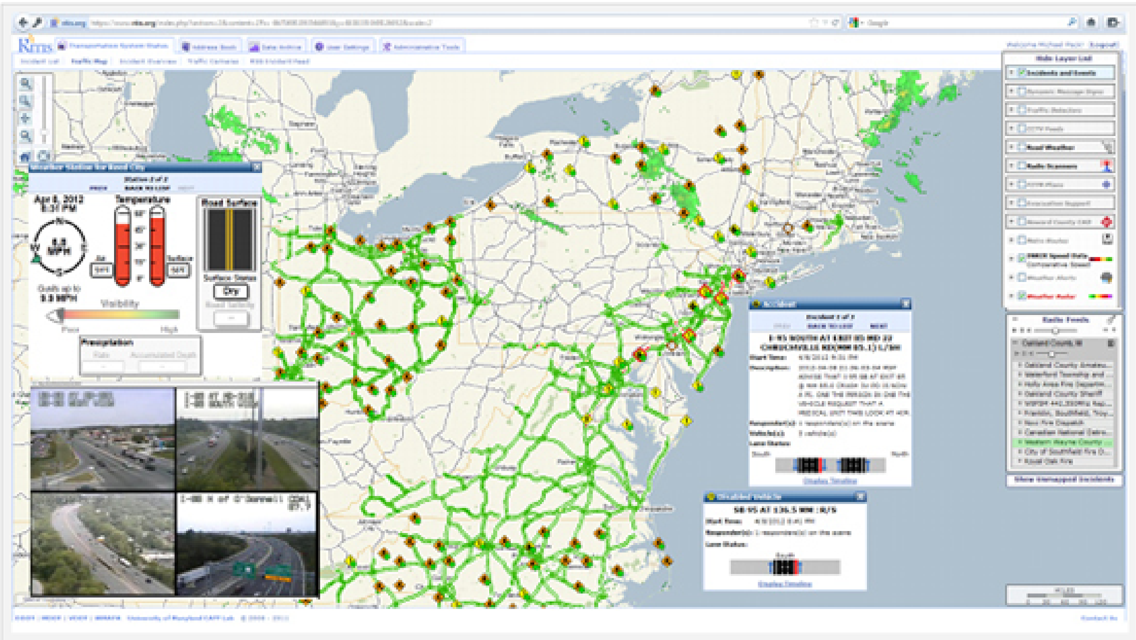
Information and communication technologies (ICT) have considerable importance for transport systems, as they provide access to travel information, planning tools, opportunities to share transport modes, to work at-a-distance, compare transport mode cost, make payment, improve safety and health, and to communicate travel patterns. Over the past decade, there has been massive growth in the availability of transportation ICT, in particular smartphone applications. There is considerable evidence that ICT has profoundly changed the ways in which transport systems are perceived and used, and mobilities performed with far-reaching implications for transport mode choices and transport demand.[15]

here is some examples of Intelligent Transport Systems:

- Advanced Traffic Management System.
- Advanced Traveler Information System.

- Advanced Vehicle Control system.
- Advanced Public Transportation System.
- Advanced Rural Transportation Systems.
- Advanced Commercial Vehicles Operations system.[35]

Figure 3: Sample screenshot of the RITIS Regional Integrated Transportation Information System (RITIS) map showing live video, weather, traffic, and incident information.



2.3.3.4 *Health*

Information technology has been very helpful to the healthcare sector. One example of a significant advancement that IT has provided to hospitals is the development of electronic medical records (EMR). This technology can convert medical information into a single database. Not only does this technology reduce paper costs, it allows healthcare providers to access pertinent patient information such as medical history, medications, insurance information, etc with just the click of a mouse.

[25] Others:

- Training.

- The economy.
- Territory planning.

2.3.4 *Healthcare information exchange*

The ability to exchange clinical data as well as other pieces of health information remains central to population health information models, HIE is defined by the National Alliance for health information Technology as the transfer of electronic health information such as laboratory results clinical summaries, and medication lists among organizations according to nationally recognized standards. A survey of ambulatory providers showed that in 2013 approximately two-thirds of US hospitals and nearly half of physician practices were engaged in some type of HIE with outside organizations, this finding represents a sharp increase in the adoption of HIE from 2008, when HIE participation among hospitals was 41% and among physicians was about 17%.[49]

2.4 HEALTHCARE INFORMATION TECHNOLOGY

Information and communication technologies (ICT) applied to health have experienced rapid development for several decades. Many IT applications have been developed over the past ten years in the health sector. These developments bring considerable progress for the healthcare system in society they cause major changes in the behavior of actors in the health system. Faced with this rapid development of the health system, we are now witnessing the implementation of a number of advanced techniques for the treatment of patients in medicine.[16]

2.4.1 *What is Healthcare information technology ?*

Health information technology is the area of healthcare that oversees the technology systems healthcare providers use to manage patient data. Health IT refers to the electronic systems health care providers and increasingly, patients use to store, share and analyze information, according to the Office of the National Coordinator for Health Information Technology (ONC). HIT includes technology like electronic health records (EHRs) and e-prescriptions, as well as tech tools that help patients meet health goals like quitting smoking or managing diabetes. This merging of technology with healthcare has allowed for more accurate EHRs that follow a patient to different healthcare facilities, and its given patients more control over their health through apps and increased access to information. Though HIT encompasses many systems and types of technology, its focus is always on maintaining patient privacy while improving patient care. Advances in secure health IT networks have allowed physicians and others on a patients care team to have better communication than ever before.[31]

2.4.2 *The importance of Healthcare information technology*

Health IT makes it possible for health care providers to better manage patient care through the secure use and sharing of health information. By developing secure and private electronic health records for most Americans and making health information available electronically when and where it is needed, health IT can improve the quality of care, even as it makes health care more cost effective.

With the help of health IT, health care providers will have:

- Accurate and complete information about a patient's health. That way, providers can give the best possible care, whether during a routine visit or a medical emergency.
- The ability to better coordinate the care given. This is especially important if a patient has a serious medical condition.
- A way to securely share information with patients and their family caregivers over the Internet, for patients who opt for this convenience. This means patients and their families can more fully take part in decisions about their health care.
- Information to help diagnose health problems sooner, reduce medical errors, and provide safer care at lower costs.[8]

Health information technology is vitally important in the digital age. "In 2019, healthcare consumers continue to demand greater transparency, accessibility and

personalization," says Patrick Gauthier, director of healthcare solutions at Advocates for Human Potential, Inc. HIT plays a key role for all of the above, and more. Being able to quickly share patient information between hospitals and clinics a concept known as "interoperability" can be the difference between life and death for some patients. The ONC shares that EHRs and other HIT tools help patient care teams coordinate with one another, leading to higher-quality patient care and more affordable healthcare costs.
Though the HIT field was struggling to keep up just a few years ago as clinics and hospitals made the transition to new technology under government mandates like meaningful use, Gauthier believes HIT has hit its stride and will only continue to grow in importance as technology transforms the healthcare field. "The majority of consumers now trust health IT more than ever."[32]

2.4.3 *The futur Healthcare information technology*

It's no surprise that as technology develops and expands, the HIT field will grow alongside it. "Government entities are now making it easier on healthcare companies to share data and that is allowing the next wave of HIT to come into the fold," says 17-year clinical HIT worker Jason Reed, owner of Best Rx For Savings. "The stage is set for an explosion of HIT to take us into the next phase of medical care." Reed predicts that HIT workers will soon be working with cutting-edge technology like virtual reality surgeries, patient monitors that report data to physicians via smartphone and even artificial intelligence. "AI will also be a growing field with many jobs as we use algorithms to teach machines how to detect trends in mountains of data collected by EHRs," Reed says. These advances in HIT are part of an exciting future for patients. From wearable health trackers to simpler communication with a care team, the HIT field is on the cusp of granting patients more control over their health than they've ever had before.[33]

2.5 Healthcare Information Systems

In the simplest terms, a health information system (HIS) is a system that captures, stores, transmits, or otherwise manages health data or activities. These systems are used to collect, process, use, and report health information. In turn, information from a health information system can be used to drive policy and decision-making, research, and ultimately health outcomes. Here's what you need to know about the key components of a HIS, the various types, and benefits of HIS.[28]

2.5.1 *The Evolution of health Information Systems*

- **1960s**: The main healthcare drivers in this era were Medicare and Medicaid. The IT drivers were expensive mainframes and storage. Because computers and storage were so large and expensive, hospitals typically shared a mainframe. The principal applications arising in this environment were shared hospital accounting systems.
- **1970s**: One of the main healthcare drivers in this era was the need to do a better job communicating between departments (ADT, order communications, and results review) and the need for discrete departmental systems (e.g.clinical lab, pharmacy). Computers were now small enough to be installed in a single department without environmental controls. As a result, departmental systems proliferated. Unfortunately, these transactional systems, embedded in individual departments, were typically islands unto themselves.
- **1980s**: Healthcare drivers were heavily tied to DRGs and reimbursement. For the first time, hospitals needed to pull signifcant information from both clinical and financial systems in order to be reimbursed. At the same time, personal computers and widespread, non-traditional software applications had entered the market, as had emerging networking solutions. The result was that hospitals began to integrate applications so that financial and clinical systems could talk to each other in a limited way.
- **1990s**: In this decade, competition and consolidation drove healthcare, along with the need to integrate hospitals, providers, and managed care. From an IT perspective, hospitals now had access to broad, distributed computing systems and robust networks. And so we created integrated delivery net-

work (IDN)-like integration, including the impetus to integrate data and reporting.

- **2000s**: The main healthcare drivers were more integration and the beginnings of outcomes-based reimbursement. We now had enough technology and bedside clinical applications installed to make a serious run at commercial, real-time clinical decision support.[9]

2.5.2 *Key Components of a Health Information System*

Health information systems consist of six key components, including:[29]

- **Resources**: the legislative, regulatory, and planning frameworks required for system functionality. This includes personnel, financing, logistics support, information and communications technology (ICT), and mechanisms for coordinating both within and between the six components.
- **Indicators**: a complete set of indicators and relevant targets, including inputs, outputs, and outcomes, determinants of health, and health status indicators.
- **Data sources** : including both population-based and institution-based data sources.
- **Data management** : collection and storage, QA, processing and flow, and compilation and analysis.
- **Information products** : data which has been analyzed and presented as actionable information.
- **Dissemination and use** : the process of making data available to decision-makers and facilitating the use of that information.

2.5.3 *Types of Health Information Systems*

Here's a look at some of the most common HIS types.[29]

2.5.3.1 *Strategic or Operational Systems*

Strategic or operational systems are typically used for information classification. Provisions are made for information systems based on the type of information they're handling. A pyramid classification system allows organizations to assess the spread of digitization. Because operational systems are generally developed before executive information systems or management information systems, this is easily achieved. The ability to evaluate dependencies can help to identify system deficiencies, as well. For example, a properly configured information system should pull data from a clinical system rather than require nurses and clinicians to collect and document data manually.

2.5.3.2 *Clinical and Administrative Systems for Managing Patient Information on an Administrative Level*

Clinical systems are dependent on administrative data. The foundation of an integrated HIS is a master index developed around the most basic patient information with links to different clinical systems, and the clinical system contains the electronic patient record (EPR), diagnostic data, outcomes, and processing.

2.5.3.3 *Electronic Health Record and Patient Health Record*

Open EHR aims to enable semantic interoperability for health information systems between various EHR systems in a non-proprietary format to prevent vendor lock-in. Knowledge concepts are stored outside the EHR as archetypes, which support the recording of clinical information. Archetype building blocks include instructions, evaluations, observations, and actions, and information built using these building blocks is stored in the EHR.

2.5.3.4 *Subject- and Task-Based Systems*

Subject-based systems are related to patients or healthcare professionals in any type of healthcare organization. Task-based systems, on the other hand, are associated with particular tasks such as admission or discharge. Subject-based systems are often preferred, as they reduce data duplication. In a task-based system, the same subject could be related to various tasks, with basic information such as the patient's ID being duplicated across each task. In a subject-based system, this basic information is entered only once and flows with the subject through various tasks. For example, an EHR is a subject-based system.

2.5.3.5 *Financial and Clinical Health Information Systems*

These systems provide easy access to patient financial information, such as costs and payors, and they also aid in monitoring patient usage of different departments or services. Financial systems typically include invoicing capabilities as well as tools for following up on non-payments.

2.5.3.6 *Decision Support Systems*

Decision support systems convert data to clinically relevant information and present it in actionable form to clinicians, aiding in adherence to regulatory guidelines and best practices. These systems can give results for several data manipulations to mimic cognitive processing. For example, a decision support system may provide a list of medications for a particular condition appropriate for the patient's demographics, such as the patient's age and weight, as well as any comorbidities. Decision support systems can also facilitate next steps in the workflow, such as submitting a prescription to the pharmacy and scheduling a follow-up appointment for the patient.

2.5.4 *Examples of Health Information Systems*

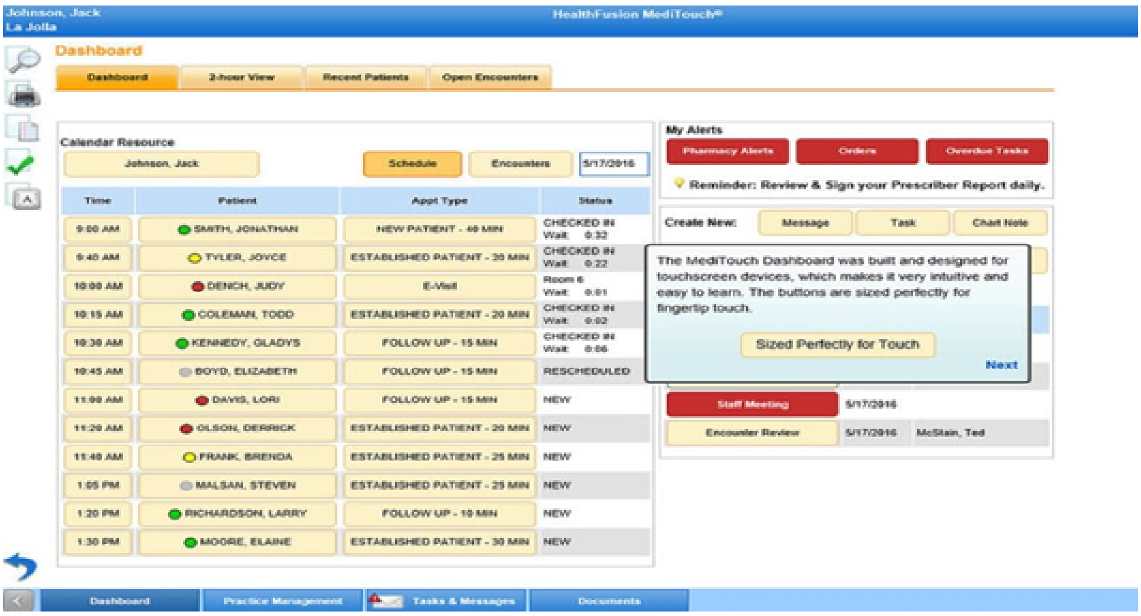
There are many specific health information systems, most of which can be classified as one of the types discussed above. Specific examples include:[1]

- **Electronic Medical Record (EMR) and Electronic Health Record (EHR)**: These two terms are almost used interchangeably. The electronic medical record replaces the paper version of a patient's medical history. The electronic health record includes more health data, test results, and treatments. It also is designed to share data with other electronic health records so other healthcare providers can access a patient's healthcare data.

Figure 4: Electronic Medical Record.

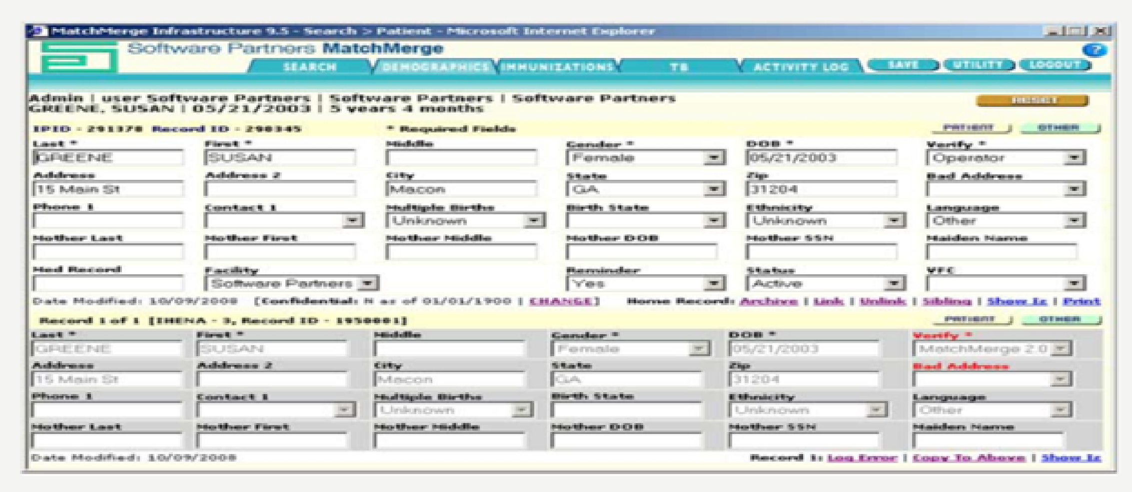
- **Practice Management Software**: Practice management software helps healthcare providers manage daily operations such as scheduling and billing. Healthcare providers, from small practices to hospitals, use practice management systems to automate many of the administrative tasks.

Figure 5: Practice Management Software.



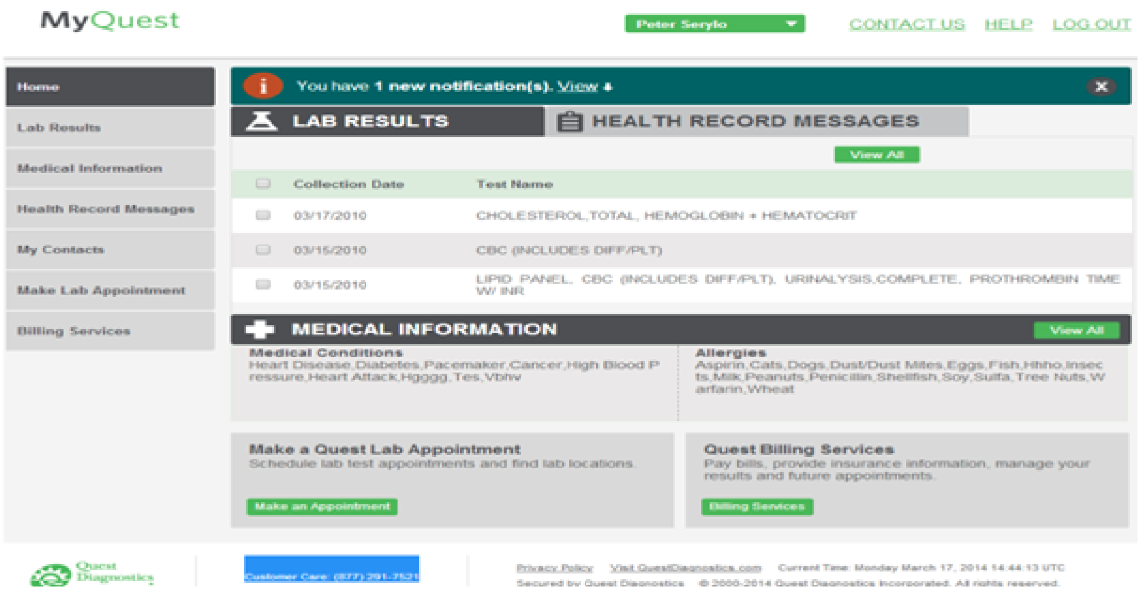
- **Master Patient Index (MPI)**: A master patient index connects separate patient records across databases. The index has a record for each patient that is registered at a healthcare organization and indexes all other records for that patient. MPIs are used to reduce duplicate patient records and inaccurate patient information that can lead to claim denials.

Figure 6: Master Patient Index (MPI).



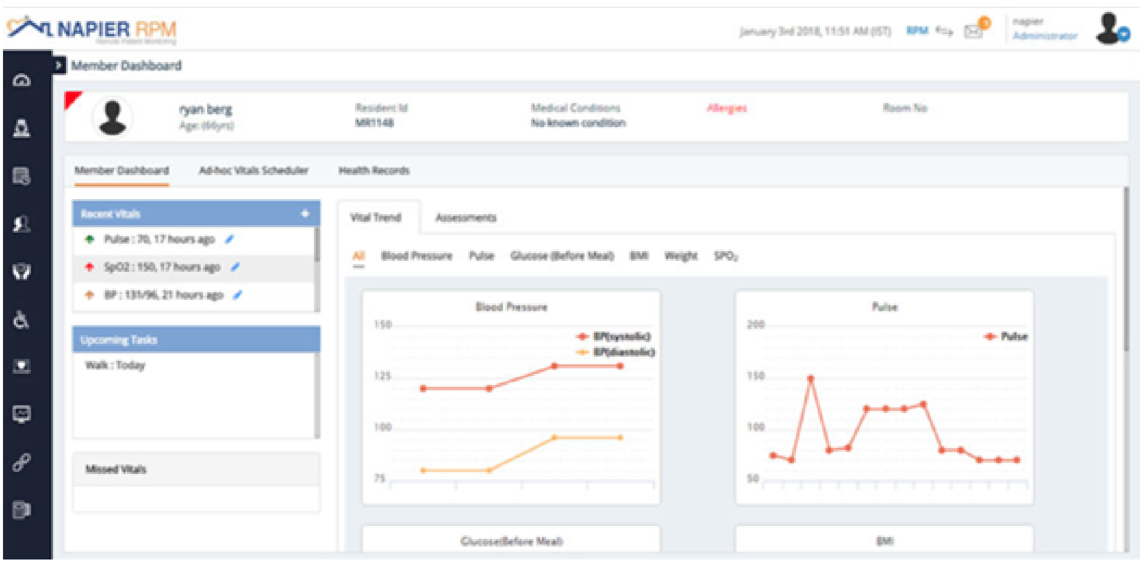
- **Patient Portals**: Patient portals allow patients to access their personal health data such as appointment information, medications and lab results over an internet connection. Some patient portals allow active communication with their physicians, prescription refill requests, and the ability to schedule appointments.

Figure 7: Patient Portals.



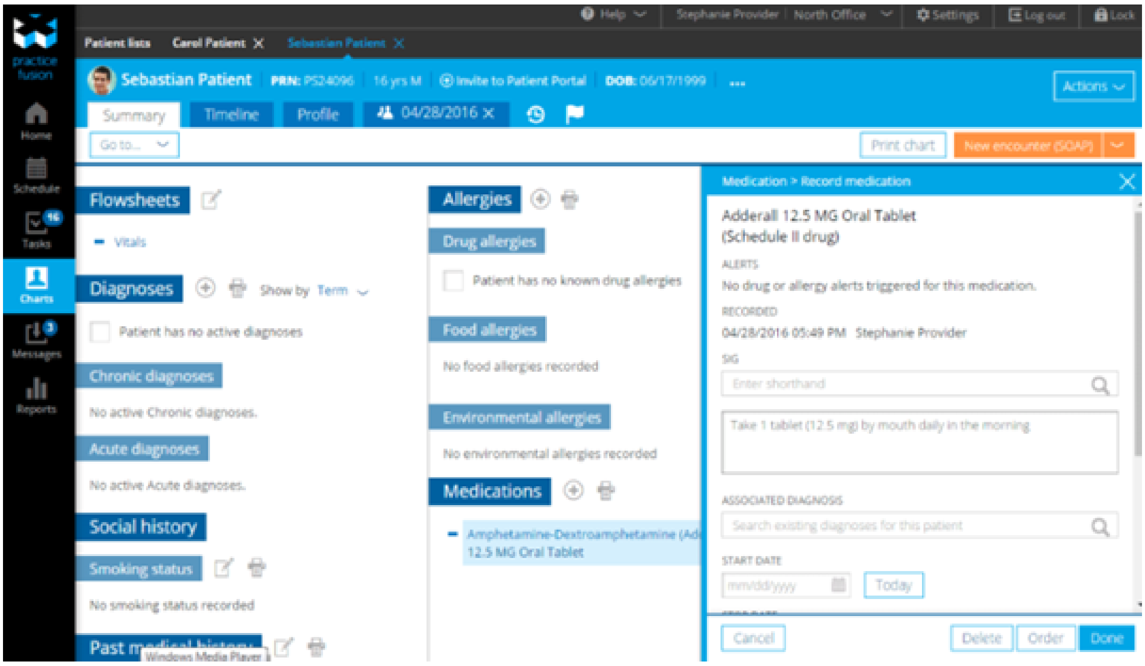
- **Remote Patient Monitoring (RPM)**: Also known as telehealth, remote patient monitoring allows medical sensors to send patient data to healthcare professionals. It frequently monitors blood glucose levels and blood pressure for patients with chronic conditions. The data is used to detect medical events that require intervention and can possibly become part of a larger population health study.

Figure 8: Remote Patient Monitoring (RPM).



- **ePrescribing**: Sending prescriptions to pharmacies can be tedious when creating orders for multiple patients. To expedite the process, physician offices began using eprescribing software. In just a few clicks a prescription is sent, filled and waiting for the patient when they get to the pharmacy. In addition to speeding up the entire prescription process, the fulfillment of prescriptions can be tracked and controlled substance prescriptions can be monitored more accurately. Practitioners can spend less time responding to prescription refill requests and more time focusing on other issues at hand.

Figure 9: ePrescribing.



2.5.5 *Benefits of Health Information Systems*

Health information systems tend to target efficiency and data management. The main drivers of health information systems are:[30]

- **Data analytics**: The healthcare industry constantly produces data. Health information systems help gather, compile and analyze health data to help manage population health and reduce healthcare costs. Then the healthcare data analysis can improve patient care.

- **Collaborative care**: Patients often need to treatments from different healthcare providers. Health information systems - such as health information exchanges (HIEs)-allow healthcare facilities to access common health records.
- **Cost control**: Using digital networks to exchange healthcare data creates efficiencies and cost savings. When regional markets use health information exchanges to share data, healthcare providers see reduced costs. On a smaller scale, hospitals aim for the same efficiencies with electronic health records.
- **Population health management**: Health information systems can aggregate patient data, analyze it and identify trends in populations. The technology also works in reverse. Clinical decision support systems can use big data to help diagnose individual patients and treat them.

2.5.6 *Challenges of Health Information Systems*

Health information systems must be both user-friendly otherwise, staff simply won't use them and cost-effective to run. They should also be able to use and interpret health data. However, achieving these goals has been challenging in the past, leading the industry to aim for interoperability which is crucial for maximizing the benefits of HIS.
Interoperability improves both the quality and use of health information, but traditional integration techniques are costly and time-consuming to implement. That's why more healthcare organizations are turning to API solutions like Integrate. APIs make interoperability more practical, cost-effective, and user-friendly, allowing for the seamless integration of a variety of disparate systems to eliminate silos and streamline the flow and management of data between systems. Lengthy barriers of application integration to start getting more value from your HIS.[29]

2.6 CONCLUSION

ICT has been recruited all over the world in multiple health fields. As e-health continues to evolve, many of the current challenges facing health systems in low- and middle-income countries, such as a lack of health workers in rural areas, diversity in quality of care, lack of patient compliance, and fraud, these challenges will likely alleviate through The widespread deployment of information and communications technology, and continuing to track any of these purposes has been successfully achieved thanks to technology is crucial, and knowing which devices and use cases are most effective in achieving these goals.

3 ELECTRONIC HEALTH RECORD

3.1 INTRODUCTION

The recent progress of ICT (Information Communication Technology) applications in health of our citizens and healthcare make it possible to establish individual EHR within foreseeable time. The goal of EHR is enabling to connect person and health care organizations at point of care. The use of EHR coupled with clinical decision support system in healthcare practice will provide tools for healthcare organizations to achieve errorless, safe, cost effective and quality care.[17]

3.2 DEFINITIONS OF EHR

3.2.1 *Definition1*

According to ISo TR 20514: 2005, the basic definition of EHR is "a repository of information regarding the health status of a subject of care, in computer processable form." On the other hand, the EHR system(EHRS) is "the set of components that form the mechanism by which electronic health records are created, used, stored, and retrieved. "It may include people, data, rules and procedures, processing and storage devices, and communication and support facifities.[17]

3.2.2 *Definition2*

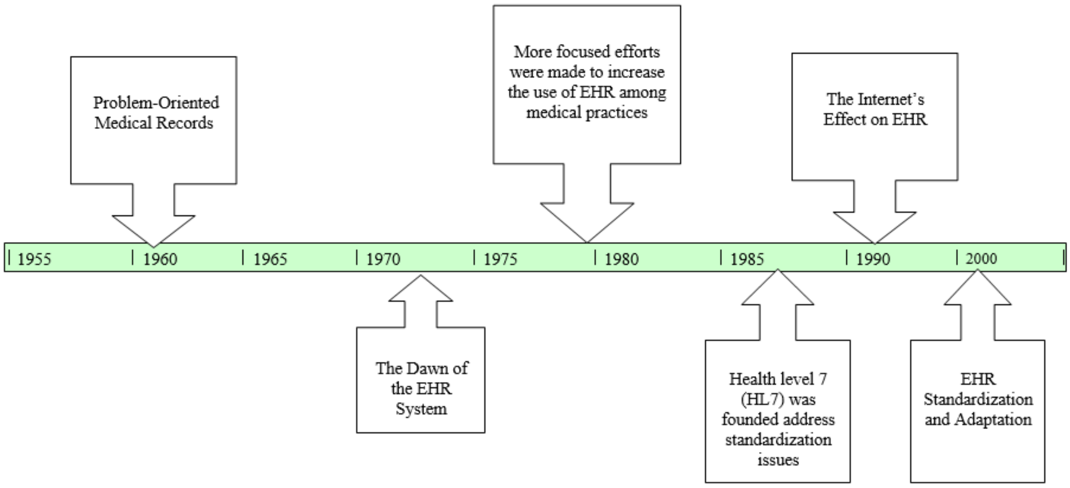
The Electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data and radiology reports. The EHR automates and streamlines the clinician's workflow. 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.[7]

3.3 HISTORY OF ELECTRONIC HEALTH RECORDS

- **1960s**
  - The first EHRs appeared in the 1960s. By 1965, approximately 73 hospitals and clinical information projects and 28 projects for the storage and retrieval of medical documents and other clinical information were underway, according to HIMSS.
  - The Mayo Clinic in Rochester, Minn, was one of the first major systems to adopt an EHR, picking up the project in the early 1960s, according to the National Institutes of Health.
- **1970s**
  - The EMRs of today first appeared in 1972 from the Regestrief Institute in Indianapolis but was so expensive that it did not spread among physicians. Instead, it was used by government hospitals, according to the University of Scranton in Scranton, Pa.
  - The federal government implemented an EHR in the Department of Veteran Affairs called the De-Centralized Hospital Computer Program and the Composite Health Care System in the Department of Defense in the 1970s, according to the American Medical Association. That system eventually became VistA.
- **1980s**
  - Health Level 7 was founded in 1987 to address standardization issues as EHR development pushed forward. Today it has members in 55 countries, according to Greater Than One Labs, a New York City-based digital communication agency.

- **1990s**
  - The Institute of Medicine set a goal in 1991 that all physicians would be using computers in their practice by 2000. It was not a law, however, and only 18 percent of physicians were using an EHR system in 2001, according to the ONC.
  - Interoperablity has been a concern since at least the mid-1990s, when a growing clinician user base made it necessary for systems to communicate with each other to effectively coordinate care, according to a 1997 book published by the Institute of Medicine, "The Computer-Based Patient Record: An Essential Technology for Health Care: Revised Edition."
- **2000s**
  - By 2004, the need to convert medical records to EHRs was recognized nationally with the creation of the Office of the National Coordinator (ONC) of Health Information Technology (IT). Shortly after, EHRs were incorporated into the Health Information Technology for Economic and Clinical Health Act (HITECH), providing "higher payments to health care providers that meet" meaningful use "criteria, which involve using EHR for relevant purposes and meeting certain technological requirements. "HIPAA regulations were adjusted to account for electronic protected health information (ePHI) that was being maintained by these EHRs.[10]

Figure 10: EHR history timeline in the last decade.



3.4 EHR TERMINOLOGY

Before progressing any further into the details of EHR's for use in the delivery of care to patients, a few key terms must be defined and differentiated from one another, The Term most commonly used to describe a patient's record of health information for use by nurses, providers and other health care professionals in an electronic format is the electronic health record or EHR, However the EHR is sometimes used synonymously with the terms computer-based patient record(CPR), electronic medical record (EMR), and at times, personal health record(PHR), while these terms all have some similarities to their definitions, there are some differences.[42]

3.4.1 *Electronic Medical Records(EMR)*

EMR is often used in parallel with EHR. It is a fully interoperable electronic health record of a patient within a healthcare organization. However, some people consider EMR as a set of records of a patient related to a single encounter or a single care episode. According to this view, EMR is a point-in-time view of a larger EHR. This approach considers an EHR to be sum total of all EMRs of a patient.[48]

3.4.2 *Personal Health Records(PHR)*

Personal health records (PHRs) contain the same types of information as EHRs diagnoses, medications, immunizations, family medical histories, and provider contact information but are designed to be set up, accessed, and managed by patients. Patients can use PHRs to maintain and manage their health information in a private, secure, and confidential environment. PHRs can include information from a variety of sources including clinicians, home monitoring devices, and patients themselves.[27]

3.4.3 *Computer-Based Patient Record (CPR)*

Lifetime patient record that includes all information from all specialties (even dentist, psychiatrist) and requires full interoperability (potentially internationally), unlikely to be achieved in foreseeable future.[51]

3.5 factors affecting implementation of ehr

An EHR system needs to deal with multiple healthcare applications and various types of healthcare providers. Hence, its implementation is a complex task that usually requires more time and effort than implementation of several other IT applications. The following factors usually affect the implementation of an EHR system and need to be dealt with properly:[48]

3.5.1 *Significant Changes in Clinical Workflow*

Implementation of an EHR system in a healthcare organization often requires significant changes in the organization's clinical workflow. Hence, it is always good to make EHR a part of the strategic vision of the organization. Design of the system needs involvement of clinical staff with inclusion of organization's policies and workflow processes.

Although an EHR can be customized for a specific medical practice, clinical workflow varies from one speciality to another. Thus, an EHR having a specific workflow for practicing medicine is usually not adaptable easily.

3.5.2 *Privacy and Security*

An EHR implementation must deal with privacy and security issues with great care because health care providers are concerned about alteration of EHR without their knowledge, and patients are concerned about unauthorized access to their private data.

An EHR system must also meet the privacy and security regulations for health data imposed by regulatory bodies in the country. This provides assurance to patients and providers that the health data is securely stored and privacy is maintained, while healthcare applications deliver appropriate services. The system should audit log the accesses made to an EHR with strict access policies.

3.5.3 *Unique Identification*

Duplication of EHR records of a patient in the same EHR system is an important issue in EHR usage. This issue arises because healthcare data of a patient is often collected from various healthcare organizations, with each organization having its own registration process. In the process, different organizations assign different identifiers to the same patient. While integrating such data, an EHR system must properly link all data of a patient to create his/her single EHR.

3.5.4 *Interoperability*

An EHR system consolidates patients healthcare data generated from various healthcare systems. Hence, it should be capable of integrating data from all such systems. Moreover, it should enable interoperability among various healthcare applications and systems that are developed independently.

3.5.5 *Consistent Use of Standards*

To support interoperability and information sharing across various healthcare applications and systems, an EHR system requires consistent use of standards such as clinical vocabulary and standardized data formats. Different healthcare applications usually offer different sets of features supporting different structures and data formats. Additionally, these applications usually do not make consistent use of security and data integrity standards. An EHR system must, therefore, make consistent use of standards and upgrade consistently to newly developed standards for addressing these issues.

3.6 SIGNIFICANCE OF EHR

An EHR system helps to provide an integrated view of healthcare records by enabling integration of various healthcare applications such as Hospital Information Systems (HIS), Pharmaceutical Systems, Imaging Systems, and Health Insurance Systems. In turn, an EHR system plays a significant role in better healthcare services by offering the following advantages:[48]

3.6.1 *Ease of Maintaining Health Information of Patients*

An EHR system enables paperless medical treatment with less space required for storing health data of patients. Additionally, with proper backup policies, the lifespan of EHRs can be increased. This reduces the cost of generating, storing, and maintaining patient records in healthcare organizations.

3.6.2 *Efficient in Complex Environements*

Large healthcare organizations have many specialty departments, laboratories, training and research centers, and so on. An EHR system helps in improving clinical processes or workflow efficiency across these units of a healthcare organization. For example, it enables an administrator to obtain data for billing, a physician to see progress of treatments, a nurse to report an adverse reaction, and a researcher to analyze efficacy of medications on patients.

3.6.3 *Better Patient Care*

Often, multiple healthcare providers are involved in treatment of a patient. An EHR system allows sharing of the patient's information among them. Moreover, it enables point-in-time data insertion, retrieval, and update, thereby providing immediate access of patient data from any specialty center whenever required. This enables healthcare providers to make timely decisions for better patient care. Availability of health information, such as past medical history, family medical history, and immunization, through EHR helps in taking preventive measures and managing chronic diseases more effectively.

3.6.4 *Improve Quality of Care*

EHR helps to decrease reporting and charting time during treatment, thereby improving quality of care. EHR also helps in improving risk management and accurate diagnosis, thereby improving quality of care.

Reduce Healthcare Delivery Costs. Due to the availability of health information data from all healthcare organizations, a healthcare provider can refer to the required test reports, thus avoiding repetition of expensive tests.

3.6.5 *Better Safety*

Through access, audit, and authorization control mechanisms, an EHR system provides better safety to a patient's health records as compared to a paper-based system.

3.7 FUNCTIONAL COMPONENTS OF AN ELECTRONIC HEALTH RECORD SYSTEM

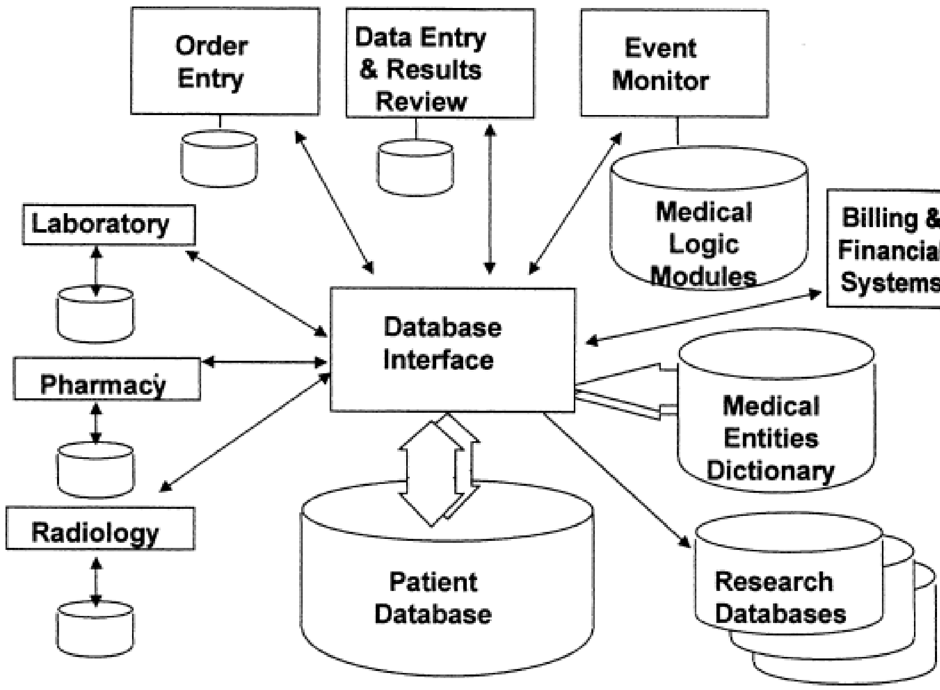
When the record is part of a comprehensive EHR system, there are linkages and tools available to facilitate communication and decision making, we summarize components of a comprehensive EHR system and illustrate functionality with examples from systems currently in use. The five functional components are:[50]

- Integrated view of patient data.
- Clinical decision support.
- Clinician order entry.
- Access to knowledge resources.
- Integrated communication and reporting support.

3.7.1 *Integrated View of Patient Data*

Clearly, providing integrated access to all patient data is the primary purpose of an EHR. Although this task may seem relatively simple, acquisition and organization of these data are major challenges because of the complexity and diversity of the data ranging from simple numbers to graphs to images to motion images and the large number and organizationally distributed sources of patient data such as clinical laboratories, radiology departments, free-standing magnetic resonance imaging (MRI) centers, community pharmacies, home health agencies. The fact that different patient data source systems use different identifiers, data content terminologies, and data formats creates substantial work. Administrators of each EHR system must revise the message formats and map coding systems from the source system to the format and codes that are acceptable to their EHR system. Today most clinical data sources can deliver the clinical content as health level 7 (HL7) messages, but senders deviate from the standard and use local codes as identifiers for clinical observations and orders in these messages.

Figure 11: A block diagram of multiple-source-data systems.

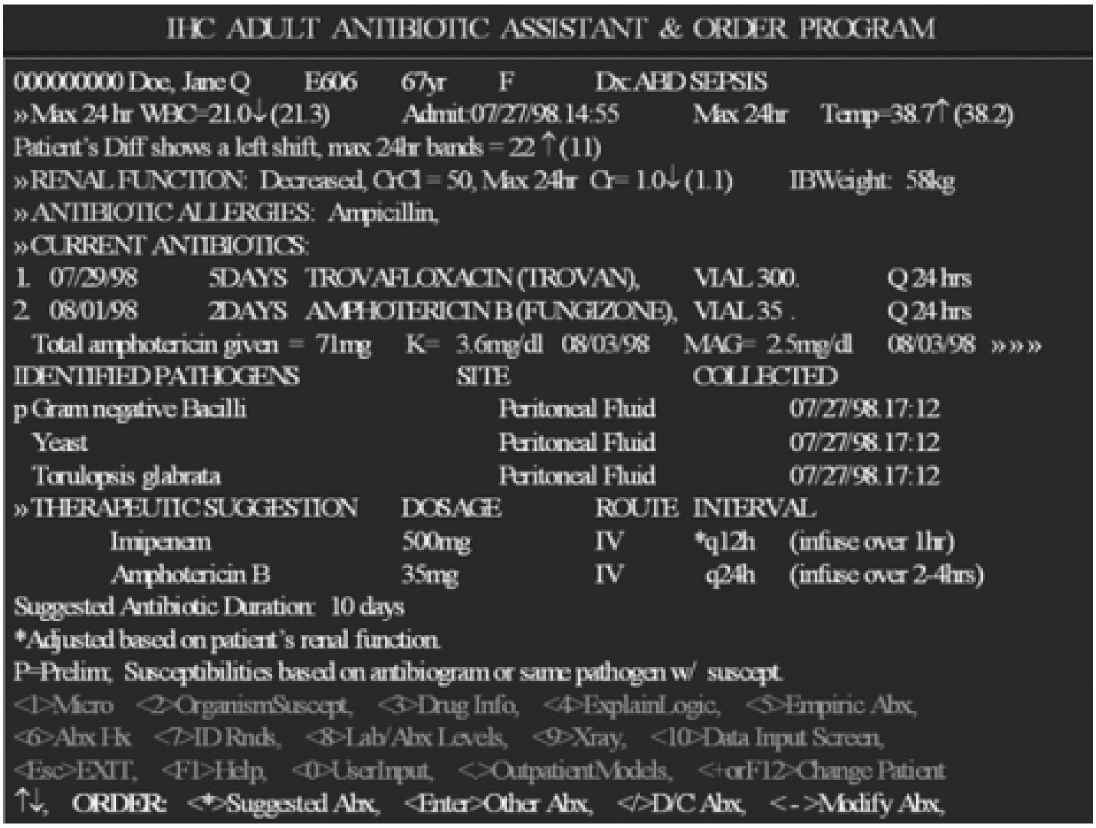


Some small amount of message tweaking and a large amount of code mapping is usually required. Interface engines facilitate the management and tweaking of the messages The database interface depicted not only provides message-handling capability but can also automatically translate codes from the source system to the preferred codes of the receiving EHR. However, human labor is needed to define the mappings that drive this automatic translation. The interface engine provides a technical and translation buffer between systems manufactured by different vendors. In this way, organizations can mix different vendors' products and still achieve the goal of integrated access to patient data for the clinician.

3.7.2 *Clinical Decision Support*

Decision support is thought to be most effective when provided at the point of care, while the physician is formulating his or her assessment of the patient's condition and is making ordering decisions. The most successful decision-support intervention makes complying with the suggested action easy (e.g., simply hitting the "Enter key" or clicking "Accept" with the mouse), while still allowing the physician to control the final decision. Providing access to a brief rationale with the recommendation may increase acceptance of reminders and at the same time educate the care provider. Figure 12 shows the suggestions of a software module in a large HIS. The patient diagnosis uses sophisticated treatment protocols that consider a wide spectrum of clinical information to recommend antibiotic choice, dose, and duration of treatment. Clinicians can view the basis for the recommendations and the logic used. A notable part of this program is its solicitation of feedback when the clinician decides not to follow the recommendations. This feedback is used to improve the clinical protocol and the software program. Providing online advice on antimicrobial selection has resulted in significantly improved clinical and financial outcomes for patients whose infectious diseases were managed through the use of the program.

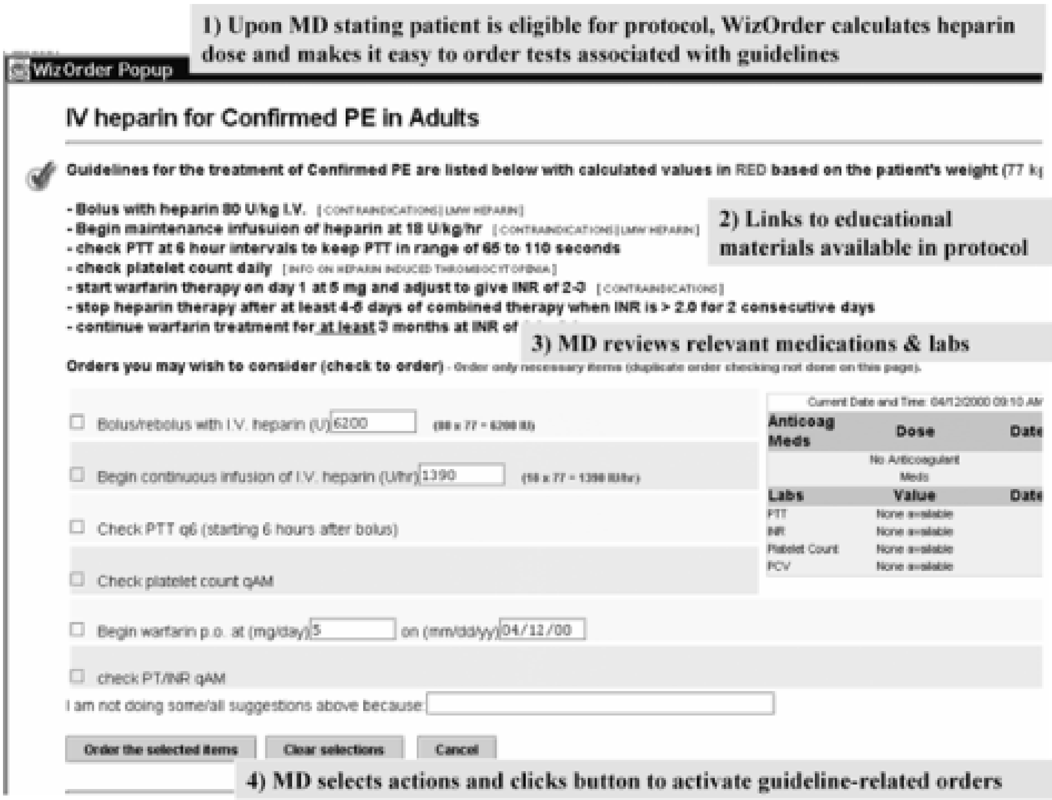
Figure 12: Example of the main screen from the Intermountain Health Care Antibiotic Assistant program.



3.7.3 *Clinician Order Entry*

If the ultimate goal of an EHR system is to help clinicians make informed decisions, then the system should present relevant information at the time of order entry. Several systems have the capability of providing decision support during the order-entry process, a clinical team in the medical intensive care unit (ICU) at Vanderbilt. University Hospital can use an electronic chart rack to view active orders and enter new orders. The WIZ Order screen integrates information about a patient's active orders, clinical alerts based on current data from the electronic patient record, and abstracts of relevant articles from the literature. Clinical alerts attached to a laboratory test result can also include suggestions for appropriate actions.

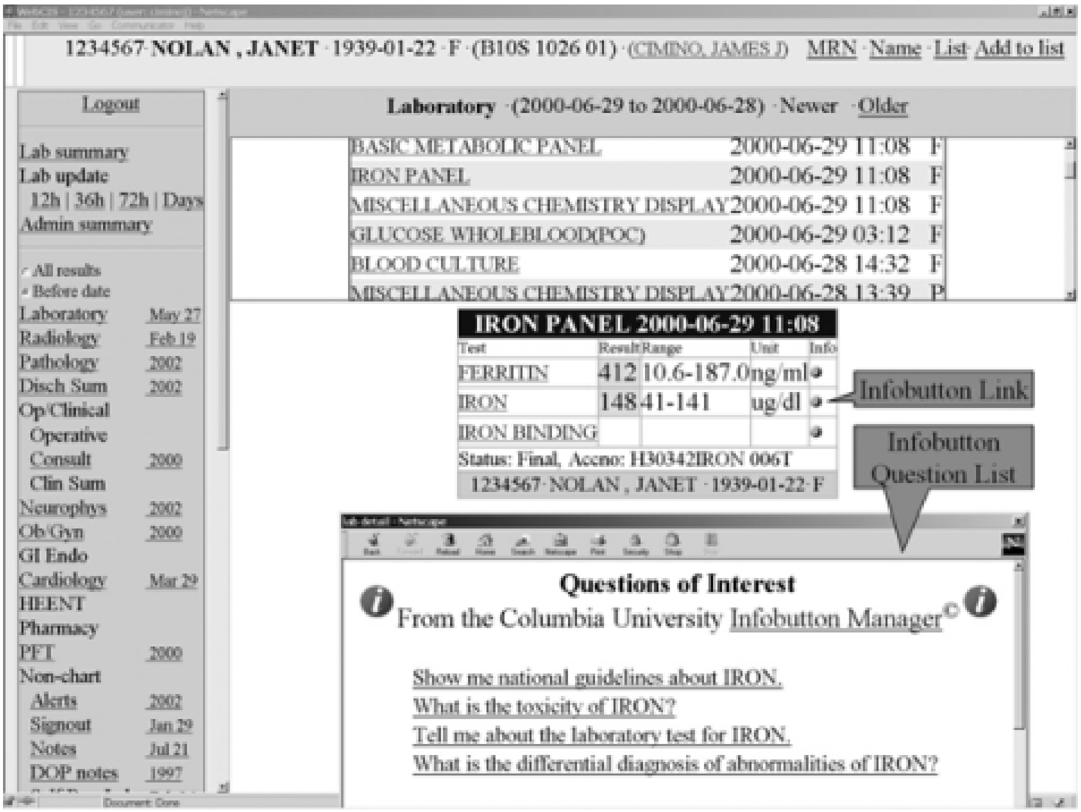
Figure 13: shows computer suggestions for dosing and follow-up of intravenous heparin orders at Vanderbilt.



3.7.4 *Access to Knowledge Resources*

Most queries of knowledge resources, whether they are satisfied by consulting another human colleague or by searching through reference materials or the literature, are conducted in the context of a specific patient. Consequently, the most effective time to provide access to knowledge resources is at the time decisions or orders are being contemplated by the clinician. Today a rich selection of knowledge sources ranging from the National Library of Medicine's free literature search site, PubMed to full-text resources such as OVID and online references such as Up-To-Date are available for perusal. Consequently, it is relatively easy for physicians to get medical knowledge while reviewing results or writing notes or orders online. However, active presentation of literature relevant to a particular clinical situation, such as an "Info button" would increase the chance that the knowledge will influence clinicians decisions

Figure 14: A Computer-based patient record (CPR) linked to knowledge resources.

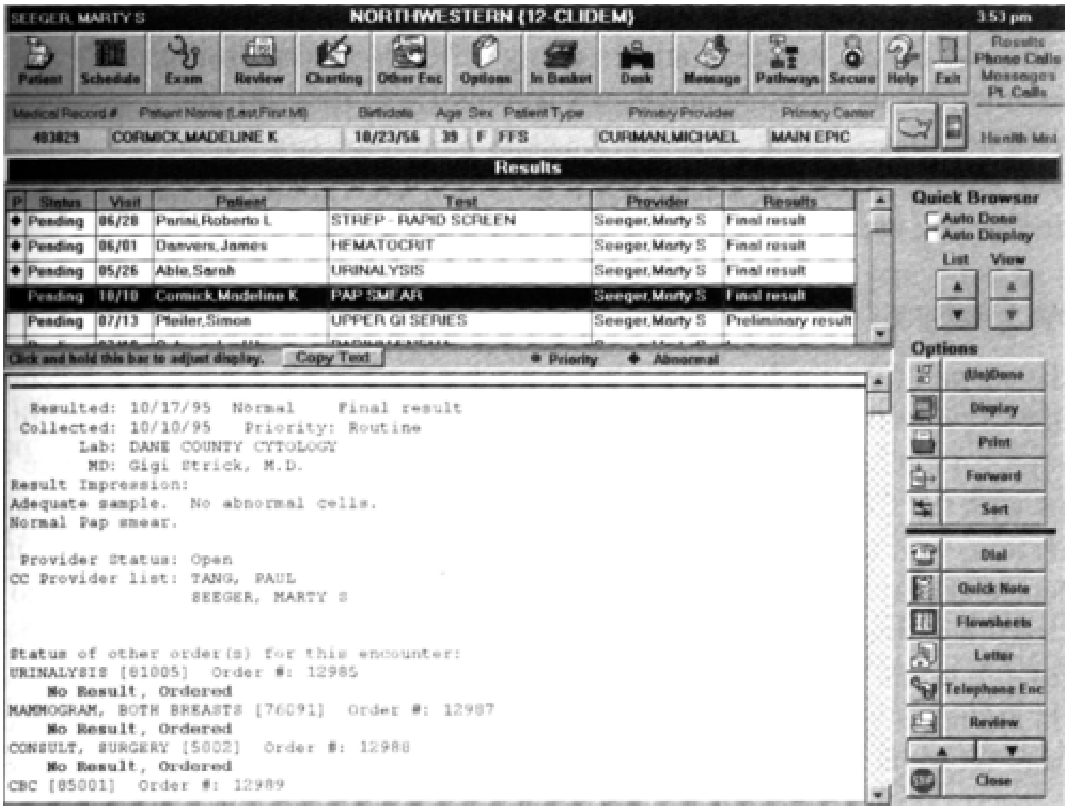


This figure shows the use of Columbia University's info buttons - during results review. Clicking on the info button adjacent to the Iron result generates a window (below) with a menu of questions. When the user clicks on one of the questions-he/she gets the answers.

3.7.5 *Integrated Communication and Reporting Support*

As the care function becomes increasingly distributed among multidisciplinary health care professionals, the effectiveness and efficiency of communication among the team members affect the overall coordination and timeliness of care provided. Most messages are associated with a specific patient. Thus, communication tools should be integrated with the EHR system such that messages (including system messages or laboratory test results) are electronically attached to a patient's record, i.e. The patient's record should be available at the touch of a button. Geographic separation of team members creates the demand for networked communication that reaches all sites where providers make decisions on patient care. These sites include the providers offices, the hospital, the emergency room, and the home. Connectivity to the patient's home will provide an important vehicle for monitoring health (e.g., home blood-glucose monitoring, health status indicators) and for enabling routine communication. Communication also can be "pushed" to the user via e-mail and or pager services) or "pulled" by providers at their routine interactions with the computer.

Figure 15: Prompt notification of laboratory test results integrated with CPR system.



When a messaging system is integrated with the CPR system, test results can be directed to the provider's in-basket as soon as they are available. By clicking on the Review button at the lower right corner, the clinician can retrieve the patient's CPR instantly and with it any relevant information that he/she reviewed before acting on the most recent result or message. Telephone messages and other patient related information can be handled in the same manner.

3.8 EHR STANDARDS

The standardization of Electronic Health Records (EHR) is a crucial factor for ensuring interoperable sharing of health data. During recent decades, a plethora of initiatives driven by international organizations has emerged to define the required models describing the exchange of information between EHRs. These models cover different essential characteristics for building interoperable EHRs, such as architecture, methodology, communication, safety or terminology, among others.[19]

3.8.1 *What is Interoperability in Healthcare*

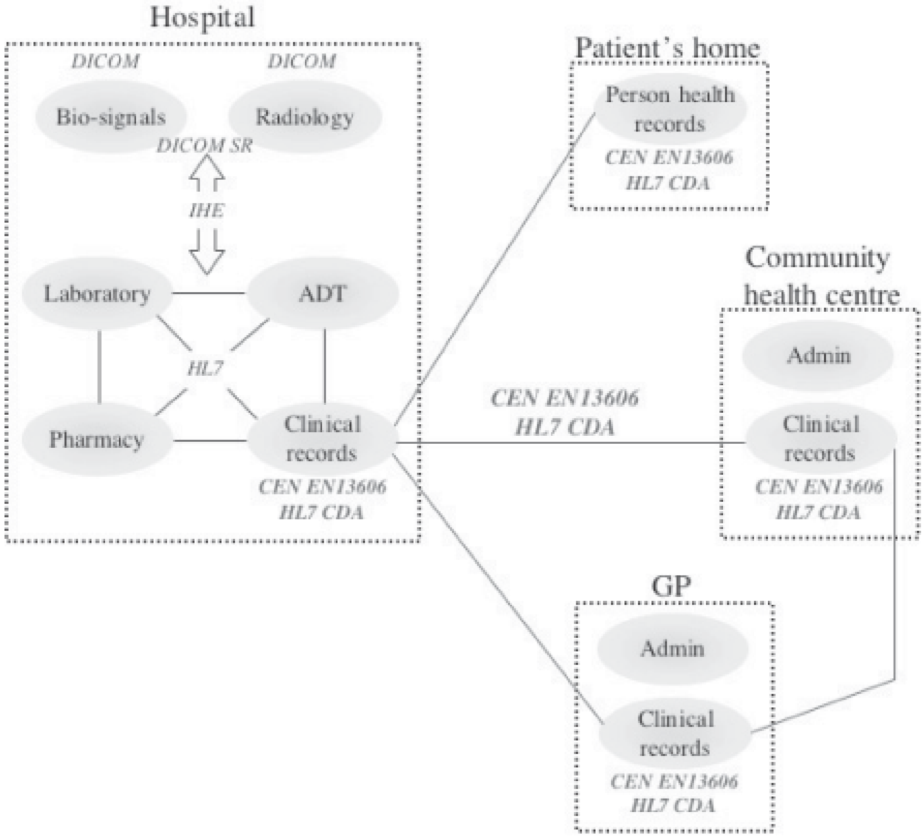
Interoperability is the ability of different information systems, devices and applications (systems) to access, exchange, integrate and cooperatively use data in a coordinated manner, within and across organizational, regional and national boundaries, to provide timely and seamless portability of information and optimize the health of individuals and populations globally. Health data exchange architectures, application interfaces and standards enable data to be accessed and shared appropriately and securely across the complete spectrum of care, within all applicable settings and with relevant stakeholders, including by the individual.[36]

Interoperability of EHR as defined in ISO (ISO TC 215, ISO/TR 20514, 2005) is "the ability of two or more applications being able to communicate in an effective manner without compromising the content of the transmitted EHR."[37]

3.8.2 *standards development organizations efforts*

In the healthcare industry, a number of different standards development organizations (SDOs) create, define, update, and maintain health data standards through collaborative processes that involve health IT users, while SDOs have created several well-known standards intended to promote interoperability, lack of widespread adoption and use lessen the effectiveness of existing standards. In addition, differences in the way standards are implemented can slow progress toward achieving healthcare interoperability.[14]

Figure 16: Domains of communication of health information covered by different industry and legislative standard.



3.8.3 *European (CEN) EHR Interoperability Standards*

CEN is the principal legislative standardisation body for Europe; Technical Committee 251 has responsibility for health informatics (interoperability) standards. Since 1990 CEN TC/251 has regarded the Electronic Healthcare Record as one of the most important and most urgent areas for the establishment of European standards.

A pre-standard ENV 12265, outlining the key architectural features of an EHR, was first published in 1995, and followed in 1999 by a more comprehensive four-part pre-standard ENV 13606. This defined the logical model of an EHR, and a message model derived from it, a set of access control measures that ought to be applied to the process of EHR sharing and a set of vocabularies to support the overall EHR model.

In December 2001 CEN TC/251 confirmed a new Task Force, known as "EHRcom", to review and revise the 1999 four-part pre-standard ENV 13606 relating to Electronic Healthcare Record Communications. The intention of this work is to propose a revision that could be adopted by CEN as a formal standard (EN) during 2005[41], the standard was further drafted jointly by CEN and ISO for publication. ISO 13606 and CEN/ISO EN 13606 are referred to as ISO and CEN standards, respectively.[48]

3.8.3.1 *The CEN/ISO EN 13606*

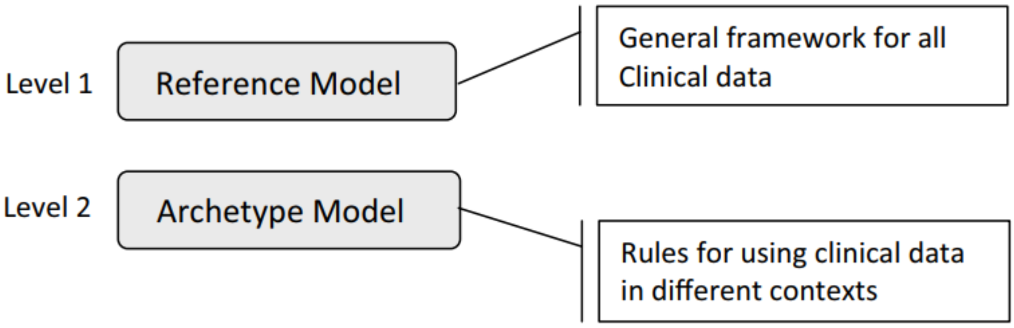
The CEN/ISO EN 13606 standard provides specifications for achieving semantic interoperability during exchange of EHR information. It primarily focuses on interoperability between EHR frameworks/standards that are popular in European countries (i.e., HL7 and openEHR) with base requirements from ISO/TS 18308 standard [ISO/TS 18308 2002]. It is a five-part standard. The EHR framework of this standard is based on the two-level modeling approach of openEHR. This is reflected in Part 1 and Part 2 of the published standard. Additionally, it provides mapping to HL7 CDA and openEHR for facilitating interoperability. The five parts are: [48]

- **part 1**: REFERENCE MODEL
- **part 2**: ARCHETYPES INTERCHANGE SPECIFICATION
- **part 3**: REFERENCE ARCHETYPES AND TERM LISTS
- **part 4**: SECURITY
- **part 5**: EXCHANGE MODELS

3.8.3.2 *The Dual Model Approach*

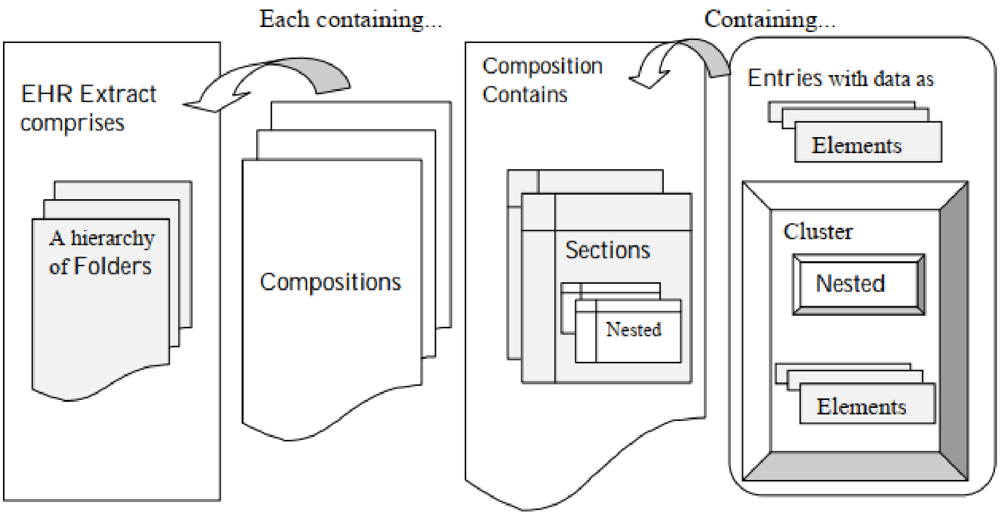
ISO/CEN 13606 is based on a dual model: a Reference Model which supports the information, and an Archetype Object Model (AOM). AOM allows defining knowledge, i.e., the concepts of the clinical domain by means of Archetypes. Archetypes are patterns that represent the specific characteristics of the clinical data. A main concept of this dual approach is that if knowledge changes (e.g., additional health characteristics are required to be included), only the archetype under the data will change.[41]

Figure 17: The dual model approach.



Reference Model represents the global characteristics of health record entries, how they are aggregated, and the context information required to meet ethical, legal and provenance requirements. This model defines the set of classes that form the generic building blocks of the EHR. It reflects the stable characteristics of an electronic health record.[41]

Figure 18: EHR Extract record hierarchy. Adapted from [EN13606-1 2007].



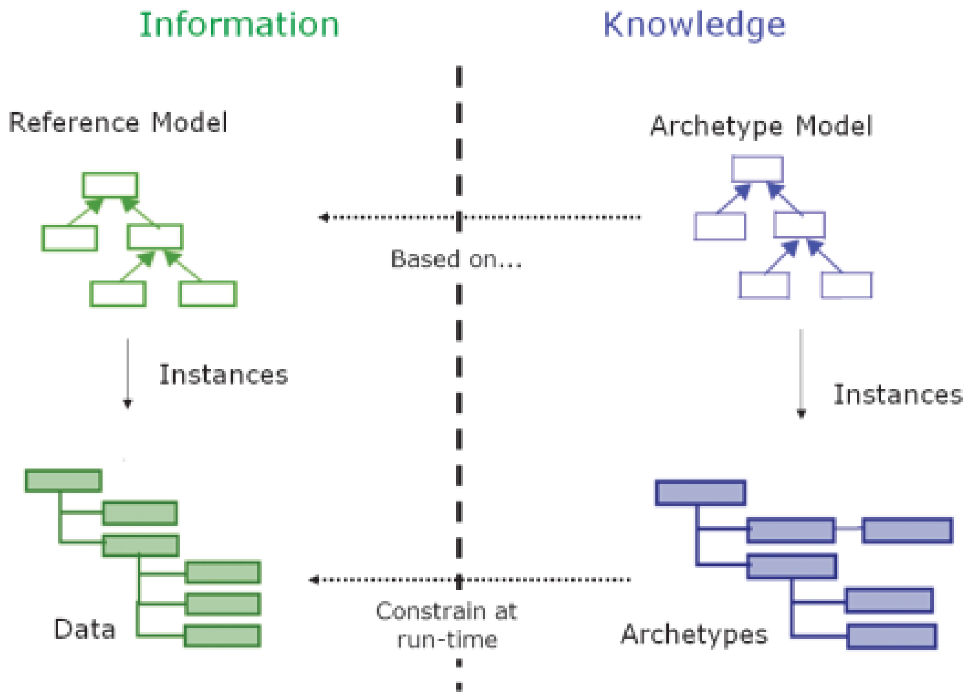
The EHR is comprised of the following logic blocks:

- **EHR Extract**: The top-level container of part or all of the EHR of a patient.

- **Folder**: Some high level organization within an EHR (episode of care, compartments of care, etc).
- **Composition**: A single clinical encounter or record documentation session (reports, test results, etc).
- **Section**: Clinical headings reflecting flow information (subjective symptoms, findings, treatment, etc).
- **Entry**: Clinical statements (a measurement, a symptom, etc).
- **Clusters**: The means to organize nested multi-part data structures (tables, time series, etc).
- **Element**: A container of a single data value. This is the leaf node of the hierarchy.

The Archetype Model represents the semantics of the dual model approach. An archetype is used for modelling domain concepts (blood pressure, body weight, etc.), constraining the Reference Model at runtime by defining the structure of the instance and/or limiting the value range of an attribute. Since this part of the norm leverages appropriate parts of the openEHR model for defining archetypes, openEHR and ISO/EN13606 share the basis of the archetype model.[45]

Figure 19: Relationship between information (instances of Reference Model) and knowledge (instances of Archetype Model).



3.8.4 *HL7 Standards Relevant to the EHR*

Hospitals and medical practices within a city or region leverage HL7 standards to facilitate the exchange of healthcare information between the in-patient and out-patient environments. Today, it is not uncommon for a patient's primary care physician to be able to see what happened to that patient when they were admitted to the hospital after an accident or illness. The flow of information and the ability for the hospital's technology and the medical practice's technology to understand data from each other is made possible by HL7 and other similar healthcare messaging standards.[11]

3.8.4.1 *Heath Level Seven (HL7)*

Founded in 1987, Health Level Seven International (HL7) is a not-for-profit, ANSI-accredited standards developing organization dedicated to providing a comprehensive framework and related standards for the exchange, integration, sharing and retrieval of electronic health information that supports clinical practice and the management, delivery and evaluation of health services.[2]

The HL7 protocol is a collection of standard formats that specify the interfaces for electronic data exchange in healthcare environments between computer applications from different vendors. The focus of the HL7 organization has historically been the interface requirements of large healthcare enterprises, but it is now engaging with healthcare systems are a higher (regional or national) level.[40]

3.8.4.2 *HL7 version 2*

HL7's Version 2 messaging standard is the workhorse of electronic data exchange in the clinical domain and arguably the most widely implemented standard for healthcare in the world. This messaging standard allows the exchange of clinical data between systems. It is designed to support a central patient care system as well as a more distributed environment where data resides in departmental systems.[12]

Figure 20: An example of an HL7 v2.x message.

```
MSH|^~\&|Sending Application^Universal Id^x400|Path Lab^Universal Id^x400|Receiving
Application^ Universal Id^x400|NID ^UniversalId ^x400|20000320^D|Security|ORU^R01 ^
ORU_R01 |MSG0001 |T^T|2.5^^|||AL|AL|IN|ASCII|LDLP^TEXT2^99^AI3^AT3^99|ISO
2022-1994| Entity Identifier ^NAMESPACE^UniversalId^x500

PID|1||WJYYU11556^^^REGAD1&IncomeTax Department&GUID^^^^^^|105^^^REGAD1
&Hospital A&GUID^^^^^^|Jim&^Toe^^^^^^^^^^^^ ||19950815^D|M||| ^^^^ 411089 ^^
^^^^^^^||||||105^^^REGAD1&Hospital A&GUID^^^^^^||MH122000435623^ RTO^||||||||||||||||

PV1|1|O|||||Reg No:6643^John&^Doe^^^^^^^^^^^^^^^^^^^^^|||||||||||||||||||||||||||||||||||||||

OBR|1|||52041-1^BloodGlucose^LN^^^|||20110506^D|||||||||||||||F||||||DR102&Tom&Ray&
&&&MD&&&||||||||||||||

OBX|1|CE|166921001^Blood Glucose Normal^SNOMED CT^^^||281301001^Within
Reference Range^SNOMED CT^00^00^00|UNIT^%^^^^|Reference range|N|||F|||||||SPM|1|||
BBL^ Blood Bag ^HL7^^^^^^||||||
```

Despite its wide uptake internationally, the problems of inconsistent implementations of Version 2 messages and the unsystematic growth of message segment definitions have limited the realisation of interoperability.[41]

3.8.4.3 *HL7 version 3*

A key feature of the new Version 3 is the Reference Information Model (RIM) a means of specifying the information content of messages through an information model that clarifies the definitions and ensures that they are used consistently.[41]

3.8.4.4 *Reference Information Model (RIM)*

The RIM is a formal information model representing the core classes and attributes that will be required (in various combinations) by the different HL7 version 3 messages. The RIM defines four major classes of information:[40]

- **Entities:** for example persons, organisations, places and devices.
- **Roles:** for example that of patient or employee.
- **Participation relationships:** for example that between a patient and a clinician.
- **Acts:** for example the recording of appointments, patient encounters, observations, procedures.

3.8.4.5 *The HL7 Clinical Document Architecture*

(CDA) is a generic message structure for the communication of a clinical document, derived as a message model from the HL7 RIM. Release One of CDA has is an XMLbased standard that comprises a header with document authorship information, organisational origin and patient identifiers, and a body whose basic structure is defined at a fairly high level.

CDA Release Two, which has recently been passed as a standard, specifies the structural organisation of finegrained information inside a document. In this regard it is now close in scope to that of the inner hierarchies of the CEN 13606 EHR architecture, and a cross-mapping has been developed between them.[41]

3.8.4.6 *The HL7 Template Special Interest Group*

Is actively developing a specification for constraints to be applied to RIM-derived message models. This work is drawing upon the openEHR archetype approach, and it is expected that some parts of the openEHR Archetype Definition Language will form part of this future HL7 standard.[41]

3.8.4.7 *HL7 EHR Technical Committee*

Has released an EHR System Functional Model as a draft standard for trial use. This standard describes an inclusive set of functions that might be available in EHR systems in particular (profiled) settings now and in the future. This set of functions provides a standardised way to describe EHR systems and their capability, as an aid to system comparison and procurement.[41]

3.8.5 *International (ISO) EHR Interoperability Standards*

ISO/TC 215 is a Technical Committee (TC) of ISO working in the area of Health Informatics. Its primary goal is to standardize health information and achieve interoperability across EHR systems. It has published various standards for healthcare information. These include standards for data structures, messaging and communications, privacy and security, devices, and so on. It also published ISO/TS 18308, which defines a common specification for EHR architecture.

3.8.5.1 *ISO/TS 18308 Requirement Specification*

ISO/TS 18308 Health Informatics Requirements for an electronic health record architecture [ISO/TS 18308 2002] is a specification for defining user and technical requirements of an EHR and its architecture. It projects EHR as a longitudinal health record and enlists requirements about the structure, content, form, and type of content. It also defines requirements for reference architecture of an EHR for exchanging or sharing health information.[48]

3.8.6 *Standards for Images (DICOM)*

The Digital Imaging and Communications in Medicine (DICOM) standard arose out of a precursor standard for images (ACR-NEMA) that was first published in 1985 by the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA). The DICOM standard is the most widely used common data representation internationally for the various medical images acquired and communicated. It has addressed many of the issues of vendor-independent data formats and data transfers for digital medical images. It is presently in version 3, with 14 chapters each relating to a different kind of image or signal data type or to a communication type. CEN and ANSI have adopted DICOM by reference in their imaging standards.[41]

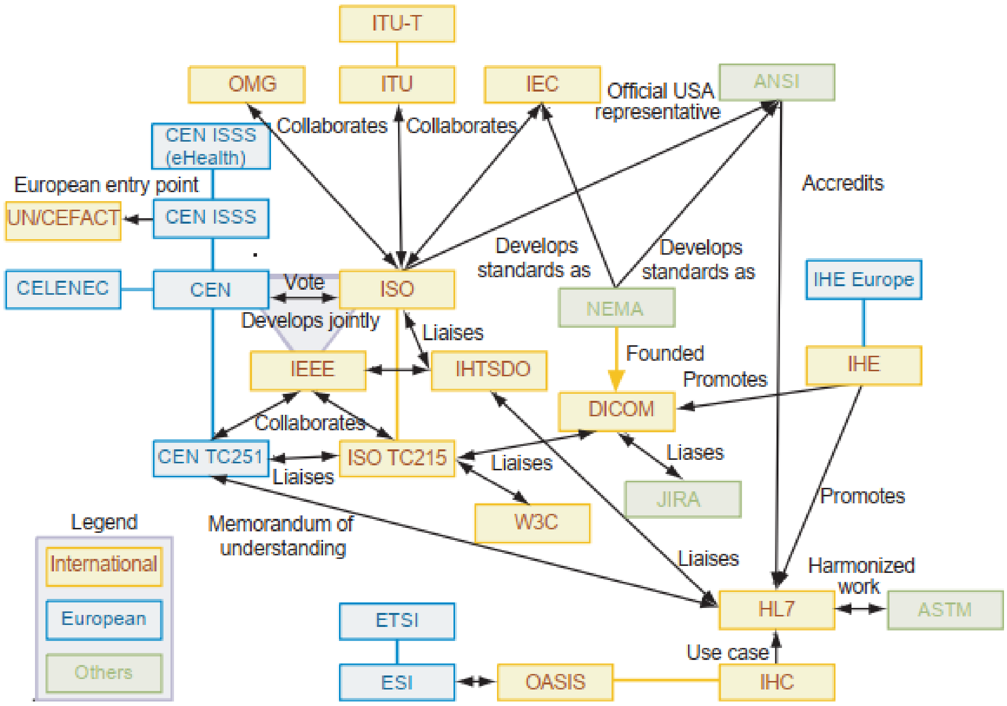
3.8.7 *Other Standards and Specifications*

It is not possible in this chapter to summarise all of the potentially relevant standards, industry standards and specifications that might pertain to parts of an EHR, such as particular data sets or data types. Examples of these include the Object Management Group Health Domain Task Force (OMG-HDTF) and the American Society for the Testing of Materials (ASTM). For example, ASTM is developing a standard "Continuity of Care Record" which is a rich data set of clinical and administrative data items that ought to be considered for inclusion in a shared care clinical communication. This is not a replacement for a comprehensive EHR, but the work on generic EHR specifications reported above either has or is evolving links with these related standards bodies.[41]

3.8.8 *Strategies for EHR standards convergence*

Convergence of existing specifications for the EHR into an universal standard hinges more on common acceptance of the underlying systems and design paradigms and theories of information gathering, than alignment of technical aspects such as data types or class names. Nevertheless, it is the latter which is required if a common formal definition for the EHR is to be agreed and standardized. Clearly, the primary quality of a universal standard must be "flexibility" that is, within its formal definition, it must allow the multiplicity of actual health record structures and semantics found in different clinical contexts, languages and cultures. Participation by all standards bodies and all interested parties if to be encouraged. The key to success is recognition of a diversity of opinions, whilst at the same time defining and following a common technical vision underpinned by good theory and proven by implementation work.[43]

Figure 21: Relationship scheme of normalization and standard development organizations for electronic health records.



3.9 THE OPEN EHR FOUNDATION

It is a not-for profit organization, which provides EHR specifications, open source implementation of these specifications, and development of clinically constrained specifications called Archetypes. The name "openEHR" applies to both specification and foundation. openEHR Foundation provides free membership to those desiring to contribute to the development and implementation of openEHR specifications using the open source development approach. A reference implementation of openEHR is available under open source licenses.[48]

3.9.1 *Significance of openEHR*

The goal of openEHR is to exemplify good designs for interoperable EHR systems through open source components, and to validate and refine these through practical clinical demonstrators. openEHR aims to:

- promote and publish the formal specification of requirements for representing and communicating electronic health record information, based on implementation experience, and evolving over time as health care and medical knowledge develop.
- manage the sequential validation of the EHR architectures through comprehensive implementation and clinical evaluation.
- maintain open source "reference" implementations, available under licence, to enhance the pool of available tools to support clinical systems.
- collaborate with other groups working towards high quality, requirements-based and interoperable health information systems, in related fields of health informatics.

The openEHR technical specifications define design principles, reference and archetype models and will in the future include other middleware service specifications. This work is becoming regarded internationally as the most complete and best-validated EHR information architecture.[41]

3.10 THE FUTURE OF ELECTRONIC HEALTH RECORDS

Although the first electronic health record (EHR) systems appeared as far back as the 1960s and the Institute of Medicine advocated for EHRs in the 1990s, their widespread adoption didn't heat up until 2009. That's when Congress passed the Health Information Technology for Economic and Clinical Health Act, which earmarked 30 billion dollars for the widespread adoption of EHR technology, The benefits of the EHR technology over the traditional method of paper are many including cost reduction, improved quality, and enhanced compliance due to the use of real-time data. As the healthcare system is moving towards an electronic health record model, what are the changes we can expect in the future? [13]

3.10.1 *Patient access will be enhanced*

EHR turns data into knowledge. It is a gateway to smarter, safer and more accessible health care. Despite making the electronic health records readily available to the public, only 50% are accessing it. And most of them do it only once a year.

In the coming years, more people should be encouraged to access this information to increase their engagement. It is also important that the providers present a simpler user interface through their SaaS systems.

3.10.2 *Unified standards will be established*

In the coming years, we will see hospital CIOs(healthcare chief information officer), developers, and vendors will start working towards developing a unified standard of medical data which will facilitate information sharing and processing.

EHRs allow digital sharing of notes, easy retrieval of patients lab results and sending prescriptions to the pharmacy. Ideally, the records should flow seamlessly. But, effective communication between the systems, known as interoperability, is still a major issue. Currently, only 25% of the healthcare organizations are finding, sharing and receiving medical data. And only 40% of the hospitals integrate the data with their EHR system.

Incoming 4-5 years, we will see hospital CIOs, developers, and vendors start working towards developing a unified standard of medical data. This will ease information sharing and processing.

3.10.3 *Cloud technology for ehr will flourish*

Using the cloud technology for data storage and processing is not new to the business world. The most notable change, with the EHR, is the major improvement in the storage and speed of information flow. Currently, the medical organizations are citing the costs of software and infrastructure as their main concerns for adopting the cloud technology. Soon they will realize that the costs are lower with cloud-hosted EHR software.

3.10.4 *Centralized database on the cards*

Patient's centralized database is the latest trends in electronic health records in 2020. The centralized database will contain all the related medical information of the patients. This will assist the physicians to access their patient's past data and help in providing a better diagnosis. Patients will have a single access to their records. The governments and R&D organizations can also access that information to identify the disease and illness trends.

3.10.5 *Patient engagement will increase*

EHR'S in 2020 will ensure that the patient engagement will increase. Patients will have their questions answered before their records arrive at the doctor clinic. They can also directly book the appointment. This will make the patient portal more user-friendly and increase their engagement.

3.11 CONCLUSION

The electronic health record (EHR) made everything more easy and comfortable plus the entered data and information more accurate and safety, EHR now is considered as one of the most popular health technologies, it improved all the aspects of health care plus providing accurate information and fast access regarding the patients. And due to its benefits many physicians had adopt it and also the satisfaction of patients has been increased because the patient now can participate in the process of his situation and he/she with the medical provider take the right decision, the patient also, have a quite awareness about his/her status.

Part III

APPLICATION PART

This part contains one chapter which are the design and development of our ehr.

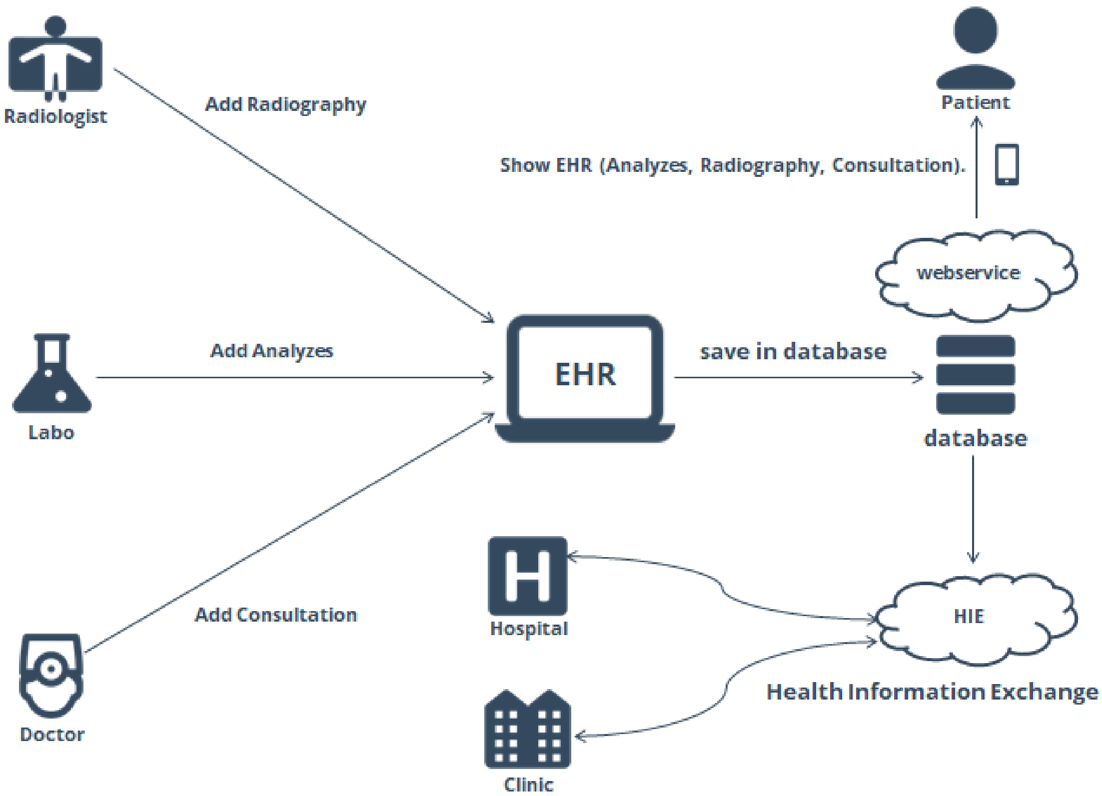
4

DESIGN AND IMPLEMENTATION

4.1 INTRODUCTION

In this Chapter we will present the conceptions of our EHR and the general structure of the environment in which we have developed the website. In the end we will explain the website some basic snapshots of the system.

Figure 22: Electronic Health Record (EHR).



4.2 OBJECTIVE

- Improve health care.

- Provide the attending physician with the most complete information so that they can propose treatment or examinations.
- Accelerate the capacities of all stakeholders to produce and share health data in a secure manner, in order to better coordinate care.
- Improving diagnosis and treatment.
- Improving data management.

4.3 GENERAL STRUCTURE OF THE ENVIRONMENT

We will talk in this section about the environment in which we develop our program with the mention of programming language used in development and some of the libraries and packages imported.

4.3.1 *Programming language*

In the development of the Ehr, we used the Microsoft C # and ASP.NET language and the java android for mobile application.

4.3.1.1 *ASP .NET*

ASP.NET is a framework for generating on-demand web pages, launched by Microsoft in July 2000, and used to implement web applications. This is a major evolution of Active Server Pages (ASP, aka Classic ASP), whereby this technique was incorporated into the Microsoft .NET platform. The ASP.NET engine is a filter plugged into the Internet Information Services (IIS) web server. It is distributed with the .NET framework. ASP.NET can be used with any programming language for the .NET platform (Visual Basic .NET, C, JScript ...).[44]

Figure 23: ASP.NET logo.

4.3.1.2 *C sharp (C#)*

C (C sharp in British English) is an object-oriented programming language, marketed by Microsoft since 2002 and intended to develop on the Microsoft .NET platform. It is derived from C ++ and very close to Java which it takes the general syntax and concepts, adding concepts such as operator overload, indexers and delegates. It is used in particular to develop web applications on the ASP.NET platform.[39]

4.3.1.3 *JAVA*

Java is a modern programming language developed by Sun Microsystems (now bought by Oracle). It should not be confused with JavaScript (scripting language used mainly on websites). One of its greatest strengths is its excellent portability: once your program has been created, it will run automatically on Windows, Mac, Linux, etc.[5]

4.3.2 *Development environment*

We will talk about Microsoft development environment and data storage using Microsoft SQL Server.

4.3.2.1 *Microsoft Visual Studio*

Microsoft Visual Studio is a suite of development software for Windows and mac OS designed by Microsoft. The latest version is called Visual Studio 2019. Visual Studio is a complete set of development tools for generating ASP.NET web Applications, XML web services, desktop applications, and mobile applications. Visual Basic, Visual C ++, and Visual C all use the same integrated development environment (IDE), which allows them to share tools and makes it easy to create solutions that use multiple languages. In addition, these languages help to leverage the functionality of the .NET framework, which provides access to key technologies that simplify the development of ASP web applications and XML web services with Visual Web Developer.[21]

Figure 24: Microsoft Visual Studio logo.

4.3.2.2 *Microsoft SQL Server*

Microsoft SQL Server is a relational database management system (RDBMS) that supports a wide variety of transaction processing, business intelligence and analytics applications in corporate IT environments. Microsoft SQL Server is one of the three market-leading database technologies, along with Oracle Database and IBM's DB2.[47]

Figure 25: Microsoft SQL Server logo.

4.3.2.3 *Developer Express Inc.*

This is a software development company founded in 1998 and headquartered in Glendale, California. DevExpress initially started producing interface controls. Currently DevExpress offers products for developers using C #, Delphi / C ++ Builder, Visual Studio and HTML5 / JavaScript technologies.

Figure 26: Developer Express Inc logo.

4.3.2.4 *Android Studio*

Android Studio is the official integrated development environment (IDE) for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development. It is available for download on Windows, macOS and Linux based operating systems. It is a replacement for the Eclipse Android Development Tools (ADT) as the primary IDE for native Android application development.[4]

Figure 27: Android Studio logo.

4.3.3 *Framework and Library*

4.3.3.1 *Entity Framework*

Entity framework is the framework Object-Relational mapping (ORM) that Microsoft makes available as part of the .NET development. Its purpose is to abstract the ties to a relational database, in such a way that the developer can relate to the database entity as to a set of objects and then to classes in addition to their properties.[46]

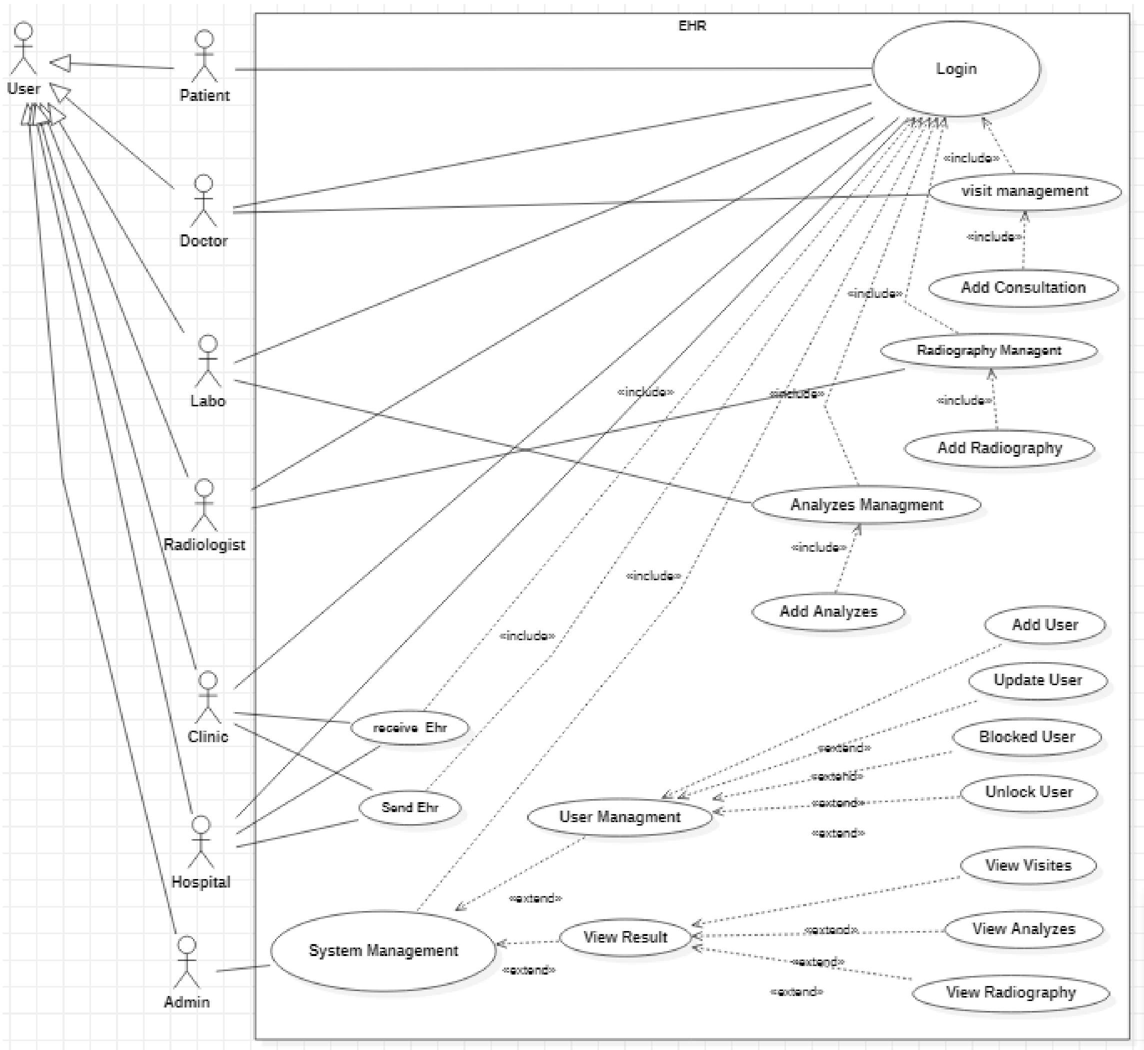
4.4 design

In this section we will present the conceptual aspect of our work using the Unified Modeling Language (UML) modeling language.

4.4.1 *Use Case Diagram: Electronic Health Record*

Use Case Diagram is precise and specify the main functional objectives of the application as well as the relation between these objectives and the users. Largely, the whole design is based on this diagram. In this diagram, we will show active and responsible users dealing with the electronic health record system, for example login, research information and management system.

Figure 28: Use Case Diagram of Electronic Health Record.



4.4.2 *Activity Diagram*

One of the important UML Diagrams is the activity diagram, which is defined as a flowchart that designs flow from one activity to another, describing the dynamic aspects of the system.

In this part, we will show some activity diagrams:

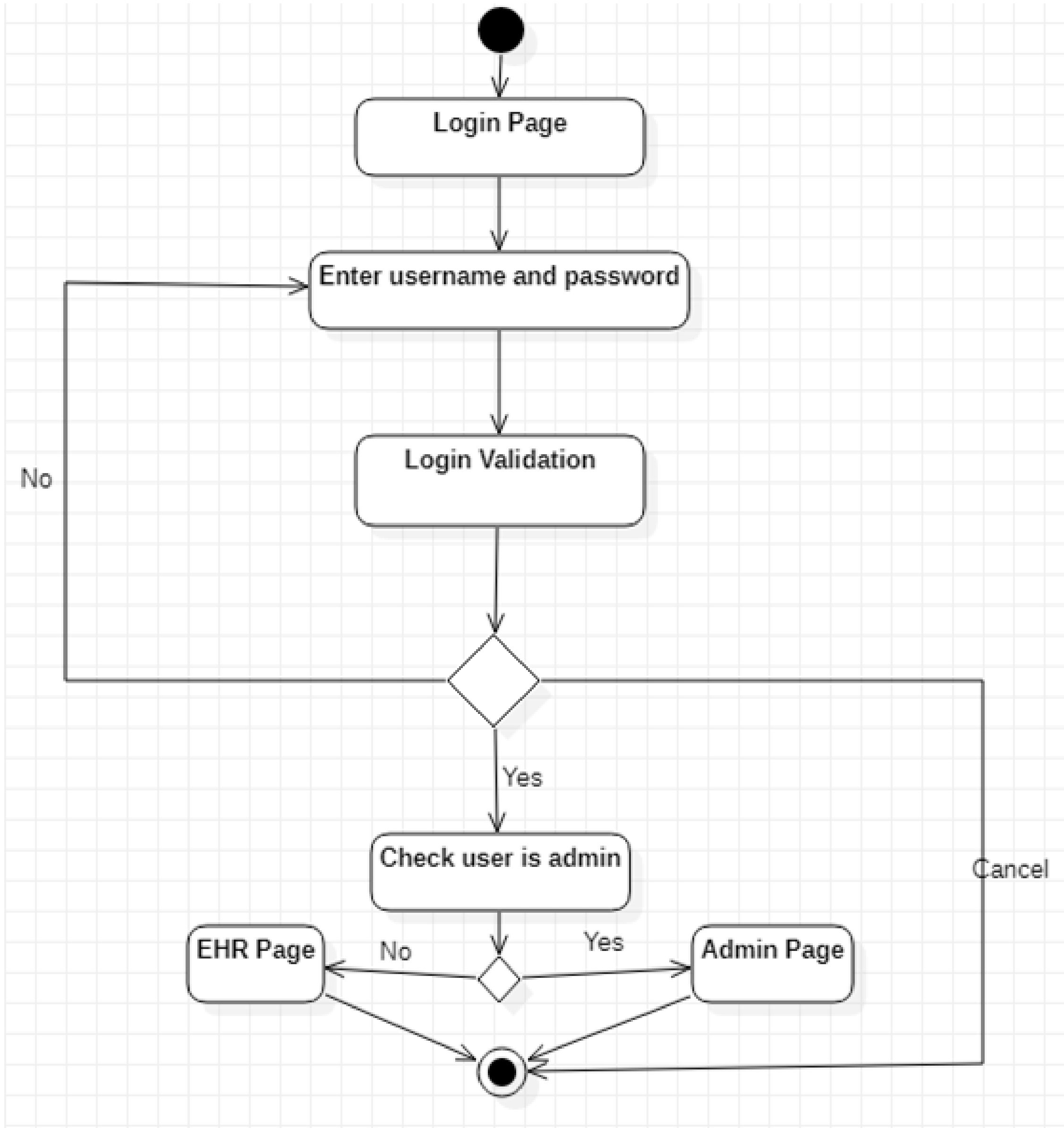
- Login Activity.
- Search Activity.
- Add Consultation Activity.

4.4.2.1 *Login Activity*

Activity diagram for login user and contains:

- Verification of information entered.
- Check the user role.

Figure 29: Diagram Login Activity.

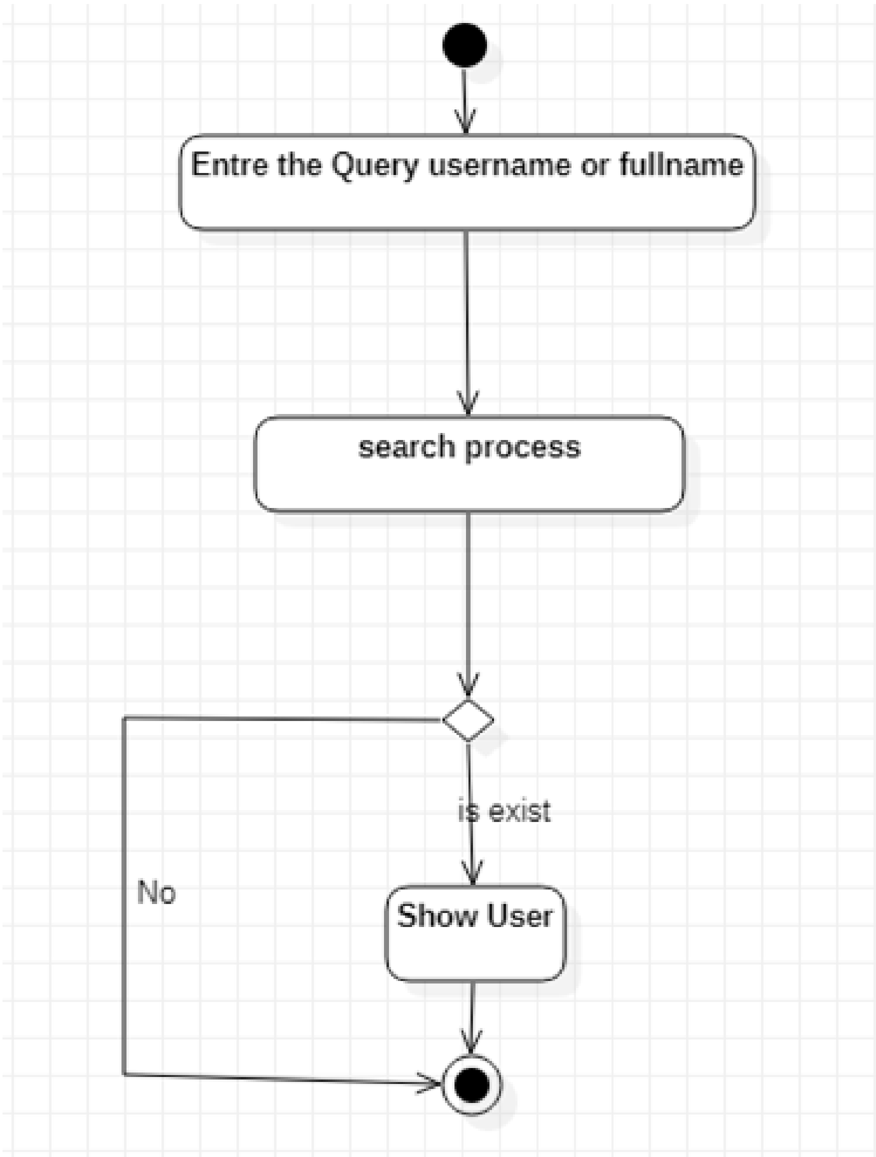


4.4.2.2 *Search Activity*

Activity diagram for a task search for input information and contains:

- Verification of the user entered.
- Show user if exist.

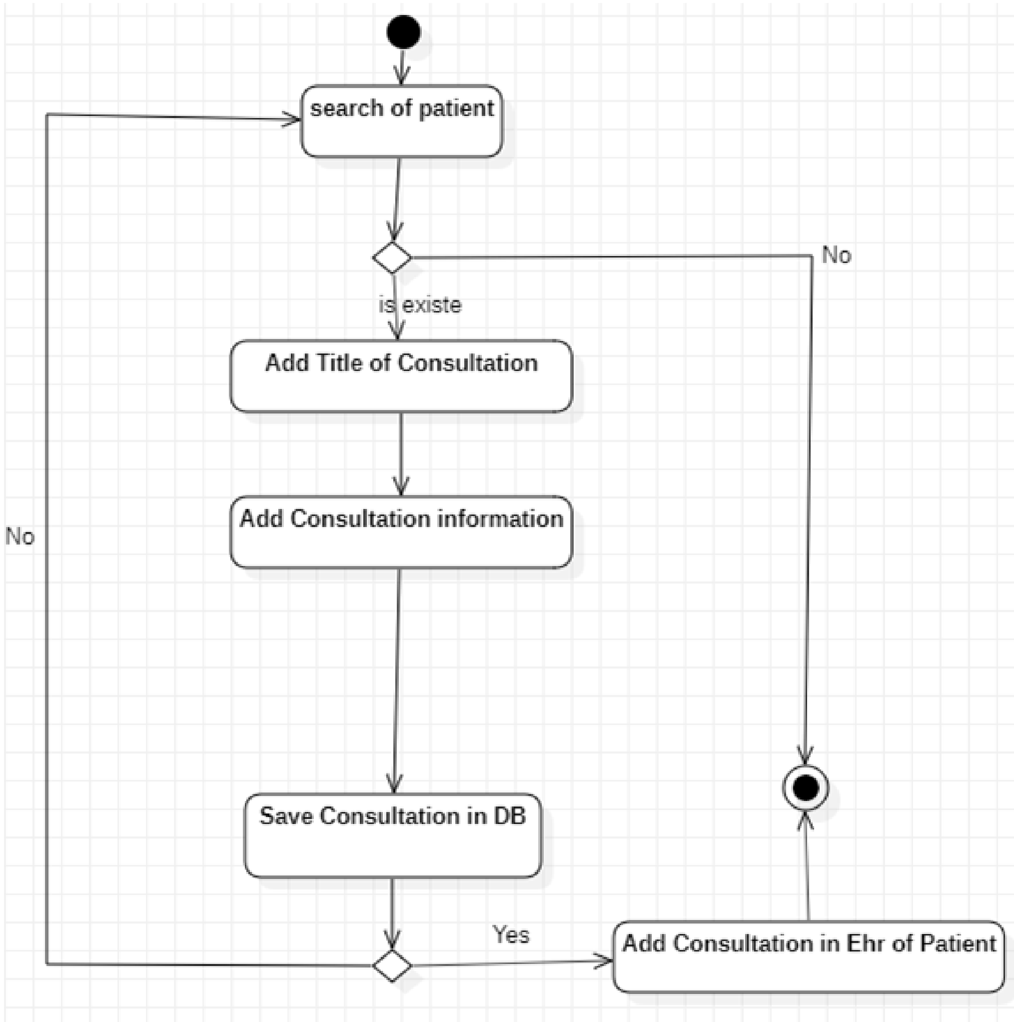
Figure 30: Diagram Search Activity.



4.4.2.3 *Add Consultation Activity*

- Search of patient.
- Add title of consultation.
- Add consultation information.
- Save consultation in DB.

Figure 31: Diagram Add Consultation Activity.



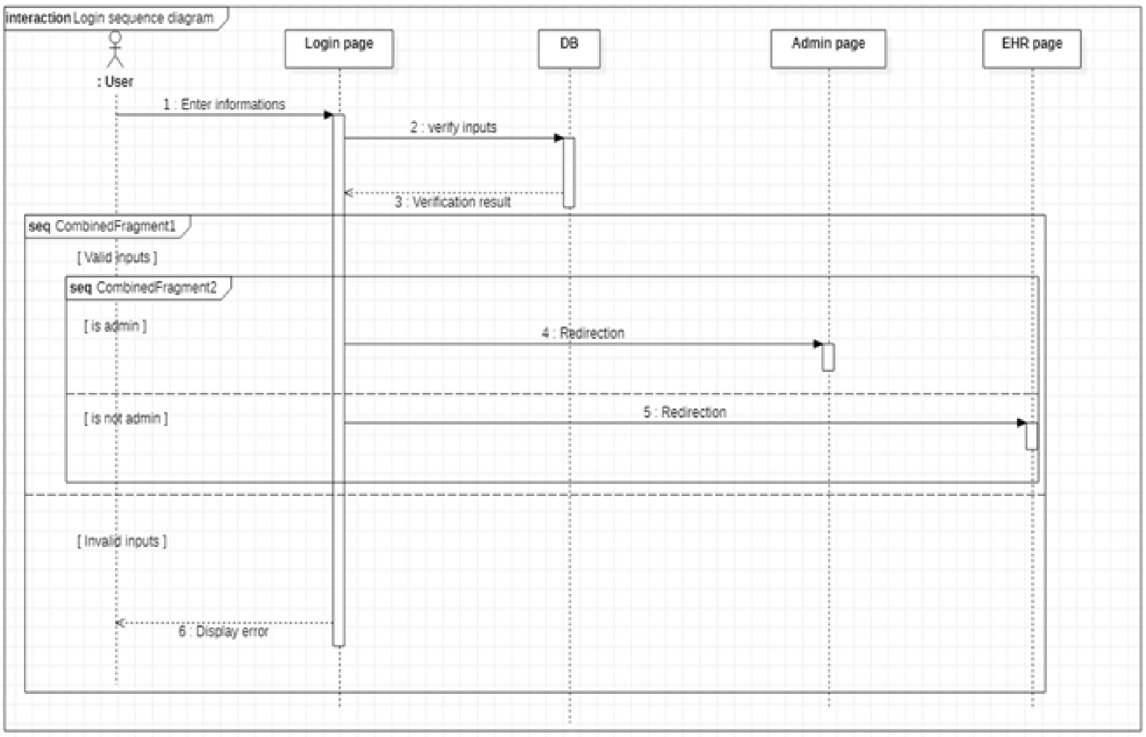
4.4.3 *Sequence Diagram*

The UML sequence diagram shows how the operations are performed, shows the order of interactions and focuses on time. This section shows us the most important Sequence Diagrams in our system such as searching for user or add a consultation with the login process.

4.4.3.1 *Login Diagram*

In the sequence diagram of user logins, we show the sequence of events. The login begins by entering the user's information, after which the information is verified and in the end it is determined whether he is allowed to enter or not.

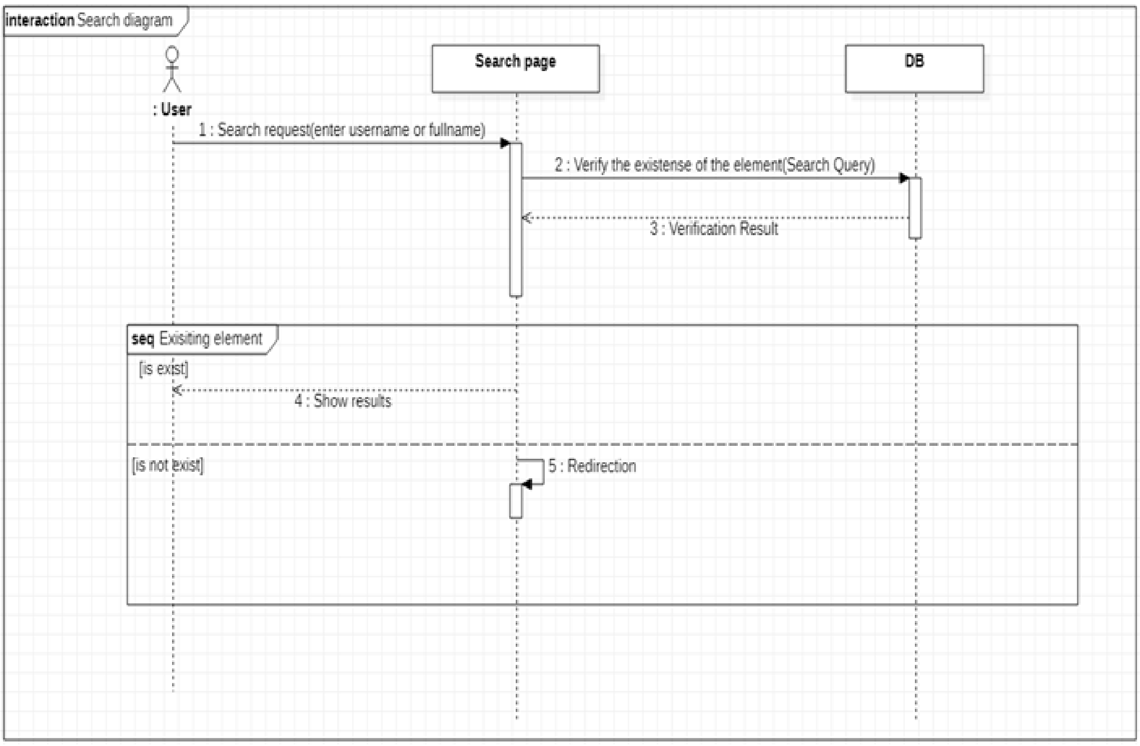
Figure 32: Diagram Sequence of Login.



4.4.3.2 *Search Diagram*

In the sequence diagram of search query, we check if the element whether is user or patient or clinic is already exist in the database or not, then the results will be shown to the user.

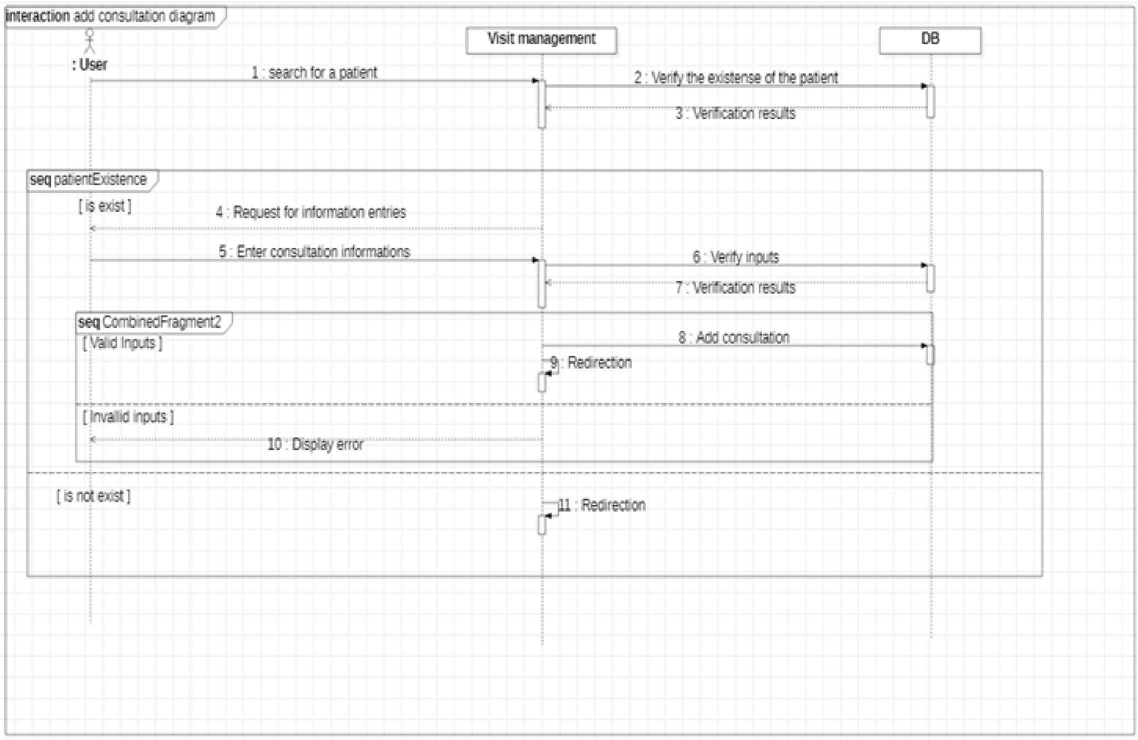
Figure 33: Diagram Sequence of Search.



4.4.3.3 *Add Consultation Diagram*

In this diagram, we check first if the patient is already exist in the database, then the user will be able to add a new consultation to the patient.

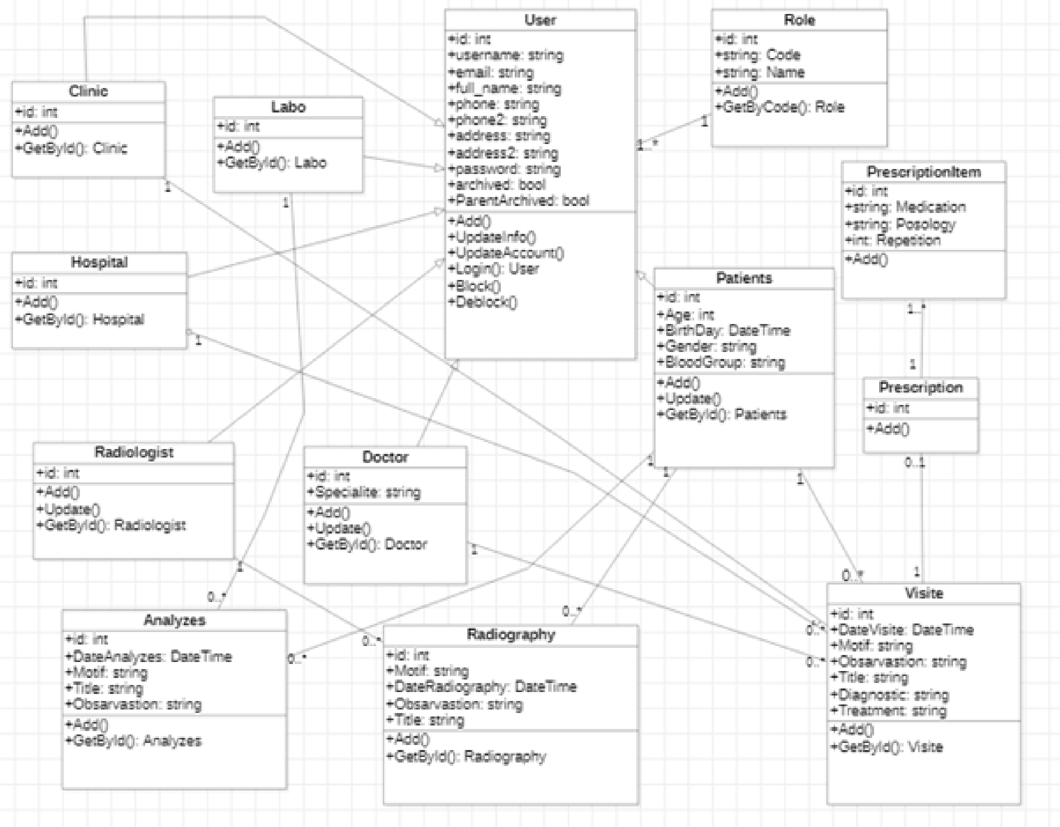
Figure 34: Diagram Sequence of Add Consultation.



4.4.4 *Class Diagram*

A class diagram is an illustration of the relationships and dependencies of source code between classes in UML. The class defines the methods and variables in an object, which is a specific entity in a program or unit of code representing that entity. Class diagrams are useful in all forms of object-oriented programming (OOP). We have used a certain number of objects in our system such as Hospital class, user class, and Patient class ... etc.

Figure 35: Diagram Class of Electronic Health Record.



4.5 IMPLEMENTATION

We will show in this section snapshots of the main parts of our website. And it consists of three sections:

- The login page.
- The admin page contains the user management (add, update, search).
- The EHR page contains management (visite, analyses, radiography).

Figure 36: shows the login page in our website.

Figure 37: shows the hospital management page.

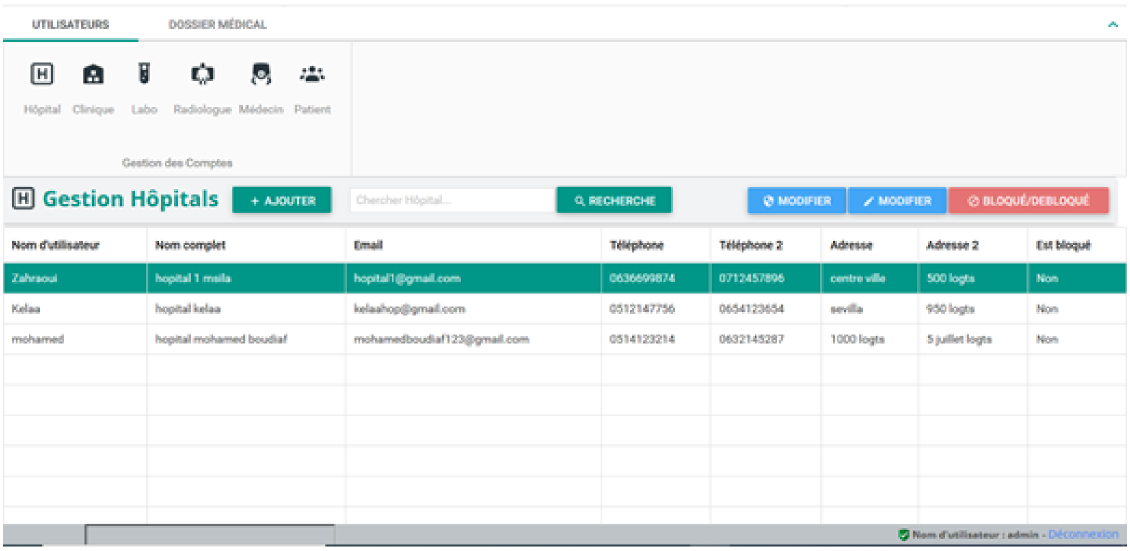


Figure 38: shows the patient management page.

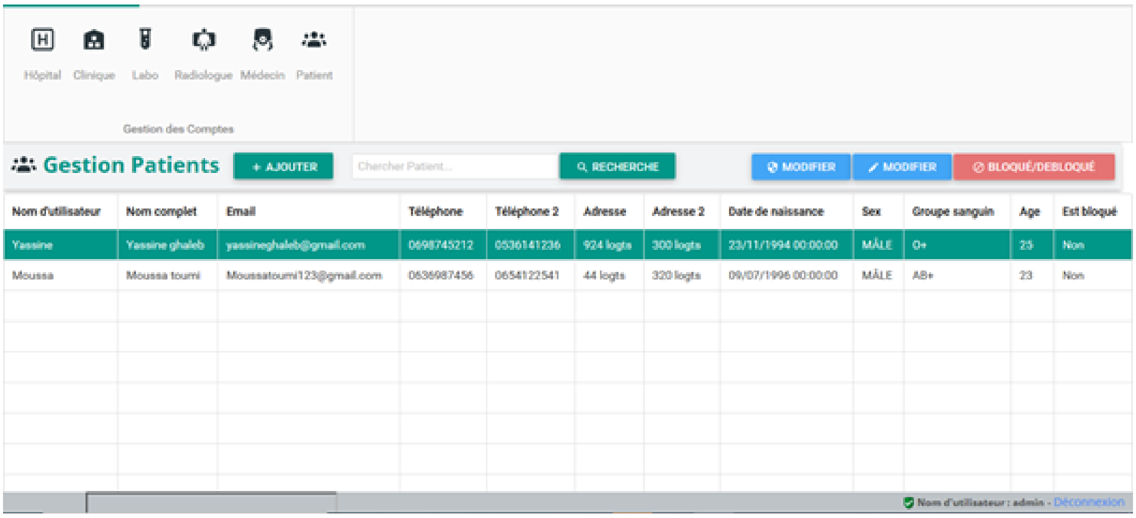


Figure 39: shows add patient.

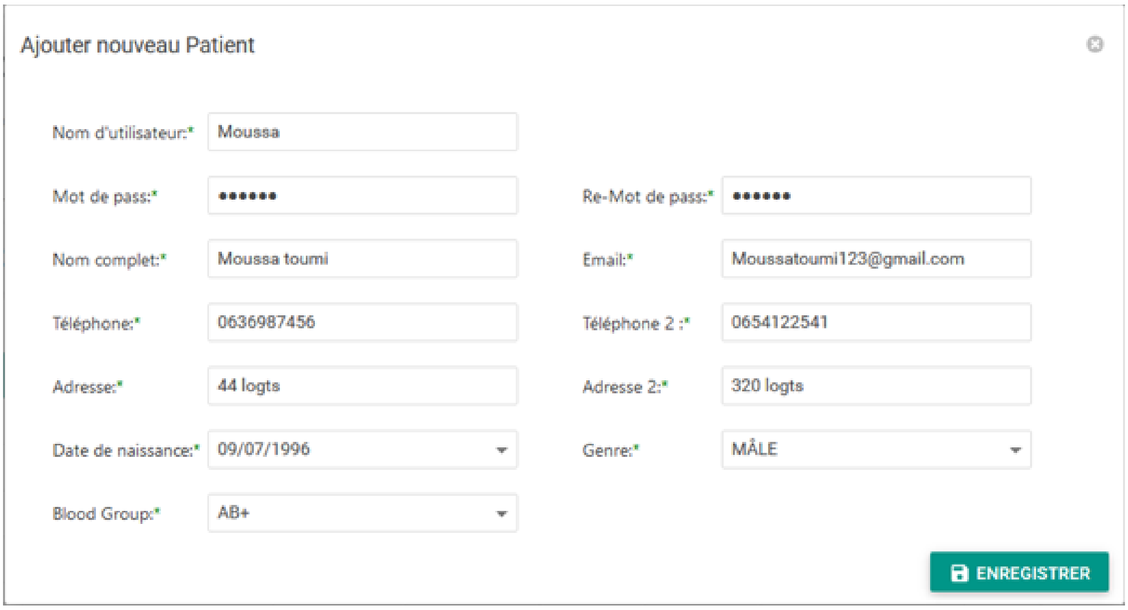


Figure 40: shows the analyses management page.

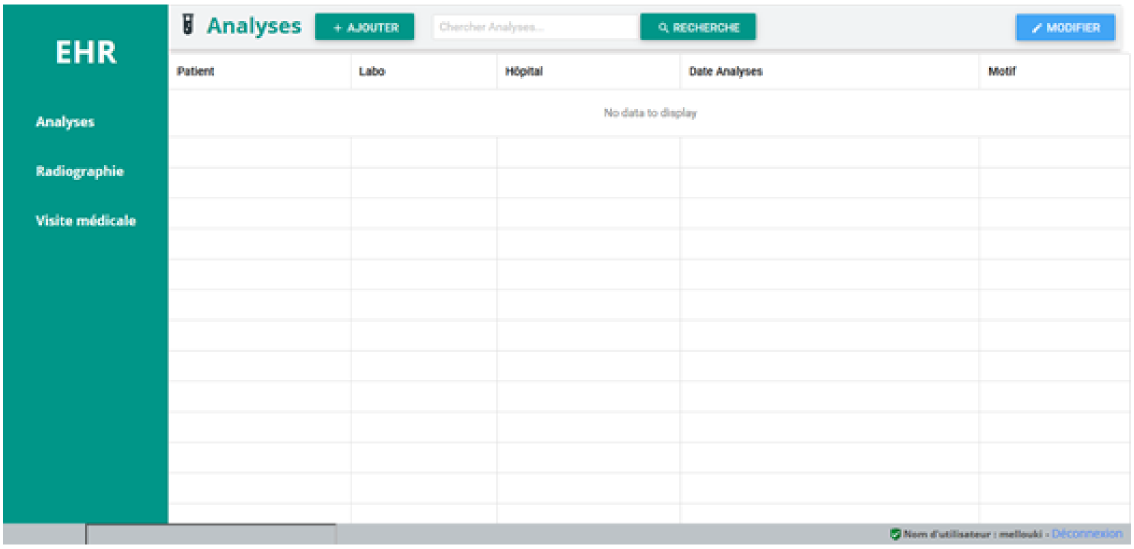


Figure 41: shows add consultation.

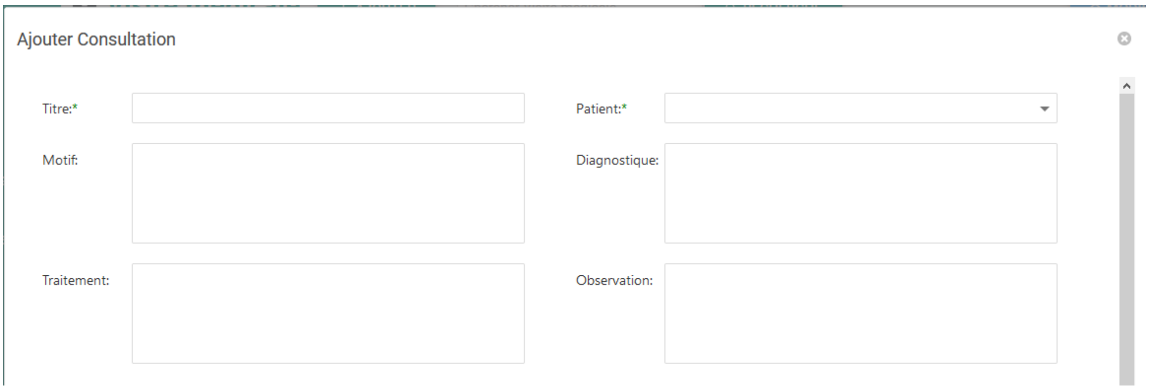


Figure 42: shows add prescription.

4.6 conclusion

We have shown in this section the application of the electronic health record. Programming the electronic health record will provide quality health care and will play an important and major role in providing health care in the future.

Part IV

GENERAL CONCLUSION

The last parts is the general conclusion and future work.

5

GENERAL CONCLUSION

Earlier parts of the dissertation introduced and discussed various healthcare IT standards, EHR frameworks, and case studies for implementations of EHR frameworks/systems. The description of each standard, framework, or case study also included the discussion on its suitability for developing a robust and complete EHR system. Their suitability was discussed based on certain requirements that included healthcare process, information model, EHR exchange specifications.

Improving performance to expand the features of EHR is one of the things we will be working on in the future Which is considered a perspective, for example, The patient can, if he needs a prescription, his/her doctor can send it to the central system, and any pharmacist can dispense the medicine. We will also add the feature of exchanging health records between medical institutions. and make our site secure from any unwanted access to features or information on the site and respecting patient privacy.

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ملخص:

تلعب تقنيات المعلومات دورًا متزايدًا في تقديم الرعاية الصحية وتساعد في معالجة المشاكل والتحديات الصحية التي يواجهها الأطباء وغيرهم من المهنيين الصحيين.

السجل الصحي الإلكتروني هو مجموعة إلكترونية منظمة من المعلومات الصحية حول المرضى مثل (التاريخ الطبي، طلبات الأدوية، العلامات الحيوية، النتائج المختبرية، تقارير الأشعة، مذكرات الطبيب والممرض(ة)). مثل جميع التطورات التكنولوجية قامت السجلات الصحية الالكترونية بتغيير ممارسات الرعاية الصحية والعلاقات وجعلت عملية الرعاية الصحية أسهل، وفي نهاية هذه المذكرة، قمنا بتطوير نظام السجلات الصحية الإلكترونية ، والذي يمكنه تخزين المعلومات حول المريض ومساعدة مقدم الرعاية الصحية لإدارة الرعاية بشكل أفضل للمرضى.

الكلمات المفتاحية: الصحة الالكترونية، السجلات الصحية الالكترونية.

Abstract :

Information technologies play a growing role in healthcare delivery and help address the health problems and challenges faced by clinicians and other health professionals.

An electronic health record (EHR) is a systematic electronic collection of health information about patients such as medical history, medication orders, vital signs, laboratory results, radiology reports, and physician and nurse notes. Like all technological developments, the EHR has changed healthcare practices, relationships and made the healthcare process easier, In end of this dissertation, we have developed a electronic health record system, that can store infomations about patient and help healchcare provider to better manage care for patients.

Key Word: e- health, Electronic Health Record (EHR).

Résume :

Les technologies de l'information jouent un rôle croissant dans la prestation des soins de santé et aident à résoudre les problèmes de santé et les défis auxquels sont confrontés les cliniciens et autres professionnels de la santé.

Un Dossier médical électronique est une collecte électronique systématique d'informations sur la santé des patients telles que les antécédents médicaux, les ordonnances de médicaments, les signes vitaux, les résultats de laboratoire, les rapports de radiologie et les notes du médecin et d'infirmièr(e). Comme tous les développements technologiques, le Dossier médical électronique a changé les pratiques et les relations en matière de soins de santé et a facilité le processus de soins de santé. À la fin de cette mémoire, nous avons développé un système de dossier médical électronique, qui peut stocker des informations sur le patient et aider le fournisseur de soins de santé à mieux gérer les soins pour les patients.

Mots Clés: Dossier médical électronique, E-santé.