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E-HEALTH APPLICATION TO COMMUNICATE WITH PATIENTS BY BUILDING AN ELECTRONIC HEALTH PORTAL

Ali Ahmed Ameen AL FAZEA

Master of Science

Supervisor

Asst. Prof. Dr. Abdullahi Abdu IBRAHIM

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E-HEALTH APPLICATION TO COMMUNICATE WITH PATIENTS BY BUILDING AN ELECTRONIC HEALTH PORTAL

by

Ali Ahmed Ameen Al Fazea

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Asst. Prof. Dr. Abdullahi Abdu IBRAHIM

Supervisor

Thesis Defense Jury Members:

Asst. Prof. Dr. Abdullahi Abdu IBRAHIM	School of Engineering and Sciences, Altinbas University	_______________
Asst. Prof. Dr. Sefer KURNAZ	School of Engineering and Sciences, Altinbas University	_______________
Asst. Prof. Dr. Mohammed ABUBAKAR	College of Business and Social Sciences, Antalya Bilim University	_______________

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

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Ali Ahmed Ameen AL FAZEA

Signature

DEDICATION

First and foremost, I would like to thank Allah Almighty for providing me with the knowledge, skill, and chance to undertake this research study and to persevere and complete it satisfactorily. Heartfelt thanks go to my father and my mother, and my wife. Every success is a direct consequence of their influence in my life and their love. In the end, I have to mention my brothers and sisters for their support and love.

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ABSTRACT

E-HEALTH APPLICATION TO COMMUNICATE WITH PATIENTS BY BUILDING AN ELECTRONIC HEALTH PORTAL

Al Fazea, Ali Ahmed Ameen,

M.Sc, Information Technologies, Altınbaş University,

Supervisor: Asst. Prof. Abdullahi Abdu IBRAHIM

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E-health portals present patients with easier access to their healthcare information and services. We design and implement an e-health portal that can effectively integrate several background medical services. The central challenge in designing such a system is to meet critical security requirements, such as confidentiality of patient data, the integrity of diagnostic results, and the availability of healthcare services. In this study, the design and implementation of a common electronic health records system, which various clinicians and patients can access, is presented depending on the RBAC access control. We focused on creating a patient-specific password through PHP programming functions. It is also possible, on this portal, to establish effective communication between the doctor and the patient, such as booking appointment electronically. Moreover, doctors can use the system to communicate urgent reports regarding the spread of newly discovered pandemics such as Coronavirus. System testing and evaluation are also offered.

Keywords: E-health, EHR, RBAC, E-health portal.

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LIST OF ABBREVIATIONS

ICT	:	Information and communication technology
IT	:	INFORMATION TECHNOLOGY
EHR	:	Electronic health record
EMR	:	Electronic health medical
PHR	:	Personal health record
ISA	:	International Standards Association
HL7	:	Health Level Seven
DICOM	:	Digital Imaging and Communications in Medicine
CDA	:	Clinical Document Architecture
TCP/IP	:	Transmission Control Protocol and the Internet Protocol
CORBA	:	Common Object Request Broker Architectures
DRM	:	Digital Right Management
HIPAA	:	Health Insurance Portability and Accountability
HL7 v3	:	Health Level Seven version 3
IDE	:	Integrated Development Environment
MAC	:	Mandatory Access Control
RBAC	:	Role-Based Access Control
TCM	:	Tees Confidential Model
UCON	:	Usage Control

UDDI	:	Universal Description Discovery and Integration
WSDL	:	Web Services Description Language
JSP	:	Java Server Page
DoS	:	Denial of services

1. INTRODUCTION

E-health is characterized as the “use of information and communications technologies (ICT) in support of health and health-related fields. It Includes healthcare services, health surveillance, health literature, health education, knowledge and research [1], which can be of total value in providing health care in multiple settings. These systems can save lives and provide detailed information for strategic planning, especially in areas where hand-compiled data are usually years out of date. The Healthcare target is to provide quality services to its customers. Healthcare uses information and communication technology to improve the quality of services. The involvement of technology informatics in health aid in reducing human errors in healthcare. In today’s e-health application, there are many IT software implementations in the healthcare sector. The following aspects must be analyzed to identify the gap in a given project:

a. Technology being used, including hardware, software, the networks, and different automated gadgets
b. Information processes like data storage and data flow.
c. The process of communication and sequence of activities.
d. The objectives of the projects.
e. Qualitative and quantitative competencies required by the staff using the software.
f. The management systems.
g. Time and money.

The letter "e" does not only include the electronic sign health; it can refer to several other issues such as:

I. Efficiency that refers to the process of reducing costs by avoiding unnecessary or duplicate treatment and ease of communication with patients.

II. Enhancing the status of care by following up on patients and facilitating communication with them to ensure the improvement of their health status and saving their data for future communication.

III. Evidence-based: The use of e-health must be based on efficient, practical evidence and not only through hypotheses, and this topic needs a lot of work and application.

IV. Empower consumers and patients by making patients access records and communicate with the Medicare Center, to make health services better.

V. Educating doctors and users of health systems about the need to go towards this field and treating illiteracy among many by using the electronic field in the health sector, especially in rural areas or poor communities.

E-health is currently one of the pillars of health care reform and one of the leading research goals of many institutions, academics, and organizations. The following acronyms indicate some of the services that standard e-health systems provide:

a. EHR: an electronic copy of a full report of the patient's health that allows all information available immediately and in a secure way to authorized users [2].

b. EMR: a digital report that contains all of the patient's medical history[3].

c. PHR: a health report where the patient maintains his health-related data in a private, secure, and confidential environment[4].

d. e-prescribing: a technology bodywork that does writing and sending prescription electronically from the healthcare institution to the pharmacy[3].

e. e-appointments: an online service makes scheduling an appointment for any health organization fast and easy while reducing waiting time.

f. m-health: a universal expression that involves health practices. It is used in mobile devices and other wireless technology[4].

g. Telemedicine: providing health services and information remotely using information and communication technology[5].

h. Telehealth: introduce health-related services and information by ICTs[6].

1.1 BACKGROUND

With the advancement of the medical sciences, there is a real need for more doctors to treat patients. Traditional handwritten records are no longer sufficient and cannot suffice for recording patient information because it has two major disadvantages. The first disadvantage is the misunderstanding due to the handwriting, which leads to more errors. The second disadvantage is the difficulty of keeping these records. In American hospitals, between 44,000 and 98,000 deaths due to medical errors are recorded annually due to the lack of information exchange between doctors and patients[7]. This limits the development of medical services. The main obstacle to the development of medical services is the mechanism of sharing medical information between doctors and patients and the sharing at the level of hospitals and health care centers. With the development of medicinal uses, the healing process becomes more difficult. It is a fact that the medical data in a continuous increase. The handwriting-based system cannot accommodate such a trend. Therefore, the interoperability of healthcare systems has become a broad field of research. Which, in turn, can support the decision and greatly reduce medical errors.

1.2 BENEFITS OF E-HEALTH

Electronic health provides proper treatment for patients, reduces medical errors, and enables urgent health care. When using electronic health systems, health data are available to health care providers, which allows it to make health services more full by communicating with patients, improving their care, and reducing delays and administrative errors. The team of professionals and health professionals can, through electronic health systems, access data safely, quickly, and promptly to provide urgent care to patients. They can share health data and effectively arrange medical interventions to avoid duplication of tasks and reduce costs. Medication errors and prescription errors can be reduced through electronic prescribing systems. If the patient is given a drug and the patient is allergic to this treatment, the system will alert this error. Thus, it leads to less time in reading prescriptions, which gives better results.

1.3 THESIS STRUCTURE

The thesis will be structured as follows. In the second chapter, we will talk about the electronic health record and access control with examples of the application of the electronic health record. In the third chapter, we mention the requirements for building an electronic health portal. Chapter 4 is about the design and implementation of the portal with job testing. Chapter Five presents the results of the implementation of the electronic health portal. The sixth chapter is about the conclusion and future work.

1.4 AIMS OF THE THESIS

The thesis aims to study the application of e-health by designing and implementing the electronic health portal. We worked to mention the benefits of e-health and the importance of using it instead of paper-based systems. We highlight the electronic health record and the importance of interoperability. The main contribution is the design and implementation of an e-health portal through a three-tier architecture. We use the RBAC (Role-Based Access Control) model. In this portal, the patient can communicate with the doctor, store his health file, and refer to him/her at any time. We focused on patient data privacy and security by not allowing anyone to enter the system without permission by creating a highly secure password based on PHP programming functions. We also highlighted the portal's capability to communicate urgent reports of newly discovered pandemics, such as the Coronavirus.

2. LITERATURE REVIEW

This chapter reviews Electronic Health Records; related work of e-Health systems and access control models are also illustrated. Moreover, the chapter provides some illustrative examples of the application of e-health in some countries.

2.1 ELECTRONIC HEALTH RECORD

The electronic health record describes all digital information technologies used in patient care. It is an electronic database that provides all the patient's health information, including personal data[8]. Electronic health records contain fewer errors and are characterized by high security with better time management and lower costs. As a result, it offers faster and more precise access to medical information. Table 2.1 compares the electronic health record with the records used manually.

Table 2.1: Comparison of electronic health records with the records manually

Area	Electron records	Manual records
Location	Available Always and everywhere	Available Always in particular places
Format of the records	All Formats	Limited forms
Purpose and access to information	Various and unlimited	Specific and limited
Save information	Active	Inactive
Space	Compact	Non-Compact
Cost	--------	Expensive
Retrieval	Quick and easy	Sometimes impossible

2.2 INTEROPERABILITY OF EHR

According to ISA (International Standards Association), the EHR must contain information about care in a computer-readable form. Multiple users can securely access it. All the users have access to their medical records, except visitors who have not been granted permission. The longer-term goal is to assist with continued, qualitative, and practical health care[9]. A patient may get care from several hospitals during his lifetime, so each of those facilities should be allowed to use his previous data without restriction[10]. When EHR systems are interoperable, they can help. When using an integrated EHR system, various research facilities and hospitals can share patient diagnosis data and results. For instance, reducing the number of physical tests done would save both time and money in the medical field. It may even potentially benefit more medical workers to have an integrated EHR. Vital information like adverse drug reactions can help the physician and patients alike. Providing detailed genetic information to the patients can improve disease prevention, detection, treatment, and diagnosis. While business information technology has managed to catch up to a great extent, there is still a considerable lag in implementing electronic health care in the sector[11]. The discovery of this reality and the continual growth in the healthcare sector have dramatically increased the demand for electronic health records systems to satisfy this need[11]. However, the policies governing the medical field can make this difficult. The patient's medical records are private. The most critical feature in an information system is the ability to keep personal information private. A large number of medical records legislation is aimed at protecting their privacy. Since it is impossible to design an EHR system without considering all policies and difficulties, therefore EHR is not to be neglected in the design process. It is necessary to use a secure, dependable, and transparent system. with the encouragement of each country's medical department and business organization, a great number of organizations and companies are now showing significant enthusiasm for EHR implementation.

Interoperability is possible to evaluate on three distinct levels: protocol, the system's behavior to the end-user, and the outcome[12]. HL7 (Health Level Seven) defines interoperability as Technical, Semantic, and Process[13]. From the technical point of view, the primary concerns are related to health data transfer and security. In the process of transmitting the data, both send and receive are done in a standardized manner.

The semantic part is an integration based on both parties' relevance and take on the information sent back and forth. Semantic tools were applied to make the researcher's findings intelligible to the participant. Process part: operation interoperability focuses on a more holistic approach to data use that results in increased value[14].

Standards play a main role in EHR interoperability. Many standards are under evaluation to solve the interoperability problem such as: (HL7), (DICOM), openEHR, CEN EN 13606 EHRcom and (IHE). HL7 is an organization dedicated to the development of international information interoperability. several well-known standards are applied to the storage of medical data and used to create data formats. In a CDA (Clinical Document Architecture), Clinical documents can be beneficial for architecture. Hospitals can set up clinical documentation in the same area, making it easy for information exchange. HL7 Version 3 messaging specifies electronic workflows for all HL7 standards. It depends on an XML encoding syntax. HL7 v3 Messaging explains a message delivery standard. Massage packaged by HL7 v3 Messaging from one EHR system which designed based on HL7 standard can read by another HL7 based EHR system. There is also the open document exchangeable modality protocol for handling, storing, printing, and transmitting medical images. (DICOM) used to import, export, and organize data, and makes it possible to create, change, and access 3D models and other project data and protocols. It is known as a lot of useful medical images that can be found here. The storage and delivery of data are defined with this standard. DICOM uses TCP/IP as its communication protocol, while TCP/IP provides data format in end-to-end communication. The CEN13606 specification recommends a semantic data model and electronic document composition rules. However, it provides a rather small set of standards for practice[15].

The primary two main functions of standards are: making something easier to see and easier to do. Refine the organization of data storage. Some of the medical data can be ordered in a unique fashion that promotes unity. Medical information was assembled under defined criteria and documented systematically. Exchangeable specifications are features that belong to the technical part of interoperability. These established standards can be employed when a new EHR is constructed. Some large health care facilities build their own EHR system based on in-house resources or help from a third party due to a lack of knowledge in the medical informatics domain. It causes some heterogeneous systems to look that way. Interoperability is difficult because the heterogeneous systems are already in place. Moving previously-stored patient data from one system to another is hard. Hospitals and healthcare facilities are unlikely to invest in a new EHRs because of the high cost of implementation. Also, the system's interoperability has its issues. Clinical information delivery can be provided at various locations, including medical clinics. A larger system requires a greater effort to put together. It is a challenge to form a distributed system. The deployment and adoption of the standards have proceeded at a slow pace. Wider variation of patient data management policies on privacy Semantic and creative interoperability are treated the same.

The term semantic interoperability is defined as being able to receive information that was sent to you in the way the sender meant. For interoperability purposes, the reviewers of this medical record utilized a different file format and could not read the record sent message by the openEHR system. To increase the cross-system semantic understandability, the information interrogated (or shared) has to have the same meaning or make sense across all the systems Semantic tools are used to define the meaning, not differentiate between presentations.

The most important benefit of semantic interoperability is that it can communicate with systems you have never encountered before. The systems are not completely standardized. Even though everybody has agreed on the standardized formats, no consensus has yet been formed on the data storage and transmission of information and interpretation of that information. If you want to have a good system, then the best thing to do is reuse the existing components. For speaking with an unfamiliar system, how do you deal with the data? No matter how well-defined the reporting rules are, HL7 systems cannot generate an openEHR record. There is an important concept called ontology matching, which can help in two ways: on the one hand, it can identify the similarities, and on the other, it can help resolve terminological and conceptual ambiguities. Semantic interop generally translates into intuitive mapping. However, one phrase may indicate “blood type,” while another system may show “blood group”. A semantic map is then used to determine “blood type”. All the terminology from one medical system can be imported into another, allowing a semantic map that accounts for the correspondence between them to be constructed.

Semantic interoperability (semi- or hybrid applications) applications have the same aim. Middleware (such as CORBA) is the technology of communicating with diverse systems that must employ different compilation environments. Middleware is software that translates software written in other languages or environments into another. Additionally, if he or she is knowledgeable, he or she can translate between people who speak different languages. Using middleware, people that know several languages are key to a successful Internet application. Middleware software that translates across systems. The middleware appears to be integrated in a lower layer than the semantic. Middleware, which facilitates the interconnectivity of and integration of distributed systems, has become critical to the business and research sectors.

Medical sharing is possible with grid electronic interoperability. It is an integration of technical and semantic/sexemtic using the HL7 Semantic Model. It can represent HL7 information conveyed by the message. XML is mainly used to send information and use web systems as a platform for everything in GRID. The WSDL, UDDI, and XML help drive the integration of different types of middleware using commonly available protocols across different platforms utilizing commonly used protocols and standards such as HTTP and XML[16]. Middleware connects disparate systems that are made of types. For a GRID model, data storage and transport systems are governed by standards. The semantic model may be used to map creative expressions to other standards. It will help with the creation of a decentralized system. XML is a common and preferred technology for delivering messages over the internet. Simultaneously, this model's availability of the above two requirements can be addressed: technical and semantic interoperability.

The above discussion suggests a simple conclusion: a new system should be design according to HL7 and openEHR standards. Most countries now use semantically specific tools to link multiple EHR systems. Semantic tools have a limitation: they are only as accurate as their source data. People need accurate information in the medical, so precision is essential. Ontology maps impact interoperability.

2.3 EHR ACCESS CONTROL

An EHR system's interoperability allows for large amounts of data storage. Much of the developed world's healthcare has arrived at a place where patients are served by physicians, therapists, primary care providers [17]. That could be a significant problem. Sharing of confidential information increases the danger of abuse and theft. Also, medical records contain private information, like a phone number for the patient and general information, like the patient's name and medical information. Patients are embarrassed to share their diagnosis with their doctor when it has nothing to do with their diseases. It is merely an attempt to share the information relative to physicians. Intrusion into medical records can be used to commit financial fraud. In order to prevent this, appropriate security measures are essential.

HIPAA (Health Insurance Portability and Accountability Act) places legal requirements on accessing patient data in systems[18].Under the HIPAA rules, we are required to implement “mechanisms that record and analyze activity in electronic health information systems”[19]. Many access control models are undergrowth to make contact with this legal requirement: Role-Based Access Control (RBAC), Mandatory Access Control (MAC), Usage Control (UCON), Tees Confidential Model (TCM), and Digital Right Management (DRM).

RBAC: Authorities are linked to functions in this model. A suitable position will be allocated to a user when they register with an EHR system. When a consumer enters a role, they receive the authority of that role. Roles are generated in an organization to accomplish a variety of tasks. Based on their responsibilities and qualifications, users are assigned to the appropriate task. When a user's duty or qualification changes, they may change their position. In general, a user's authority is determined by their position.

DRM: Public and private key pairs were generated. The key pair is provided by a third-party organization, known as a digital authorization center, that users consider to be trusted. A public key can be used for both encryption and decryption. Only the recipient of the message will be able to read the message. Creative expression: The record generator generates the key pair. Copies may be made, but the end-users cannot print or share. In any digital rights management (DRM) system, data is always encrypted, making it hard for anyone who does not have permission to read it. Digital Rights Management (DRM) may restrict data usage because it prevents unauthorized copying or distribution, so it prevents unauthorized data access[20].

UCON: Subject, object, and right are the three components. Authorize also has three other components: an authorization law, a requirement, and an obligation. The authority is dependent on the subject and object attributions, as well as the authority criterion. Before or after the access acts, access rights may be assigned. When compared to other access control models, the mutable attribute is the most distinguishing feature. The mutable attribute will change as the access result changes. RBAC, MAC, and DRM are all part of the UCON model. It is a new generation of control access models.

TCM: permissions are applied to users regardless of role, and assign algorithm processing to various resource types[21]. Not only user roles, but also identities. The identity is a department in a wider role. It describes more of a role than a feature. What is unique about usernames is that the user identities can be assigned to each person. Identity allows users to administer the right of access in a more versatile manner.

MAC: Not tied to any user action. The system is administered by security administrators. In the MAC model, subjects and users are placed into different security categories. Determine whether to grant or deny access to the users. For example, registered nurses deal with many patients. The administrator should assign a higher security level before the nurse does. Her security level is sufficient for her to allow her to access patient data at a lower level.

If a patient has been accessed, an audit log will be created. Verification of this audit log records can be done when treatment is underway. Everyone who accessed the patient's data can be identified during treatment. The access audit tool concentrates on creating an automatic access log. It is important to have access to a patient's medical record to see and control the condition of their records. For example, a smart card and a credit card serve a similar purpose. The card is magnetically encoded. It is considered data storage. User's data and medical records are included in this chip. The user has a smart card; it is up to the user to decide whether to share it.

Compared with all the various access control models, UCON is promising. The latest model of access control. A UCON-based system is more difficult to operate than the others. It costs more money and time to design and implement a system like this. An RBAC model is simpler to design than the UCON model. EHR system offers state-of security and provides considerable flexibility. Using the Role-Based Access Control (RBAC) approach was found to be appropriate because permissions are assigned to roles[22]. The people in the hospital are divided into two groups: patients and medical practitioners.

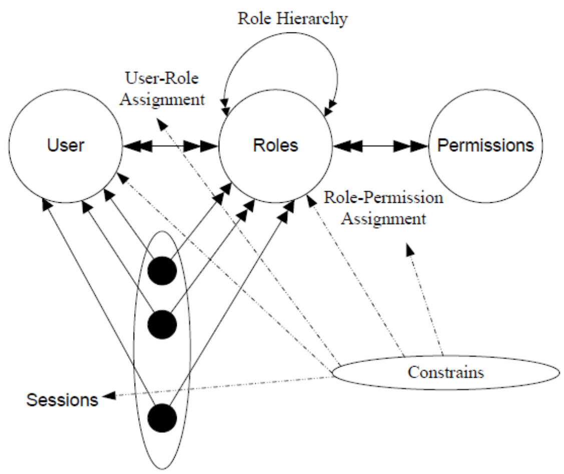


Figure 2.1: Role-Based Access Control Model [23]

2.4 RELATED WORK

This section describes the background related to e-Health portals and Related work of e-Health systems.

2.4.1 Portal

As enterprise and business growth, it is critical to have a single application that can aggregate applications and systems in one location to share resources. It offers all internet users a single access point to all applications. All of these goals can be accomplished through portals. Each browser window may contain one or multiple portlets, but a portal lets users view different applications or Web pages. It is an application's collection of resources that can be easily displayed in various predefined, personalized, and custom views. Ports are basic components that can be manipulated and presented in a portal. Portlets produce fragments, and then they are aggregated into a portal page. A portal page typically consists of a group of portlets, where each portlet is rendered in a separate window. Thus, a portlet looks a lot like a web-based application (such as a JSP, HTML page, or Java Page Flow) in a local or remote web server. The Portlet API specification enables portlets to interoperate among different portals. This API set defines a set of mechanisms for interacting with the portlets regarding personalization, presentation, and protection. Apache Pluto is compliant implementation of JSR 168. Other vendors (IBM, BEA, SUN), and others also provide standard portlet container implementations commercially.

Those are some of the characteristics and benefits of portal solution:

a. Business processes that are fully supported by different applications, services, and hardware or other resources are necessary for organizational success.

b. Portal technology enables the delivery and rendering of content on multiple devices (such as PC, PDAs, smartphones, etc.).

c. personalization: Capability to personalize the delivery of dynamic responses to the user.

d. Ease of content management: Portals may be quickly modified, content added, or deleted.

e. Single Sign-on: Portal is a place where a user can authenticate once and gain access to the resources of multiple backend systems.

f. Federation: This feature enables a portal to aggregate resources that are distributed elsewhere. It cuts down on maintenance, tests, as well as minimizes deployment, and promotes component re-interoperability.

2.4.2 SECURITY AND PRIVACY

security in the electronic health portal and electronic health records includes information safety, data confidentiality, anti-malware, availability of services, privacy protection, and access control. In the use of electronic health records, reliance is on the network and service layers, which facilitates the process of blocking, and denial of service (DoS), The security project in the web application of the e-health portal faces the most critical weaknesses as follows:

a. Insecure web interface like virtual accounts and SQL injection.

b. Insufficient authentication/authorization, such as no two-factor authentication and weak password.

c. Network services are not as secure as DoS attacks.

d. The cloud interface is not as secure as virtual accounts.

e. The computers used are not as secure as multiple accounts, not to close the account.

f. Insufficient security configuration such as lack of password security options and no security monitoring.

Specific patient data, clinical information, epidemiological status, and medical history should be considered for e-health application design Malfeasance Mean of the above represents a threat to the security and effectiveness of the electronic health portal. E-health applications will succeed in the more, the greater the degree to which privacy and security are given to the patients' data and information is protected. With electronic health portals, it is always necessary to have a certain level of security applied to all the data elements, so it is necessary to cover all data exposure points at all times in application; for this reason, data security and communication channels must always be covered with electronic health portals[24]. When communicating or adding a large number of users as well as patients, the security level of the system must be emphasized; although most electronic health care systems use some level of security, they remain vulnerable to security breaches and threats Such as stealing information, disabling services, and remote hacking, an additional problem is implementing complex security algorithms that require extensive communications and computational capabilities. Because the electronic health portal system collects personal and private information, the security problem represented by data protection and privacy arises during data collection and exchange. It is possible to transfer and exchange data on the electronic health portal that you face the risk of data leakage or tampering with it. Figure (2.2) reveals the relationship between electronic health and security problems.

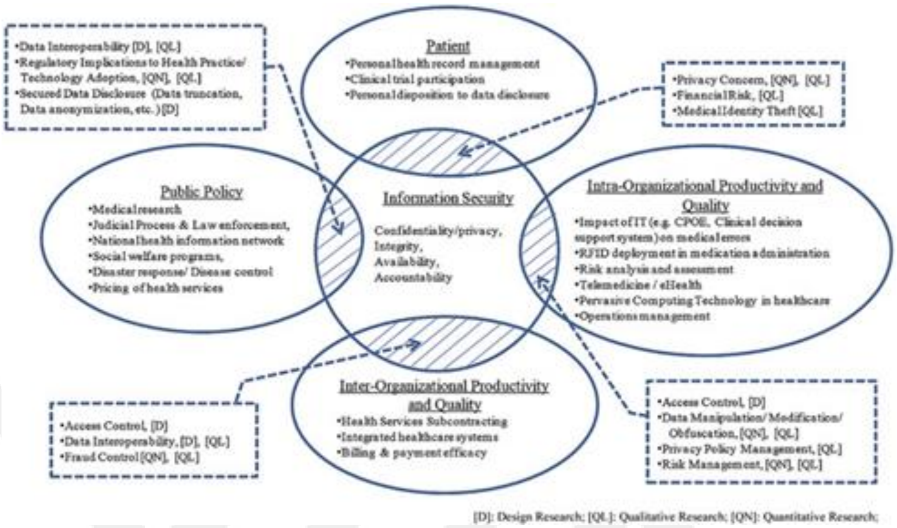


Figure 2.2: Reveals the relationship between electronic health and security problems[5]

To provide proper access to electronic healthcare systems, users must be authenticated. Some of the typical methods for confirming a user's identity: password, PIN (personal identification number), voice pattern, palm print, or fingerprint. With these methods, the message can be confidently assumed to be from the source[25]. For secure data transfers, there may also be a requirement to use protocols that use encrypted authentication and communication channels. Sharing sensitive medical data must also include privacy and confidentiality, and availability. To protect the patient's privacy and ensure that medical records cannot be changed or modified, the data transfer must have the integrity of the patient's data[26].

2.4.3 CLOUD COMPUTING TECHNOLOGIES

The use of cloud computing allows shared programs, information, and resources on client computers separated from the host. An information technology classification describes the use of computer systems for medical records. Cloud computing can provide practical value to healthcare services like e-health, thanks to its recent advancement. Cloud computing enables patients to cut costs while improving clinical outcomes, results, and other health-related services. Health Information Technology (HIT) classifies information and computer systems based on the electronic health record. Electronic health records systems allow healthcare governance such as hospitals, consulting clinics, and health care centers by entering, storing, processing, accessing, and managing patient data[27]. The data in the electronic health records includes the doctor's information, the health institution's information, and the patient's information as shown in the figure (2.3)

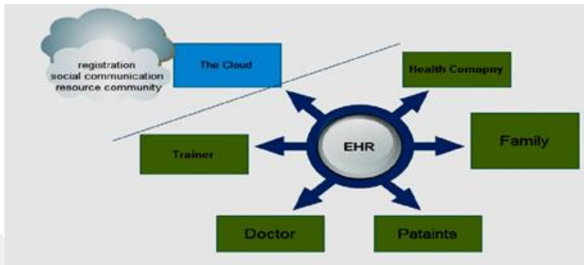


Figure 2.3: Schematic of EHRs[28]

All electronic health records components can be linked through a cloud-based application[29]. The cloud contains an infrastructure built in order for users to deploy and run applications[28]. Many health institutions install programs in their offices or through interconnection, sharing with potential power outages or software updates, human error, or hardware damage. When the system is within the cloud computing, the program can be upgraded without stopping the practice, which means it is continuously used. Cloud computing is divided into three layers: the characteristics, Models, and Deployment Layers[30]. The characteristic layer includes four stages (on-demand service, resource pooling & Rapid elasticity, broad network, measured services)[31]. At present, it aims to provide users with information relating to internal systems and promotes rapid development of cloud-based information access and application integration[32]. the model layer involves three models arranged as follows:

I. Infrastructure as a Service (IaaS): The supplier is responsible for operating and managing the used hardware, such as storage, servers, and network elements[29].

II. Platform as a Service (PaaS): it supports the use of virtual servers, as well as the ability to run any existing layer or to be developed, such as Google products and services[30].

III. Software as a Service (SaaS): It gives software permission to run on infrastructure and provides licensed services to end-users[33].

HEALTH CLOUD TECHNOLOGY (HCT)

Health information technology is increasing widely due to increased patient data, which needs more computing power. That leads to additional computing resources in order to continue efficiently in performance. This order eliminates the need for more devices to disrupt that could accompany the devices' installation and requirements[34].

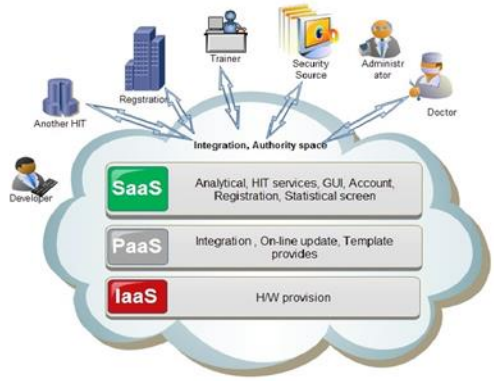


Figure 2.4: HCT architecture[28]

A healthy computing architecture has been established for the cloud-based service has been redesigned as a modular cloud platform. To HCT is made up of three layers, and the integration region contributes to:

a. having such abilities as registering with the cloud, being connected to another system, and being able to use cloud pages

b. Checking the electronic health record: such as verifying the transition to the cloud.

c. Integration between traditional EHR files with the Cloudy EHR for HCT.

2.5 TELEMEDICINE AND E-HEALTH SYSTEMS

Many researchers have turned their attention to e-Health services due to the high demand[35]. A number of different e-Health and healthcare-related systems have been created. Some of them are only found in special areas, such as trauma[36]. neurosurgery[37],cardiology[38], pathology treatment [39].etc. Several of are used for special tasks, such as for emergencies[40]. marine purpose[41], patient monitoring[42],aeronautic cure[43],etc. With the benefits of wireless technologies, m-Health systems are coming to the forefront[44]. The common feature of these systems is that they will only be used by e-Health providers, if at all. Our goal is to develop an e-Health system tailored to the specific needs of the location/area/context. also, we are concentrated on a general e-Health framework, which integrates most of the existing healthcare applications or modules. Various telemedicine and e-Health system architectures have been proposed. In this section, we summarize.

HISA (Healthcare Information System Architecture) [45] deals with the medical information system's architecture. Even though this e-Health architecture has no direct link to the healthcare industry, we still benefit from it. It is built on three-layer architecture and employs middleware (CORBA and DCOM) to create diffused healthcare information systems that exchange information consistently. Later, SAMTA [23] created an open platform for multimedia telemedicine applications, which lets designers utilize the network bandwidth effectively. According to differing levels of complexity, the service provider groups all services into medical, technical, physical, and administrative classes. To hide the technical specifications of medical services, this service separation is required. These levels of services are directly provided to the user. A service corresponds to one or more real-world operations. A direct relationship between technical services and the medical field pays attention to network transmission, specific service, compressing, and person-to-person interaction. This includes structures, protocols, and services of the technical services. They are close to the physical system and serve as an interface between the application and the physical worlds (such as hardware and software platforms). Some of the authors [23] propose a Telemedic Interoperability architecture, which includes two levels of interoperability. The first level of a telemedicine system is focused on the composition of stations and delivery of functionality. These specifications refer to three separate layers: the station to device, the station to station, and the station itself. The second level describes how stations inside a system discover each other and then begin transactions. This level aims to facilitate independent systems locating (discovering), negotiating (quality of service parameters). These features support various interoperability levels. [46] introduced a distributed frame of Web-based telemedicine system which discusses two types of servers, i.e., Web servers and data servers. This framework is based on the CORBA technique.[47] introduced an SOA-based health service architecture presented an idea. There are six components to isolate inter-domain interactions in this software architecture. In this architecture, consumers include the healthcare enterprise and the healthcare providers (hospitals, doctors, or other e-Health organizations). A support function helps customers find, deploy, and call for health services and infrastructures. If the high availability, reliability, Fidelity, and QoS are enabled in the control layer, the system becomes an excellent product. This layer aims to employ fault tolerance, load balancing, load distribution, and service replication. The infrastructure layer contains health care facilities. The system provides authentication, authorization, and various other functionalities. Also, the management system attempts to restrict the flow of data from one layer to another. Moreover, [48] introduced the comprehensive access control requirements of the Health Information System (HIS). However, it is based on the small part based HIS. Several other research works have been conducted with views to the access control requirements for the healthcare system[49]. The largest of them focus on the access control of a special subsystem, especially (EPR) system.

2.6 EHR IN IRAQ

Many people in Iraq die each year because of avoidable medical errors; this is considered a severe problem by the World Health Organization (WHO). Multiple errors can be avoided; there is an estimated total cost to the health service and medical facilities of many human life mistakes within the healthcare systems that can also hurt patients' faith. One of the WHO's major findings is that medical errors frequently originate from faulty systems, occur due to broken processes or inefficiencies, and go unnoticed. IT is increasingly permeating healthcare. However, as evidenced by this information, Iraq's medical sector has dismissed electronic health records' value (EHRs). One likely cause for this is that the key users, such as physicians and nurses, have not used the technology to its full potential yet[50]. Due to poor working equipment, insufficient drug supplies, and fragile infrastructure, Iraq's health system is under-developed. Widespread damage to and debauchery to health The health care program's cost has exceeded the limits imposed on it by the treasury, thanks to corruption and inefficiency[50].

2.6.1 Ehr Barriers in Iraq

The financial challenges associated with implementing an EHR estimates the total implementation cost to be over $77,000 per bed in Iraq. Due to the huge budgetary issues, the EHR project presented an insurmountable obstacle for the Iraqi Ministry of Health (MOH). of the hospitals' facilities that were implemented (most public hospitals and medical centers were unable to implement facilities like infrastructure, software, and information technology that was required). Harder and more frequent technical issues, in most hospitals in Iraq, little to no infrastructure-structural support is provided, and many do not even have an IT department. This further exacerbates the problem. It is hard to support and maintain databases due to the huge volumes of data, and, or with the software, there are still a lot of issues unresolved issues (e.g., power failures, systems crashing, data being lost). In most countries, healthcare systems, patient privacy is of the utmost importance. However, on the other hand, privacy regulations or policies in Iraq are absent. Additionally, there are different types of threats and attacks on cyberspace privacy, such as hackers and viruses.

In our thesis, we propose an electronic health portal, and we hope that it will be part of a future electronic project to implement e-health in Iraq.

3. USER REQUIREMENT AND ANALYSIS

Many hospitals in the middle east still use the classical way of storing data. The Ramadi Hospital in Anbar province in Iraq is a good example. The Iraqi Ministry of Health administers the hospital. In this hospital, there is no electronic storage of medical information. The traditional paper record is still in use. Doctors handwrite patient records. These paper records are intended for patients only. There are serious flaws in this system. Patients do not have records stored in electronic form, making the patient unable to know his health record. Every time patients want to see a doctor, they are required to bring their paper medical records. However, hospitals do not keep a lot of paper medical records. Since a patient's medical records are written on paper, only paper records can be shown to the new doctor when he needs to change hospital. Such sharing of information is very slow, and handwriting can lead to misunderstanding. This can lead to very dire consequences. In the following sections, the main needs of patients, doctors and database administration are briefly presented.

3.1 PATIENT’S REQUIREMENTS

Patients need an electronic health record (EHR) system that enables them to view their medical information. Patients should use their own medical records in various hospitals. Patients are always free to view their records whenever they want. An effective electronic health record system should be a person- or patient-centric. Patients should be able to find the medical record at any time. It is important that the patient also contact the doctor by correspondence and email. Moreover, the patient must be allowed to find his prescription and ask the doctor for a response.

3.2 DOCTOR’S REQUIREMENTS

Doctors want a system that enables them to access records from information systems when their patients authorize them. So they do not have to display a handwritten log. This can significantly reduce medical accidents caused by mistake. Doctors hope that not only will they read a patient's medical record, but they can also generate new medical records and change old medical records. During the pandemic time, doctors find it is urgent to share medical reports about the Coronavirus and other epidemic cases.

3.3 ADMINISTRATOR'S REQUIREMENTS

The director of the electronic health portal can add doctors and view the reports sent from them. Administrators want an efficient method to fix errors and delete unimportant records. They also prefer an easy way to manage the who database. Moreover, in the health organization, the official bodies need fast access to evaluate the medical services.

3.4 SECURITY REQUIREMENTS

To avoid damage in the registration process, all users may only register one account. In order to register for an account, they had to provide their ID number. With the assistance of the registry, medical professionals can determine their own passwords. For patients, a password is created specifically for them by the system administrator. Only the person who knows the password is allowed to log into the account.

4. DESIGN AND IMPLEMENTATION OF EHP

This chapter includes the design and implementation of an electronic health portal to deal with patients and monitor Coronavirus cases through reports that are exchanged among doctors and officials. It also allows the patient to access his electronic health record and communicate with the private doctor, know his prescriptions and responses from the doctor, and determine the dates of electronic reservation. This portal was built using several descriptive languages, programming languages, and a database such as PHP, MySQL, HTML, CSS, with Bootstrap framework to make this portal suitable through mobile phones tablets.

Collecting the patient's electronic health record through an electronic copy of a comprehensive report on the patient's general health provides all information instantly and safely to authorized users and the electronic medical record through a digital report. That includes all the patient's medical history and personal health record through a health report. The patient keeps his data related to his health in a private, secure and confidential environment.

Many of the previous works were concerned with one or two sides. However, the work is integrating through direct communication with the patient and his follow-up by the specialist doctor in this system. This system also provides electronic appointment reservation with high speed and rapid response to the patient and keeping an exceptional electronic record of what the patient suffers from, especially acute diseases, where the doctor can deal with them with caution.

The system also includes:

I. communicating with the doctor by the administration,

II. identifying emergency cases and outbreaks of serious diseases such as Coronavirus and HIV

III. sending reports on urgent cases.

The patient can easily create his electronic health record by communicating with the system administrator and providing full information. Moreover, for ease of use, the system administrator gives usernames depending on phone number, and the password consists of only four numbers, which facilitates the memorization process.

4.1 SELECTION OF SOLUTIONS

As stated before, a variety of standard and rule-based models are used and developed. In this work, the EHR implementation is based on standards and access models.

4.1.1 Interoperability

Two popular methods for creating interoperability are being used at the moment. The first step is to take the standard ones. OpenEHR and HL7 are the most commonly used standards. They serve the same function. They are striving to make global standards for storing and transforming medical records. The HL7 has been in continuous development. Standards have been regularly upgraded due to extensive research done in hospitals. Also referred to as public health policies, the regulations cover these medical agencies' policies. It makes the standards highly complicated. It is challenging to implement an HL7 EHR system completely. Most policies hinder it from programming. Thus, most EHR systems do not fully implement HL7's guidelines. In the same way, the problem appears in openEHR. The standards are too complicated and comprise many policies, which has made implementing an EHR system difficult. At best, various nations and companies have given lukewarm or negligible attention to electronic health records (EHR). Over the past several years, development has remained at a slow pace. All kinds of standards compete, which makes information sharing among standards difficult. The second class of functions consists of semantically-oriented software tools. The development and application of semantic tools are linked to the Semantic Web. Information sharing is accessible through semantic techniques, allowing diverse healthcare institutions to produce their EHR applications while not passing information on to each other. Semantic tools are quantifiable. When the number of heterogeneous systems that must interconnect is low, semantic mapping is simple. However, if the number is high, the semantic mapping will be complicated. However, at the same time, it will make the prediction less accurate. If the semantic mapping is not accurate, it will have serious consequences. Semantic mapping must be ensured at a high level of accuracy. Therefore, such precise and thorough semantic mapping is difficult to implement. These two information-sharing solutions both use a client/server model. User information must be transferred from system to system on both sides of the communication. This effect mentioned before. In this study, we will put the browser/server solution to the test. Within the B/S (Browser/Server) architecture, users may directly use the database. No user information transfer is required. This will also ensure the data integrity in the database.

4.1.2 ACCESS CONTROL

Many access control models have been examined in previous studies. The models differ in terms access control strategies. The UCON is considered to be the most flexible one. There are two access layers: a general authorization layer and an individual authentication layer. However, it is not usually necessary in the healthcare system. If a doctor needs a patient's record, he does not need to issue an individual authorization request. The patient should allow the doctor to have access to the record. We decide to go with the RBAC model. The RBAC model is well-suited for healthcare facility management. It is possible to implement an RBAC in a hospital information system. As a rule, hospitals and their patients are the main users of technology. In the RBAC model, the roles of doctor and patient can be divided into two groups. The user has to select roles (doctors or patients). Authorities will be given to the recipients based on their role in the registration. According to programming of the RBAC model, it is simple to design. This arrangement of authority is appropriate for people to comprehend.

4.2 SYSTEM DESIGN

The user appears in front of three logging options as shown in figure (4.1): administrator, doctor, and patient. The interface contains the electronic health portal's name and some details about the institution (such as the name of the institution, private phone numbers, and the location).

Access to any of these sections is through a username and password that the portal administrator creates.

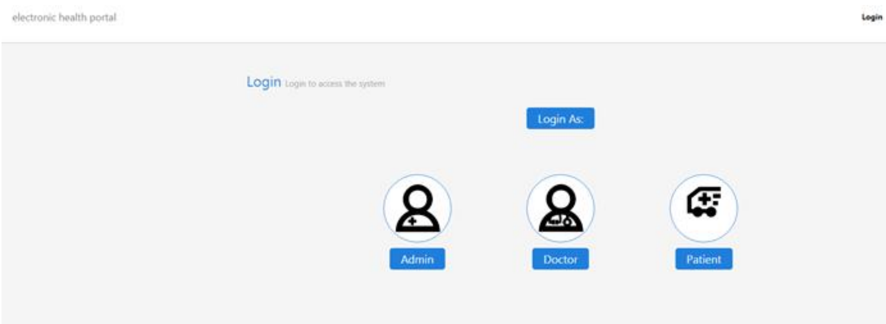


Figure 4.1: First page of ehp

4.2.1 Foreground

In this section, the patient and the doctor can access the electronic health portal by registering with the user name and password. Each user, doctor, or system administrator enters the section designated for him/her, as shown in Figure (4.2)

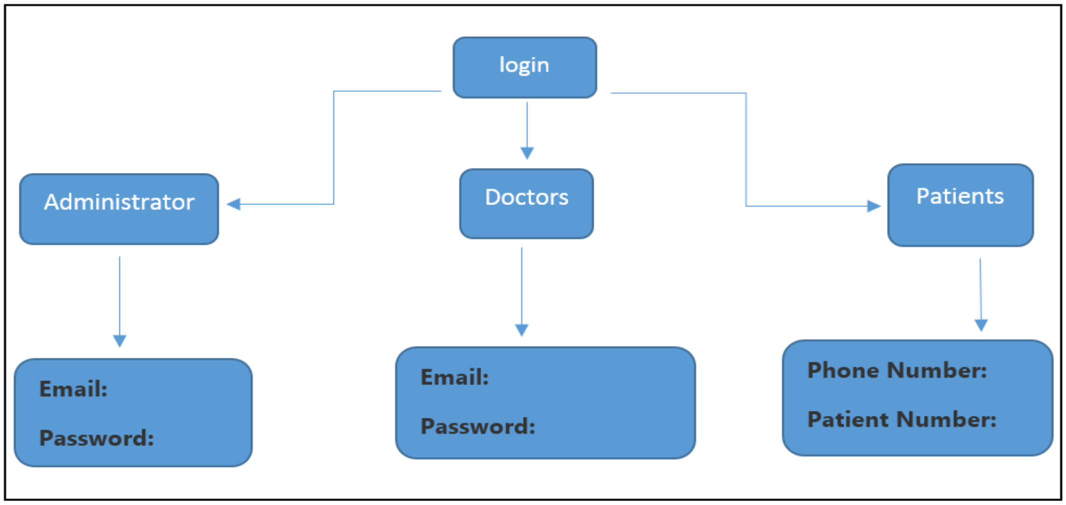


Figure 4.2: Foreground Structure

4.2.2 Access Control

I. **Patients**: The login to patient interface by a username (the mobile number is used for ease of use instead of the email because some patients may have no email). The password is given to the patient by the health institution. As is evident, the password is the essential thing that preserves the electronic health portal's security. In this portal, an equation was adopted by the PHP language to maintain confidentiality

```
$patientNumber = substr(preg_replace("#[^09]#", "", md5(uniqid().time())), 0, 4);
```

In figure (4.2), the process of creating a password is illustrated using the above programming function.

The main parts of the code, presented in figure (4.2), are defined as follow:

a. $patientNumber = A variable representing the patient's number, which is the password in the portal.

b. The substr() function returns part of a string.

c. The preg_replace() function returns a string or array of strings where all matches of a pattern or list of patterns found in the input are replaced with substrings.

d. The md5() function counts the MD5 hash of a string. md5() function uses the RSA Data Security, Inc. MD5 Message-Digest Algorithm.

e. The uniqid() function achieves a unique ID based on the micro time (the current time in microseconds). The generated ID from this function does not guarantee the uniqueness of the return value. To generate an extremely difficult to predict ID, the md5() function is used.

The time() function comes back to the current time in the number of seconds in the Unix Epoch.

This means that the first function substr() will take a part of the string starting from the value 0 by four elements. This is done by replacing the values with the preg_replace () function from the uniqid () + Time () functions, which will be entered into the md5 () function. So that the last function will be a combination of unique ID based on both the micro time and current time in the number of seconds since the Unix Epoch is adopted. Then, md5 () uses the RSA Data Security for the values contained within it.

The following simple symbols "# [^ 0-9] #" refers to purifying the resulting series of functions from any symbol or letter and keeping the numbers only so that only the first four digits are taken, thus the patient's password.

When registering, the patient cannot see the records of other patients, and medical records cannot be deleted, added or modified, because they are provided by doctors only.

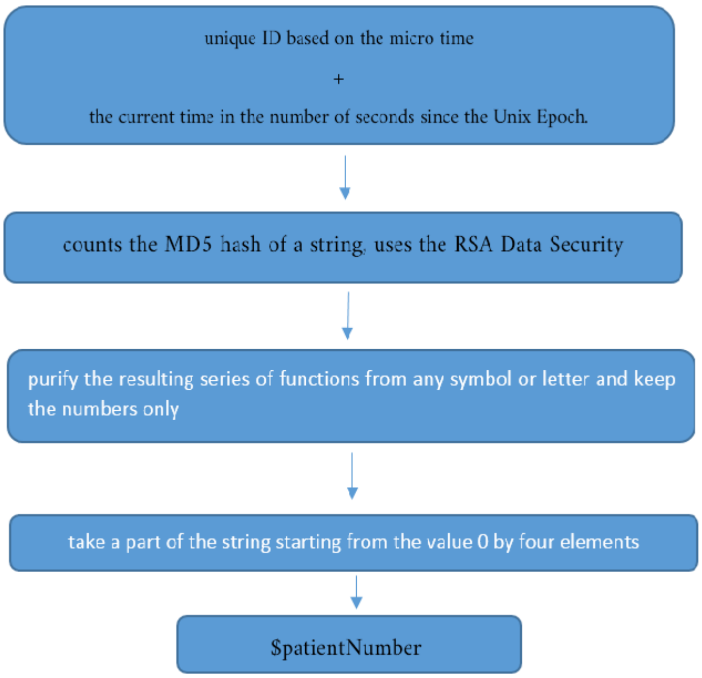


Figure 4.3: Password creation scheme

II. **Doctors**: Logging in for doctors to the electronic health portal is through an email and password. This is done through a prior addition by the system administrator. The doctor's password is "hospital", then the doctor can change it from the doctor's department special settings. The doctor can access the patients' electronic health records by knowing the patient's number and approve electronic reservations, add patients to the portal, and add their information and prescriptions in addition to responding to patients' questions.

III. **Administrator**: The administrator is responsible for the electronic health portal, he/she works on adding doctors to the portal and following up on updating records, and sending reports on epidemics and online patient reservations.

4.3 SELECTION OF TOOLS AND MODELS

In this part, we introduce the tools used in designing the electronic health portal, the system architecture, programming languages, database, compile software, and RBAC model.

4.3.1 B/S Architecture

B/S refers to the Browser/Server architecture, or WEB application. It is a 3-tier architecture, and it is distinct from C/S (Client/Server 2-tier). In this architecture, the WWW browser identify the user interface and some works done by the browser. The server does the main section of the work. With this point, users can visit texts, images, and video information through the WWW browser. Classes of Web servers generate that information. Web servers are connected to the database servers. It sends an application to database servers to get the information stored in another database. The databases are created in the database servers, so actually, the information is stored in database servers. Compared with C/S, B/S architecture WWW browsers take the section of different client applications using in C/S. Users need a WWW browser generally. They do not need other user applications. Users can download applications from Web servers to local computers. Applications can be used to operate databases stored in database servers.

Benefits of B/S:

a. The public attributes, query, browse, and other settings can be done anytime and anywhere.

b. It is easy to develop server functions by adding web pages.

c. it is easy to prepare. Users updates can be done by modifying web pages.

d. It is easy to improve.

e. Easy to share.

4.3.2 Rbac

Role-based access control. It is based on the authorities that are mentioned in the literature review. The use of RBAC was made to realize the system's access control solution.

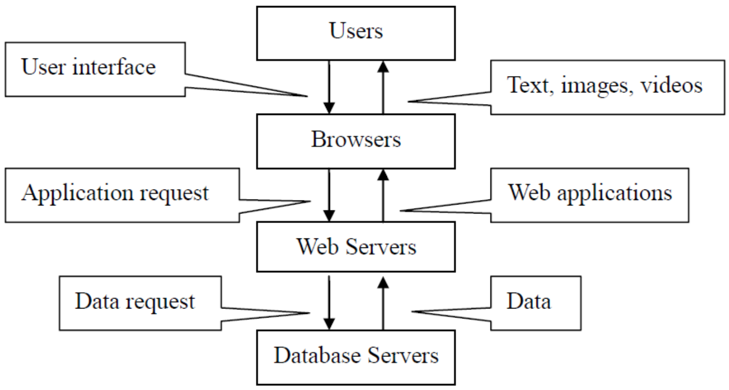


Figure 4.4: B/S Architecture [10]

4.3.3 Sql

It stands for "Structured Query Language". Its main function is to generate a connection to various databases. It is considered as a standard language for relational database management systems by ANSI (American National Standards Institute). SQL is used to find, delete, and update data.

4.3.4 Php

A widely-used scripting language. It is suitable for website development and can be applied to almost any purpose. It is swift and flexible. It Supports the most popular websites. Stand-alone programs can be created with it as well.

4.3.5 Html

A short for (HyperText Markup Language). It is regarded as the standard markup language for creating websites. It usually operates with other languages to present content in final forms, such as CSS and JavaScript.

4.3.6 Css

Short for (Cascading Style Sheets). Explains how to show HTML elements on the screen. Using CSS, one can design many pages at once. With it, we combine colors and effects to HTML factors.

4.3.7 Javascript

A high-level programming language essentially used in web browsers and has other wide uses in other domains. It essentially adds high interactivity to the web page. JavaScript was developed mainly for amateur programmers. It was used and developed by many expert programmers, and later released in more powerful versions. JavaScript files are generated naturally, and the .js suffix is added to the file to recognize it as a JavaScript file. It is used in web programming very generally, and it is one of the basics and rules of any web programmer. You will never find any actual web programmer who cannot handle the JavaScript language. JavaScript is directly included in designing and programming the web alike. It has its design characteristics as its programming features in equal measure, particularly with the development of modern JavaScript libraries such as Vue.js, Angular, and of course, jQuery.

4.3.8 Bootstrap

It is the most important and great library that manages HTML, CSS, and JS to create pages, sites, and web applications. It is essentially useful in creating sites consistent with multiple screen sizes, involving cell phone and tablet screens. It is a free and open-source library available to everyone on the Github site and was created by Twitter Inc. Bootstrap library has expanded very since its launch in 2011 for free, and programmers around the world chose it, and this was not by luck, but behind the success of this library several important characteristics, including:

a. High flexibility and ease of use.

b. Design fit with all devices.

c. Fit with all browsers.

d. Appears a stable and reusable design.

e. It can be learned easily and quickly.

f. High scalability with JavaScript.

g. It involves pre-installed support for JQuery.

h. JavaScript API assistance.

i. It can be done in any editor or programming environment.

j. It is fitted with any technology or language within the server, such as ASP.NET

4.4 SYSTEM FUNCTIONS

In this portal, the jobs are divided into three sections: Patients, Doctors, and Portal Administrator.

4.4.1 Patient's Functions

When the patient logs into the electronic health portal through the phone number and password previously set by the system administrator, five options for the patient will appear as shown in the figure (4.5). The first option is the personal data, which represents the patient's electronic medical record, which contains the historical records and medical prescriptions of the doctor who examined him and personal information such as name, age, and location. The second option is to book an online appointment by sending a message to the doctor that the patient wants to visit. The patient can choose the specialist doctor from a drop-down list that contains doctors. The third option is the electronic reservation sent to ensure that the reservations are sent. The fourth option is the doctor's responses to let him know the date of the reservation, the new prescription, or any matter he wrote to the doctor about. The fifth option is to log out of the portal. Figure (4.5) shows the patient block diagrams.

In Table (4.1) for creating a patient record, there are user information items. Items in the data type are "String". The user in the electronic health portal needs to fill in the information when registering for the portal. Such as name, gender, date of birth, phone number, and location to prevent unauthorized access to the portal. This helps the doctor to know more about the patient.

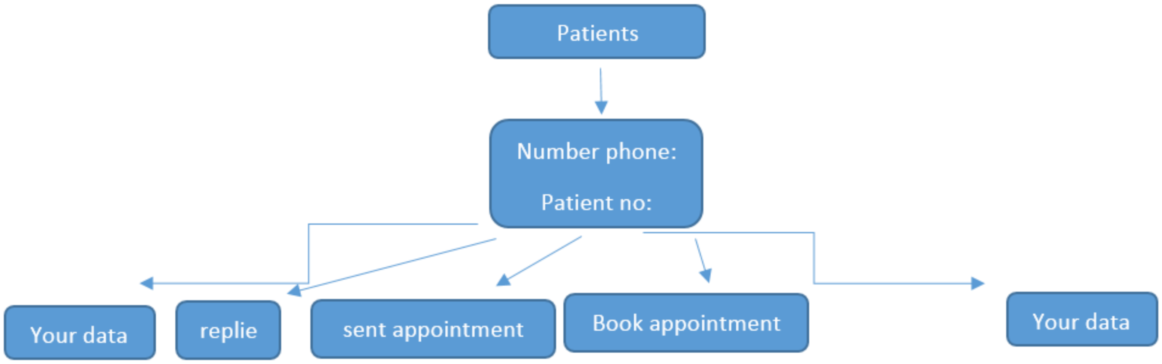


Figure 4.5: patient block diagrams

Table 4.1: User Information Data Type

Full Name	Data type (string)	Gender	Data type (string)
phone	Data type (string)	location	Data type (string)
Date of Birth	Data type (string)	Diagnosis/ Symptoms	Data type (string)
Prescription	Data type (string)	Condition	Data type (string)

4.4.2 Doctor's Functions

The doctor function includes a dashboard, profile, appointment booking, adding or searching for a patient, patient reservation responses, and adding an outbreak situation such as Coronavirus and HIV reports. The doctor can change his password by modifying the personal information in the control panel. The default password is "hospital".

Dashboard
Profile
Patients book
Add patient
Appointment
Add outbreak
Likely outbreak
Hiv
Hiv report

Figure 4.6: Doctor's Block Diagram

4.4.3 Administrator Function

This section, responsible for the electronic health portal, has the advantage of specializing in the database, adding the doctor to the system and delete, following up on epidemiological cases, disease outbreaks, numbers of patients, reservations for doctors, and other features.

Dashboard
Profile
Patients book
Add doctors
Doctor's records
Appointment
Add outbreak
Likely outbreak
Hiv
Hiv report

Figure 4.7: admin's Block Diagram

4.5 IMPLEMENTATION

4.5.1 Login Page

To log into the electronic health portal, users need to enter a username along with a password as in show figure (4.8). There are three options to log in on for the responsible person, one for the physician, and one for the patient. As we mentioned earlier, the patient's username and password is a phone number, and the password is made up of four numbers.

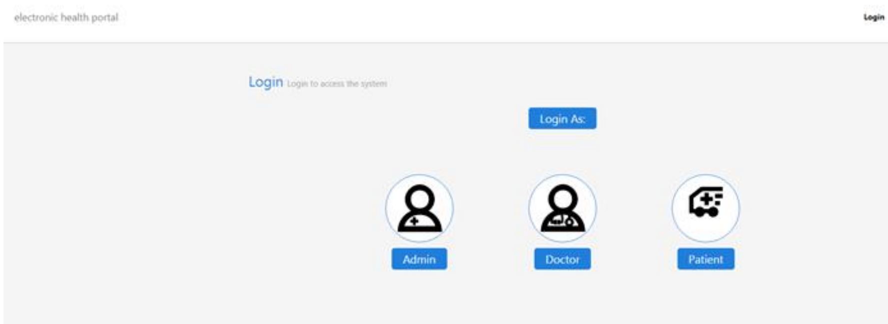


Figure 4.8: main interface of the portal

4.5.2 Patient Part

The patient's part contains:

a. **Personal Data**: name, location, age, date of birth, date of detection of the doctor, diagnosis, prescriptions, specialist doctor, and a particular field for printing or downloading.

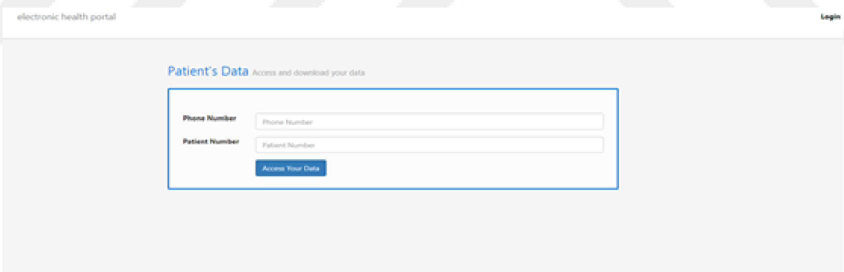


Figure 4.9: Patient login interface

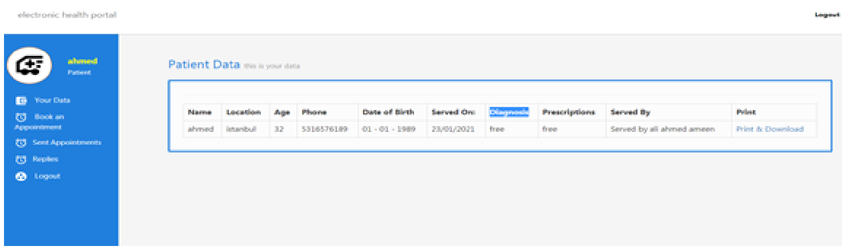


Figure 4.10: Personal data and electronic health record

b. **Book an Appointment**: It contains a particular field to send a message to the doctor to book an appointment to clarify the health status. Moreover, choose the right doctor.

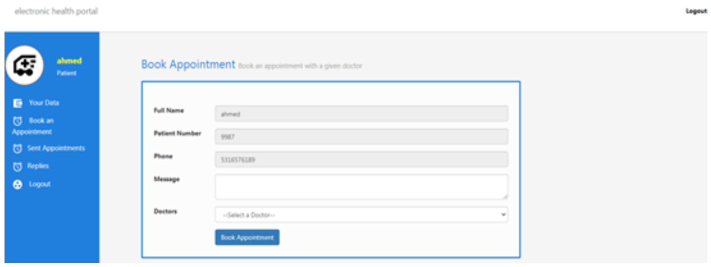


Figure 4.11: Book an appointment

c. **Sent Appointment**: Includes pre-booking appointments and shows full details.

d. **Replies**: It includes responses from the specialist doctor, scheduling the date of reservation, or providing medical advice.

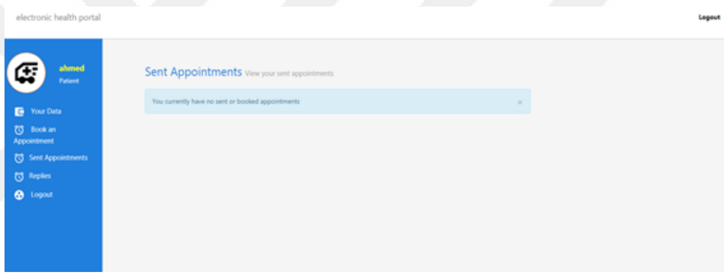


Figure 4.12: Sent appointment

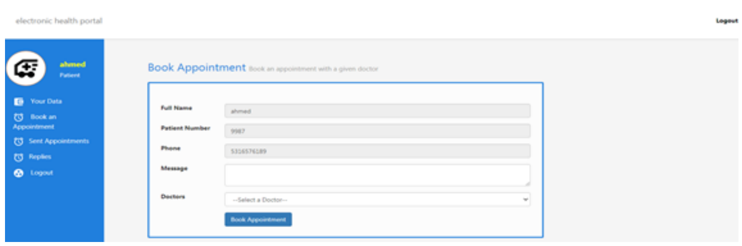


Figure 4.13: Replies

4.5.3 Doctor Part

When the doctor is logged in using the username and password, the doctor can later change the password through his control panel.

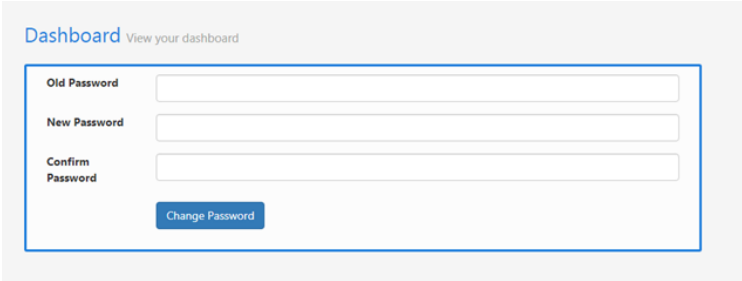


Figure 4.14: Change the password for the doctor

The doctor part includes a dashboard, profile, appointment booking, adding or searching for a patient, responses to a patient reservation, and adding an outbreak situation such as Coronavirus and HIV report. It is important to note that an essential feature has been added to this portal. When the doctor obtains information through electronic diagnosis on a possible cause of an epidemic such as Coronavirus or the new strain, the doctor sends a report to the whole institution to deal with this patient and the geographical location.

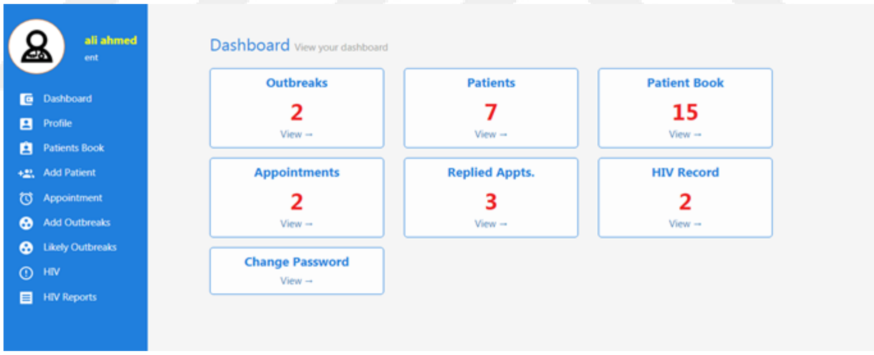


Figure 4.15: Doctor main interface

It is important to note that an essential feature has been added to this portal. When the doctor obtains information through electronic diagnosis on a possible cause of an epidemic such as Coronavirus or the new strain, the doctor sends a report to the whole institution to deal with this patient and the geographical location. As shown in the figure (4.15)

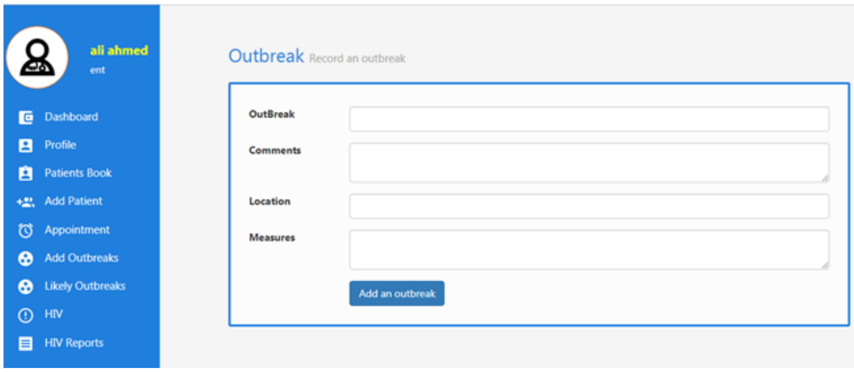


Figure 4.16: Report an outbreak

4.6 TEST AND EVALUATION

In this part, many tests are performed to evaluate this system and show how the system meets users' requirements.

4.6.1 Add Patient

In figure (4.16), if the doctor wants to add a new patient, he/she must enter all the required information in the electronic health portal. Then a number will be generated for the patient, as we mentioned earlier, which represents the patient's password when logging in and the private number when searching.

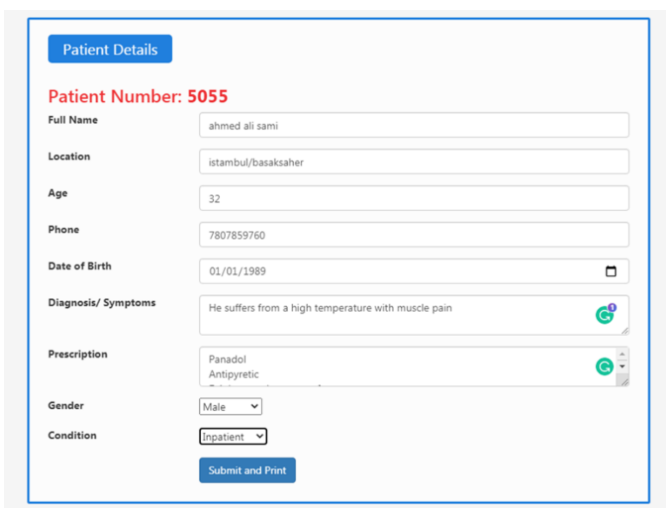


Figure 4.17: Add patient

4.6.2 Patients Booking

In figure (4.17), patient booking and health records are shown in the doctor's window. Through it, the doctor can view the patient's health record without modification.

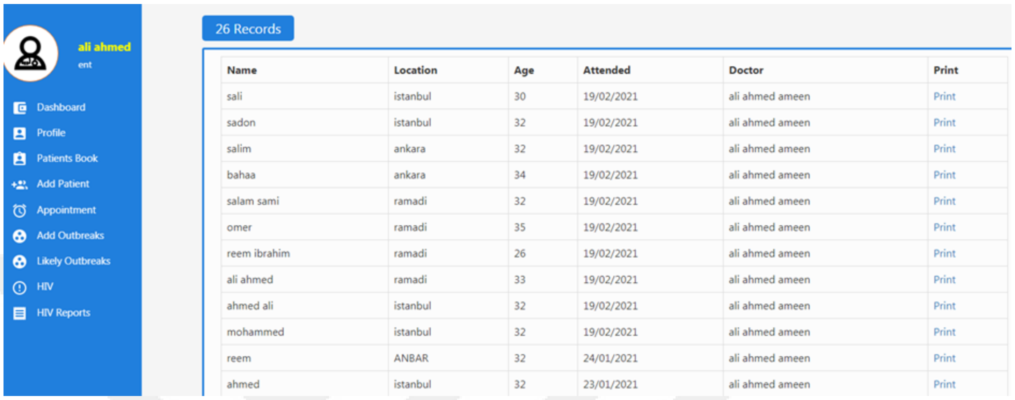


Figure 4.18: patients booking

4.6.3 Add Outbreak

An important addition to our work is this option. The doctor can add a report on a specific patient's epidemiological situation or a new virus outbreak. This report informs the official responsible for the electronic health portal and all the doctors inside the portal about the new situation, see figure (4.18)

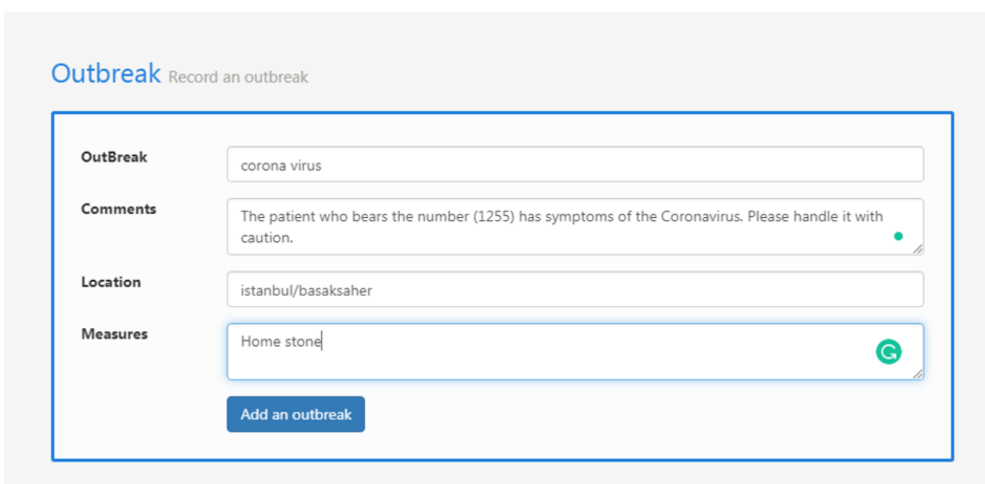


Figure 4.19: Add outbreak

4.6.4 Replies of Doctor

Figure (4.19) shows the responses and correspondence between the doctor and the patients. To take an appointment for review and examination or prescribe medication.

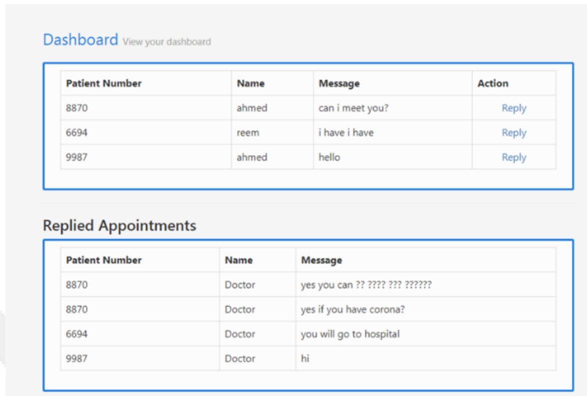


Figure 4.20: Replies of doctor

4.6.5 Change Password of Doctor

In the figure (4.20), the doctor can change his password. The default password from the administrator is "hospital".

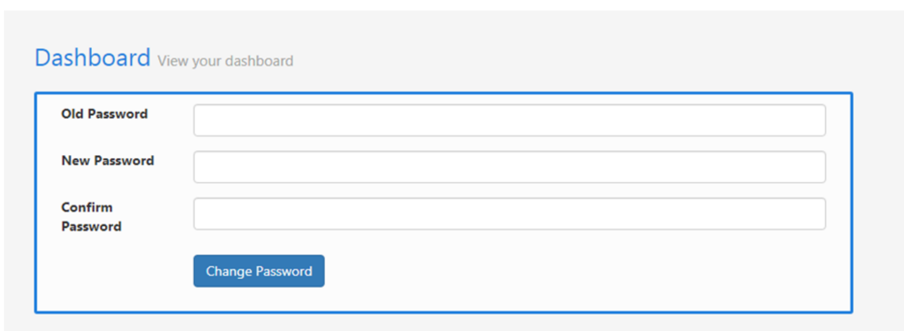


Figure 4.21: Change password of doctor

4.6.6 Book an Appointment

In the figure (4.21), the patient can communicate and book an appointment with the doctor electronically. The patient can choose the appropriate doctor within the doctor's option.

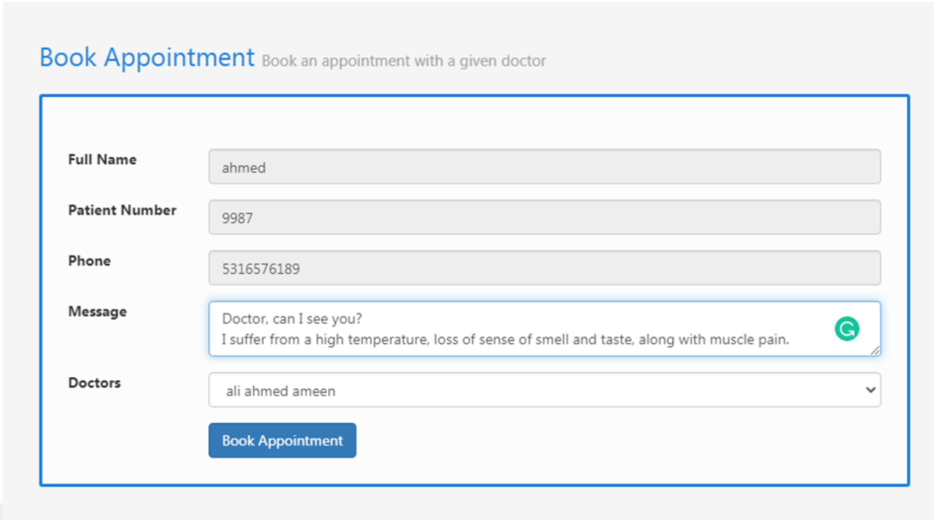


Figure 4.22: Book an Appointment

4.6.7 Fake Login

In figure (4.22), it is clear if someone tried to log in from an authorization enter with no valid password and username. The system will show him/her the following message: "Details you entered could not match any of our records".

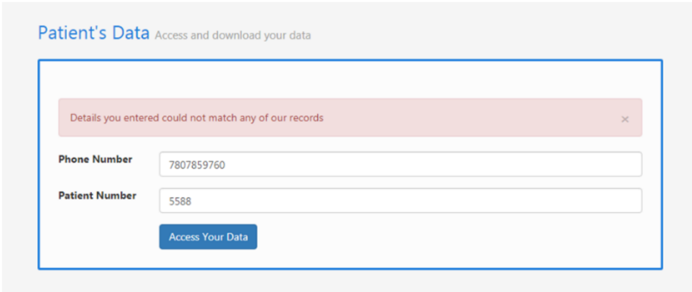


Figure 4.23: Fake login

4.6.8 Add Doctors

In Figure (4.23), only the web portal administrator can add Doctors. It can also delete doctors or modify files, as in Figure (4.24)

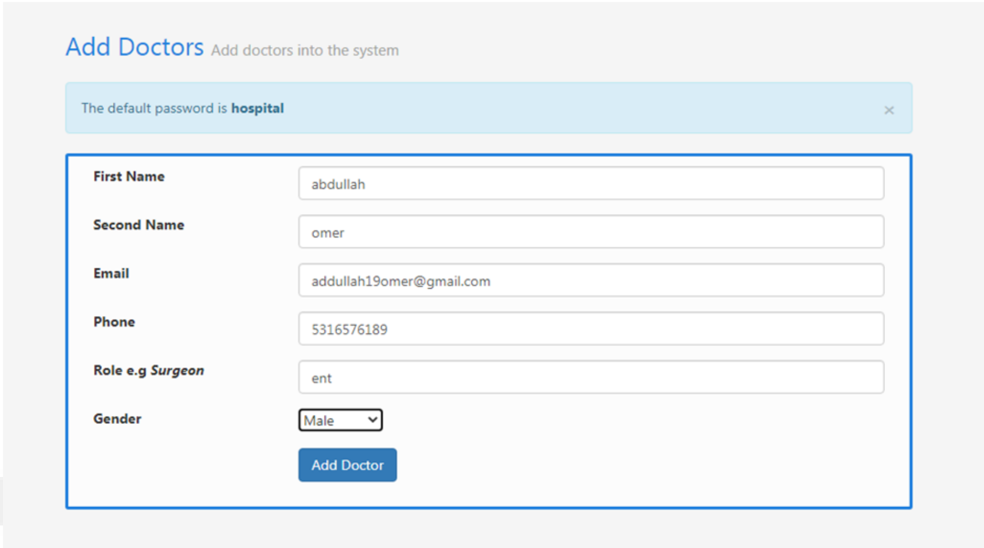
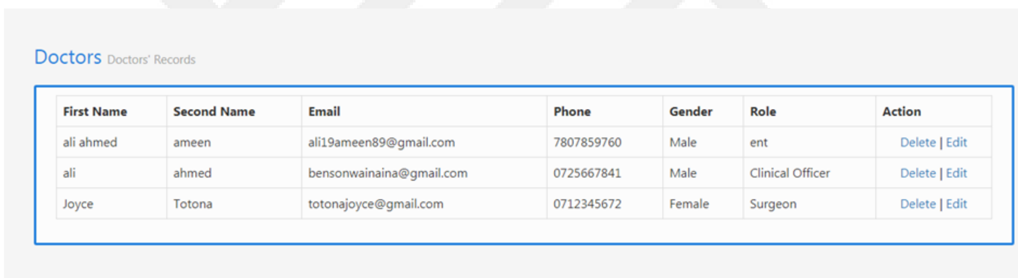


Figure 4.24: Add doctors


Doctors Doctors' Records

First Name	Second Name	Email	Phone	Gender	Role	Action
ali ahmed	ameen	ali19ameen89@gmail.com	7807859760	Male	ent	Delete | Edit
ali	ahmed	bensonwainaina@gmail.com	0725667841	Male	Clinical Officer	Delete | Edit
Joyce	Totona	totonajoyce@gmail.com	0712345672	Female	Surgeon	Delete | Edit

Figure 4.25: Doctors' Records

4.6.9 Black Box Test

The black box test is also called the function test. It is mainly used to test system functionality. The black box test can find the wrong function, input error, initialization error, and end error. The whole black box test should take into account all input and output situations. Thus countless situations must be tested in the real test. The black box test is hard to finish. So we ran some targeted tests. These tests focus on the main function of this system.

a. **Function Test**

The basic electronic health portal functions are selected as in Table (4.2)

Table 4.2: Function Test Result

No.	Function	Expected outcome	Result
1	Add patient	User can login the system.	Pass
2	Add doctor	User can login the system.	Pass
3	password Change of doctor	A successful notice popup.	Pass
4	Replies	Doctor can see it	Pass
5	Book an appointment	A successful notice popup.	Pass
6	Add outbreak	A successful notice popup.	Pass
7	Edit& delete	admin can delete or modify the doctor's file	Pass
8	create random password for patient	Generate a random patient pass-word	pass

b. Submit Data Without Meeting All Field Tests

In this section, we examine not to fill in text areas. There should be a warning popup if the user has not filled all areas of the text to be filled.

Table 4.3: Non-fulfilled Test Result

No	Text field	Expected change	Results
1	Password change	A reminder should popup.	pass
2	Add user	A reminder should popup.	pass
3	Login	A reminder should popup.	Pass
4	Patient details	A reminder should popup.	Pass
5	Add outbreak	A reminder should popup.	pass
6	Book an appointment	A reminder should popup.	pass

5. RESULTS

In the electronic health portal, the implementation of information sharing is integrated with the access control function. Patients can define the accessibility function using the RBAC model. The doctor cannot modify or delete the patient's file without permission from the patient or the system administrator. It also cannot share patient files to maintain privacy. Therefore, the amendment to the patient data cannot be accessed and modified by the doctor except with the electronic health portal person. Therefore, the patient chooses the doctor who wants to communicate with him/her and add data and prescriptions. In this case, the doctor can view the patient's data and share his data. The patient can communicate with the doctor and receive responses. He can also view and print his health record and prescriptions. Its stock remains in its file. Also, in this electronic health portal, a private password for the patient was created, based on programmatic functions, to maintain the patient's data privacy and security. Using the unique programming functions to create a password based on the RSA algorithm, it becomes clear that the patient's password will be strong and not similar to other passwords, which gives him data privacy and high security. Table (5.1) below shows a group of patients and their passwords taken while entering the system.

Table 5.1: passwords of patents

Name	date of appointment	Password
Omer	19/2/2021	2861
reem Ibrahim	19/2/2021	1727
ali ahmed	19/2/2021	3450
ahmed ali	19/2/2021	8074
Mohammed	19/2/2021	0827

We can make the password more than four digits by switching the number of elements that we want to change in the programming functions as in Table (5.2)

Table 5.2: Passwords of patents with 5 digits

Name	date of appointment	Password
Sali	19/2/2021	19988
Sadon	19/2/2021	76405
Salim	19/2/2021	24678
Bahaa	19/2/2021	82596
salam sami	19/2/2021	28531

In figure (5.1), the process of registering a patient and giving him/her a unique number, which is the password, as shown in the programming functions mentioned above.

Figure 5.1: Registering a patient

6. CONCLUSION AND FUTURE WORK

Many electronic health systems fail to meet the requirements to keep the patient’s health record electronically, and the patient accesses his health record at any time. Moreover, communicate with the doctor remotely, especially in health institutions that do not have electronic systems to deal with the health record, making the loss of health data a possibility. In this work, an electronic health portal was developed to integrate various medical services and applications. It keeps the patient’s privacy and facilitates the patient’s communication with the doctor, especially at a time of epidemics. A medical consultation service is also available on this portal, and the doctor sends reports on Coronavirus. In future work, we will work to make the electronic health portal work as an application on mobile phones and websites. Additionally, attaching files and adding more multimedia data to patient’s records will be available. Moreover, electronic storage and video chat between the patient and the doctor, which can facilitate the telemedicine process, will be the upcoming feature of the portal.

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