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RESEARCH ARTICLE

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

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Abstract: Patients have better access to their healthcare records and resources thanks to e-health portals. We create and deploy an e-health portal that efficiently integrates a variety of background medical services. The most difficult aspect of implementing such a system is ensuring that essential security criteria are met, such as patient data confidentiality, diagnostic outcome accuracy, and healthcare service availability. 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.

1. Introductıon

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" (Ngoma 2006), which has the potential to be extremely useful in delivering health care in a variety of settings. These systems have the potential to save lives and provide comprehensive data for strategic planning, especially in areas where hand- compiled data is often years out of date. The aim of Healthcare is to provide high-quality services to its clients.

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. 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:

i. EHR: an electronic file of a complete report on the patient's health that makes all information accessible to approved users instantly and securely. (Car et al. 2008).

ii. EMR: an electronic report containing the entire medical history of the patient (Walker et al. 2005).

iii. PHR: a health report in which the patient keeps track of his medical information in a personalized, safe, and confidential manner (Laxman, Krishnan, and Dhillon 2015).

iv. e-prescribing: a form of technology that allows a healthcare facility to write and deliver prescriptions to a pharmacy electronically. (Walker et al. 2005).

v. e-appointments: An online service making an appointment with any health organization quick and convenient, while also cutting down on wait time.

vi. m-health: a universal term that includes health-related activities It's used in cell phones and other wireless devices (Laxman, Krishnan, and Dhillon 2015).

vii. Telemedicine: providing health services and information remotely using information and communication technology (Maksimović and Vujović 2017).

viii. Telehealth: introduce health-related services and information by ICTs (Conrad 1998).

The paper aims to study the application of e-health by designing and implementing the electronic health portal. 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. Electronıc 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 (Armstrong et al. 2007). EHR 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.

2.1. 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 (TR 2005). 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 (Huang and Yin 2012). Interoperability is possible to evaluate on three distinct levels: protocol, the system's behavior to the end-user, and the outcome (Eichelberg et al. 2005). HL7 (Health Level Seven) defines interoperability as Technical, Semantic, and Process (An 2011). 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 (Arzt and Salkowita 2007). 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. Medical sharing is possible with grid electronic interoperability. It is a combination of technical elements and semantic/ sexemtic using the HL7 Semantic Model. It can be used to represent the message's HL7 data. 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 various types of middleware using widely used protocols across different platforms utilizing commonly used protocols and standards such as HTTP and XML (Bilykh et al. 2003).

2.2. EHR Access Control

An EHR system's interoperability allows for large amounts of data storage. Most of the developing world's healthcare has progressed to the point where patients are treated by doctors, therapists, primary care providers (Jin et al. 2009). HIPAA (Health Insurance Portability and Accountability Act) access to patient

data in applications is subject to regulatory restrictions (Helms and Williams 2011). Under the HIPAA rules, we are required to implement "mechanisms that record and analyze activity in electronic health information systems" (King, Smith, and Williams 2012). 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). When compared to all of the different access control models, UCON is promising. The latest model of access control. A UCON-based system is more difficult to operate than the others. A framework like this takes more resources and time to design and execute. An RBAC model is easier to create than the UCON model. EHR system offers state-of-of security and provides considerable flexibility. Using the (RBAC) approach was found to be appropriate since functions are given permissions (Mchumo and Chi 2010). The people are divided into two groups in the hospital: patients and medical practitioners.

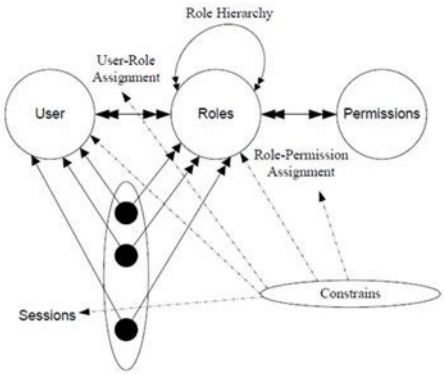

Figure 1. Role-Based Access Control Model (Lu et al. 2017)

3. Design and Implementatıon of E-Health Portal

This section 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.

The system also includes:

a. Communicating with the doctor by the administration,

b. Identifying emergency cases and outbreaks of serious diseases such as Coronavirus and HIV

c. Sending reports on urgent cases.

3. 1. System Design and Implementation

The user appears in front of three logging options as shown in Figure 2 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.

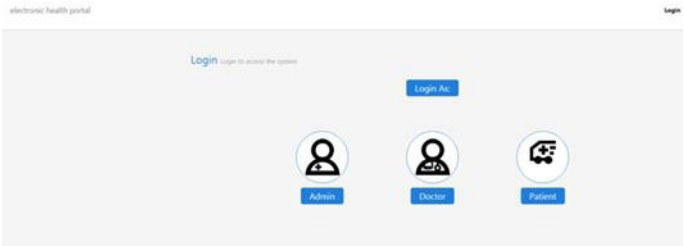

Figure 2. *First page of ehp*

3. 1. 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 by the Figure 3.

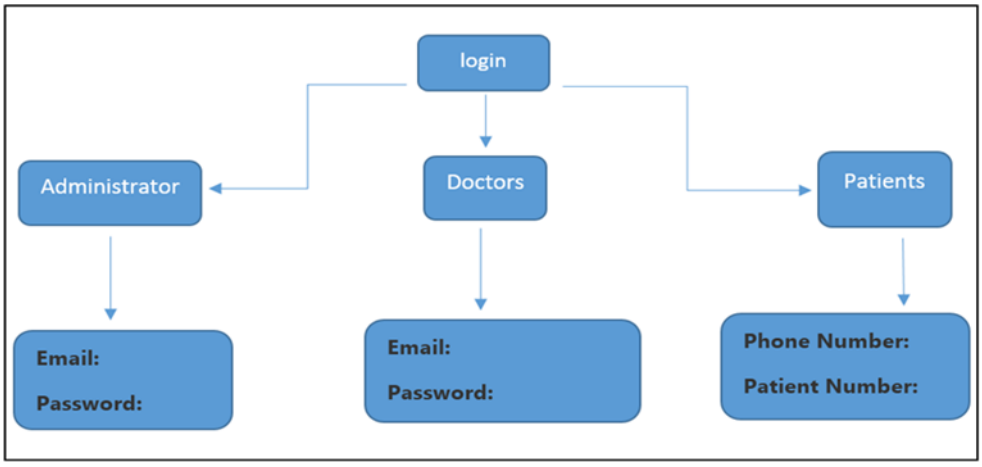

Figure 3. *Foreground Structure*

3. 1. 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);
```

The main parts of the code 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: All matches of a pattern or list of patterns contained in the input are replaced with substrings, resulting in a string or sequence of strings.

d. The md5() function calculates a string's MD5 hash. The MD5 Message-Digest Algorithm is used by the md5() function from RSA Data Security, Inc.

e. Based on the micro time, the uniqid () function generates a unique ID (the current time in microseconds). The return value's uniqueness is not guaranteed by the provided ID from this function.

The md5() function is used to generate an ID that is incredibly difficult. 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.

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.

3. 2. System Functions

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

3. 2. 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.

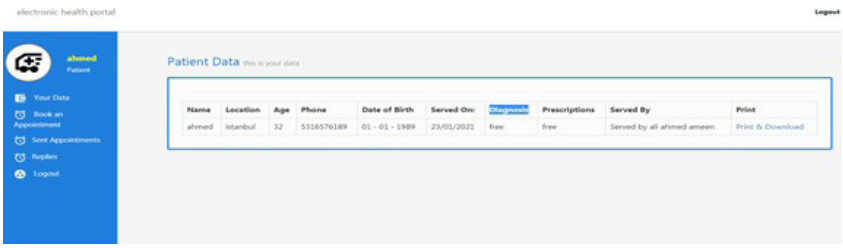

***Figure 4**. patient block diagrams*

3. 2. 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".

3. 2. 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.

3. 3. Test and Evaluation

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

3. 3. 1. Add patient

In Figure 5, if the doctor wants to add a new patient, he/she must enter all the required information in the electronic health portal.

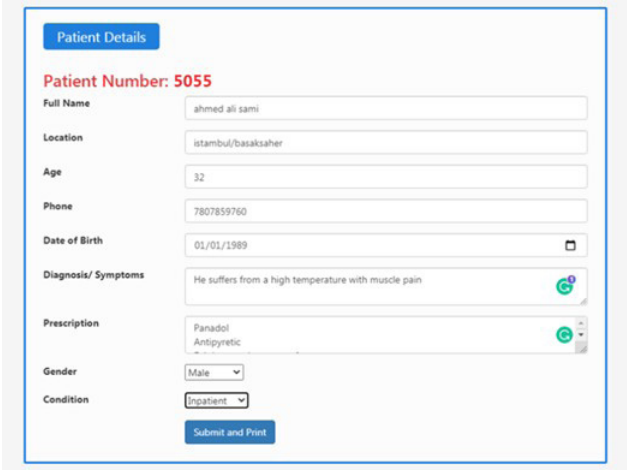

Figure 5. *Add patient*

3. 3. 2. Patient's booking

In Figure 6, The doctor's window displays appointment bookings and health records. The doctor will access the patient's health record without making any changes through it.

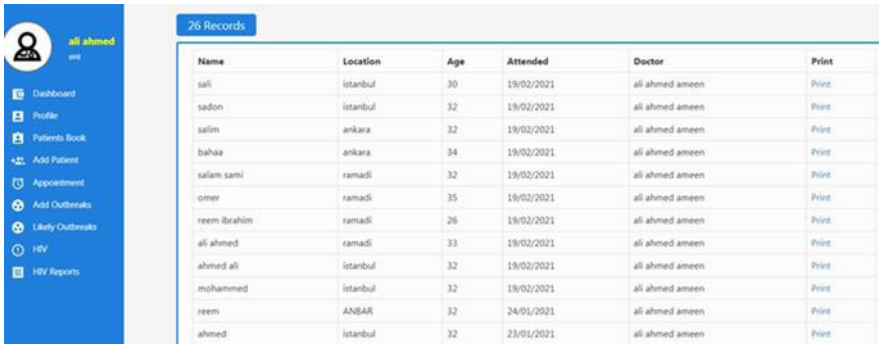

Figure 6. *Patients booking*

3. 3. 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 7.

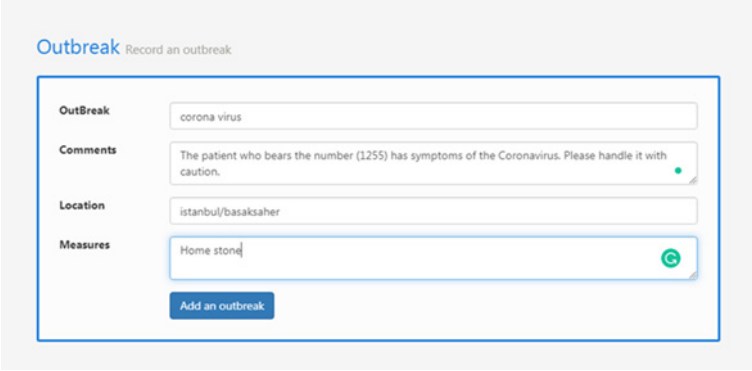

Figure 7. *Add outbreak*

3. 3. 4. Replies of doctor

Figure 8 shows the responses and correspondence between the doctor and the patients. To take an appointment for review and examination or prescribe medication.

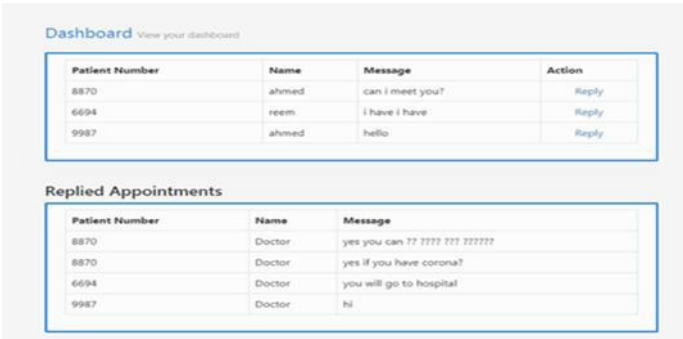

Figure 8. *replies of doctor*

3. 3. 5. Black box test

The black box test is mainly used to test system functionality. It can find the error function, input error, initialization error, and end error. Both input and output scenarios should be included in the overall black box evaluation. As a result, a large number of scenarios must be put to the test in a real-world

environment. It is challenging to complete the black box test. As a result, we conducted a series of focused experiments. The emphasis of these tests is on the system's primary role.

a. Function Test

The basic electronic health portal functions are selected as in Table 1.

Table 1. 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 password.	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 2. Non-fulfilled Test Result

	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

4. Results

In the electronic health portal, the access control feature is combined with the application of information sharing. 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.

5. Conclusıon 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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