Adopting React Personal Health Record (PHR) System in Yemen Health Care Institutions

اعتماد نظام السجل الصحي الشخصي التفاعلي (PHR) في مؤسسة الرعاية الصحية اليمنية

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Abstract. Health care is a critical sector of society that requires quality improvement of healthcare services**,** information technology IT systems have a great impact on improving the quality of these services**,** unfortunately**,** The effect of information culture on the implementation of information systems by healthcare providers in the developed countries is little known, considering the importance of information culture. Despite that many Yemeni healthcare facilities have been already using information systems to digitize the management of healthcare providing procedures, The patients' health information including disease history and prescriptions is not fully recorded and additionally, there is no implementation of Personal Health Record PHR systems where patients can access, and control their health records from another place where their records are stored locally in the healthcare providers' databases**.** The existing electronic health record systems are limited and do not exploit the available technology solutions and services. To explore the advantages of using PHR systems, multiple kinds of research are being studied and the proof of use has been cleared by these researchers' conclusions**,** also a survey was made; to ensure people intention to using PHR systems, and to observe their opinion on what they need to be provided by the system and what interests them. Designing the web-based system was done after going through the available platforms to choose the most correct and suitable solutions to assure that the system meets the requirements needed. Adopting innovative and modern technological solutions such as PHR web applications is a fine way to improve patient safety and quality of care, increase efficiency, Decision supporting, and Increase patient and health workers' satisfaction. The proposed solution ensured the patients' satisfaction and safety by giving them access to their health records whenever and wherever they are through their device's browser and helped the doctors to make the right decisions and speed up the healthcare providing process which reduced the damage caused by the current systems, saving human lives and preventing serious health issues.

الملخص

تعتبر الرعاية الصحية قطاعًا حيويًا في المجتمع يتطلب تحسين جودة خدمات الرعاية الصحية ، ولأنظمة تكنولوجيا المعلومات لتكنولوجيا المعلومات تأثير كبير على تحسين جودة هذه الخدمات ، وللأسف تأثير ثقافة المعلومات على تنفيذ نظم المعلومات من قبل مقدمي الرعاية الصحية في البلدان المتقدمة غير معروفة كثيرًا ، نظرًا لأهمية ثقافة المعلومات ،فلم يحظى تبني انظمة السجلات الصحية الشخصية personal health records systems في اليمن الاهتمام الكافِ برغم ضرورته . على الرغم من أن العديد من مرافق الرعاية الصحية اليمنية قد استخدمت بالفعل أنظمة المعلومات لرقمنه إدارة إجراءات تقديم الرعاية الصحية ، فإن المعلومات الصحية للمرضى بما في ذلك تاريخ المرض والوصفات الطبية لم يتم تسجيلها بالكامل ، بالإضافة إلى ذلك ، لا يوجد تنفيذ لأنظمة سجل الصحة الشخصية PHR حيث المرضى يمكنهم الوصول إلى سجلاتهم الصحية والتحكم فيها من مكان خارج المؤسسة الصحية حيث يتم تخزين سجلاتهم محليًا في قواعد بيانات مقدمي الرعاية الصحية. أنظمة السجلات الصحية الإلكترونية الحالية محدودة ولا تستغل الحلول والخدمات التقنية المتاحة. لاستكشاف مزايا استخدام أنظمة PHR ، تتم دراسة أنواع متعددة من الأبحاث وتم توضيح دليل الاستخدام من خلال استنتاجات هؤلاء الباحثين ، كما تم إجراء مسح ؛ للتأكد من نية الناس في استخدام أنظمة PHR ، ولمراقبة آرائهم حول ما يحتاجون إلى أن يقدمه النظام وما يهمهم. تم تصميم النظام المستند إلى الويب بعد المرور عبر المنصات المتاحة لاختيار أنسب الحلول وأنسبها للتأكد من أن النظام يلبي المتطلبات المطلوبة. يعد اعتماد الحلول التكنولوجية المبتكرة والحديثة مثل تطبيقات الويب PHR طريقة رائعة لتحسين سلامة المرضى وجودة الرعاية وزيادة الكفاءة ودعم القرار وزيادة رضا المرضى والعاملين الصحيين. يضمن الحل المقترح رضا المرضى وسلامتهم من خلال منحهم إمكانية الوصول إلى سجلاتهم الصحية متى وأينما كانوا من خلال متصفح أجهزتهم وساعد الأطباء على اتخاذ القرارات الصحيحة وتسريع عملية تقديم الرعاية الصحية التي قللت من الضرر الناجم عن الأنظمة الحالية ، وإنقاذ الأرواح البشرية ومنع المشاكل الصحية الخطيرة.

Keywords: Health records systems, PHR systems, Healthcare, Technological solutions.

1. Introduction

Healthcare is a remarkable sector in which we must be evolving every technological solution or invention we reach; we must try hard to give a better and innovative way of solving the problems in this particular sector. The way healthcare systems are managed is radically changed by technical growth, more specifically by the digital revolution [1].

Broadly, the introduction of the new innovations will allow governments to deliver value-added services to people and shows a range of developments in technology, firsthand health monitoring, and medical care[16].

Despite the remarkable development in the healthcare sector in the whole world, Yemen still has a lot of deprivations and obstacles related to this sector. For Yemeni public health, it has been stated that the information has still not been recognized as a culture. The potential of IT in the health sector is still not properly utilized[3].

As a result of a 4 year ago study on the quality of handwritten prescriptions in Sana's, Yemen [2] which covers 2178 prescriptions from 23 randomly selected pharmacies with different geolocation considered, 99.12% of the analyzed prescriptions were considered as low-quality prescriptions which have writing errors related to physicians and patient information and to the prescribed medications where spelling and instruction of use are the most errors found.

Thus, the current healthcare systems in Yemen as in many other countries don't exploit the technology revolution and the available software technologies (e.g.: APIs, frameworks, services ...etc) which would make a majestic impact on the treatment process and caregiving procedures if they were implemented. For such systems to meet most of these requirements, they must use web-based solutions that support data sharing. Easy access and availability can be achieved by using appropriate platforms to improve interactivity and make the web app more user friendly and responsive and allow developers to create web-based mobile-friendly applications [17] while getting significant benefits from using specific APIs (i.e. symptoms, a large number of drugs containing information and conflicts) to make it easier, faster and safer to choose the right medicine and automatically provide suggestions and help with making more accurate decisions.

The main aim of this paper is to encourage healthcare providers in Yemen to adopt PHR systems by showing them all the benefits that can be gained and additionally direct them with a design proposal along with the required technologies, this design will expose new, innovative technologies to ensure an appropriate design supported by health care APIs for instance which allow healthcare providers to access and use electronic applications and data in more innovative ways [18] than those used in current EHRs and unfortunately, in our country and many other countries, healthcare institutions still use desktop-based HealthCare applications, and even if they are; users -patient- don't have access to their health data. The complexity and time cost of fully implementing healthcare applications in the health providing procedures increases while the user experience and ease of use are not taking into account at the beginning of building the system, i.e. doctors can't use these systems to store patients symptoms and prescriptions, because it takes more time or requires full attention or specific conditions in the case of speech-recognition input methods these problems can be solved if the designer of the system takes an effort to make the application easier to use and more simple and time-efficient, it must benefit the doctors and helps them makes good decisions and prevents common errors, it also must speed up the process not slow it down.

This can be achieved easily using modern mobile applications, to make use of the application from every device and from different and multiple places as health data need to be made available wherever or whenever, users can simply use their phones, tablets and any portable device's browser with a decent internet connection. This allows individuals to access their PHRs via the Internet, using state-of-the-art security and privacy controls, at any time and from any location [12].

Recent web-based technologies opened the door for completely new possibilities for creating various medical information systems. Web-based applications are offering competitive benefits to old-style software-based systems, permitting businesses to consolidate and streamline their systems and processes and decrease costs [10].

Technology is becoming more and more advanced as we can now use IoT devices, sensors to measure and monitor human health metrics, send them into mobile or web applications, and access them through our portable devices and computers.

The Personal Health Record (PHR) is an Internet-based set of tools that allows people to add, maintain, access, and coordinate their lifelong health information [12,13,14,15], and make appropriate parts of their own medical and health-related information available to those who need it (specialists, doctors, nurses, family members, etc) [12]. Whereas EMR is a patient's health information inside a specific medical institution that is unshared in more than one. EHR has the same meaning of EMR but in addition of sharing it among more than one of an institution, but all the operations that are done on them -both EMR and EHR-, done by medical professionals or staff of the institution and no way to the patient to have hand in it as management or control. PHR comes to include the EHR concept with making the information more flexible and giving the patient the complete power to manage, control, and provide access to it. So PHRs patients are more comfortable with adding information to their health record and review all records at any time. Moreover, privacy is felt due to who can access what exactly in his records regardless of geographical distance. PHR abbreviates all that patients and health providers need to know from any place at any time and makes it easy to share with keeping privacy and giving the patient all his rights to deal with his health information.

2. Related Works

This section will cover both related works on persuading healthcare providers to adopt web-based applications, and similar systems proposals. since this paper aims to encourage healthcare providers to adopt web-based PHR systems, and to provide a proposed system design with the technologies which would be used, and the main idea for this proposed work allowing the patients in Yemen to have their medical records and health data on their own. The idea was to go over

multiple researches and applications that discussed the implementation of PHR systems including the advantages and disadvantages of health information access for both patients and doctors.

As a motivation for healthcare providers, implementing good electronic health services is an effective step toward making the patient more satisfied, where The quality of healthcare services in Yemen from the patient's perspective has been studied and researched by Mr. Bashar Mohammed Al-Sofyani [8] in his thesis for the master degree of public health, he concluded that Satisfied patients due to providing good quality of care are more likely to comply with treatment and continue to use services. This will improve utilization and will finally lead to better general health indicators. Albokai et al [4] improved the Quality of Healthcare by using the Information Technology System in the Hospitals of Yemen showed that it improves patient safety and quality of care, increases efficiency, Decision supporting, and Increase patient and health workers satisfaction. However, it was observed that multiple healthcare providers in Yemen have already implemented EHR systems but in limited services and without supporting the information access for patients. Although collecting information about patients is important and critical to construct a proper treatment plan for the patient. this is considered as one of the most important difficulties facing the general medical staff and the private doctors [4].

The adoption of PHRs and EHRs with patient access-support should be considered and "Late adopters of the electronic health record should move now" [9]. A Proposed PHR Architecture for Saudi Arabia Health Services concluded that such a system once approved for adoption in Saudi Arabia, will improve the health services and it will assist in disease prevention and emergency treatment intervention. They also hypothesized that increased patient engagement in their healthcare can improve the quality of the provided services and surely improving their health lifestyle [7]. A study aimed to elaborate the functional specifications of the pregnant woman PHR and to create and propose a prototype, although the study followed some functional principles i.e. (promoting information sharing among women, health professional's hospitals and diagnostic services and promoting documentation of care), a specific design technology wasn't provided [12]. P. Thummavet1 and S. Vasupongayya2 [13] propose a novel scheme for handling accesses to PHR information in emergencies, they focused on how to give emergency staff access to PHR information even when the owner is not able to give his/her consents using threshold cryptosystem, based on the owners' PHR policy. The system consists of three levels of confidentiality (security, restriction, and exclusiveness), the PHR owner can define a confidentiality level to each record before it is uploaded to PHR server and emergency staff will have variety access ability either encryption key through a service provider (EmS) used for encryption or instantly if they are trusted users and pre-selected by the PHR owner. Although This scheme is efficient in case of security, somehow has a level of complexity for simple users. Muhammad H. Aboelfotoh et al [14] proposed mobile-based system architecture that allows patients to use the online PHR systems that they are subscribed to and at the same time use their portable devices to provide direct data access to physicians using authenticated and integrated Backend infrastructure without fully interconnecting healthcare systems network, However, their proposal requires an existing online PHR system along with additional requirements i.e. (Smart health Card, Healthcare Provider (HCP) terminal) which increase cost and system complexity.

Yeong-Tae Song et al. [15] proposed a PHR system that utilizes applications standards such as SNOMED CT, and HL7 CDA to achieve interoperability between different EHRs and PHR systems, a mobile application is used to collect medical data and store it in HL7 CDA format. Their model consists of four main models; Clinical Data Collection Module: the mobile application is used to collect medical data and generate CDA files that can be uploaded to a cloud-based management system, Cloud file Manager Module: this model used to store the CDA files for each individual, CDA Query Module: which uses XML parsing program to search nodes and extract codes and other values so that the Diagnosis Module can use them as input, Diagnosis Module: the extracted codes will be used to create the clinical decision logic, matches symptoms in the personal medical data to the diagnosis rules, they used Rule-based system CLIPS.

3. Advantages of Using and improving the PHRs Systems

Patients who have medical documents comprise advisory opinions, lab results, prescriptions, and MR, CT, Ultrasound images, and such on. in various formats and forms. That what makes the patient's medical information is stored in different places according to which institution the patient goes to, which makes the ability to access it, by the patient himself and share it with others, is necessary to face changing places especially for people that travel a lot. What keeps effort, time, and cost that took in repeating diagnoses with repeating examinations and such like. Or the risk of taking incongruity medicine to end a patient's life. Actually, there is no way to limit the need to use personal health records (PHR) but at the same time, we must ensure high performance, whether in-facility or speed and care about security. So, such advantages can be summarized as follows:

- PHR provides a continual monitor for patients' health status and acquaintances all necessary health information (medical history, medical examination data, physiological parameters, healthy lifestyle, etc.) at any time, anywhere, from any platform [8].
- Educating patients: Patient-accessible medical records improved recall and understanding of medical information by objective measurement in two randomized controlled trials. Among medical outpatients, smokers who received a copy of their most recent progress note were significantly more likely to identify smoking as a problem 2 weeks after their appointment, and this trend persisted at 6 months.43 Older patients with chronic medical conditions also showed significant increases in their recall of medical problems and treatment plans that did not involve medications.
- Empowering patients.
- Improving doctor-patient communication.

- Improving patient satisfaction.
- Patient-accessible medical records are particularly helpful for patients who are concerned about what might be hidden in the chart.
- Facilitating correction of errors: Patients found inaccuracies in the medical record in many of the studies. A descriptive study of medical inpatients found that half of the patients "made some addition or correction on a point of fact."
- Effects on documentation: Although both patients and staff had the impression that patient access to the records changed documentation patterns, little change was identified on objective analysis, and made the staff more accurate in what they wrote.

4. Methodology and System Design

Several hospitals and healthcare institutions were visited to explore and identify existing EHR systems. Many hospital personnel was questioned and the level of satisfaction was observed with the current systems. In this work, each patient will have his or her health profile, accessible at all times and across mobile or digital devices, to support the existing healthcare systems with productivity, time-saving, and data sharing probability. We first have to measure the level of participants and willingness to use an online PHR system, and what would be the most important part of the system that they need, and will encourage them the most to use the system. And second, by going over multiple proposed PHR systems to collect ideas about what the system should implement.

Having this information will help us to propose the most proper and suitable plan for constructing a PHR system for our society.

4.1 Determining Level of Interest

Either From the patient's perspective or the doctors, it's hard for them to collect the health data, we can see that After making a questionnaire about the effectiveness of the proposed system idea and. The survey contained a group of questions that the respondents had to answer. The target of the survey was every individual at the age older than 15. A total of 131 random individuals were given a link to a Google form that must be submitted in 3 days.

The included questions aimed to observe and study the level of excitement and interest to have such ability, it is also aimed to see how much they see the importance of this idea and how useful it would be.

And was divided as follows:

- **Basic information** (age-gender-education level- having a chronic disease):

  People of different ages will have different interests and needs of PHR system parts, As well as gender and education level, additionally the possibility of having a chronic disease will affect the willingness of people to use the system.

  Although Table1shows the level of interest for peoples of different genders and health states, in general, we can see that more people are encouraging this idea and interested in using a PHR system.

- **Online activities related to healthcare:**
  - Search about some diseases: seeking information about a health issue or disease is critical while some sources may be tricky or misleading.
  - Search for information about a doctor or contact a doctor by email or specific application.
  - Used a PHR or health-related application before: having an experience will have a different impact on the level of participation.
  - Received a notification about a test result or browse his medical prescriptions with his mobile.

- **Feelings about the idea of having PHR**

  Four levels of interest will be provided (highly interested, interested, not interested, highly not interested (thinks that the idea will have a negative impact). As it is shown in Table1 most of the participants are interested in having and using a PHR system no matter how their health conditions would be.

- **Prioritizing system services:**

  Prioritize the system aspects from most important to less important from everyone's perspective most important service they wish the system will provide, and what they think it's not that important. Fig. 1 is shown the priority of health services from participants' perspectives.

- **Concerns and limitations:**

  What are the negative sides of implementing this system and what concerns them and probably prevents them from using the system and if there are limitations?

Table 1. Level of Interest Based on Gender and Chronic Disease

Basic Information	Filter Type	Participants Number (%)		
		Highly interested	Interested	Not Interested
gender	M	31(41.9%)	28(37.8%)	15(20.27%)
	F	17(28.8%)	27(45.76%)	15(25.42%)
Have chronic disease	Yes	5(55.5%)	3(33.3%)	1(11.1%)
	No	39(34.2 %)	49(42.98%)	26(22.8 %)
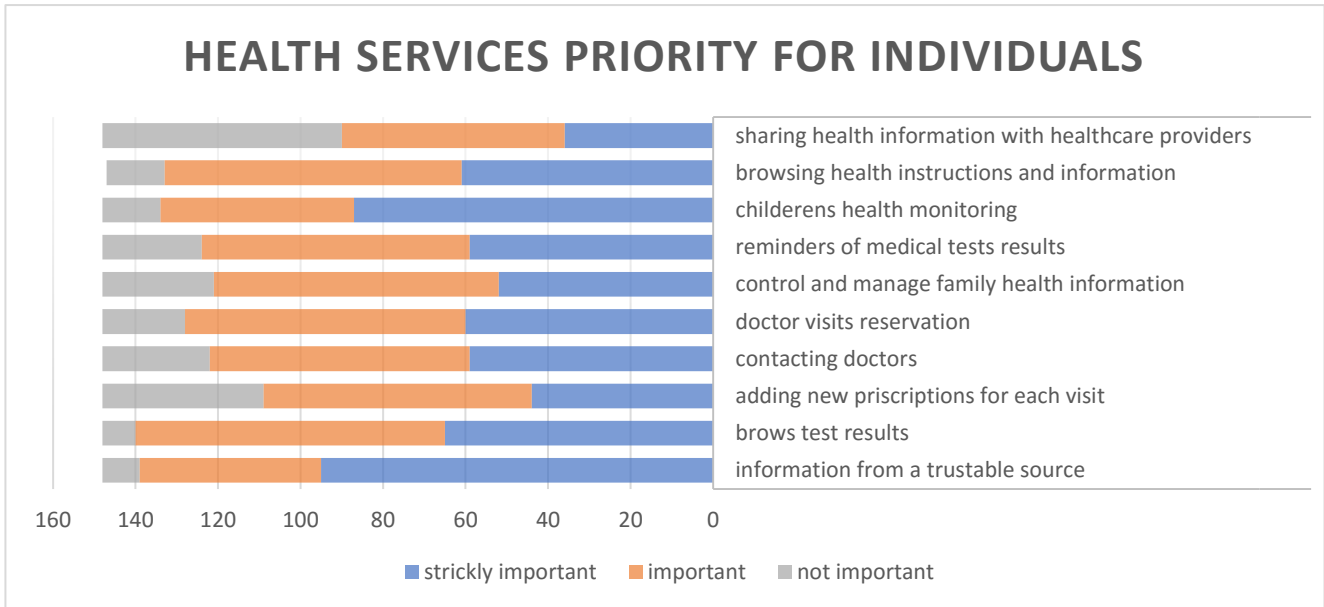
Fig.1. Health services priority for individuals

Additionally, to gain a better insight into the positive impact on both patients and doctors, and to ensure the effectiveness of the proposed system, by going over multiple researches and articles that proved the usefulness of using PHR systems in general and using web-based systems in specific.

4.2 System Technology Selection

To make the application be accessed from every user device from different and multiple places, as health data requires to be available no matter where or when this can be fulfilled easily with the use of mobile applications, users can simply use their phones, tablets, and any portable device's browser with a decent internet connection.

React-NodeJS Web application

The system designer must make an effort to facilitate the interactive, time-efficient, and interactive use of the application. React 's capability assists in designing a simpler user interface that facilitates the application and enhances the user experience. In this section, we will explain more about the React.js framework. React is a component-based library which is used to develop fast interactive UI's (User Interfaces). It is currently one of the most popular JavaScript front-end libraries which has a strong foundation and a large community supporting it. As list advantages and giving some reasons why React-Js was the chosen technology, we can summarize that in the following points:

- Easy creation of dynamic applications: because it requires less coding and offers more functionality, as opposed to JavaScript, where coding often gets complex very quickly.
- Improved performance: Where react uses Virtual DOM (VDOM) thereby creating web applications faster. Virtual DOM compares the components' previous states and updates only the items in the Real DOM that were changed, instead of updating all of the components again, as conventional web applications do.
- Reusable components: Components are the building blocks of any React application, and a single app usually consists of multiple components. These components have their logic and controls, and such that can be reused throughout the application, which in turn dramatically reduces the application's development time.

- Unidirectional data flow: This means that when designing a React app, developers often nest child components within parent components. Since the data flows in a single direction, it becomes easier to debug errors and know where a problem occurs in an application at the moment in question.
- Small learning curve: React is easy to learn, as it mostly combines basic HTML and JavaScript concepts with some beneficial additions. Still, as is the case with other tools and frameworks, you have to spend some time to get a proper understanding of React's library.

- JSX: JSX stands for JavaScript XML. It's an XML/ HTML-like syntax used by React.
- Virtual DOM: Manipulating real DOM is much slower than manipulating VDOM because nothing gets drawn on the screen. When the state of an object changes, VDOM changes only that object in the real DOM instead of updating all of the objects.
- Performance: React uses VDOM, which makes the web applications run much faster than those developed with alternate front-end frameworks. React breaks a complex user interface into individual components, allowing multiple users to work on each component simultaneously, thereby speeding up the development time.
- Extensions: React goes beyond simple UI design and has many extensions that offer complete application architecture support. It provides server-side rendering, which entails rendering a normally client-side only web application on the server, and then sends a fully rendered page to the client. It also employs Flux and Redux extensively in web application development.
- One-way data-binding: that means unidirectional data flow as explained previously.

- Debugging: React applications are easy to test due to a large developer community.

4.3 System Framework and users' interface

Using created auto-complete recommendations from multiple APIs, such as (medicine names, symptoms, prescriptions, and medical instructions), the system's ease of use and efficiency will be ensured, which will give the PHR some kind of ease and aid in decision-making and reduce time costs while medical staff provides this information. APIs can also be used as a source to get valuable information about diseases and medicines; thus, it helps to get the correct information for the patients and prevent misleading, confusing, and sometimes wrong information from untrusted websites. Several advantages have been proposed by this system, and one of this advantage is when the patient leaves, he will be able to access all his recent treatment procedures and brows his medical reports and prescriptions through his browser anywhere in order to get any information he needs or instructions or medicines he has to take, along with other parts as it is shown in Fig.2. the second advantage is, if he ends up visiting another doctor or had another medical condition and transferred to another health provider, the medical staff can easily find the information they needed in order to construct a proper treatment plan.
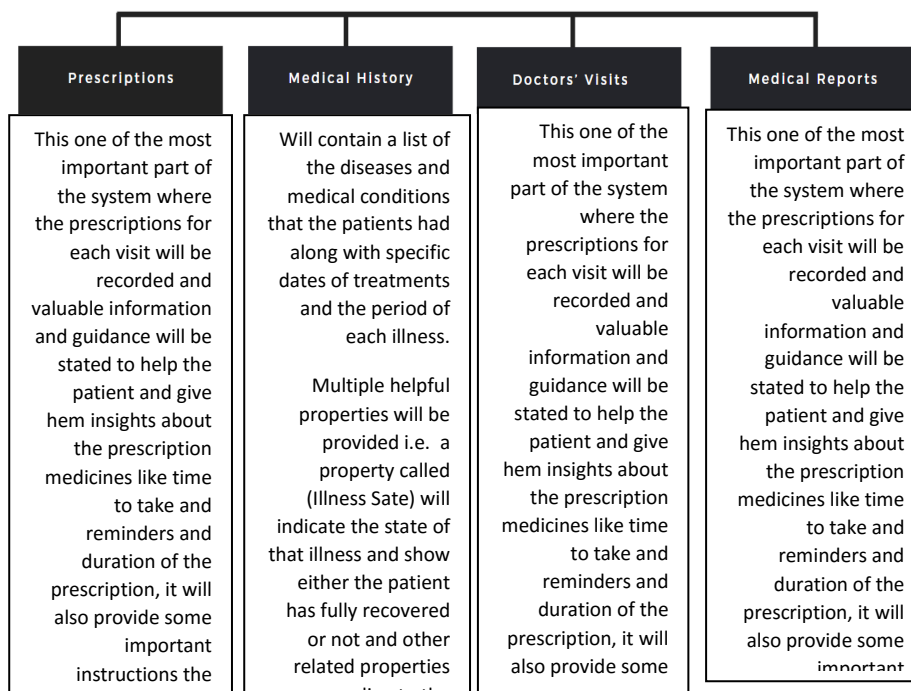
PHR SYSTEM COMPONENTS

Prescriptions	Medical History	Doctors' Visits	Medical Reports
This one of the most important part of the system where the prescriptions for each visit will be recorded and valuable information and guidance will be stated to help the patient and give hem insights about the prescription medicines like time to take and reminders and duration of the prescription, it will also provide some important instructions the	Will contain a list of the diseases and medical conditions that the patients had along with specific dates of treatments and the period of each illness. Multiple helpful properties will be provided i.e. a property called (Illness Sate) will indicate the state of that illness and show either the patient has fully recovered or not and other related properties	This one of the most important part of the system where the prescriptions for each visit will be recorded and valuable information and guidance will be stated to help the patient and give hem insights about the prescription medicines like time to take and reminders and duration of the prescription, it will also provide some	This one of the most important part of the system where the prescriptions for each visit will be recorded and valuable information and guidance will be stated to help the patient and give hem insights about the prescription medicines like time to take and reminders and duration of the prescription, it will also provide some important

Fig.2. Main PHR System Components

5. Conclusion

Seeking health information access is not just claimed from the doctors but in fact, it has already been a legal right in many countries [6]. Adopting PHR system is highly required for the sack of a better HealthCare for every individual in our country, not only because other people in other countries have such system, but having such system in our country would help to increase people's safety and gives them a great satisfaction about the services of the caregivers. Our study shows that Yemeni people are different from others country's people and a high percentage of people feel that they need that kind of systems they can use to assets them into having a better health state and make it easy for them to get any information they need without worrying about whether it's wrong or dangerous to take these medications in their prescriptions, they want to share their health information without going over all the healthcare places they went to, and they are ready to continue using the service that satisfies their needs. Thus, caregivers in our country must make a fast move towards implementing PHR systems. Our study proposed the system components they should put in mind when they decide that they will implement PHR system, that's what people need, and that's what they want, they can't effort the high cost of expensive PHR systems and they fear that they may not be able to use a complex PHR system so it has to be simple and clear to them when they use the application, ease of use and interactivity must be fulfilled; that's why we recommend using react as a framework to design the system. Our future work will focus on privacy and security when decentralized databases are used and blockchain technology using Hyperledger fabric is implemented. Interoperability is another issue that we can discuss to share healthcare data between multiple systems using scandalized records systems and design the system to support global standards like HL7 and other CDA.

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