Development of Electronic Medical Record for Individual Physician Practices

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Abstract

Electronic Medical Records (EMR) are widely used by hospitals. However, EMR adoption is still low and is dominated by a large hospital. The majority of small clinics and private physician practices have not used computers for medical data recording. This paper aims to design EMR applications for individual physician practices. The EMR application is built for mobile and web devices to be easily accessible. Terms and rules on medical records were studied. Observations and interviews about medical record recording have been conducted in health clinics and physicians. International Statistical Classification of Diseases and Related Health Problems (ICD-10) standards is used for EMR recording. The system has been implemented by building web applications and wrapping it into Android apps. This allows Physicians to access the EMR system online, both web and mobile. Simulation of Mobile EMR implementation has been done to get an expert opinion from a physician. Physicians concluded that the functional mobile EMR application could be used for physician practice. a physician concluded that EMR mobile applications run properly. It also meets non-functional needs such as confidentiality, integrity, authentication, availability, access control, and non-repudiation.

Keywords: *Electronic Medical Records, ICD-10, Mobile Applications, Family Medicine Clinic*

1. INTRODUCTION

Electronic Medical Records (EMR) has been implemented in many hospitals worldwide. EMR records patient information including patient complaints (anamnesis), diagnosis, and medical treatment. EMR is used by healthcare organizations to simplify and streamline the management goal of patient information and medical information[1]. Adoption and use of EMR are still dominated by large hospitals, their use in small or independent hospitals is still not optimal [2]. In fact, some health organizations still apply medical records manually. It leads to a deficiency, among others, such as the use of a less efficient, requiring space for storage, and data can be easily damaged.

General practice or family medicine in Asia-Pacific difficulties in adopting the development of information technology. It occurs because there are barriers in the application of information technology. Merely 5% general practices in Australia use computers for EMR recording, the majority used for administrative and management needs [3]. The figure is even lower for the Singapore, Indonesia and Malaysia regions. [4].

Lots of effort has been made to the governance of information technology in the medical area [5] [6] [7] [8] and EMR. EMR development trends are transitioning from desktop systems to mobile systems [9]. Various studies on mobile healthcare have been done. Such as the development of a system for the interaction between patients and physicians using Android applications [10]. Another study is the development of mobile clients using Android that is connected with medical data from the hospital [11]. But not many studies have focused on developing EMR specifically for general practitioners. Though the general practitioner is the front guard in doing health services to the community.

In this paper, we built an EMR for Family Medicine Clinic. The system is designed so that the physician can easily enter information into the EMR via web or mobile phones. This system will be developed with several functions, namely: view medical record history, searching for certain medical record data and store medical record data.

2. ELECTRONIC MEDICAL RECORD

In the field of medicine and dentistry, medical records are one of the written proofs of the service process provided by physicians and dentists. Therefore every medical service activity must have complete and accurate medical record. The medical record is a file containing notes and documents about patient's identity, examination, treatment, actions, and other services that have been provided to the patient. Medical records have the purpose and benefits of [12]: (a) Patient Treatment, (b) Service Quality Improvement, (c) Education and Research, (d) Financing, (e) Health Statistics, (f) Proof of Legal Matters, Discipline and Ethics.

Any patient visiting a health care facility for the first time will be served by an outpatient. The patient will be in the interview along with given a special form for the new patient to fill out. Each new patient will obtain a patient number to be used as an ID card. Each new patient will receive a patient number to be used as an ID card. The patient shows the patient's card if they want to seek treatment. The officer will prepare and check the patient's medical records. Physicians fill out medical records by writing down all medical practice services performed [13]. Each record in the medical record shall be accompanied by the name, time and signature of the officer providing the service or action. If a mistake occurs during recording on a medical record, records should not be deleted in any way. Error correction in medical records can only be done by deletion and then affixed with the officer's signature. If utilizing an EMR system, the duty of signing can be changed by using a personal identification number. Physicians are required to maintain confidentiality regarding the patient's medical history in the medical record. The contents of the medical record can only be opened at the request of the patient or law enforcement request.

Electronic medical records are the process of maintaining electronic health information on health status and health care. An electronic medical record is a tool that enables registered users to access information about patients and clinical decision support tools. Only authorized officers may enter medical information into the computer. Patient data must be closely guarded. Only personnel who have access can open medical data. No information can be opened without a patient's permission. The distribution of medical information should be restricted to authorized persons only. The information is also not allowed to be transferred to others. Data that has exceeded the

time limit of storage may be removed after notifying the physician and his patient (or his heirs). On-line terminals can only be used by authorized persons. The efficiency of medical records that can be observed include [14]: Faster response time, The system will automatically process the data into information, Information presented more up to date, No more storage space required, and paperless.

The EMR type is divided into 2 parts, namely "basic" and "advanced" [2]. Basic functional EMR has such as: Order Entry / Results, Clinical Data Repository, and Clinical Decision Support. While advanced EMR features Physician Documentation and Computerized Physician Order Entry (CPOE). CPOE is the process of a medical professional to enter medical instructions and prescriptions electronically. The functionality of the EMR consists of: clinical notes, automated medical prescriptions, appointments systems, communications standards, structured data [15]. A good EMR design should be Enhanced personal connections, Seamless input of contextual data, Record and summarize dynamic narratives [9].

3. EMR REQUIREMENT ANALYSIS

3.1 Observations and Interviews

Observations were conducted at the Telkom Surabaya Health Foundation. This clinic was chosen because it has successfully implemented an electronic medical record system. From the observation found the findings as follows : (a) Electronic medical records filling procedure.(b) Diagnostic filling standard with ICD-10 (International Classification of Diseases) data. (c) Examples of patient medical records. (d) A manual in filling out an electronic medical record for a General Practices.

Interviews were also conducted to find out more about medical records. The interview has conducted with a physician at dr. Soetomo Hospital. Based on interviews are known some facts as follows : (a) Medical records may not be filled by unauthorized persons. The physician is fully responsible for the contents of the medical record. (b) Medical personnels are allowed to fill out medical records, but physicians retain full responsibility for medical record data. (c) A medical record filled with every patient comes to visit. (d) The diagnosis on the medical record is written using ICD-10 code. (e) Medical records are written using predefined units. (f) The medical record filing procedure starts from the time the patient arrives until the patient returns.

TABLE I. *EMR PROBLEMS AND SOLUTIONS*

Problems encountered	**Alternative solutions**
Medical record data may only be filled by a physician or medical officer.	Create login features, and add user features.
The physician or medical officer wants to change user data.	Create features to change user data.
Medical records should be filled in accordance with existing procedures and formats.	Make the appearance of medical record form in accordance with the existing procedure sequence. Equipped with unit descriptions.
Searching medical record data manually takes a long time.	Provide features to search patient medical record data. Patient search can use patient ID.

Based on the results of observations and interviews can be concluded that the electronic medical record program should be portable and compatible, but still can maintain data integrity. Table 1 presents some of the problems along with the alternative solutions that are summarized from observations and interviews.

3.1 Functional Requirement

Based on the analysis of existing problems and solutions, here is a list of the fungtional requirement of electronic medical record to be created:

System authority : The system can differentiate users who enter the system. Able to determine the functions - functions that are active based on the existing user.user is divided into two, namely medical officers and physicians.

Added the patient : For patients who have never visited, the system provides a feature to enroll new patients. The system provides a form filled with new patient identity data.

Renew the patient's identity : The user can update the patient's identity data. Patient data is distinguished by patient id number.

Update user data : The system provides features for users to change their identity data. Identity data including name, address and phone number. Users can also change their username and password.

Write medical record data : The user enters the medical record data with a predefined format.

Displays medical record data : Physicians and medical officers can display the patient's medical record history. Medical record data based on previous patient visits. This function is needed so that the physician can determine what actions are taken to deal with the patients.

Validate medical record data : Medical record data entered by medical personnel should be reviewed by a physician. The system can record the person and time of the data entered.

Update the list of actions or services : This system comes with a list of actions. This data concerns the type of medical procedure and pricing. This list of actions can be changed at any time.

Seek medical records based on diagnosis : The goal is to know what actions have been taken to patients who have been diagnosed with certain diseases.

3.1 Security Requirement

In addition to the above functional requirements, the system also has several needs on the security side, among others [16]:

Confidentiality : Maintain private information from unauthorized persons.

Integrity : Keep information unchanged without the permission of the owner of the information. In the medical record rule, if there is a change of data then it should include the signature and date of the change. But in an electronic medical record, if there is a change, it should include information about the person who changed and when the change was made.

Authentication : The user is required to login first to access the system. This is done to ensure that the person accessing has the authority to access. The medical record records the person performing the examination and the date of the examination.

Availability : The electronic medical record system can be accessed when the patient visits. Data must be available at any time for easy access.

Access Control : The system has two user roles: physicians and medical personnel. Each role has a specific ability in the system.

Non-repudiation : Medical records are confidential and should be accountable. The medical record logs the complete data, including name, date, and location.

3. EMR DESIGN

Actors involved in the system are physicians and medical personnel. Based on needs analysis, the features to be made are : system authority, adding patients, updating patient identities, updating user data, filling out medical records, displaying medical record data, medical record validation, updating service action lists, and presenting diagnostic medical records. Each use case is defined by the set of procedures performed, taking into account the normal-alternative-exception flow. Class diagrams and sequence diagrams are created to illustrate the detailed design of the system. The database design is made according to the data requirement.

Individual Physician Practices EMR application design can be seen in figure 1. Medical users such as physician can access the app using multiple devices (Android phone and laptop). Individual Physician Practices EMR application available online so users can use them anytime. The client device will be connected to the EMR server. This server stores data related to the medical record.

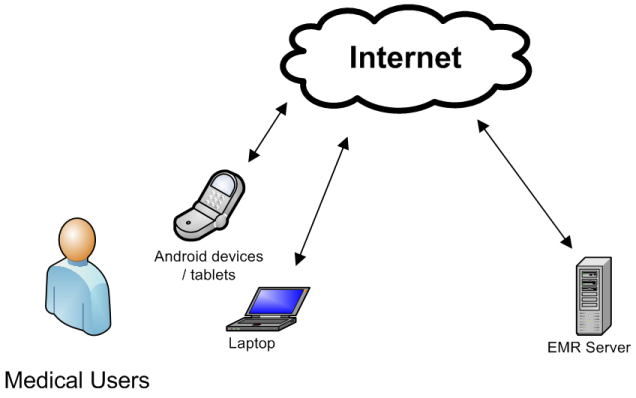

Figure 1: EMR System Architecture

3. EMR IMPLEMENTATION

Implementation of electronic medical record system design is using mobile Android applications and cloud data. Web applications built in PHP, JavaScript, and HTML. Android applications created by wrapping web applications into Android APK. Android Studio is used to transform web applications into Android applications. This transformation is necessary so that the application is easily accessible via mobile phone. Cloud database technology using MySQL machines connected to the internet.

Some of the system functionality that has been implemented is as follows :

Login and Dashboard page : This page allows users to log in to the system. After the user has successfully logged in, the dashboard page will be displayed.

Medical action page : Configuration page to add or change the list of medical actions.

Patient list page : This page is accessed when the user wants to perform an examination, view the patient's medical record, or change the patient's identity. There is a list that can show all registered patients. Users can search the patient by entering patient's number or patient's name.

Patient examination page : when the patient details are selected, this page will appear. Users can access previous medical record data. The main function of this page is

to enter medical record data into the system. Fig. 2 illustrates the detail display of the patient's record.

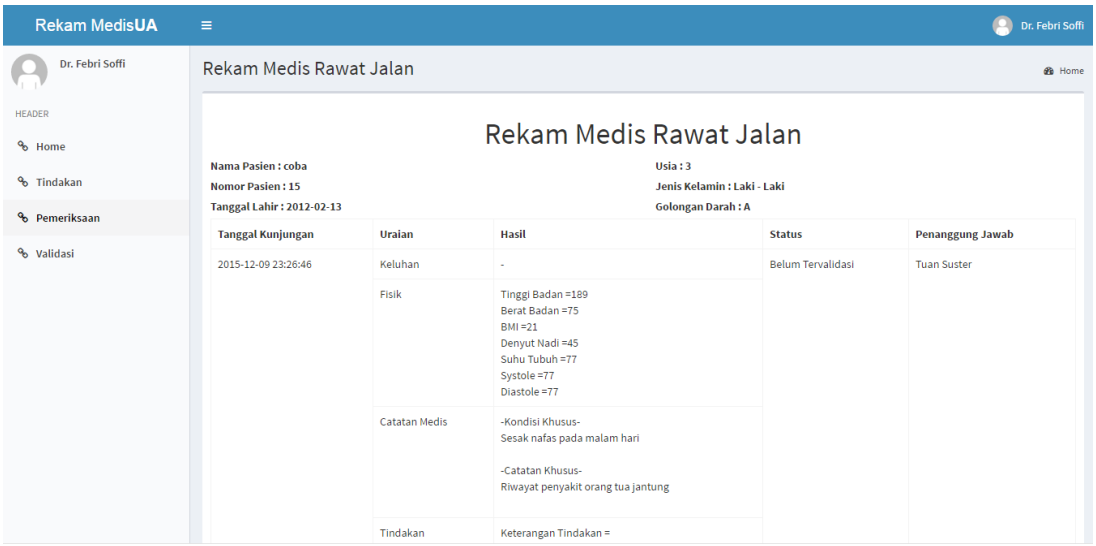

Figure 2: Display of medical records.

Medical record validation : This page is only accessible by physicians. To validate the medical record data that has been entered by the nurse. Before the patient is examined by a physician, usually the nurse enters the initial physical examination data (Fig. 3).

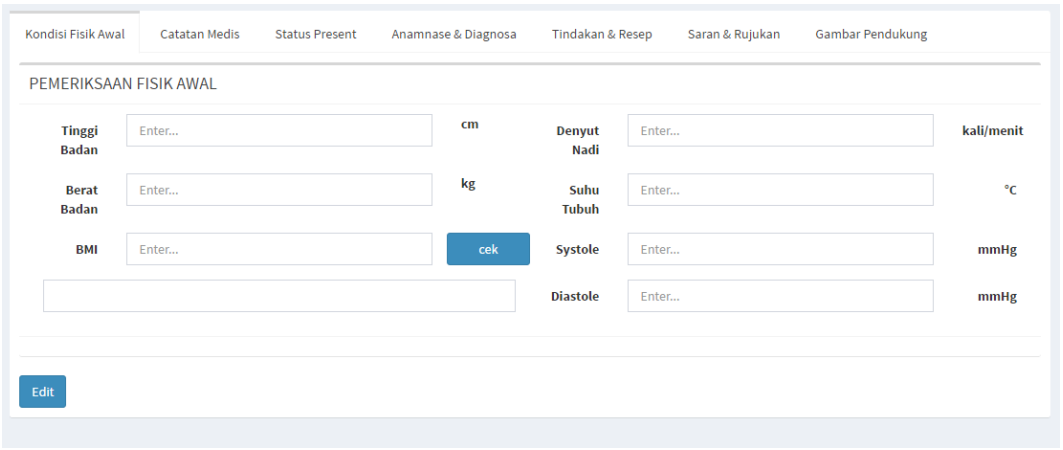

Figure 3: Initial physical examination.

Looking for a diagnosis : This page shows a list of ICD - 10 that physicians use to determine a patient diagnosis (Fig. 4).

6. SYSTEM TESTING

The testing process has been done by performing functional tests based on user needs.Use case models are used to obtain test cases.Input parameters and expected results are determined based on the scenario of the use case.This step is done to ensure

that all the functional requirements identified in the requirements analysis phase have been tested and run as planned.

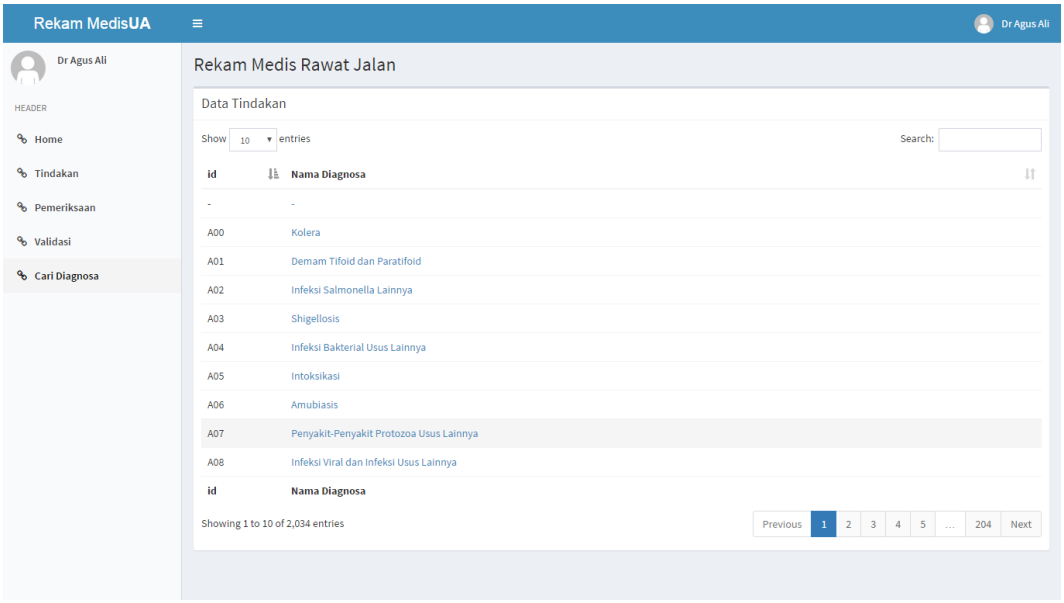

Figure 4: Diagnosis list page

After functional testing successfully done, we conducted an interview with the physician to evaluate the system. Before the interview, a physician was asked to use medical record application using an Android device while accompanied by the author. Evaluation is done to test functional and nonfunctional needs from the stakeholder point of view. The interviewed physician said that the functional features fit his needs, the units used in the medical record are also appropriate.The results of the interview discussions suggested a feature of the recipe with a more complex format. Besides proposing to complete the anamnesis part with several supporting factors, such as urine test results, blood, feces, and radiology. The results of the non-functional requirement evaluation indicate that all aspect of confidentiality, integrity, authentication, availability, access control, and non-repudiation can be received by the physician.

From the evaluation results, a physician also said that preferring the EMR that can be accessed via phone/tablet. Medical personnel will often move to conduct patient checks, so the phone/tablet will be an attractive option compared to desktop computers.The mobile phone used should have a large size. So physicians easy to perform medical record activities. The physician believes that the system is ready. In general, physicians also have the resources, time, and funds to apply this technology.But requires adjustments to familiarize users with switching from the manual medical record system to electronics.but requires an effort to familiarize the user, in order to switch from the manual medical record system to the electronics.

6. DISCUSSION

In this study, we built an EMR system that can be used using mobile devices for physicians. This will make it easier for physicians to manage patient medical records. For the future, there are still great challenges and opportunities in developing EMR. For example, build a medical record that allows patients to see his data [17]. So patients do

not lose their medical records when they exchange physicians, clinics, or hospitals. ICT has the potential to dramatically change the existing processes in the medical domain [18], this has led to resistance in the implementation of ICT in the medical world. The main problems and constraints on the implementation of medical records are physicians and other health professionals who are required to make medical records in accordance with their competence are not fully aware of the benefits and usefulness of medical records. both in health care facilities and individual practice. Resulting in incomplete, unclear, not on time, and incomplete medical records[19].

The emergence of ethical dilemmas on the application of information technology in the field of health. The ability to store and transfer confidential patient information data raises serious concerns about security and privacy issues [4][20]. Several ways to ensure privacy in medical data have been developed and implemented, from encrypting data to using Bar codes and QR codes for medical data exchange [21]. The unification of mobile and cloud technologies for health data will help many parties [22]. The storage of health data in the cloud can provide benefits, including cost savings, flexibility, ease of administration, and data security [23]. But the challenge of integrating mobile EMR and cloud lies in technical aspects such as Synchronization data, Management of Bandwidth Usage, and Security Risks [24].

6. CONCLUSION

We have implement and evaluate a Individual Physician Practices EMR for General Practices or Family Medicine Clinic. Based on the evaluation results, the Individual Physician Practices EMR system we have developed meets the functional requirements related to electronic medical records. Development of electronic medical records system could be part of the effective adoption of ICT in the medical field in Indonesia. There is still a long way to go, such as the need to build an integrated system of electronic prescriptions and queuing systems of patients. there are challenges from both technological and social aspects. For example, issues of security and privacy, resistance to the use of ICT in the medical field, as well as ensuring that physicians, medical personnel, and patients are willing to use the system continuously.

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