Jurnal
Teknologi

Full Paper

THE DESIGN OF MOBILE PERSONALISED HEALTH RECORDS

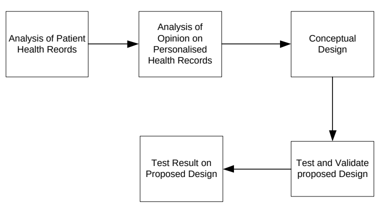
Mohd Khanapi Abd Ghani[a*], Farah Aris[b]

[a]Biomedical Computing and Engineering Technologies (BIOCORE) Applied Research Group
[b]Faculty of Information and Communication Technology, University Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

Article history
Received
15 May 2015
Received in revised form
1 July 2015
Accepted
11 August 2015

*Corresponding author
khanapi@utem.edu.my

Graphical abstract



Abstract

Pervasive Electronic Health Record provides important medical history record for an individual within a healthcare system. By using pervasive storage devices, patient's health records can be accessed electronically by authorized healthcare providers and healthcare professionals in the right place at the right time. However, the research found that not all healthcare practitioners are ready to adopt this approach and mobile technology into their daily work while providing healthcare services to the patients. This is important indicators to be acquired before implementing the technology in the real environment of healthcare. The aim for this paper is to identify the crucial clinical dataset to be captured and viewed by the healthcare professionals and important design components for mobile personalized health records. The input will indicate that the healthcare professional tend to use the technology. In addition, the collected datasets could be used as input to design mobile personalized health record application.

Keywords: Mobile health, personalised health records, pervasive computing

1.0 INTRODUCTION

Electronic Health Records (EHR) have make the medical data in digital format can be exchanged securely and accessible by authorizes users[1]. EHR is important as it can show an accurate, up to date and complete patient's healthcare records. As a result, medical practitioners can easily and effectively diagnose patients, reduce medical errors and enhance patient and medical practitioners' interaction and communication with patients. The use of EHR during doctor-patient episodes could provide more reliable and accurate patient medical information for future reference. EHR can also increase privacy and security of patient data and can improve productivity of medical practitioners as they do not require to re-key in patient biodata and perhaps read the many style of hand-writing of other practitioners [2].

According to [3] personalized health records (PHR) is single person healthcare records on entire lifetime and this record is not restricted to one healthcare provider. PHR is another approach that individual can upkeep by using pervasive storage devices [9]. In Malaysia healthcare system, patients are freely to visiting healthcare centre across the country as long as they feel comfortable and easy to be accessed [10]. This is due to change of workplace, home address, preferred doctor, or even because of financial issues.

EHR is normally resided and maintained by healthcare provider and the certain procedure and policy is needed to be followed by the health workers if the information to be exchanged. Exchanging EHR across healthcare providers or healthcare professionals are one of the standard protocol need to be adhered. Even if patients managed to exchange their medical data to another institutions not all EHR have to be shared[3]. Therefore, a study needs to be conducted in order to identify which biological and clinical data are important to be captured and viewed.

The aim for this paper is to identify the crucial clinical dataset to be captured and viewed by the healthcare professionals. The input will indicate that the healthcare professional tend to use the technology. In addition, the collected datasets could be used as input to design a mobile personalized health record application.

2.0 OVERVIEW OF MOBILE COMPUTING

One of the concepts of PHR is it can accessible anywhere and anytime [3]. This concept is the same with the pervasive computing or also known as ubiquitous computing. The concept of pervasive computing is having a computer embedded on everyday life items such as watch, clothes, smart phone, tablets and etc. [4]. Another definition of ubiquitous computing is that as having a multiple computers available in the physical environment without visible the computers to users [5]. The aim for the pervasive computing is achieving the aims of accessible anywhere and anytime. PHR and pervasive computing could be collaborated as it both needs to achieve the accessible anywhere and anytime concept.

Mobile computing can be considered as pervasive computing. Earlier days, mobile phones only used as communication devices, user only can call and text message to other phones. Nowadays users can even access website from their mobile phones and this show that the computers have been integrated into mobile phones. This shows that mobile computing is a part of pervasive computing [6].

3.0 THE NEED FOR PERVASIVE HEALTH RECORD IN HEALTHCARE SERVICE

Pervasive computing is often mentioned in the context of improving healthcare. By way of example, pervasive computing in healthcare involve consumer monitoring devices such as blood pressure cuffs and glucose meters that can upload data to Electronic Medical Records (EMR) application system for collection and dissemination to healthcare caregivers. By collecting patient health records in setting more varied than doctor's offices, healthcare providers hope to better understand the many facets of patient's daily live and then modify therapies to the individual [4].

Portable devices and wireless technology applications in healthcare can be recognized as both emerging and enabling technologies that have been applied in various countries for improving patient care services. For example, a variety of wireless technologies such as mobile computing, wireless networks and global positioning systems (GPS) have been applied to ambulance care in Sweden [5] and emergency trauma care in the Netherlands [6].

With the emergence of information and communication technologies (ICT) and healthcare practices, there is now a variety of daily used items upon which medical records can be stored and displayed. These include items such as universal serial bus (USB) flash drive, personal digital assistants (PDAs), mobile phones, smart cards and laptops which are readily available at all times [2], [12]. When applied to a healthcare context, these devices are useful for continuity of care purposes such as storage for health records and clinical decision support systems.

In the context of a typical episodic doctor-patient consultation, a substantial portion of the healthcare provider's time is spent in obtaining the patient's medical history and subsequently recording, dictating, transcribing and arranging the information in an organized manner before a diagnosis can be made or before an appropriate treatment can be prescribed and administered [3].

If the patient needs to be referred to another medical provider for an expert opinion or second opinion, the entire procedure of information collection may have to be repeated; any necessary pathological (and perhaps radiological) data collection process is a laborious task, one which cannot be delegated to another healthcare professional [7]. Crucially, the absence or incompleteness of such data may lead to inappropriate diagnosis and treatment or one that is contrary with the person's physiological condition, for example allergies [8].

Pervasive health records are therefore important for continuing care and these efforts are currently progressing in many countries such as Canada, the UK and countries in mainland Europe [9]. The government of Canada is committed to the development of web-based interoperable enterprise health records solution by integrating approximately 40,000 existing health information systems in use across the country [10]. This is to enable the health records of patients to be available and accessible anywhere at any point of time.

It can be learned from the above discussions that disparate health records and health information systems may not be sustained in the long term. Healthcare will not be improved if the services are still episodic and if access to health records is always restricted within a healthcare facility and an application system. Pervasive computing would enable the disparate EHR system to be integrated through pervasive health records that could interact with smart phones anywhere at any point of time.

4.0 METHODS

4.1 Domain and Data Requirement Analysis

The research was done through a case-study approach conducted at health centre Universiti Teknikal Malaysia Melaka. Doctors, Medical Assistants, Nurses and Pharmacists were interviewed for collecting important dataset for patient demographic and clinical record used during doctor-patient encounter. The questionnaires have been distributed to 43% female and 14% male healthcare worker, 14% female doctor and 7% female and 22% male medical assistance. Demographic data are as follows, age range 20-30 with 14% female and 22% male; age range 31-40 with 36% female; age range 41-50 with 14% female; and age range above 51 with 14% male.

The existing clinical information system was also been reviewed for providing important inputs in designing the proposed M-PHR.

The structured questions have been distributed to sixteen respondents and the feedbacks have been received and analysed. The questionnaire items have been divided into 3 important parts. The first part of the questionnaire is about the demographic data of the respondents. The second part is the respondents' opinion about pervasive healthcare records and the third part of the questionnaire is the opinion of respondents regarding important EMR datasets to be captured and viewed for diagnosing patients.

The results will be collected based on the frequency of each answer in every question. The table will be plotted based on the percentage on each answer. The equation to calculate the percentage is shown as follow.

$$percentage(\%) = \frac{frequency}{\sum respondents} x100\%$$

4.2 Analysis of Clinical Dataset

The data collection for analysis of clinical dataset was collected from two sources through case study done at UTeM Health Centre and secondary data collected from previous study done by [11]. The two inputs will be compared and the similarity of opinions will be used for drafting the crucial datasets.

4.2.1 Primary Data Collection: Case Study

The objective of the primary data collection was to investigate the opinion of health workers regarding important datasets to be viewed for treatment purposes. There were sixteen respondents involved in the interview and the questions focus on seven crucial datasets include demographic information, medical history, family history, vital sign, medication and previous treatment as depicted in Figure 1.

It was noted form the interview that all health workers agree the seven crucial clinical datasets very important to be seen during doctor-patient consultation. It was also noted that these information would help them a lot for providing right advice and medication plan on problem suffered by the patient.

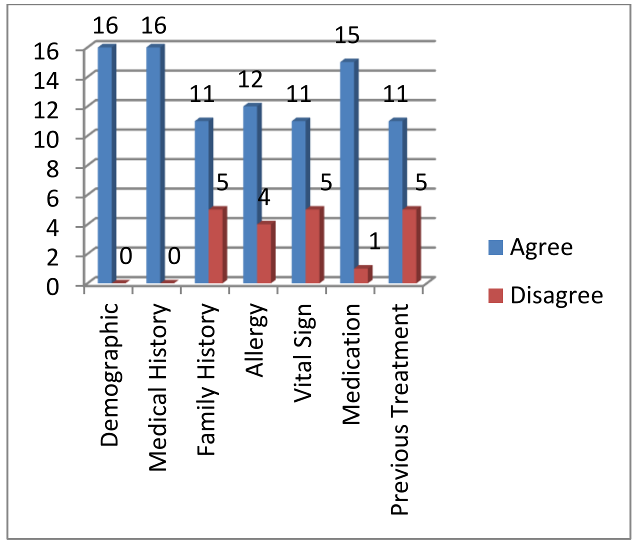
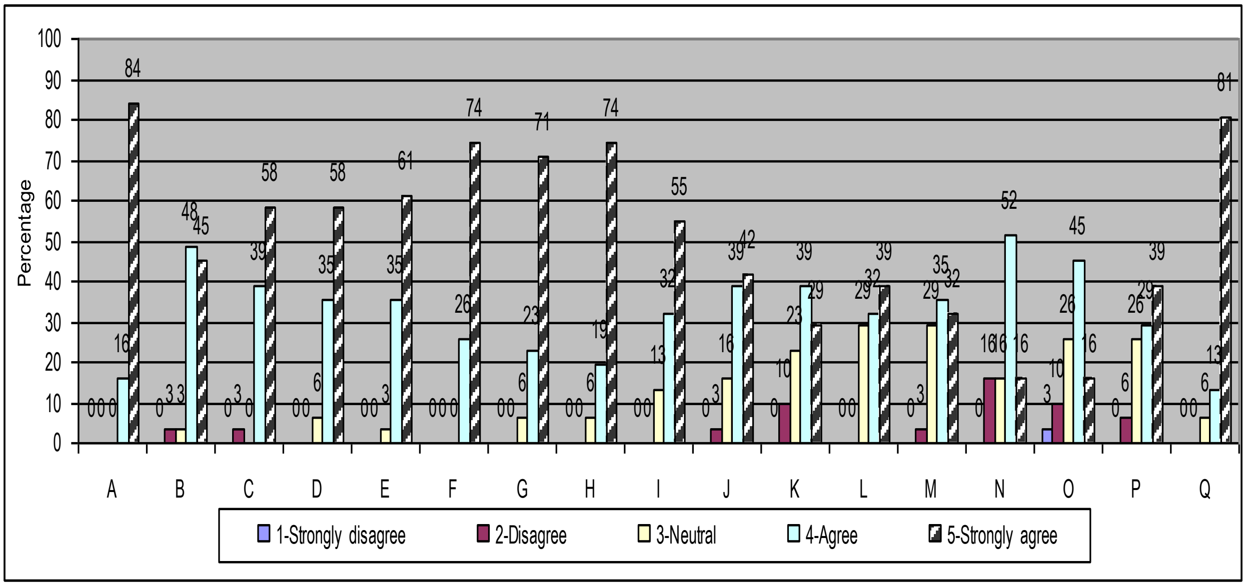


Figure 1 Health workers opinion regarding patient medical history to be viewed during consultation

4.2.2 Secondary Data Collection

Based on the research conducted by [11] regarding patient's medical history that could be important to be viewed during doctor-patient consultation, the doctors agree that all of the information are crucial for helping them in diagnosing patient's problem and providing the right treatment and accurate medication. Based on findings given in Figure 2, the doctors ranked diagnosis/problems, allergies information, lab test result, radiology report, medication information, complaints information, symptoms, vital signs, family history, social history, date of previous visit and onset date of diagnosis (see column A, C, D, E, F, G, H, I, J, L, P and Q) as very important. They elaborated that these information provide critical evidence and knowledge on patient's health condition in the past. Such information could give the doctors the ability to carry out better clinical prognoses and provide accurate treatment for the patients.

Based upon analysis of the clinical dataset mentioned in section 4.2.1 and 4.2.2 above, it was confirmed that only several clinical information are important to be captured and viewed during doctor-patient episode. Among the crucial information requires by the doctors (similar answer between Figure 1 and Figure 2) include medication history (diagnosis & sympthoms), family history, allergies, vital sign, medication and previous treatment. This information provides the answer on what are the important datasets to be captured and viewed by doctors.



A. Diagnosis/problems
B. Blood information
C. Allergies information
D. Lab test result
E. Radiology report
F. Medication information
G. Complaints information
H. Symptoms
I. Vital signs
J. Family history
K. Immunisation
L. Social history
M. Disability information
N. Previous doctor attending to the problem
O. Previous healthcare facility
P. Date of the visit/episode
Q. Onset date of diseases

Figure 2 The list of patient medical history to be viewed by the doctors during consultation [11]

4.3 Opinion on the important of Personalised Health Records

The data collection was conducted by way of structured interview with sixteen health workers at University Teknikal Malaysia Melaka (UTeM) Health Centre. The objectives of the interview are to get the opinion of medical practitioners regarding with pervasive health records. There are three types of question include i) Question 1- Opinion whether the patient will get benefits if they keep their own health records close to their possession; ii) Question 2 - Opinion on whether the health workers agree patients should keep their health records; iii) Question 3 - Opinion on whether personalized health records would speed-up diagnosis process and assist doctors to make accurate advice on medication to be consumed.

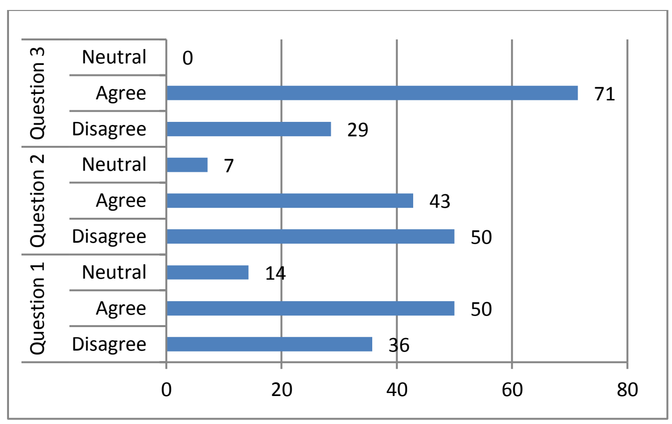


Figure 3 Summary of Opinion on Personalised Health Records

The findings and evidences obtained from the primary data collection shows that seamless and continuous access to patient health records was critical and crucial. This fact was supported from the findings during the primary data collection include; approximately 50% agreed that the patient will get benefits if they keep their own health records close to their possession. However, the remaining 36% and 14% of the respondents said disagree and neutral. This is due to the opinion that not all of our communities have adequate knowledge in mobile technology.

Additional findings was that an approximately 50% of the doctors disagreed that patients should keep their health records. Nevertheless, the remaining 43% and 7% of the respondents said agreed and neutral. The reasons given by the 50% disagreed respondents were due to technology awareness that should be given to the communities before the personalised health records could be implemented. More or less, this reason has relationship with question 1.

When the respondents were asked whether the personalized health records would speed-up diagnosis process and assist doctors to make accurate advice on medication to be consumed, 71% of the respondents said agree. This showed that the healthcare professionals still require improvement by way of having seamless and continuous access to patient health records at right time and place as they could predict patient problems fast and accurately. The remaining 29% of respondents said disagreed and 0% neutral respectively. This scenario showed that the outpatient clinics require improvement by way to enforce all healthcare centres use standardised process to upkeep personalised health records. A proper way in is crucial for ensuring the medical history can be accessed accordingly and promptly in future.

Based on the results of question 1, 2 and 3 in Figure 3, shows that healthcare professionals agree on the concept of personalized health records and to allow patients to keep their important health records. However, the pre-implementation training and technology awareness shall be conducted for avoiding misused and inadequate understanding to the proposed technology. This statement can be extended by the opinion of the respondents saying that with patient keeping their own medical data it can make good health awareness to them. On the other hand, some of the respondents raised their concerns regarding the issues of data privacy and confidentiality that should be addressed before the implementation of the technology.

The above statement was also supported by physician workflow study conducted by U. States *et al*. [7]. The report shows that with using electronic health records, 74% says that it increases overall patient care and 30% says they ordered fewer tests due to lab results' availability. It showed that by having PHR readily for doctors, it can increase the overall patient care and in turns decrease the cost from doing the same lab tests.

4.4 Implementation of Mobile-Personalized Health Records (M-PHR)

This section starts with the description of the use cases and continues with the description of the components of the architectural framework of M-PHR.

A. M-PHR Use Case

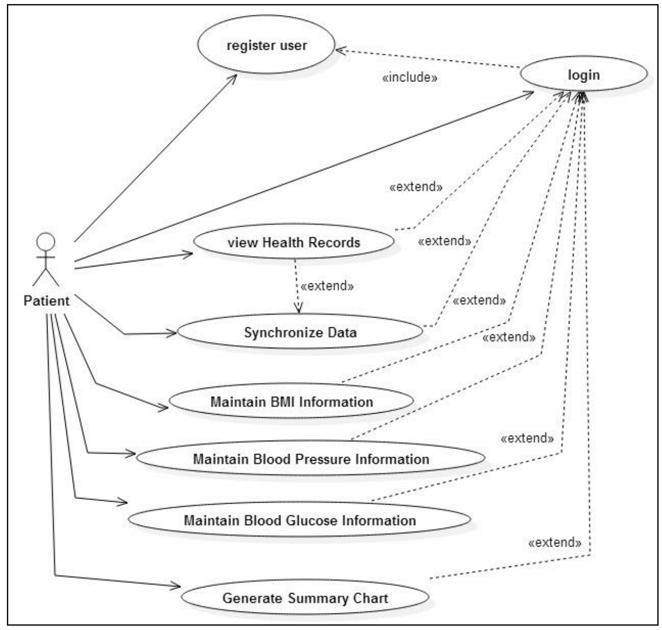


Figure 4 M-PHR Use Case View

Based on case study done at health facility centre, the use cases were identified for supporting the system implementation and to mitigate those issues described in the previous section. The main actor involved in the use case is patients. The patients are the main user interacting with the system.

M-PHR will perform several tasks that mainly displaying patient health records history and adding the vital sign data. This mobile app has several sub-modules include health records, BMI App, summary chart and help functions. Basically M-PHR consists seven use cases:

- Register User:
  This use case is to sign-up and register new person. The person shall be participated in any healthcare centre so that their medical history could be captured during doctor-patient encounter and their health records history could be viewed seamlessly.

- View Health Records:
  The use case View Health Records will display previous patient health records include patient information, blood pressure and heart rate, height

and weight, symptoms, medication, medical history and family history.

- Maintain BMI information:
  The use case will calculate BMI value based on the height and weight that have been input by the patient.

- Maintain Blood Pressure information:
  The use case will allow the patients to capture their blood pressure reading anytime and anywhere as they wish to monitor their blood pressure level.

- Maintain Blood Glucose information:
  The use case will allow the patients to capture their blood pressure reading anytime and anywhere as they wish to monitor their blood pressure level.

- Generate Summary Chart
  This use case will show a graphical data on vital sign data that is systolic, diastolic, pulse rate, height, weight and BMI.

- Synchronize Data
  This use case synchronise the data that could not send to central system during system offline. The system lookup offline data in local device and upload or transmit them to central database.

B. Architectural Design

M-PHR has three layers of services that are mobile apps layer, web server layer and backend layer as depicted in Figure 4. The mobile apps layer will be used for the patients to retrieve and add important vital sign information such as blood pressure, blood glucose and weight into database resided in central server. M-PHR is divided into two components that consist of interface component and processing component. Interface component responsible to interact with the system. The interface component used HTML (Hypertext Markup Language) and JQuery Mobile for graphical user interface purposes. Second component of M-PHR is processing layer where JavaScript is used to fetch and save the data into SQLite resided in local database storage. This role will be activated once the system get offline message from the system. Processing component is also responsible for requesting and sending the data to central server.

The Web Server layer acts as bridge for connecting the mobile application to central database server. The mobile application via JavaScript will send AJAX (Asynchronous JavaScript and XML) request to M-PHR's Web Server. M-PHR web server is divided into three components include decode and encode, processing and connection. Decode and encode component is a servlet application receive AJAX connection via JavaScript. M-PHR web server will convert the requested data into JSON (JavaScript Object Notation) format and the connection between mobile M-PHR and M-PHR server will be established and the data will be encode or encode. Processing component is Java class responsible for sending decode data to the connection layer of M-PHR. Connection component then establish a contact with RMI library for authorising data requisition and authorisation.

The third layer namely backend layer responsible for all type of data requisition located in the central server. The server manages data for M-PHR system and legacy clinical support system (CSS). M-PHR system will allow the user to retrieve or add the authorised and encrypted data from M-PHR database. Figure 5 overview the architectural design of M-PHR.

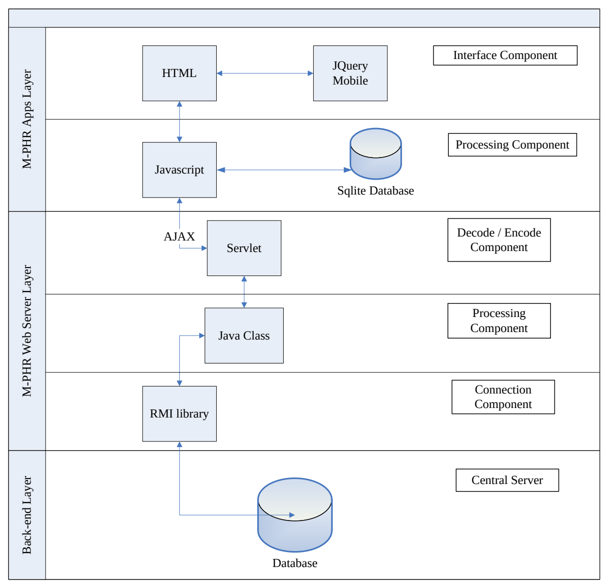


Figure 5 High Level Architectural Design

C. Application Process

i) Sequence Diagram for Login and Register

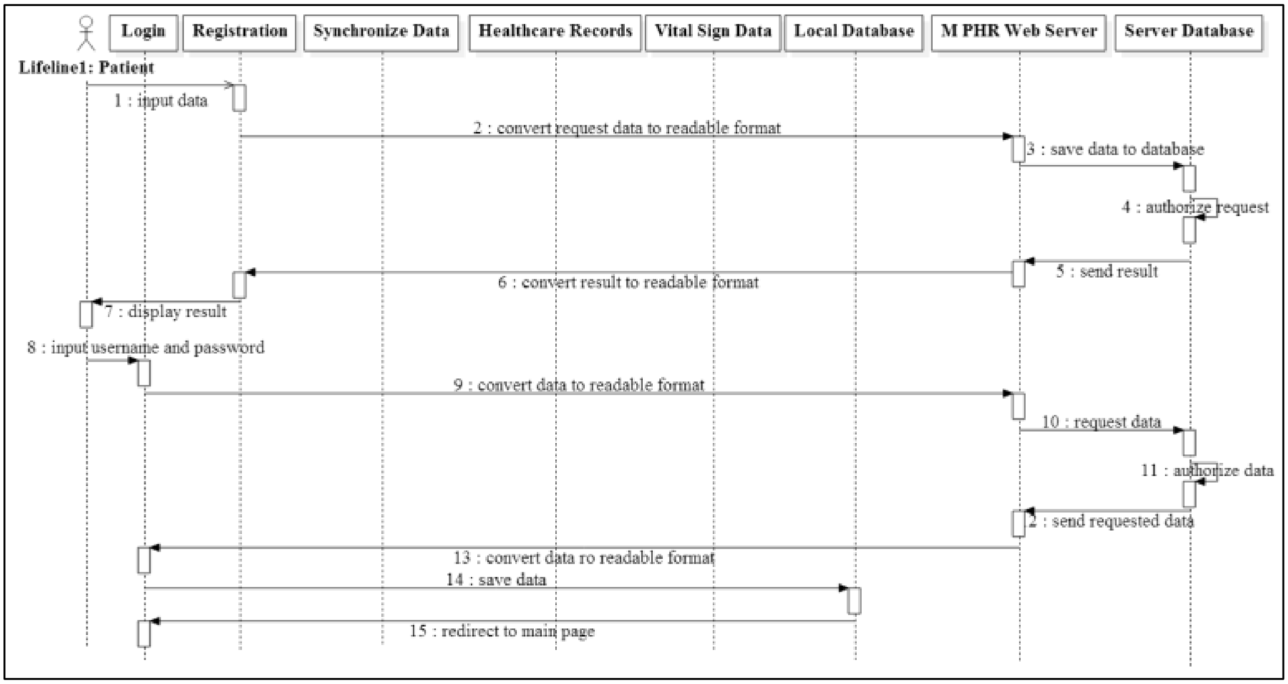


Figure 6 Sequence Diagram Login and Register

Figure 6 show the process of registration and login. User will first input the required data for registration; the data will be converted to JSON format and will be send to web server. From web server, the data will be saves on the server's database. After the request has been received, a result will be sent back the web server. Web server convert the result back to JSON format and sent it back to M-PHR and display the result to user.

After register, user will input the username and password. The data will be converted to JSON format and will be send to web server. From web server the requested data will send to server's database. After the request have been authorize, the server will send back the requested data to web server. The web server will convert the data to JSON format and send it back to M-PHR. The requested data will save on local database and user will be redirect to main menu page.

ii) Sequence Diagram for View and Add Vital Sign

Pre-requisites: User have been logging in to M-PHR.

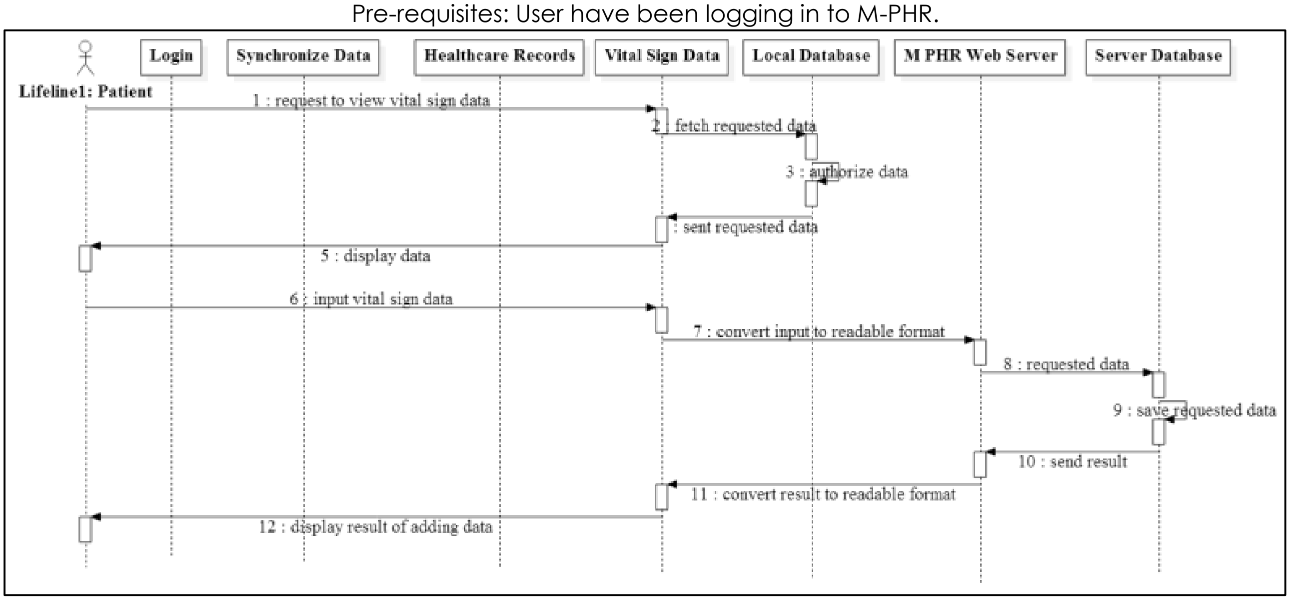


Figure 7 Sequence Diagram for View and Add Vital Sign

Figure 7 show the process of viewing and adding vital sign data. User will request to view the vital sign data. Data will fetch from local database. After authorize the request, local database will send the requested data and the data will be displayed.

User will input the vital sign data for adding the vital sign data. The requested data will send and converted to JSON format at web server. The web server will send the requested data to server's database. At server's database, the data will save and the server's database will send result of adding the data. The result will be send to web server and from there, the result will be convert to JSON format and the data will be send back the M-PHR. User will be inform the result of adding the data.

iii) Sequence Diagram for Synchronize Data and View Healthcare Records

Pre-requisites: User have been logging in to M-PHR.

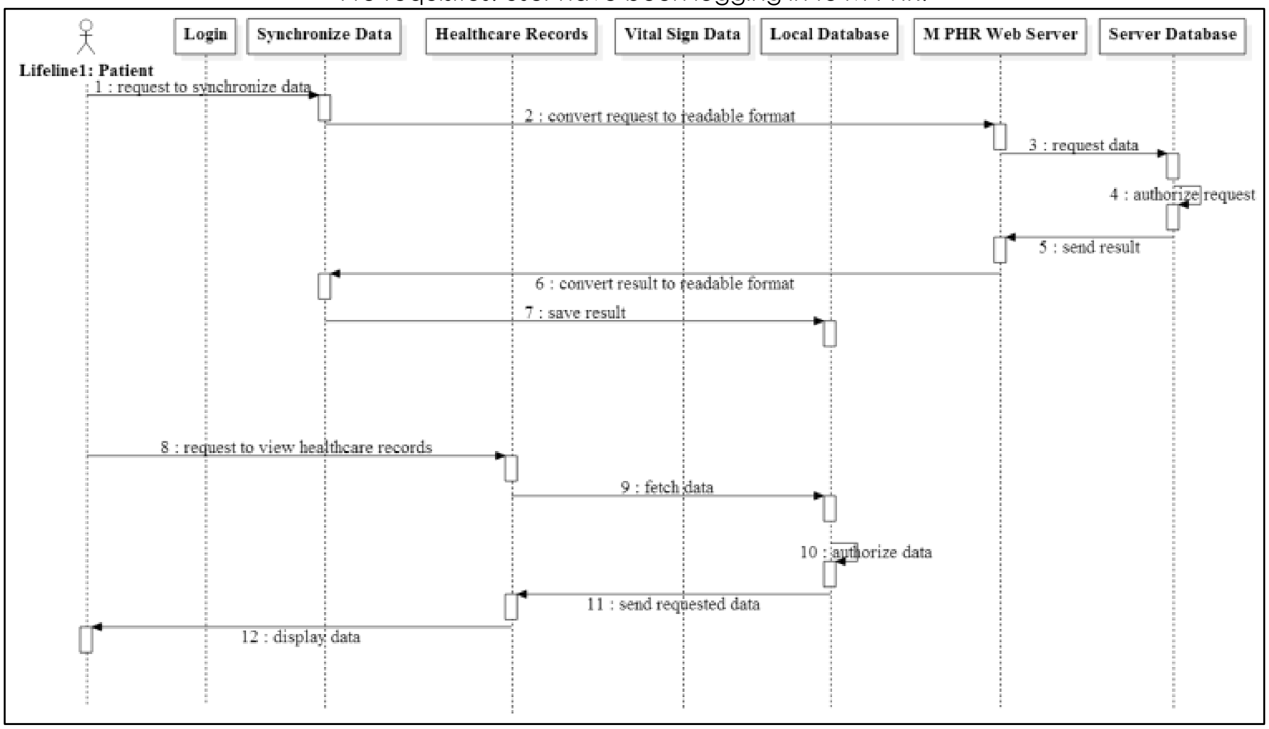


Figure 8 Sequence Diagram Synchronize Data and View Healthcare Records

Figure 8, shows the process of synchronize data and view healthcare records. User will request to synchronize data. The request will convert to JSON format and will be send to web server. Web server will send the request data to server's database. The server's database will authorize request and will send the result back to web server. The web server will convert the result to JSON format and send the result to M-PHR. The result will save at the local database.

After synchronizing the data, to view healthcare records user will request to view the healthcare records. The data will request to local database. The local database will authorize the request and send back the result of requested data. The result will display to user.

5.0 RESULTS AND DISCUSSION

A. Crucial clinical datasets

It was noted from the findings that the healthcare professional have similar opinion on important clinical datasets to be viewed during doctor-patient consultation. This shows that the patient health records required by the doctors should be simplified and standardised for storing and accessing into/from mobile devices such as smartphone and tablets. In fact, the important version of health records could facilitate the doctor to maintain the personalised health records continuously within the limited time allocated for each patient in the consultation room. This would enhance the prompt access to patient health records and to ensure the personalised health records could be created and stored in limited storage of mobile devices. These datasets will be used for M-PHR system prototype as describe in the next section.

B. Mobile personalised health record components

The design of M-PHR system supported the need for personalised health records such records provide invaluable information to healthcare professionals during doctor-patient encounters. The four important functionalities designed for M-PHR include view health records, maintain blood pressure information, maintain blood glucose information and BMI information among the frequently application used and monitored by the user and healthcare professional. The research concluded that a simplified version of patient health records should be established for supporting the development of personalised health records. By judicious use of M-PHR system, a pervasive EHR could easily be accessed and created for use in mobile devices. Healthcare services provided to the patient could therefore be improved where doctors have improved knowledge and prompt access to patient health records to provide seamless and more effective treatment to patients.

Figure 9 until Figure 14 shows the interface of M-PHR apps. Figure 9 shows the interface to view health records; Figure 10 shows the interface of blood pressure and heart rate data; Figure 11 shows the sample of clinical data; Figure 12 shows the interface of graphical data for glucose; Figure 13 shows the interface of graphical data for blood pressure; and Figure 14 shows the interface of graphical data for BMI.

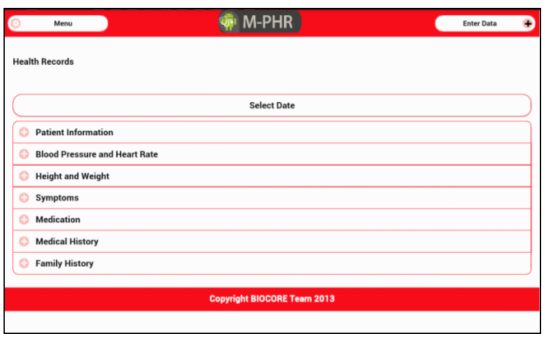


Figure 9 Main Menu of M-PHR apps

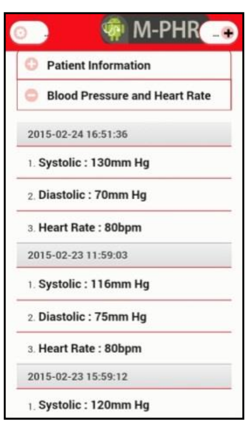


Figure 10 View blood pressure and heart rate data

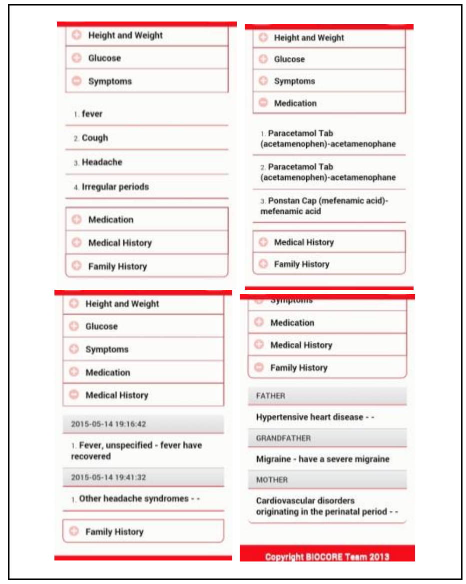


Figure 11 View Health Records History

Figure 12 Blood Glucose Monitor

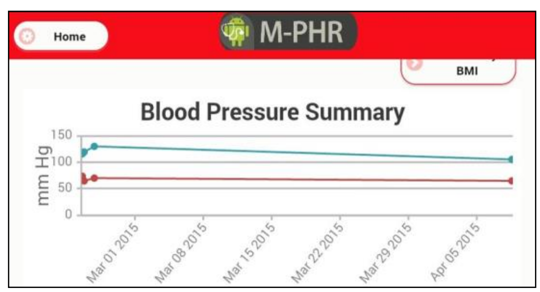


Figure 13 Blood Pressure Monitor

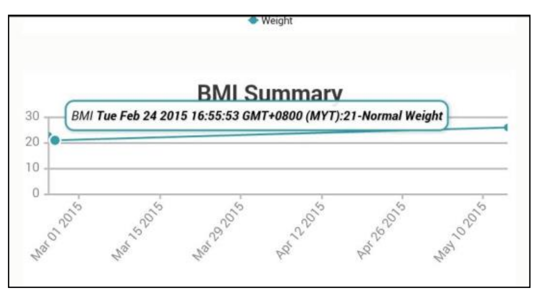


Figure 14 BMI Monitor

6.0 CONCLUSION

To achieve two objectives that are the opinion of healthcare practitioners about important components of mobile personalized health records system and to identify important EMR datasets that related and meaningful data to be captured and viewed by the doctors, interviews have been conducted to health workers of Healthcare Centre of Universiti Teknikal Malaysia Melaka (UTeM). The data collected had shown that healthcare professionals agree of allowing patients to keep their own medical data. Furthermore, the respondents have listed out the most important and meaningful health record datasets to be viewed and captured by healthcare professional during doctor-patient encounter.

In addition, M-PHR proto-type system tested by the healthcare professional showed that this simple Apps provide invaluable tools for patients to upkeep their important health information close to their possession and prompt access when required.

However, the current design of M-PHR would only mitigate for Android users which will bring the issues of portability and platform dependent. As such, further research on multi-users dependent is crucial to be incorporated and implemented.

Acknowledgement

We would like to express our gratitude to Universiti Teknikal Malaysia Melaka (UTeM), BIOCORE Lab for the knowledge and helping in this study. Thank you to UTeM Clinic's healthcare personnel for giving time and cooperation in this survey.

References

[1] K. Häyrinen, K. Saranto, and P. Nykänen. 2008. Definition, Structure, Content, Use and Impacts of Electronic Health Records: A Review of the Research Literature. *Int. J. Med. Inform.* 77(5): 291-304.

[2] HealthIT.gov. 2014. What Are the Advantages of Electronic Health Records? 2014. [Online]. Available: http://www.healthit.gov/providers-professionals/faqs/what-are-advantages-electronic-health-records. [Accessed: 13-Aug-2014].

[3] Markle Foundation. 2003. The Personal Health Working Group Final Report.

[4] Pervasive Computing. *webopedia*. [Online]. Available: http://www.webopedia.com/TERM/P/pervasive_computing.html. [Accessed: 15-Jul-2014].

[5] M. West and C. College. 2011. Ubiquitous Computing. In *ACM Conference on Computer Science*. 175-181.

[6] D. Saha and A. Mukherjee. 2003. Pervasive Computing: A Paradigm for the 21st Century. *IEEE*.

[7] U. States, D. Woodwell, K. Palso, and E. Rechtsteiner. 2012. Physician Adoption of Electronic Health Record Systems.

[8] HealthIT.gov. 2013. What information does an electronic health record (EHR) contain?" 2013. [Online]. Available: http://www.healthit.gov/providers-professionals/faqs/what-information-does-electronic-health-record-ehr-contain. [Accessed: 13-Aug-2014].

[9] Abd Ghani, M. K. and Lee, C. W. 2011. *The Design of Flexible Pervasive Electronic Health Record (PEHR)*. In: IEEE Colloquium on Humanities, Science and Engineering Research (CHUSER2011), 5-6 December 2011, Penang, Malaysia.

[10] Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Wickramasinghe, N. S. 2008. Electronic Health Records Approaches and Challenges: A Comparison between Malaysia and Four East Asian Country. *International Journal of Electronic Healthcare.* 4(1): 78-104.

[11] Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Wickramasinghe, N. S. 2010. Critical Analysis of the Usage of Patient Demographic and Clinical Record During Doctor-Patient Consultations: A Malaysian Perspective. *International Journal of Healthcare Technology and Management.* 11(1/2): 113-130.

[12] MK Abd Ghani, RK Bali, RNG Naguib, IM Marshall, AS Shibghatullah. 2007. The Design of Flexible Front End Framework for Accessing Patient Health Records Through Short Message Service. *IEEE Applied Electromagnetics, 2007. APACE 2007. Asia-Pacific Conference on*. 1-5.