

Application Paper

## Development of a Personal Health Record System Based on USB Flash Drive and Web Service

Hye-Jeong Jeong<sup>1,3</sup>, Namhyun Kim<sup>1,3</sup>, Hasuk Bae<sup>2,3</sup>

Dept. of Medical Engineering, College of Medicine Yonsei Univ.<sup>1</sup>,  
Dept. of Rehabilitation Medicine, School of Medicine, Ewha Womans Univ.<sup>2</sup>,  
Center for Construction of Uniquitous Medical Hub<sup>3</sup>

### Abstract

**Objective:** The development of information communication technology (ICT) and the demand for managing the healthy lives of individuals are accelerating the informatization of the health and medical field. Considering this environment and the needs of the individual, this paper has designed and developed a web and mobile storage device-based personal health record (PHR) system that individuals can manage by themselves anywhere, anytime, whether on-line or off-line. Based on the experience of implementing the system, its development method, results, and relevant technical issues are described. **System Design and Description:** This system is implemented to manage PHR, including vital signs and ingested/consumed calories for a lifetime by connecting a PHR-integrated web server to each hospital's information system, and the PHR programs installed in the individual's PC or USB flash memory drive. To achieve this, an interface module, web server system, and PHR viewer program for individuals are developed. **Results:** When it is off-line, the PHR program is operated to inquire the data saved in the DB, and the self-measured information can be inputted. When it is on-line, it calls the web service function to inquire the medical information, including hospital visit history, prescription history, diagnosis result, image inspection result and medical treatment result. **Conclusion:** This system connects home and mobile healthcare to hospitals but minimizes information leakage because the data is not accumulated. By loading a plug & play, PHR viewer to an easy-to-carry mobile storage device, the systems supports a sustainable health management. (*Journal of Korean Society of Medical Informatics 15-3, 341-350, 2009*)

**Key words:** Personal Health Record (PHR), Medical Records, Personal Health Information, Access to Information, USB Flash Drive

**Received for review:** September 7, 2009; **Accepted for publication:** September 22, 2009

**Corresponding Author:** Namhyun Kim, Department. of Medical Engineering, Yonsei University College of Medicine, 134, Sinchon-dong, Seodaemun-gu, Seoul 120-752, Korea

**Tel:** +82-2-2228-1915, **Fax:** +82-2-363-9923, **E-mail:** knh@yuhs.ac

DOI:10.4258/jksmi.2009.15.3.341

## I. Introduction

The increase in the desire for healthy life management and the information empowerment of consumers have fused with the rapid development in information communication technology and it is giving traction to the creation of a new health and medical environment that supports individuals to collect and manage their health information anywhere, anytime, and helps them with prevention and early discovery of diseases. In order to establish the next-generation healthcare system popularly called ubiquitous healthcare, research is actively being carried out on the development of a new platform and customized service that supports collecting, transmitting, processing, storing, and using health information without any space-time restrictions. Health and medical informatization is based on information digitalization. The U.S. Institute of Medicine (IOM) divided the development of electronic medical record (EMR) into five stages: Automated Medical Records, Computerized Medical Record, Electronic Medical Record, Computer-based Patient Record, Electronic Health Record (EHR)<sup>1)</sup>. These days, however, as individual-centered medical care begins to receive more attention, Electronic Health Record is again evolving into Personal Health Record (hereinafter, PHR)<sup>2-4)</sup>.

### 1. Concept of PHR

The PHR is still largely undefined and PHR models are still in their infancy. In 2003 as part of Markle Foundation's Phase I of Connecting for Health, the Personal Health Working Group defined the ideal PHR as: "an Internet-based set of tools that allow people to access and coordinate their lifelong health information and make appropriate parts of it available to those who need it. PHRs offer an integrated and comprehensive view of health information, including information people generate themselves such as symptoms and medication use, information from doctors such as diagnoses and

test results, and information from their pharmacies and insurance companies. Individuals access their PHRs via the Internet, using state-of-the-art security and privacy controls, at any time and from any location. Family members, doctors or school nurses can see portions of a PHR when necessary and emergency room staff can retrieve vital information from it in a crisis. People can use their PHR as a communications hub: to send email to doctors, transfer information to specialists, receive test results and access online self-help tools. PHR connects each of us to the incredible potential of modern health care and gives us control over our own information<sup>5)6)</sup>." According to American Health Information Management Association (AHIMA), "the PHR is a tool that person can use to collect, track and share past and current information about their health or the health of someone in their care. Sometimes this information can save person the money and inconvenience of repeating routine medical tests. Even when routine procedures do need to be repeated, their PHR can give medical care providers more insight into their personal health story. Important points to know about a PHR are that: Person should have access to their complete health information; Information in their PHR should be accurate, reliable, and complete; Person should have control over how their health information is accessed, used, and disclosed; A PHR may be separate form and does not normally replace the legal medical record of any provider<sup>7)</sup>." The PHR as defined by the Key Health Information Technology Terms Project is: "[a]n electronic, record of health related information on an individual that conforms to nationally recognized interoperability standards and that can be drawn from multiple sources while being managed, shared, and controlled by the individual<sup>8)</sup>." HIMSS defines an ePHR in its ePHR Definition and Position Statement by stating, "An electronic Personal Health Record (ePHR) is a universally accessible, layperson comprehensible, lifelong tool for managing relevant health information, promoting health maintenance and assisting with chronic disease management

via an interactive, common data set of electronic health information and e-health tools. The ePHR is controlled, managed, and shared by the individual or his or her legal proxy(s) and must be secure to protect the privacy and confidentiality of the health information it contains. It is not a legal record unless as defined and is subject to various legal limitations<sup>9)</sup>.”

In the event, PHR is the core of consumer-oriented medical service to save medical costs and enhance welfare by managing chronic diseases and preventing diseases while individuals manage their own information related to health for a lifetime and take care health by themselves and support decision making for medical treatment based on the health data accumulated during their lifetime.

## 2. Types of PHR

The previous researchers distinguished a “tethered” PHR (bound to a certain organization) from a “stand-alone” PHR and the ideal “interconnected” PHR.

### (1) Standalone PHR

Standalone systems are generally considered to be those offered via the Web from a commercial vendor. Although an individual may provide access to a provider (or payer) for the purpose of helping to populate a (Web-based) standalone system, more often these systems rely on an individual or family member/caregiver entering information themselves. Such information may be copies of forms from a provider or payer that are scanned into the system or an abstraction from that information. Other formats of standalone PHRs also exist, such as on a flash drive, CD, or smart card; in a computer file with e-faxed or scanned documents; on Medic-Alert-type jewelry; or in an organized hard copy file of provider documentation or a paper-based health diary<sup>10)</sup>. In its simplest form, the PHR is a stand-alone application that does not connect with any other

system<sup>11-13)</sup>.

### (2) Interconnected PHR

The interconnected PHR can be populated with patient information from a variety of sources, including EHRs, insurance claims, pharmacy data, and home diagnostic equipment. Therefore, they can provide both consumers and providers a more complete view of relevant health information. The consumer is an important contributor to the interconnected PHR content and is allowed to enter information into selected areas of the record. Some interconnected PHRs are offered in connection with services related to a health condition or disease and feature patient data integrated with personalized health advice and guidance<sup>14)</sup>.

### (3) Tethered PHR

A tethered PHR is a subset of data compiled by a provider and other healthcare entity. The individual can access and update the tethered PHR. The individual provides his or her health information or sends pertinent documents to the PHR vendor to be filed in the record. These services allow password-protected access to records anywhere, anytime via an Internet connection<sup>15),16)</sup>.

### (4) Integrated PHR

The integrated PHR (iPHR) concept is supported by an increasing number of health information technology advocates because its transformative potential far surpasses the value proposition of the standalone PHR<sup>17),18)</sup>. The major capabilities underlying iPHRs’ potential as a transformative technology. Include patient/provider interactive communication, virtual integration between closed systems, care management, health knowledge promotion, portability, auto-population, and data sharing with authorized patient proxies<sup>19)</sup>.

As a part of the effort to establish an effective and

efficient PHR system, this paper has designed a system that incorporates web and mobile storage devices, and based on the experience of implementing the system, will describe its development method, results, and relevant issues.

## II. System Design and Description

The system pursued by this study is 'integrated' PHR system. This was designed to support both online and offline environment. The purpose of this paper is to provide an individual a lifetime health record and thus help the individual to achieve increased health and disease prevention through self management. Lifetime health record includes not only to medical records produced at hospitals but also bio-information measured from various sensors while at home or during movement such as blood pressure, blood sugar, heartbeat, temperature, SPO<sub>2</sub>, ECG, and body fat, and it presupposes an information exchange network between hospitals and

between sensors and servers. For safe information exchange, users can query patient records from more than one hospital when they want to without accumulating data, and they can also selectively save the queried information to their PC or mobile storage device. For this purpose, web servers were designed to only retain each hospital's index, log, and membership information.

The scope of development and exchanging data of this system is as follows.

### 1. PHR web server

The web server is divided into DB server and application server. It allows data exchange between individual and n hospitals through web service interface module for each hospital. The medical treatment information is not saved in the web server, but the vital sign and calorie information will be saved in the DB server<sup>20</sup>. The hospital information exchange network of this system is as Figure 1.

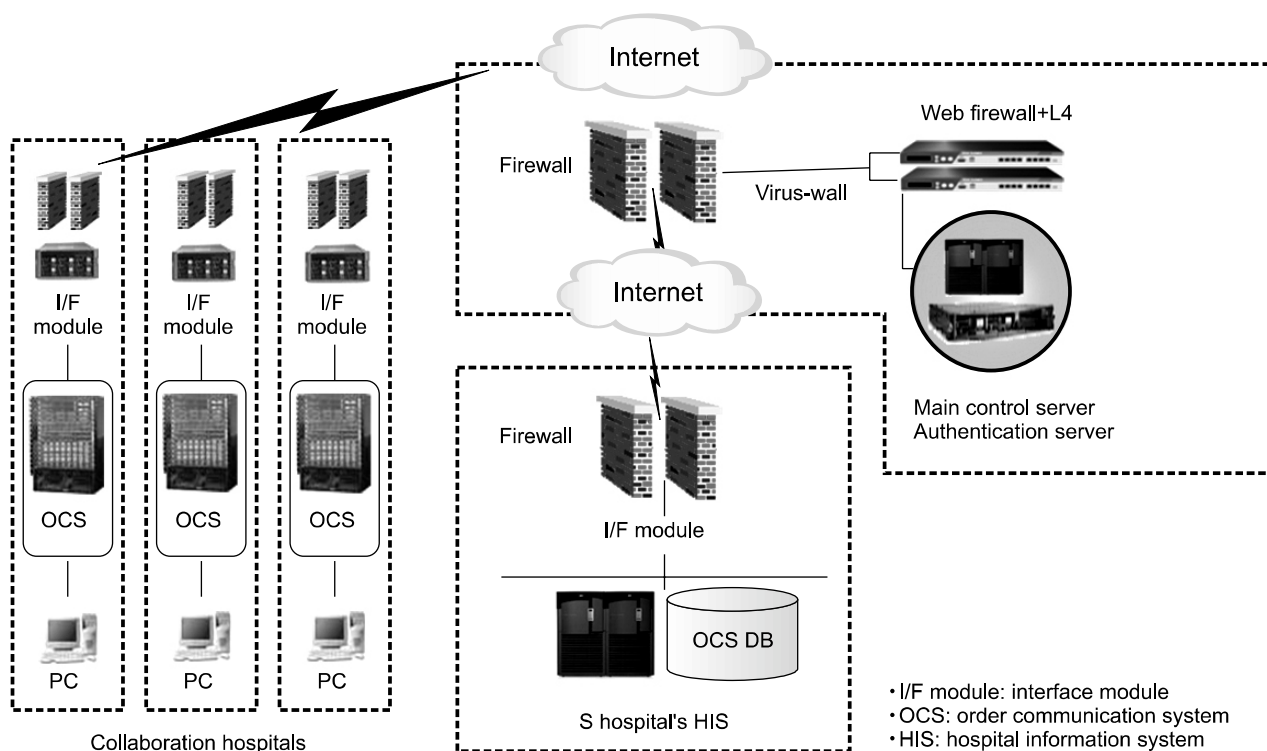


Figure 1. Structure of medical information exchange system.

## 2. Medical treatment information inquiry system

The scope of data which can be inquired by users from more than one hospital is hospital visit history, prescription history, diagnosis result, image examination result, medical treatment result, hospitalization/discharge description, and reservation information. These are reflected by the output of PHR data sets from the previous researchers<sup>21),22)</sup>.

The Figure 2 shows the Data Flow Diagram of the medical treatment information inquiry system.

## 3. Client's PHR program

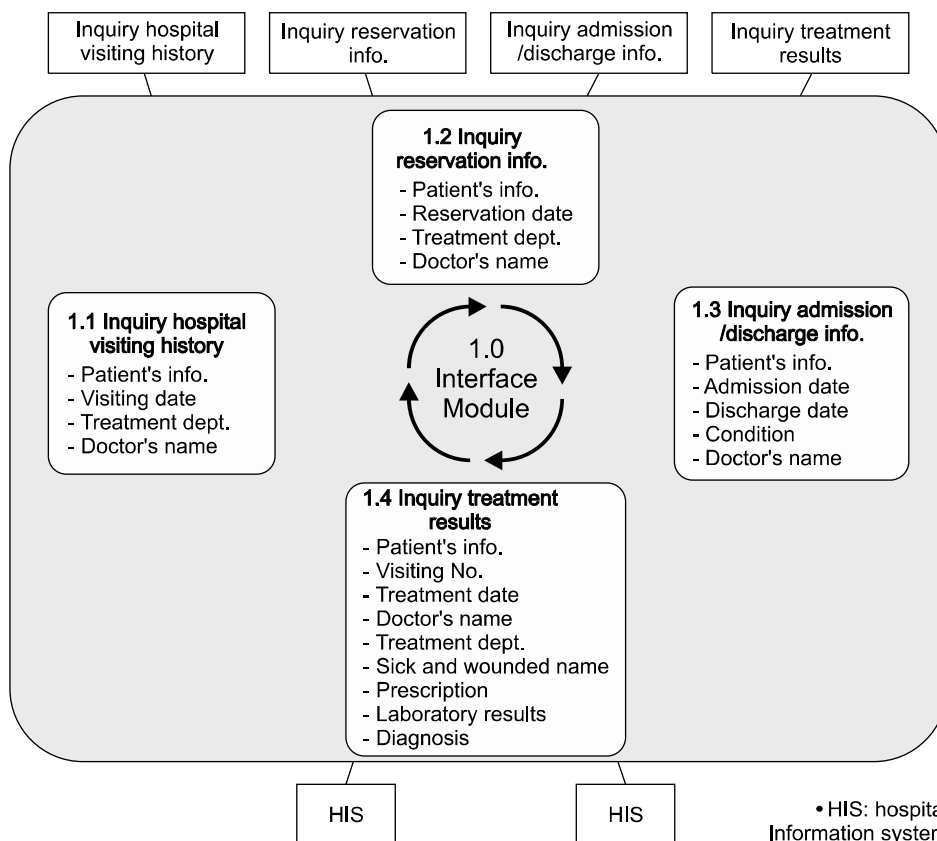
Users can inquire medical treatment information through the PHR program installed in their PC or USB (Universal Serial Bus) flash drive, and save the data into the PC or USB flash drive. Also, it supports mana-

ging chronic diseases and diet through vital signs including blood pressure, blood sugar, pulse, body temperature, SPO2, ECG and body fat, and input, inquiry and management of ingestion and consumption of calories.

## III. Results

### 1. Development environment

Microsoft Visual Studio 2003 was used as server to develop the system in .NET environment, and Microsoft Windows XP Home or Professional operating system with Code gear Delphi 2007 Enterprise (Update 1) was used as client. The SOAP (Simple Object Access Protocol), file compression, and encoding technique based on Microsoft Office Access 2003 database were used. The client program was developed device-independently and not influenced by USB flash drive type.



**Figure 2.** Data flow diagram of interface module.

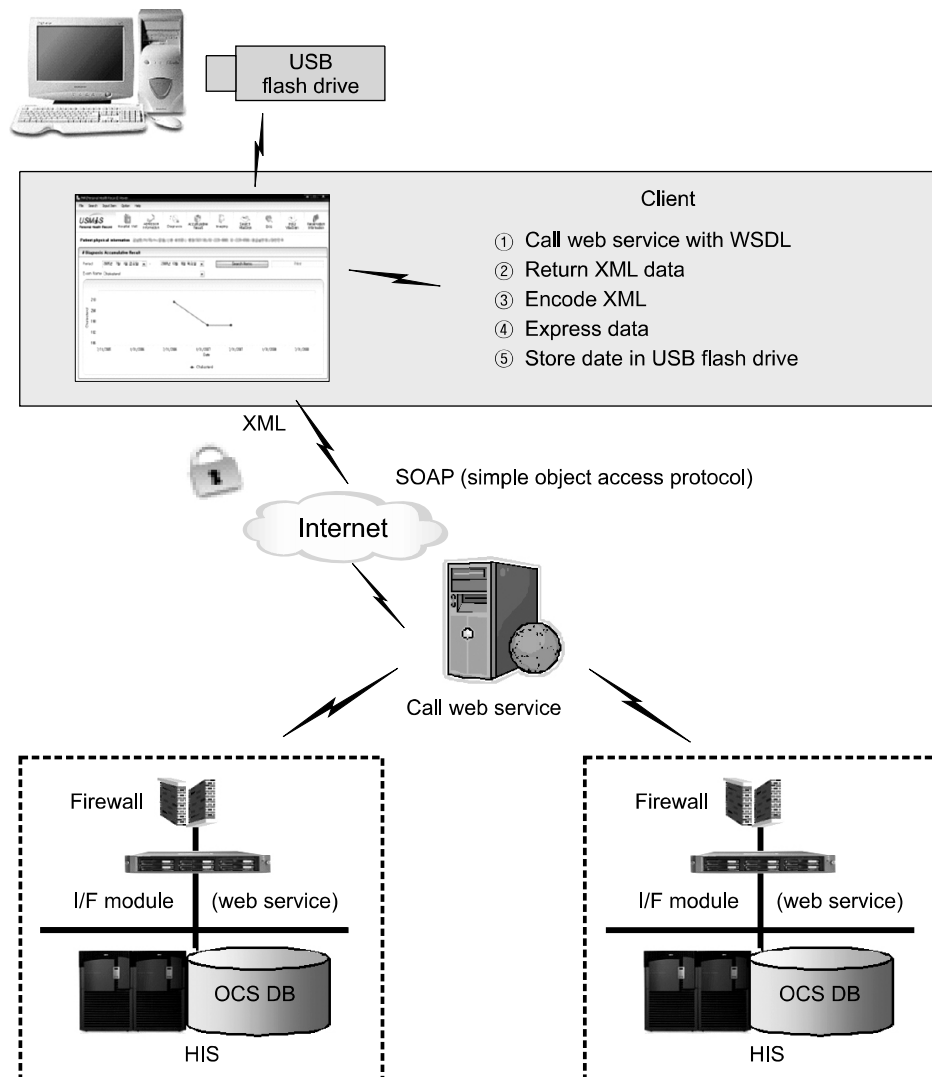


Figure 3. PHR system overview.

## 2. Operating mechanism

The Client uses WSDL (Web Service Definition Language) to call web service. Then XML (eXtensible Markup Language) data is returned, and the transmitted XML is encoded to express data queried by the user and stored in USB flash drive. The mechanism is shown in Figure 3.

The specific operating process of PHR system is shown in Figure 4.

## 3. Data transmission process

The communication process repeats the following steps ①-⑦. ① Information being queried is inputted (e.g. when querying patient record, input start and end dates for the query) and a function is called. ② The called function uses WSDL (Web Service Definition Language) to call the relevant web service function. ③ When it is called, the web service function is carried out using SOAP (Simple Object Access Protocol). ④ As the function is executed, the needed data is queried in the database and results are returned. ⑤ The returned

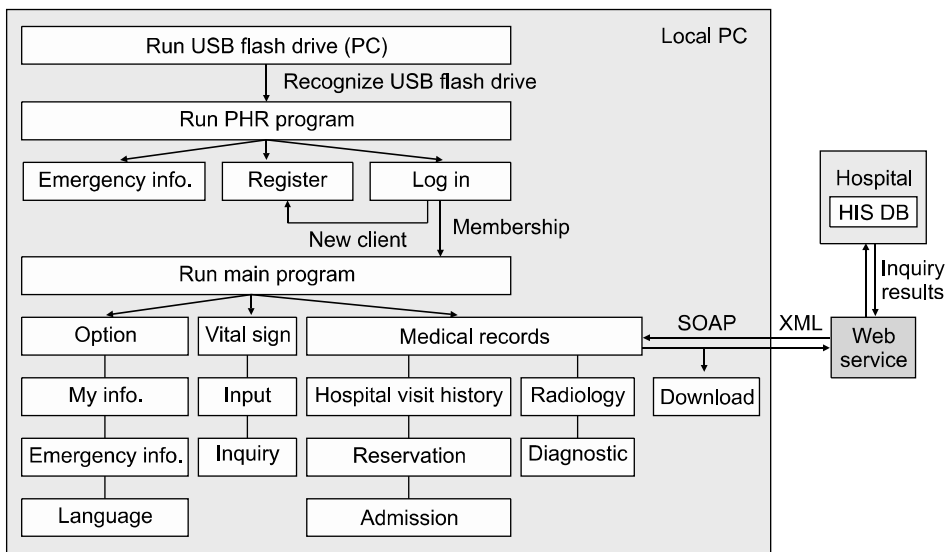


Figure 4. Operating process of PHR system.

results are stored in XML format and, using SOAP, are transmitted to the client that called. ⑥ A parser is used on the transmitted XML to translate them into a dataset format. ⑦ the translated dataset is expressed on a grid. ⑧ When other information is queried, steps ①-⑦ are repeated.

#### 4. Design PHR program user interface

Individuals can connect to a web server and query and download information such as patient record, examination results, and medication prescriptions, and even when they are not connected to a network, they can query their mobile device and input bio-information. To enable users to effectively their PHR when they end up visiting a hospital during an overseas business trip or in an emergency situation, a mobile storage device-based PHR plug & play viewer was developed (see Fig. 5 and Fig. 6). User convenience was considered in allowing accumulated data to be queried using a visual statistical graph according to various search conditions.

#### 5. Personal emergency information

Since the portable PHR program divides the data domain into disclosed domain and non-disclosed do-

main, if the user is under emergency situation, then any one can obtain the portable PHR program and find out the information saved in the disclosed domain (main hospital, contact information of the hospital, the information of the attending physician, blood type, allergy, emergency contact information and information of guardian). Therefore, this allows immediate and precise evaluation and treatment, and this is one of characteristics of this system.

#### 6. Standardization

In order to standardize the exchanged data, HL7 Version 3.0 is applied when inputting and inquiring vital sign, and inquiring the diagnosis inspection to enhance the interoperability of information exchange between heterogeneous systems.

#### 7. Information protection

In order to guarantee the confidentiality, integrity and availability of information, the improvement of information control has been selected as the biggest goal. Accordingly, it was developed to save and manage information in individual PC or USB flash drive according to individual intention instead of accumulating

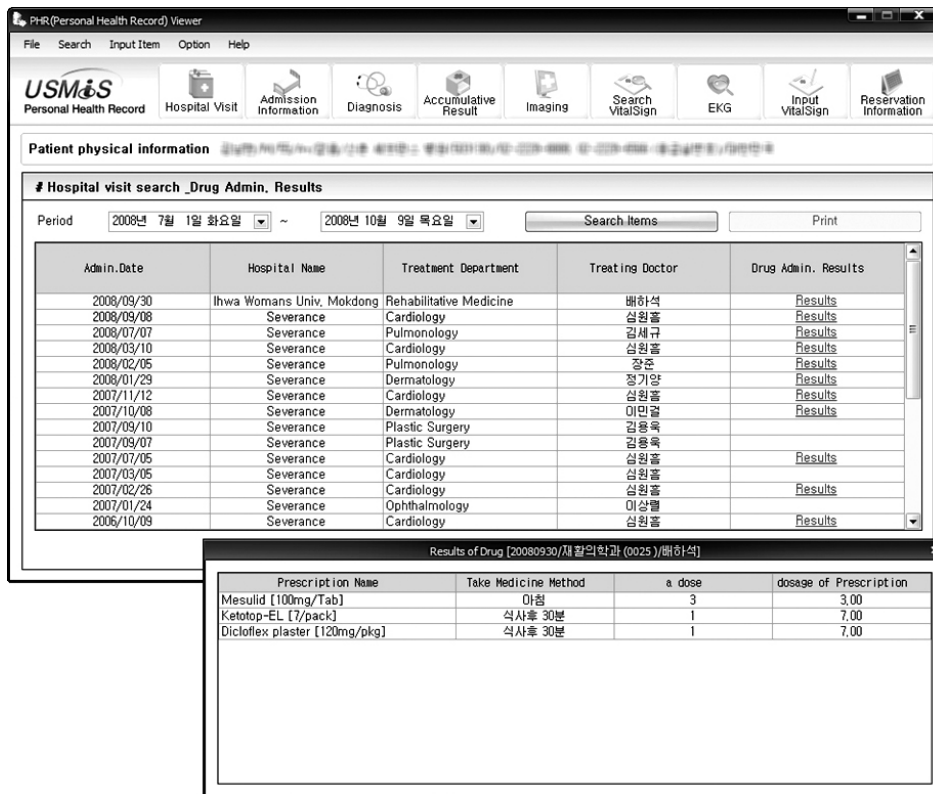


Figure 5. UI of USB flash drive-based PHR program (hospital visiting history).

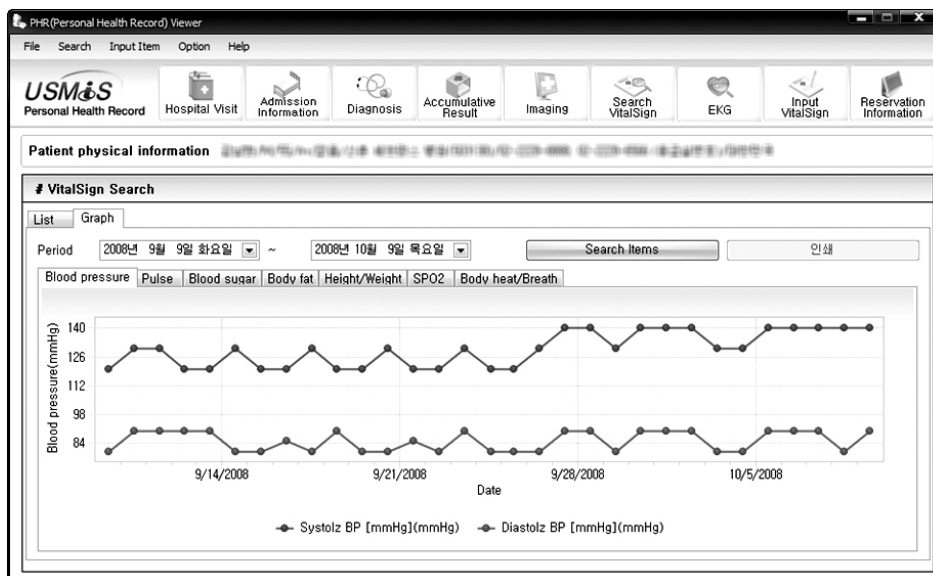


Figure 6. UI of USB flash drive-based PHR program (vital sign management).

information on web server. Encrypted module is applied to the transmission zone of data, and the encryption of saved data is also implemented. The certificate authorization method is adopted additionally to the password authorization, and all passwords are encrypted in one-

way to maximize the technical information security.

## IV. Discussion

The combination of increasing interest in health and



spectacular advance in technology is changing the paradigm of medical treatment. With the conversion in the flow of medical treatment, from the existing “medicare” environment where the patient with illness seeks out a hospital for treatment to the concept of “lifecare” where the consumer now self-manages health and prevents disease and the hospital seeks out the patient, the PHR service is nascent. On the other hand, the concerns about information leakage has grown serious as well. The personal health information is sort of the most sensitive information and must be maintained throughout the reliable and secure process.

This paper designed and developed a web and mobile storage device-based lifetime PHR that enables individuals to manage their health information by themselves anytime, anywhere, on-line or off-line, by providing a tool for individual-centered lifetime health information management. The advantage of this system lies in the fact that it connects hospitals and home & mobile healthcare while minimizing the dangers of information leakage by not accumulating data, and supports a sustained health management by loading a plug & play PHR viewer to a convenient mobile storage device. Since this is not dependent on hard ware, it can be used in any PC or USB flash drive.

The OCR (Optical Character Recognition) synchronization program needs to be developed to enable the integrated management of treatment records in paper form (prescription, checkup results, and diagnosis) and in order to convert that information into digital data to be managed with the existing data in response to the poor medical status of direct information communication between medical organization due to various reasons such as policies and standards to maximize information communication. For future research, feedback through demonstrative operations using actual users and work on adjusting and supplementing the system are being planned, as well as the development of a PHR system using universal subscriber identity module and CDMA (Code Division Multiple Access) method based mobile phones.

## Acknowledgement

This research was supported by a grant of the Seoul R&BD Program (10608) and the Korea Health 21 R&D Project, Ministry for Health, Welfare and Family Affairs, Republic of Korea (Grant No: A040032).

## REFERENCES

1. Institute of Medicine. The computer-based patient record: an essential technology for patient care. Washington, D.C.:National Academy Press;1991. pp.1-20.
2. National Committee on Vital and Health Statistics. Personal health records and personal health record systems: a report and recommendations from the national committee on vital and health statistics. Washington, D.C.;2006. pp.11-19.
3. Roger AE, Robinson DL. EMR and PHR: healthcare's ultimate connection. For The Record 2006;18(25): 18-19.
4. Mon DT. PHR, EHR: what's the difference? Journal of AHIMA 2005;76(10):60-61.
5. The Personal Health WG. A public-private collaborative: final report. Markle Foundation's Connecting for Health 2003:1-58.
6. WG on Policies for Electronic Information Sharing Between Doctors and Patients. Connecting Americans to their healthcare: final report. Markle Foundation's Connecting for Health 2004:1-145.
7. AHIMA. The role of the personal health record in the EHR. Journal of AHIMA 2005;76(7):1-16.
8. The National Alliance for Health Information Technology. Defining key health information technology terms;2008.
9. Miller HD, Yasnoff WA, Burde HA. Personal health records: the essential missing element in 21st century healthcare. Chicago (IL):HIMSS;2009. p.28.
10. Stratis Health. Health information technology service: PHR technology. Aging Services of Minnesota 2009: 1-3.
11. Tang PC, Lansky D. The missing link: bridging the patient-provider health information gap. Health Aff (Millwood) 2005;24(5):1290-1295.
12. Tang PC, Ash JS, Bates DW, Overhage JM, Sands DZ.

- Personal health records: definitions, benefits, and strategies for overcoming barriers to adoption. *J Am Med Inform Assoc* 2006;13(2):121-126.
13. Endsley S, Kibbe DC, Linares A, Colorafi K. An introduction to personal health records. *Family Practice Management* 2006;13:5.
  14. Waegemann CP. Testimony to national committee on vital and health statistics regarding personal health records. Chicago:U.S. DHHS;2002. pp.2-3.
  15. AHIMA e-HIM Personal Health Record Work Group. The role of the personal health record in the EHR.. *Journal of AHIMA* 2005;76(7):64A-D.
  16. Julie W, Beth F. Health records for the people: touting the benefits of the consumer-based personal health record. *Journal of AHIMA* 2005;76(10):28-32.
  17. Cohn SP, NCVHS. Letter to Secretary Leavitt on personal health records [letter]. Washington, D.C.:U.S. DHHS;2005. p.20201.
  18. Nash DB. Electronic personal health records come of age. *Am J of Med Quality* 2006;21(3):5-15.
  19. AMIA. The transformative potential of integrated personal health records. Bethesda, MD:Am Med Inform Assoc;2006. pp.1-16.
  20. Available at: <http://www.u-smis.com>. Accessed August 31, 2009.
  21. Miller HD, Yasnoff WA, Burde HA. Personal health records: the essential missing element in 21st century healthcare. Chicago (IL):HIMSS;2009. pp.52-53.
  22. AHIMA. Common Data Elements in the PHR;2005. pp.1-16.