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A CASE STUDY OF INTERCONNECTED PHR SYSTEM IMPLEMENTATION

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Abstract. *The desire for better health is constantly increasing. Recently, due to the development of ICT, interest in PHR field for personal health care has amplified and various studies are being conducted on the subject. The global trend of PHR investigated in this paper is the development of PHR platforms in the type of Interconnected PHR. This paper analyzes the current state of the PHR market. It also introduces examples of Interconnected PHR introduction following the global trend, suggests directions for the PHR market, and contributes to the development of the PHR market.*
Keywords: Hospital information system, Personal health record, Electronic medical record, Electronic health record

1. **Introduction.** Recently, due to the rapid development of Information & Communication Technology (ICT), the desire of individuals to manage their own health and diseases is increasing [1]. A representative that reflects this need is the use of the Personal Health Record (PHR) [2]. The PHR global market is growing and expected consistently growth [3]. However, PHR technology is not growing. The Gartner group expects PHR technology to be inactive [4].

PHR field does not have a technology model that can present directions for development of technologies. Therefore, this study sought to find a development model. So, in this paper we researched to identify the global trend of the healthcare information technology. And, we checked whether the PHR market player is moving in line with the trend. In addition, by introducing a case of *Interconnected PHR* system implementation that follows the trend, we would like to present a developmental direction for PHR market.

The rest of the paper is organized as follows. Section 2 discusses PHR and recent trends of PHR and surveys the key players in the PHR market. Section 3 introduces the results of a survey on the actual condition of PHR application in Korea. Section 4 presents a case of *Interconnected PHR* application. Finally, Section 5 offers conclusions.

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2. Related Work.

2.1. Personal Health Record (PHR).

The term PHR was first introduced in 1978, and is defined differently by various organizations. Personal Health Working Group of the Markle Foundation's Connecting for Health collaborative defined PHR as "an electronic application through which individuals can access, manage and share their health information, and that of others for whom they are authorized, in a private, secure, and confidential environment" [5], while e-HIM Personal Health Record Work Group of AHIMA defined PHR as "The Personal Health Record (PHR) is an electronic, universally available, lifelong resource of health information needed by individuals to make health decisions". In addition, AHIMA classified the types of PHR into paper-based, PC-based device, web-based device, hybrid desktop/web-based and portable devices [6]. It is unusual that the paper-based device was included.

In a broad sense, PHR means to manage the health records themselves for personal health. In that sense, PHR is not an entirely new concept. It is just a field that enhances convenience and utility by combining information technology with existing methods (paper-based personal health record: for example, a child care diary). Also, many other organizations have published different definitions, but the general idea is that the patients themselves, not institutions or governments, manage and continually monitor their own health records to improve their health.

PHR can be classified into three categories according to their structures [7]. The first type, *Stand-alone PHR*, is a system that is implemented in a variety of media and devices, such as smart cards, USB drives, CDs, and Web applications. *Stand-alone PHR* is also built independently without relying on external data. The second type, the *EMR-tethered PHR*, refers to a system implemented in the form of a portal so that an individual can access his or her health information by accessing the EMR (Electronic Medical Record) system of the individual medical institution where the patient's health information is recorded. The last type, *Interconnected PHR*, is a system that maximizes the utilization of PHR by integrating and managing various information from different medical institutions, health information directly inputted by individuals, and information measured by smart devices in the data repository of the service provider. Generally, this is made by the form of platform system built on a cloud basis.

Figure 1 shows a schematic diagram of the PHR type characteristics [7]. It is evaluated that the *Interconnected PHR* type is the most efficient in all characteristics except system complexity.

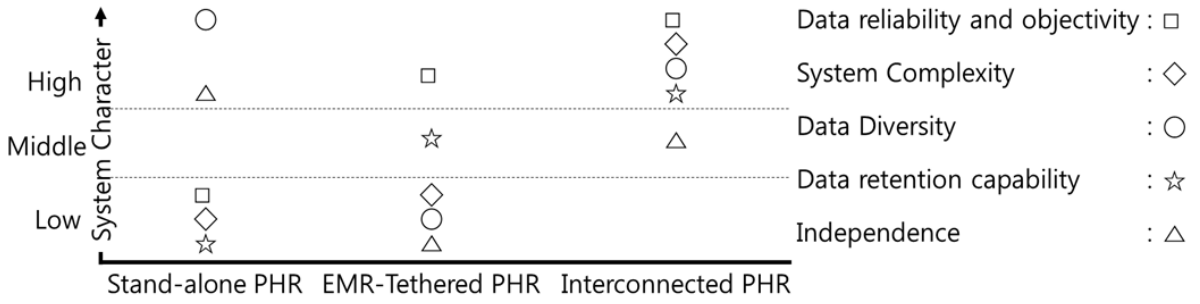

FIGURE 1. Characteristics of PHR types

2.2. Trend of PHR.

It is very hard to investigate the trend in the PHR market and technology independently. Therefore, we checked the trends in the field of health information technology that PHR belongs to. The five kinds of trends in the Health Information Technology (HIT) field reported recently in HIMSS 2018 are 'Patient engagement' (strategic patient experience improvement), 'Cloud computing' (the aim for secure accessibility),

'Revenue cycle' (mapping a vision to the new consumer landscape), 'Connected health' (evidence-based innovation), and 'Machine learning & AI' (contextualizing AI for healthcare). PHR is also a part of the HIT and follows the trend described above.

First, there is an active trend of researching mobile-based PHR system development, which is easy for individuals to access and plays a key role in patient participation in the HIT field [8]. Also, in order to secure the objectivity of personal participation data, researches for the combination of PHR and Personal Medical Device (PMD) are being actively carried out [9].

Second, PHR has applied a lot of cloud computing technology in order to manage information derived from various sources, such as information inputted by individuals themselves and medical institutions. Since personal medical records are highly sensitive and require high levels of security, security issues are constantly being addressed and studies are under way to enhance security [10,11].

Third, research on PHR platform strategy outlook shows that HealthKit, a service in the PHR sector provided by Apple, and Google's Google fit are likely to have different revenue structures [12]. It is expected that the main revenue sources of PHR will be through provision of personal health care services and B2B healthcare business expansions through user data analysis. Researches on the possibility of direct profit generation through PHR have not yet been actively conducted, and it is expected that studies will be carried out after the application of PHR is actively proceeded.

Fourth, researches are under way to incorporate the concept of ubiquitous computing to implement information-based healthcare services using PHR information [13]. InPHR, an example to be covered in this study, implemented medical connection services such as remote medical consultation.

Finally, since PHR possesses various health records of individuals, allowing a larger ripple effect by combining machine learning or AI technology, both hot topics, related studies are being performed steadily [14,15].

As we have seen, the PHR field is still immature, but researches are actively under way from various perspectives. It is a field that is rapidly developing with the combination of various IT.

2.3. **Key player survey.** We are looking for a technology model for the PHR market. So, we looked to see if the key players are following the trend. Figure 2 shows the current status of key players. As a result of the survey, it was confirmed that the *Interconnected PHR* type follows the trend well.

The *EMR-tethered PHR* type only uses information from EMR or EHR (Electronic Health Record). The data of the hospital is highly reliable, and when processed, it becomes high-value information. However, patient participation is very limited when generating data. So, the type and amount of data are less than the other types. And, it is only used as additional service to the hospital information system or public service. Therefore, it is not attractive in terms of profitability in the market.

The *Stand-alone PHR* type collects various patient's life logs. So, it improves patient engagement for a variety of data gathering. Besides, it uses big data technology actively to store and use large amount of data. It is an independent service that generates revenue through usage fees or sales of related products. However, it does not include data from the hospital, so the information is not reliable. Thus, there is no appeal to the user. Also, it is difficult to refine and analyze the data because the types of data are excessively diverse. The *Interconnected PHR* type was expected to be the most efficient in the past researches, and it reflects the trend most properly. Consequently, we designed and implemented a system based on *Interconnected PHR* type.

	Blue Button	Cleveland Clinic	VALIDIC	DOCOMO Healthcare	Apple HealthKit	MS HealthVault
Type	EMR-tethered PHR	EMR-tethered PHR	Stand-alone PHR	Stand-alone PHR	Interconnected PHR	Interconnected PHR
Patient Target Scope	Only americans	Only patients in the hospital group	All third partie app user	Connected device user	Only apple user	Only microsoft user (Windows 8 or later)
Patient Engagement	None	None	Available to input the life log by manual or personal device	Available to input the life log by manual or personal device	Available to input the life log by manual or personal device	Available to input the life log by manual or personal device
Cloud Computing	IaaS (Storage)	None	IaaS (Storage)	IaaS (Storage, Analysis fittness)	PaaS (Storage, Analysis health, Open API)	PaaS (Storage, Analysis health, Open API)
Revenue Cycle	Public service	Additional service of the hospital group	System usage fee	Selling personal devices	Selling personal devices & OSX system usage fee (by third parties)	Selling personal devices & solution
Connected Health	Only EHR or EMR	Only EHR or EMR	Only life log	Only life log	EHR or EMR & life log	EHR or EMR & life log
Machine Learning & AI	Medical services by third parties	Medical services	None (All services by third parties)	Fitness services	Fitness services (Medical services by third parties)	Health (fitness + medical) services

Does it follow the trend? Excellent Good Not good

FIGURE 2. The current status of key players

3. **PHR Application in Korea.** PHR application in South Korea is still at an immature stage. However, according to a survey by the Korea Small and Medium Business (SMB) Administration, the demand for high quality medical services is rising due to the rapid spread of smartphones, the increase of elderly people and singles, and the lack of satisfaction about medical services for national health insurances [3]. Therefore, the market is expected to expand rapidly.

Korea's PHR application is usually developed and operated in cooperation with the individual EMR systems. This is because there is a high risk of information leakage related to the transmission of security-sensitive personal information to other systems. Also, it was investigated that PHR alone could not establish the correct revenue model [16]. Therefore, the legal system for the utilization and service of PHR was not established.

Most Korean PHR companies are developing and operating PHR in the type of *Stand-alone PHR* or *EMR-tethered PHR* for various reasons mentioned above. Looking at the research trends in the PHR field, the PHR field will probably evolve gradually into the *Interconnected PHR* type. Korea is a representative IT powerhouse and has the technical ability to implement the *Interconnected PHR*. However, in the field of PHR, it is significantly behind the developed countries, and is clearly not following the trend at all. This problem has also been proven by a survey of Korean SMB Administration [3]. According to the survey results, there is no other platform technology as blank as the technology field in Korean PHR. This is not a problem for Korea alone. Most PHR markets around the world have like these problems. Therefore, we expect that the InPHR system that we designed and implemented to reflect trends in the market will be a technology model that meets market needs.

4. A Case Study of Interconnected PHR Application.

4.1. **System architecture of InPHR.** InPHR is the first implementation case of *Interconnected PHR* type in Korea. InPHR has formed partnerships and relationships with

a number of hospitals in Korea and abroad to store and manage personal medical information in a cloud server and to design a standard interface for different forms of EMR data. In addition, it has successfully connected to more than 150 kinds of PMDs by collaborating with many PMD manufacturers in order to facilitate the entry of objective health data. This enabled InPHR to collect data from various pathways for personal health records.

Figure 3 shows the system architecture of InPHR composed of five layers. The first layer is a client-side application. It consists of an IoT Application and a Web part. And, IoT Application part provides iOS App, Android App, Windows Mobile App, Web App. So, InPHR has built an access path to use the system in various environments to improve user accessibility. The second layer is a sensor gateway, connecting and managing more than 150 health devices to the system. The sensor gateway has adopted the ISO11073 standard for data integration. IEEE 11073 health informatics is medical health device communication standards that enables communication between medical, health care and wellness devices, and external computer systems. The third layer is the platform gateway for gathering data from the APP, EMR or EHR and sensors. Platform gateways employ various data communication standards such as Message Queuing Telemetry Transport (MQTT), Constrained Application Protocol (CoAP), Hypertext Transfer Protocol (HTTP), and Transmission Control Protocol (TCP) to collect data on various channels. These standards help to trade data lightly and accurately. The fourth layer is the healthcare data processing layer which controls the entire system using the collected data. This layer is a core layer in InPHR architecture. It manages and authenticates connected health devices, manages sensor data, manages big data repositories and integrates with existing systems. Also, it manages the event flow of the entire system. In addition, it provides open APIs to use the platform. The fifth layer is the operation management WAS which manages the basic services provided to the user. It uses data processed by the healthcare data processing layer to provide functions such as chronic disease management, fitness management, medical teleconferencing, and patient management for doctor.

The architecture of InPHR applies technical standards to collecting various information and supports users to use the system in various environments. In addition, the system users are not limited to patients and doctors, but extend to all participants in the entire health care service.

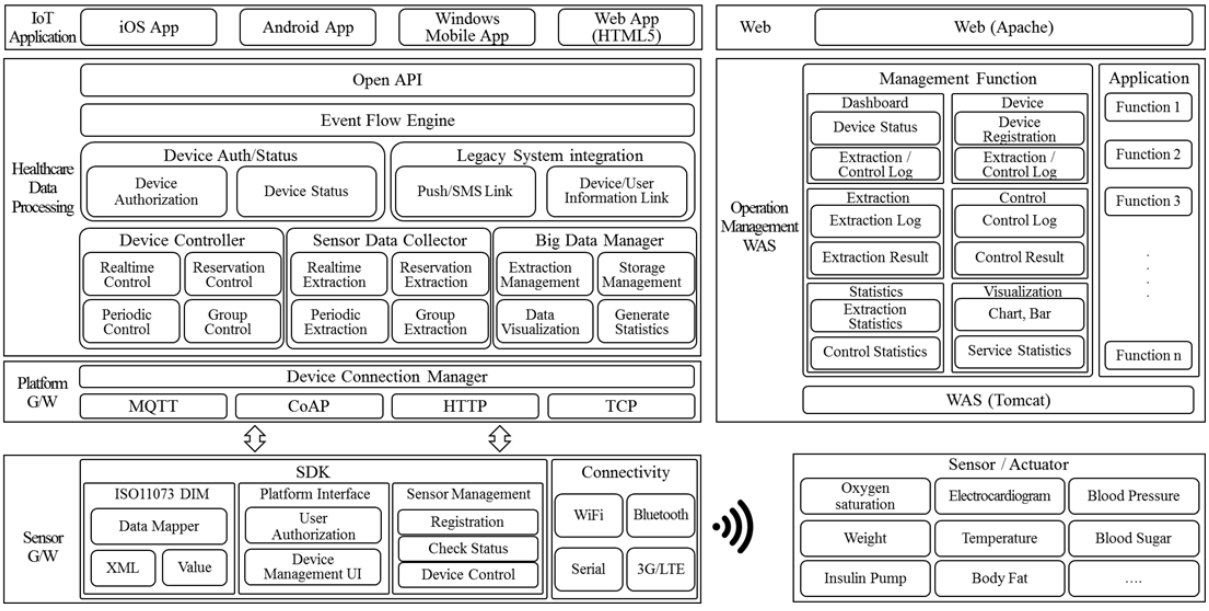

FIGURE 3. System architecture of InPHR

4.2. **Implementation of InPHR.** The designed and developed *Interconnected PHR* platform is used not only for health records, but also for medical staff support, symptom improvement, medical information system developer support, etc.

Figure 4 shows the service architecture of InPHR. As mentioned earlier, InPHR strives to diversify platform users. For example, InPHR provides open APIs for hospital information system developers to use this platform, and offers development training and testing support. It also provides system consulting for hospital management and language supports for various countries in order to expand the users. InPHR provides a variety of services for direct users. 'InPHRcare' is the main portal of the InPHR platform. It can record and check an individual's life log and medical records. It also suggests ways to improve life styles based on PHR data, supports telemedicine, and enables collaborative treatment. In addition, 'InPHRcare' also supports basic information management, family management, appointment and management of primary care physicians, and medical tourism services.

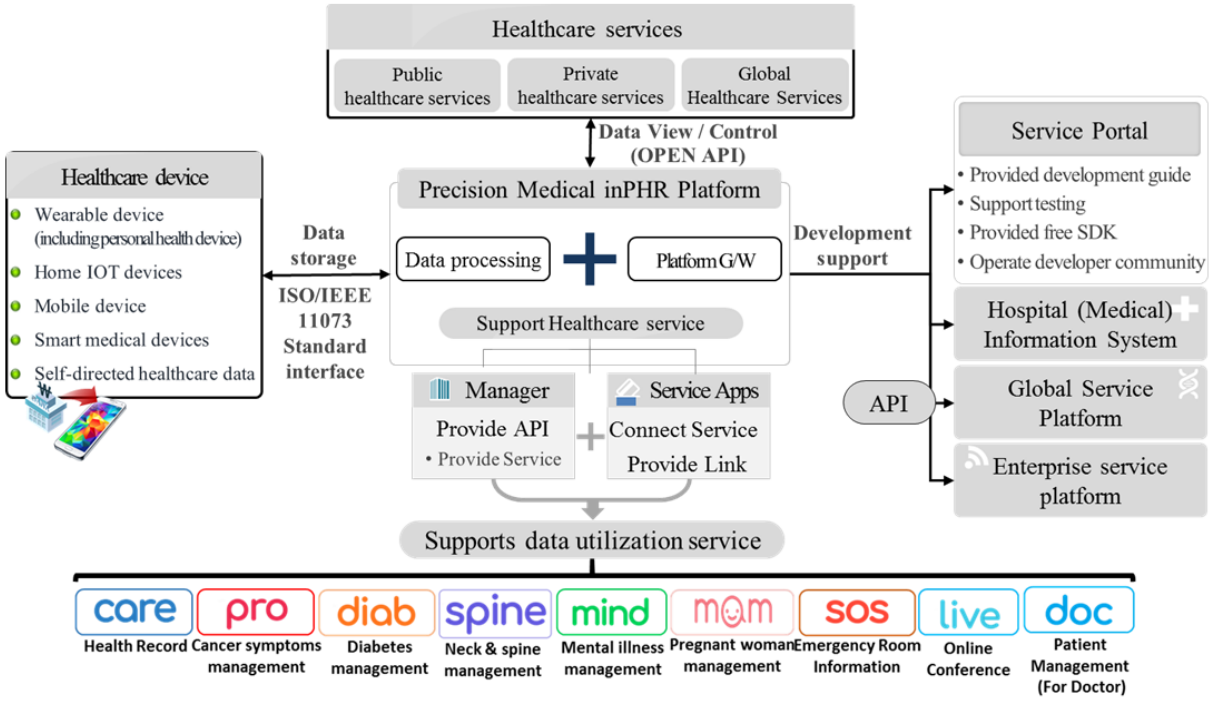

FIGURE 4. Service architecture of InPHR

Figure 5 shows the user interface of 'InPHRcare'. 'InPHRcare' provides web-based interfaces and mobile apps. It is configured so that users can see as much data as possible easily and briefly. And it is implemented so that the user can intuitively use the function. 'Pro', 'Diab', 'Spine', and 'Mind' are chronic disease management applications. Several studies predicted that PHR would be effective in improving the patient's symptoms (especially for diseases requiring continuous management such as chronic illnesses) [7]. InPHR's management programs for individual illnesses have also resulted in evidence-based, ongoing management services that can help prevent disease and improve symptoms. It is actually appreciated by users. 'Mom' is a healthcare management application for pregnant women and babies. 'SOS' supports quick emergency medical support. 'Doc' and 'Live' support doctors' work based on PHR information. 'Doc' provides doctors with information about their patients and facilitates collaboration between doctors. 'Live' is a web conference application for only medical staffs. It is a useful training program and it makes possible quick medical cooperation using the PHR data.

Except for 'InPHRCare', we are currently developing an English version of each application. Therefore, we will introduce it in detail in future studies.

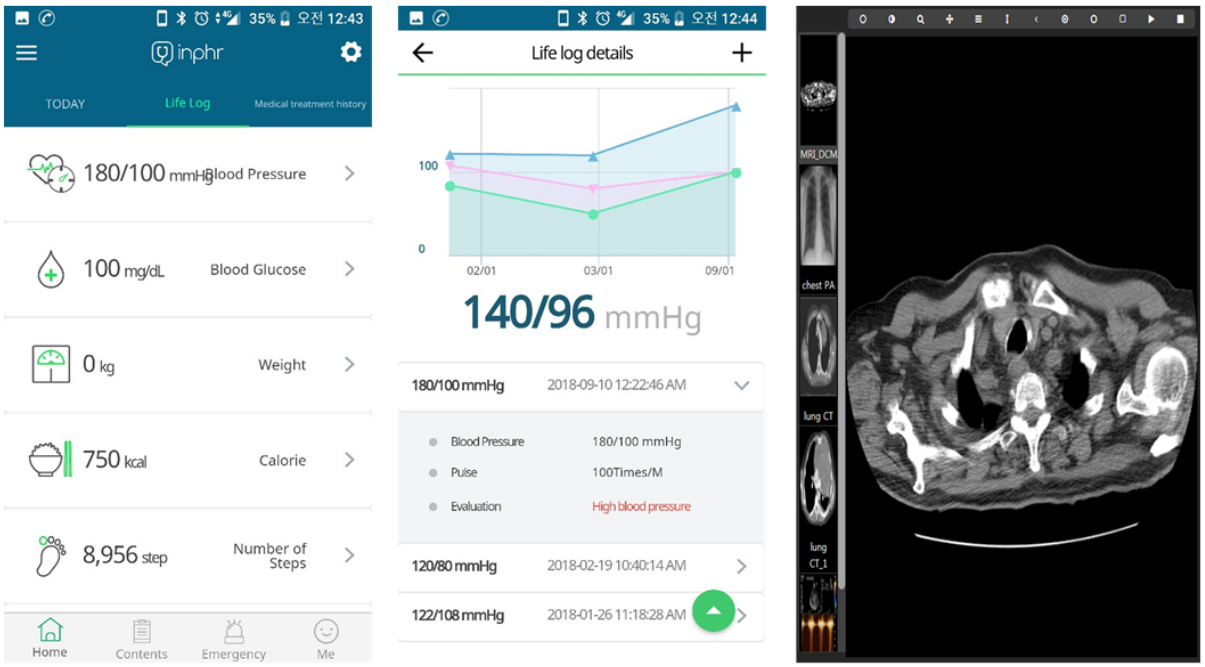

FIGURE 5. InPHRcare user interfaces

5. **Conclusions.** In this study, we analyzed the trend of PHR markets and examined the current status of the PHR market. The PHR market is expanding, but the development of technology is not following it. We also analyzed the best case that followed the trend. In various studies and trends, the direction of PHR was proposed in the form of *Interconnected PHR*. If we stick to the role of the existing simple personal health record, there will be no differences from paper-based PHR. It is important to integrate various data in order to take full advantage of PHR benefits. In addition, we studied case of *Interconnected PHR* to find a technical model of PHR. We expect to present the direction of the PHR market and promote public health through this study.

However, in this study, the validity of the application of PHR has not been proven. Therefore, future studies will examine the effectiveness of PHR by tracking and analyzing the results of health improvements of user group and non-user group of PHR platforms and present a concrete direction of development for PHR.

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