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A STUDY OF THE STATE OF PERSONAL HEALTH RECORD RESEARCH

By

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ABSTRACT

Purpose: The purpose of this study is to gather and analyze Personal Health Records (PHR) literature to provide a review of the current state of PHR, its deployments and to explore future trends that might influence the adoption of PHR.

Objective: To conduct a cross-sectional survey of PHR past, present, and future trends. In addition, to investigating the world of operational patient-centered PHR for input on several matters such as usability, usefulness, and user perspective on these matters.

Results: PHR systems are still evolving. PHR have the potential of improving the healthcare system. However, adoption rates have not reached critical mass. Even more, healthy patients do not know of the service or potential values and benefits of PHR.

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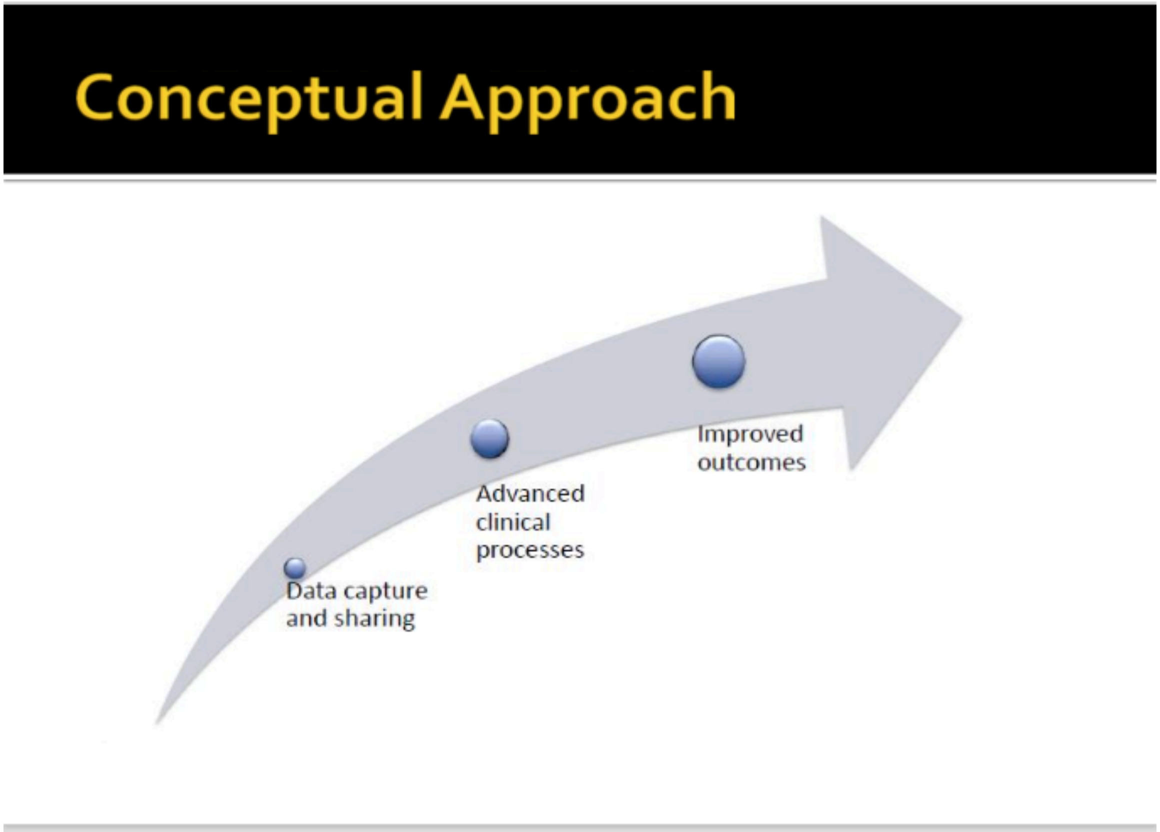
1. Introduction

As a part of the American Recovery and Reinvestment Act (ARRA) of 2009, the Health Information Technology for Economic and Clinical Health Act (HITECH) incentive program was introduced to increase the adoption of Electronic Health Records (EHR), and Health Information Technology (HIT). This program rewards healthcare providers who satisfy and attest the Meaningful Use (MU) of EHRs through large payments via Medicare and Medicaid programs [26, 30, 31]. These laws and programs aim to transform the American healthcare system for the better and reduce medical errors, disparity, and save lives [25].

The Department of Health and Human Services (HSS), through the center for Medicare and Medicaid Services (CMS), defines MU as "*using certified EHR technology to: improve quality, safety, efficiency, and reduce health disparities; engage patients and families; improve care coordination, population and public health; and maintain privacy and security of patient health information*" [32, 33]. MU conceptual approach as shown in figure 1 is divided into 3 distinct stages. Stage 1 focuses on data capturing and sharing. Stage 2 is concerned with advance clinical processes. Finally, stage 3's objective will be measuring the improved health outcomes due to the adoption of EHR, but this is not scheduled to happen until 2016. These stages have core objectives that the provider must satisfy and attest for in order to qualify for CMS payments.

Figure 1. Illustrates the conceptual approach of MU



Both stage 1, and 2 of the MU program have objectives that are aimed at increasing the patient's and the family's engagement in their care process [29, 30]. By improving the care system to ove come the old norms of the traditional care system and encourage the patients to participate in the care process. Effectively paving the way to more efficient patient-centered care system. This paradigm shift from an organization-centered to a patient-centered care changes the communication dynamics between the patient and care provider from a unidirectional to bidirectional communication [30]. Therefore, providers started implementing new EHR systems that granted the patient access to his/her medical records. These systems engage and empower the patients to manage their health information. While still in its early stages for a wide consumer adoption and acceptance rate, American consumers market surveys show that 60 percent of American consumers would support the creation of PHR [9]. Furthermore, about 69 percent of participants stated that they would use the system to check for mistake in their medical records [9]. This shows the eagerness of healthcare consumers to participate and engage in their health care process.

Whenever and wherever healthcare consumers are, they can participate in the care process via Personal Health Record System (PHRS). Effectively changing the relationship that patients use to have with their physician. In this paper, we are going to discuss and survey current issues of a patient-centered PHR and evaluate the patient's, or even (the citizen's) before becoming a patient, and discuss interaction with PHRs to participate in the care process. Also, develop a multifaceted view point of PHR from the stakeholder's perspective. These stakeholders include providers, nurse practitioners, and patients. We will cover as much literatures as possible, and conduct interviews with these stakeholders to measure the gap between the state of the art and the stakeholders understanding and expectation of PHR.

Moreover, we will also take a look at new technologies that may have huge impact on PHR such as wearables especially smart watches, health trackers, and other technologies that may be used to contribute to the personal health records by providing up to date health information. We will also investigate the implementations of medical devices such as assistive medical device that are used by patients in their homes or other medical devices that have the ability to communicate and contribute to the medical information of the patients such as Implantable Medical Devices (IMD).

2. Background of PHR

Before we delve deeper into PHR we need to clarify and define what is PHR? How is it different from EHR?

According to M. S. Housh et al, PHRS is defined 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].*"

Also, the website HIT.GOV defines PHR:

> "*Contains the same types of information as EHRs, diagnoses, medications, immunizations, family medical histories, and provider contact information but are designed to be set up, accessed, and managed by patients [2].*"

PHR is a great tool to engage and inform the patient about the care process. It enables the patients to actively participate in the care process. This involvement in the care process impacts patient-physician relationship in a positive way. Baird et al [7] described the current relationship between physician-patient as an episodic and traditionally paternalistic relationship. In other words, the physician would take a more dominant role and becomes more like a guardian. PHR on the other hand, is the mediator of patient-centered care and has the potential to alter that relationship dynamics. Patient-centered care is defined as:

(1) The needs of the patient come first.

(2) No decision about the patient can be made without transparently involving the patient.

(3) Every patient is the only patient. [7].

This consumerist view of healthcare is driven mainly by healthcare reform. The main goal is empowering and giving the patient ownership of their medical records, allowing the patient to contribute in the care process, as well as share their medical records with all care providers.

There are two distinct types of PHRS:

(1) Tethered, which is a PHRS that is connected to a medical service provider EHR such as My HealtheVet. My HealtheVet is a proprietary tethered PHRS that is connected to the Veterans Affairs EHR [11].

(2) Untethered, which is not connected to an EHR. Patients enter and maintain their own data. Microsoft Health Vault is an example of an untethered PHRS.

There are multiple formats of PHR such as paper based PHR, standalone PHRs where health records are kept on personal computer or other medium such as USB flash drive [20], and the majority of PHRs are internet-based. There are multiple ways for a patient to use PHRs

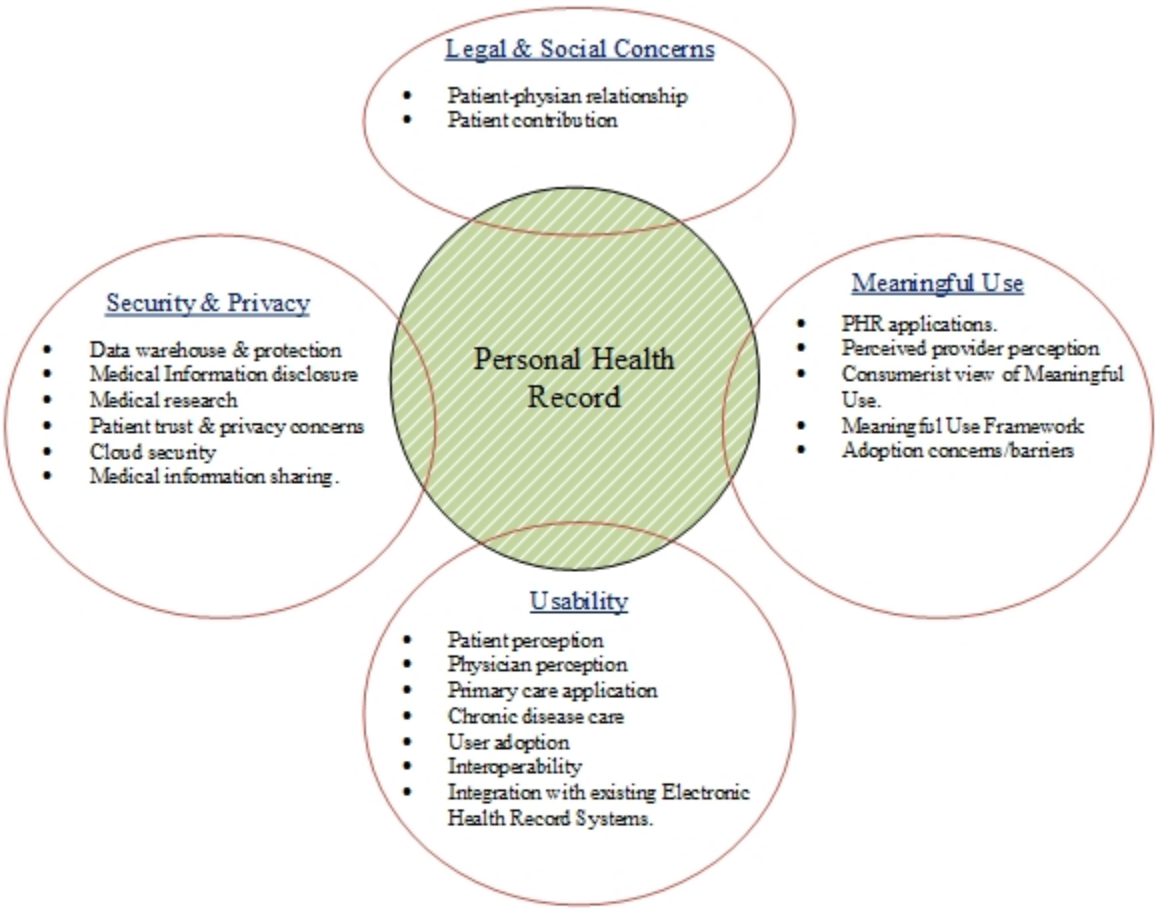
1. Some insurance companies provide PHRs
2. A medical service provider might sign the patient up for a PHR.
3. Publicly available independent PHRs are available in the market such as Microsoft Health Vault or the discontinued Google Health [20].

3. PHR current state of research

This section discusses a comprehensive review of PHR literature. We pooled articles and research papers from multiple world renowned scientific research databases such as the Institute of Electrical and Electronics Engineering (IEEE), the U.S. National Library of Medicine National Institute of Health (PubMed), Elsevier, and the Association for Computing Machinery (ACM). We searched for articles that are relevant to PHR and selected paper that show new trends or the papers that shows how the state of the art was in the past. Figure 1 captures the main research domains that we encountered during our survey quest.

As shown in figure 1, we categorized the PHR domains into 4 domains. The first domain is the security and privacy of PHR. There has been a substantial work done about the security and privacy concerns. No one likes his/her medical information disclosed to unauthorized users. Even though, sharing medical data is essential in the continuity of health care. Consolidating both aspect made this an unlimited source of research articles and proof of concepts that promise to deliver both features without compromising the outcome. Second, the legal, ethical, and social domain of PHR and how the use of personalized medicine will affect the social setting of the patient-physician relationship. Further, some physician as we will see in later section raised concerns about allowing the user to edit and update medical information citing insurance claims as a motive for falsifying or manipulating these records to avoid insurance penalties [37]. Next, meaningful use of PHR domain. This domain focuses on the usability and perceived usefulness as a critical success factor for PHR. Finally, usability domain which directly affects the success or failure of PHR. As we will see usability, and other factors had dramatically effected existing PHR and even lead to some of those PHR demise. In this section we will investigate each domain and present relevant supporting evidence from the literature.

Figure 1 PHR research domains



3.1 History of PHR

At the end of the 20-century, Sitting [16] wrote a paper about 27 pioneers of PHR. He identified and described PHR, and the systems that were available back them. This paper serves as its title indicates a snapshot of PHR in the early 21-century and an evolution baseline. It serves a critical reference point where we can look back at these pioneers and assess the changes, impact, and compare the situation before and after. Sittig's goals were described PHR, justify the need for internet-based PHR, and identify early adopters [16]. They study review 27 publicly available PHRs around the year 2002. The study concluded that PHR was best described as beta release and still in its early stage. More recently, in 2011, Kim et al [17] did an extensive study of the history and trends of PHR in PubMed, the National Library of Medicine (NLM) research database, which focused on the evolution of PHR and served as an informative background knowledge base. The majority of PHRs back then were Internet-based PHRs. Especially in Sitting's [16] era because cell phone technology was not as mature as the current smart phone technologies. A difference that carries serious consequences to the development, access, and implementation of PHRS.

3.2 PHR benefits

PHR have a great potential to help eliminate an array of medical problems such as Preventable Adverse Events (PAE) and Adverse Drug Interactions, lower medical costs, and increase productivity. As a matter of fact, in 1999 the Institute Of Medicine (IOM) produced a report titled *To Err is Human* which estimated that as many as 98,000 Americans die each year from PAE [18, 28, 29]. Not only this but, in a Senate Hearing (July 17, 2014) titled: "*More than 1,000 Preventable Deaths a Day Is Too Many: The Need to Improve Patient Safety*" [22], Joanne Disch, RN clinical professor at the University Of Minnesota School Of Nursing, who spoke before congress, mentioned that there's also the 10,000 serious complications cases resulting from medical errors that occur each day. In 2013 James's [19] investigation of PAE and premature death of patients associated with preventable harm to patients estimated based on defensible evidence that more than 400,000 die each year, and that serious harm seems to be 10 – to – 20 fold more common than lethal harm [19].

Preventable Adverse Events (PAE) can be categorized into these categories:

- Errors of commission,
- Errors of omission,
- Errors of communication,
- Error of context, and
- Diagnostic errors [19].

To understand how PHR can help alleviate those Errors and help prevent them we need to make the distinction between each type. First, the Error of commission, which occurs when a wrong action harms the patient either because it was the wrong action or it was the right action but performed improperly [19], James gives an example of that error *"the patient may need his gall bladder removed, but during the surgery, the intestine is nicked, and the patient develops a serious infection, such as was alleged to be the cause leading to the death of Representative John Murtha"*[19]. Second, Errors of omission, which can be detected in the patient's medical records that an action must be taken to heal the patient yet it has not been done, James gives an example of a patient that needed β-blockers but because it was not prescribed the patient died prematurely [19]. Third, errors of communication, which occurs in communication between two or more providers, to illustrate the lethality of this error James [19] gives an example of 19 years old patient whose cardiologists failed to warn him against running. The patient had experienced syncope while running and was hospitalized for 5 days but tests were inconclusive. So, doctors discharged the patient and did not warn him against running. The patient resumed running and died 3 weeks later while running. Forth, contextual error occurs when a doctor fails to recognize some unique constraints in a patient's life that could bear on successful, post discharge treatment. Finally, diagnostic error that result in late treatment, lack of treatment, or wrong treatment James [19] mentions that a small subset of these errors might be considered as errors of commission or omission.

Technology can offer a course correction for the American healthcare system. One example is the adoption and implementation of PHR. PHR is an improvement that can help prevent such mistakes. Considering all the previous errors, only if patients are empowered and given tools to participate in the process. They can help reach a better and improved outcome. This is one of the goals of MU. To reach an improved outcome of the care process patients can use PHR to prevent these fatal errors by being engaged in their care process even before doctors decided to take a certain course of action. Remember the definitions of patient-centeredness, not only the patients are fully engaged in the process, but they have the power to engage multiple care providers to reach a better decision regarding their health condition. All in all, PHR is an efficient care coordination tool, patient-centeredness mediator, and just as the EHR has proven to save life [25] it can and will do just that. Not to mention patient empowerment and engagement which we will going to review and mention in next sections.

3.3 Legal and social aspects of PHR research

The traditional healthcare system is a unidirectional system. It is an organization-centered system where all the care is administrated and recorded. In addition, all the medical documentation that results from each visit is kept in the care providing organization whether it is a hospital, a clinic, or a small doctor's office. Medical records pre-Electronic Medical Records (EMR) were kept in a hand written format and in large sophisticated file cabinets that might occupy a couple of floors due to its large filing hardware system. So, when the patient wants to visit the doctor due to a medical event or to do a regular follow up visit the files need to be pulled up from the filing department and taken in paper format to the doctor for review. This is a very dangerous practice because there are multiple threats and risk factors that can affect the patient's health records due to fire or other natural disaster that might take place and destroy all the physical health records. Afterward came the early EMR era that helped reduce the use of paper-based medical records and all the related issue that paper based medical records had. Of course, it was extremely expensive to own and operate a large complex EMR system. Nonetheless, the benefits outweighed the cost. Back then medical records existed in proprietary format and were fragmented between care providers and among deferent departments under the same care provider's facilities. Typically, EMR systems used to exist in complete isolation. Basically, they were the digital format of the paper charts in the doctor's office [2]. Also, they were not completely integrated and lacked interoperability among different ancillary departments. Clinicians had to have multiple log-in credentials and their own patient identification system [24]. Furthermore, EMR vendors used different standards for vocabulary, and medical terminology. There was not a unified way for sharing information or access to these isolated systems.

Recently, healthcare laws and regulations such as the Health Insurance Portability and Accountability Act (HIPAA), Health Information Technology for Economic and Clinical Health Act (HITECH), American Recovery and Reinvestment Act (ARRA), AND

Affordable Care Act (ACA) helped pave the way for great advances in Healthcare Information Technology (HIT). It is a non-stop evolution for the pursuit of better-improved care quality, while aiming at reducing healthcare fraud, cost overruns, and wasteful practices [26]. It has also opened doors for drastic changes in HIT. Changes that vendors are taking into serious consideration to achieve customer satisfaction such as combining data from large ancillary services, interoperability, and patient engagement to fulfill the MU requirements so their customer can collect CMS payments and avoid penalties. With this in mind, both EHR providers and clinicians will incorporate and focus on engaging the patient not as an afterthought but rather as core requirement of the care process and to fulfill and satisfy the American Recovery and Reinvestment Act (ARRA), The Health Insurance Portability and Accountability Act of 1996 (HIPAA), and The Health Information Technology for Economic and Clinical Health (HITECH) Act requirements.

This new era of Patient-Centered Care (PCC) is a natural evolution to EHR and HIT that was predicted 10 years ago by the Institute of Medicine (IOM). According to Robinson et al., in 2001, the IOM predicted the era of PCC as one of the six essential aims of the healthcare system [36]. Focusing on the patient constitutes a paradigm shift in the relationship between the doctors, and patients [26]. The care process communication, and cooperation is no longer limited to organization members only. It is centered around and focused on the patient. It has not yet materialized to full potential; nevertheless, the improvements that are taking place are huge. HIT and EHR are undergoing major changes in the few coming years and patients are to going feel them. Bluementhal and Travenner [26] mention that once patients experience the benefits of this technology, they will demand nothing less from their providers. Involving the patient in the care process requires establishing new communication channels for the patient to view and exchange medical information. It also depends on the type of the services and operations that the user is going to perform to be part of the care process.

As a matter of fact, the CEO of the American Health Information Management Association, Alan Dowling, in his article about enabling the patient-centered system says that more and more patients are recording and transmitting data about themselves from home monitoring devices [28]. Also, Dehling and Sunyaev [27] state that smartphones with their rising market penetration has established themselves as valuable choice for patient-centered HIT services. For this purpose, current implementations of a patient-centered PHR that enables patients to record and transmit personal health information, using a ubiquitous mobile systems such as cell phones, smart watches, and/or other medical devices and incorporating them into a health record systems that enables the users to participate, share, and monitor their current medical information.

As mentioned by Baird et al. [7] the current social setting of physician-patient communications, visits, and relationship will be directly impacted by PHR. PHR will empower patient to be engaged in his or her care or at bare minimum be informed and be granted oversight of the processes related to his/her care. Although not everybody will participate or take advantage of PHR as Bird et al [7] reported, the option of taking an active role is ultimately be given to the patient and the patient will decide. Bird et al [7] reported that 19 subjects (or 28.360%) of their sample, which was 71 students in an evening graduate program, do not plan to use PHRS. It is not clear why they do not plan to use a PHRS. But, maybe because PHRS adoption in general is still low. In fact, Bird et al [7] mention that even though their sample is made up of young tech savvy students, they would use and adopt PHRS if they see others doing so. Their result suggests that social influence is a major motivator of PHR adoption.

Cushman et al. [41] analyzed a number of PHR and Personal Health Application (PHA) related ethical, legal, and social issues (ELSI) including the incorporation of social networks as a mechanism for information-sharing, peer counseling, and general encouragement especially for chronically ill patients. Table 1 shows the sum of ELSI categories and their applicability to PHR and PHA. The authors stressed the fact that there is a legal uncertainty that PHR providers need to clarify to the users about what might/might not be prohibited improper disclosure of medical information. Especially, for those PHR systems that incorporate social networking as part of their features.

Table 1. Cushman et al. [41] summary of ELSI categories and their applicability to PHR/PHA

Ethical, Legal, Social Issues	**Applicability to PHR/PHA**
Privacy and confidentiality	• Granular control over PHR disclosure • Ubiquitous monitoring to generate PHR data • Cohort effects and vulnerable populations using PHRs • Social networking reliance of PHRs • Legal uncertainty regarding non-traditional actors
Data security	• Challenges of PHR data protection in distributed environments
Decision support	By PHAs using PHR data, provided to patients sometimes without clinical intermediaries and in extra clinical settings
Legal-regulatory environment	Multiple federal requirements and state requirements for PHR-based data and new environment, all evolving

In addition, in a PHR success paper by Spil et al. [37] physicians voiced of concerns of ethical and legal concerns with regard to the accuracy of the records. Either patient might input information that had not been verified or that patient might also omit or alter their information to avoid possible consequences from their insurance carriers [37].

3.4 Meaningful use of PHR

As mentioned in the introduction section, the meaningful use of EHRS is geared toward the meaningful use of EHRS, but it does include requirements for patient engagement especially in Stage 2 of the MU program. The Department of Health and Human Services (HSS), through the center for Medicare and Medicaid Services (CMS), published the Stage 2 criteria that Eligible Professionals (EPs), eligible hospitals, and Critical Access Hospitals (CAHs) must meet in order to continue participating in the incentive program. According to CMS, Stage 2 criteria became effective in 2014. Table 3. Shows the progression of meaningful use stages from when a Medicare provider begins participation in the program [48].

Table 2. Meaningful Use Stages progression [48]

1st Year of Participation	Stage of Meaningful Use										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2011	1	1	1	2	2	3	3	TBD	TBD	TBD	TBD
2012		1	1	2	2	3	3	TBD	TBD	TBD	TBD
2013			1	1	2	2	3	3	TBD	TBD	TBD
2014				1	1	2	2	3	3	TBD	TBD
2015					1	1	2	2	3	3	TBD
2016						1	1	2	2	3	3
2017							1	1	2	2	3

Each MU stage has a core and menu objectives that must be achieved in order to attest for. According to the CMS, to demonstrate meaningful use under Stage 2 criteria:

- EPs must meet 17 core objectives and 3 menu objectives that they select from a total list of 6, or a total of 20core objectives.

- Eligible hospitals and CAHs must meet 16 core objectives and 3 menu objectives that they select from a total list of 6, or a total of 19 core objectives.

Patient engagement in Stage 2 is clear in the core objectives of both EPs, Eligible Hospitals and Critical Access Hospitals. The following core objective of stage 2 underscores the patient engagement in the care process:

- Eligible Professional must provide patients the ability to view online, download, and transmit their health information within four business days of the information being available to the EP [49].
- Eligible Hospital must provide patients the ability to view online, download, and transmit information about a hospital admission [50].

So far the majority of MU research is being done on EHR. Nonetheless, there is a movement in the research community about MU and MU framework toward PHR. M. S. Househ et al [5] introduced a framework for understanding meaningful use of PHRS and reported the main challenges in developing patient-centered PHR for relevant use by patients or healthcare consumers. Adoption concerns and/or barriers can also be considered part of meaningful use of PHR since perceived perception of the usefulness of PHR might affect the adoption of the system. Major work has been done to investigate the adoption concern. Baird et al [7] work focus is on the evolution of patient-physician relationship. The authors did a consumer adoption assessment of the attitudes, values, and beliefs through the use of focus groups. The authors employed adoption of innovations model to evaluate barriers to adoption and consumer concerns to the forefront and discussed them.

Furthermore, Although PHR has many benefits and has the potential to transform the patient-physician relationship, PHRs has not yet reach mass adoption yet. This fact can be attributed to many factors such systematic barriers, individual patient adoption, security of health information, and the lack of uniformity of PHR.

In 2007, the Office of National Coordinator for Health Information Technology (ONC) requested a thorough review of existing PHR privacy from the American Health Information Community (AHIC) represented by the Altarum Institute, a nonprofit research organization [15, 23]. The alarming report shows that out of 30 publicly available privacy policies there were a wide variation in understanding and implementation. According to the report, each PHR vendor's website has a publicly available privacy policy, and that more than once the user was asked to sign up and provide sensitive information before accessing the privacy policy.

The report reached the following conclusions:

- Based on the review of 30 PHR vendors, existing privacy policies are incomplete;
- Consensus requirements for the contents of a PHR privacy policy do not yet exist, and many vendors appear to have focused instead on security procedures and Internet privacy descriptions;
- Transparency of secondary use of data could be greatly improved;
- The majority of vendors reviewed did not reference HIPAA;
- Data disposal rules and regulations are ill-defined, especially for closed accounts and vendors that go out of business; and

- Many specific terms including “personal health information” are not defined in the privacy policy or related documentation.

The report provided the following three recommendation:

- Privacy, in the context of the PHR, should have a commonly-understood meaning among all vendors, healthcare providers and consumers.
- Consumers and vendors will need to establish a form to develop a common understanding of the most important components of a PHR privacy policy, especially on the level of transparency in secondary use of data; and
- There is a clear role for the AHIC work groups to help define a “model privacy policy” for the PHR industry, an ideal form against which other policies can be compared, as for example the Office of Management and Budget (OMB) provided for the Federal Web site privacy policy.

In addition, complexity has a direct impact on PHR adoption. In their PHR usage and Intention survey Baird et al [7] found that *complexity* reduces the probability of PHR adoption. PHR designers must build PHRS to appeal to a wide spectrum of users and user skills in order to harvest adoption. Otherwise, they will risk setting up the system for failure and mass disapproval of all of its valuable services. Segall et al [4] proposes the use of Human Centered Design (HCD) methodology to increase efficiency, effectiveness, satisfaction, and decrease complexity, decrease training time, and decrease errors. According to Segall et al, applying HCD principles is of great importance since most of patients have not managed their health information online before.

Health literacy is another a critical success factor. Indeed, the amount of health information that the user might come across is very challenging. The IOM defines health literacy as "*the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions."* Dontje et al. [6] study confirms that many patients regard health literacy as a challenge and that many of the participants in the study have found that information in PHR was often difficult to understand. Additionally, many of those patients were interested in having the PHR Web portal configured so that links would be provided to reputable sources of information to assist in interpretation of their medication names, diagnoses, and other laboratory results [6].

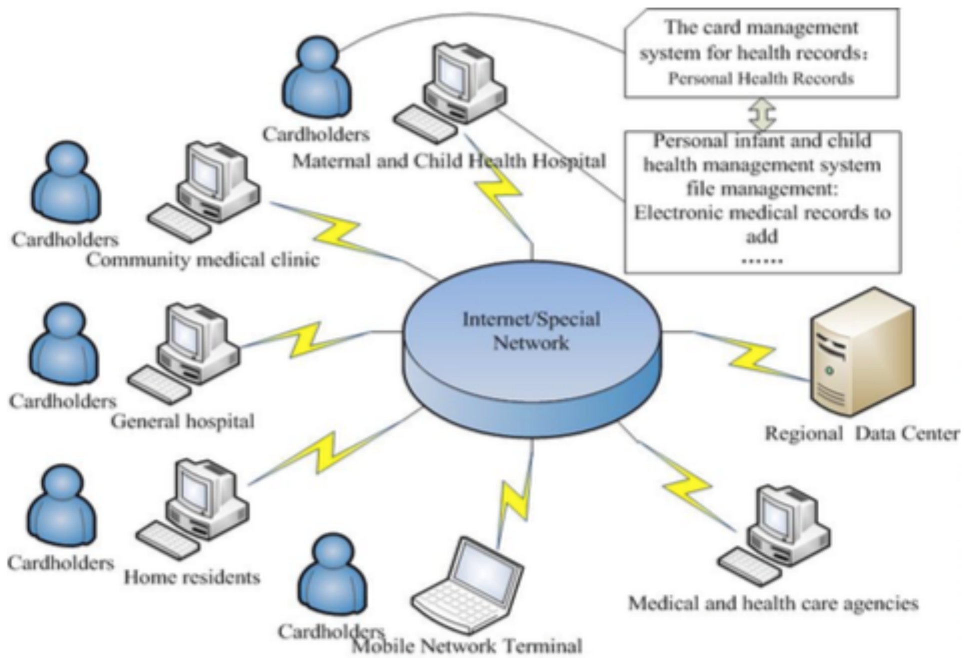
In our survey, we found several different implementation of PHRS. Although they may provide similar services however, from a technological point of view they vary. This means introducing a unique set of architectural and management challenges for each type of PHRS and PHA. For example, some PHRS exist and provide services on the Internet. While others provide their service in a standalone format. The current models reference by Israelson and Cankaya [40] shows different implementation and applications of PHR that we came across while surveying the literature. They are standalone, integrated, tethered, and hybrid [40]. They provide a model comparison of each type in table 2. This comparison also helps to understand how each type might differ from one another.

Table 3. PHR model comparison [40]

PHR type	PHR owned solely by patient	Contains data from multiple providers	Changes made by medical provider	Portable across insurance plan or medical service providers
Standalone	Yes	Yes	No	Yes
Integrated	No	Yes	Yes	Yes
Tethered	No	No	Yes	No
Hybrid	Yes	Yes	Yes	Yes

Standalone PHR systems are systems that does not connect to other medical record system at all. They offer highly secure PHR, limited accessibility, and availability of PHR depends on the availability of the medium that houses those medical records. For example, Ma et al. [39] Portable Child health Records (PCHR) system employs storage cards for record keeping. Figure 2 shows the deployment of the entire system. The patient has ownership over the digital information stored on the card. Furthermore, the patient then takes it to his or her medical provider on visits. This storage card is secured using biometric authentication. If the medical worker wants to access the data the system built security measures would require both the owner's and the medical worker's fingerprint in order to permit access to medical data. The goal of this system is to maintain childhood medical records for children ages 0 -6 [39]. According to Ma et al. [39] children's health begins during pregnancy and fetal health. PCHR follow both HL7's and OpenEHR standards and guidelines for transfer protocols and standard hospital data to optimize the clinical share ability and management of medical information among providers. The only disadvantage of the standalone PHRs is that providers may be uncertain whether to rely on the information or not because of data accuracy issues [37].

Figure 2. PCHR entire system deployment [39]



Unlike standalone PHR system, integrated PHR are system that offer high integration to other medical record systems. Israelson and Cankaya [40] make a clear distinction between integrated PHR and other types of PHR by stating that there is no single owners of the medical record. Rather the records are update and shared partially by patient, care provider, pharmacy, and insurance companies. As mentioned in previous section, tethered has a one-to-one relationship between the PHRS and the medical service provider or the insurance company EHR. Finally, hybrid PHR leaves the ownership of the record with the patient, allows updates by only medical professionals, and incorporates review process through which patient can request change as needed from medical professionals.

3.5 Usability

Complex systems such as PHRs fall under the sociotechnical system categorization [43]. Sociotechnical systems are characterized by having one or more technical systems but, more importantly, includes people who understand the goal of the system from within the system itself [43]. One of the most important distinct characteristics of sociotechnical system, crucially important when considering security and dependability, is having emergent properties. These properties cover the entire system not just part of it and include usability [43]. Usability is a non-functional emergent property which can be defined as the reflection of how easy is it to use the system. It relates to the behavior of the system in its operational environment [43]. Sociotechnical systems are oftentimes affected by external constraints such as national laws that govern the system and its interaction. These constraints can affect the usability requirements of the system and might lead to contradictory results. For example, the usability of the system can be contradicted by the security requirements and security policies. Keeping a balance between the two is a struggle for designers. PHR vendors might want to build easy to use PHR however, security requirement and laws such as HIPPA, HITECH, and ARRA forces the designers to increase the security of the system. This might mean have strong easy-to-forget login credential or other types of functional and non-functional requirements which might render the system unusable as appose to a more usable one. According to Suzanne and James Robertson, when gathering several usability requirements one must include personalization and internationalization requirement, learning requirement, accessibility requirement, understandability and politeness requirement [44]. Again keeping the balance between usability and other system's emergent properties and requirements is a key success factor and failing to do so might lead to a very catastrophic adoption and ultimately mass user rejection and failure of the system as we will see evidence for that in the literature.

Google had a free Web-based PHR service called Google Health which started in 2008 and was retired early 2012 [37]. In four years of service Google was not able to attract and maintain users for this service and had to take it down because of several reasons. In 2014, Spil and Klein [37] conducted interviews of 51 users of both Google Health (27) and Microsoft HealthVault (24), which Microsoft's PHR, to study the user perspective of both services and investigate the cause of Google Health's failure. According to the study, more than half of the Google Health interviewees responded negatively about usability issues such as the system's use of too many medical terms. Furthermore, the study aligned with consistent literature found that perceived usefulness, which is aligned with usability and an indicator of relevance, a negative in both Google Health and Microsoft HealthVault.

Ozok et al. [3] present another study of usability and perceived usefulness of PHR for preventive healthcare from both patient's and primary care provider's perspective and evaluate the value of usability in improving awareness and compliance with preventive care guidelines. The research used a specific PHR called MySafe-T.Net which aims to improve preventive care, preventive screening, and serve as health repository for the patient. The study reported negative review on tailored and individualized information, understandability of medical terminology, and difficulty remembering their personal and family medical history [3]. Segall et al. [4] evaluated the usability and functionality of HealthView the PHR of Duke University. The research asked twenty chronically ill participants who most likely will use the system frequently and asked them to "think aloud" or describe their thoughts while completing nine tasks or scenarios in random order. Upon completion the participants were asked to rate HealthView usability on a scale of 1 to 5. They gave HealthView an average of 3.9 on characteristics such as consistence, clarity of messages, learnability, and information organization. The observation of the think aloud sessions showed that 30% to 60% participant experienced difficulty finding the lab test results, vital signs, allergies, payment history, add children page, and introduction video some task were even hard or frustrating to complete. As we mentioned before, the authors encourage designers to incorporate the HCD approach to improve both system acceptance and user satisfaction [4].

Not all usability reports focus on negative perception of PHR system. However, we provide the highlights of the main ideas and points that might affect the system negatively. The usability reports have a lot in common with other sections in this paper especially the next one which focuses on the security and privacy. Because usability intersects with other emergent properties. We will present them again when it is appropriate to do so. But for reference and more pointer on usability we urge the reader to go to the references section and seek the papers and books that were cited in this section and elsewhere.

3.6 Security and Privacy

Information Security in general is concerned with the integrity, confidentiality, and availability of information on the devices that store, manipulate, and transmit the information through products, people, and procedure [42]. Healthcare federal and national laws such as HIPAA and HITECH have clear security rules that must be followed and complied with. Neglecting to follow these laws or lacking secure PHR may lead to legal and financial consequence.

As the case with cyber and network security PHR vendors need to follow standard procedures, implement proper security frameworks, and use risk management in order to minimize the damages that might occur from these attacks. There is also a need to define and develop attacker profiles so that information security officers can develop secure counter measure for each profile and know how to handle these risks before they take place [42].

Privacy is also of great concern to PHR users, and medical research participant. According to Ciampa [42], an organization must have a privacy policy that outlines how the organization will collect the information and how it will be used. We already mentioned some critical evidence about the PHR privacy policies in the legal section 3.3. In this section, however, we will introduce evidence found in the literature that correlate security and trust to the failure of PHR system. Also, medical research and how some PHR might collect data for population public health purposes and epidemiology and medical research and how it implement security and privacy checks and balances. But we need to underscore the fact that medical providers are liable by law to secure medical information. Of course, information security includes all aspects of medical information, but to be very specific HIPAA covers certain medical information that might lead to successful identification of the person of which this information belongs.

The U.S. law under HIPAA protects the security and privacy of patient health information in oral, written, or electronic format, which HIPAA refer to as Protected Health Information (PHI) [45]. According to Herzig [45], there are three major concerns when sharing PHI. These concerns revolve around three risks: how confidant am I that my health information has not been viewed or tampered with by an unauthorized user(s), or malicious software? What if the PHI is not handled by unauthorized users? Will the data be available when I need it?

To, achieve privacy and information security we first need to understand what are PHI? And what should we protect? Herzig [45] states that PHI is not the actual health information or medical record, rather all data elements that could be used to uniquely identify a person when linked with that person medical data. HIPAA includes an outline of 18 identifiers that are considered PHIs [45] they are:

1. Names
2. All geographic subdivisions smaller than a state including street address, city, county, precinct, ZIP code and equivalent geocodes.
3. All elements of dates (except year) directly related to an individual, including date of birth, admission and discharge dates, date of death, and all ages older than 89 years, as well as elements of dates (including year) indicative of such age.
4. Telephone numbers.
5. Fax numbers.

6. E-mail address
7. Social Security number.
8. Medical record numbers.
9. Health plans beneficiary numbers.
10. Account numbers.
11. Certificate/License numbers.
12. Vehicle identifiers and serial numbers, including license plate numbers.
13. Device identifiers and serial numbers.
14. Web universal resource locators (URLs).
15. IP address numbers.
16. Biometric identifiers, including fingerprints and voiceprints.
17. Full-face photographic images and any comparable images.
18. Any other unique identifying number, characteristic, or code, unless otherwise permitted by the Privacy Rule for re-identification (164.513©).

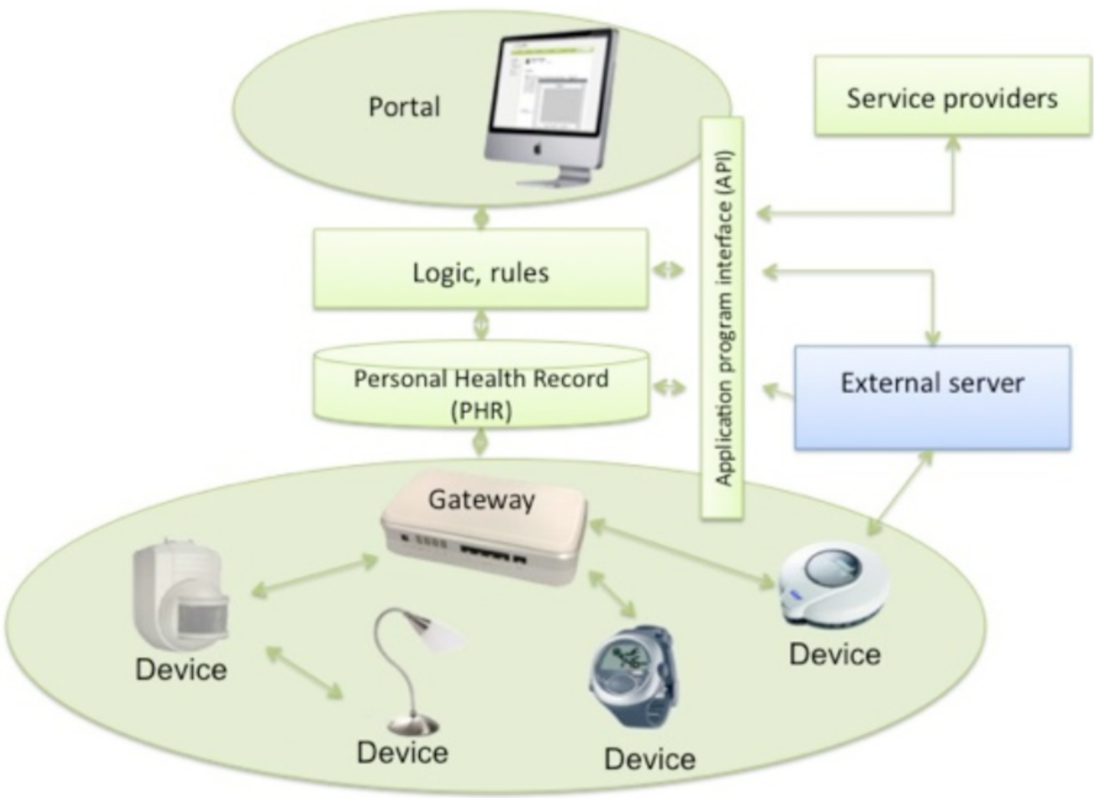
Therefore, it is necessary to protect the integrity, confidentiality, and availability of PHIs using appropriate information security guidelines and procedures. Security measures such as encryption, access control, and Message Digest algorithms (MD) must be an integral part of any healthcare system that store, manipulate, and transmit PHI. Audit is a very important security tool that can be implemented to increase security and ensure the availability of trail that can be looked at after the fact to analyze security related incidents or for legal purposes.

Information security and privacy in healthcare does not differ much from the information security in PHR. In fact, HIPAA applies to both EHR and PHR with one major difference which is the patient now shares the responsibility for the security and privacy of his or her own medical information. Patients need to be diligent when it comes to using publicly available PHR to protect themselves from unauthorized disclosure of their personal health and medical information. This issue is of concern to both doctors and patients as well [36]. Patient who control their personal medical records need to know who are they giving access to and why. Web-based PHR is inherently vulnerable to Internet threats and attacks [36] therefore; PHRS users need to use proper precaution when transmitting information over the web.

According to Carrion et al. [36], security standards for PHR do not exist yet. Unlike PHR, EHR has a widely known internationally accepted security and privacy standards such as ISO/TS 13606. Moreover, the integration of PHR and publicly available social network increase the risk of medical information disclosure if not properly secured and/or anonymized. They risk here is twofold. First, would be an insider risk where an insider from the administrative staff can gain an unlimited access to all the medical data on the user profile. Second, the authors [36] mention a study where the researches successfully identified a person from aggregated data and the person's information that had been stored on a social network. Nonetheless, Carrion et al. [36] believe that it is possible to develop Web-based PHRs that is safe to use and ensures privacy.

Evidence shows that PHR is helpful in emergencies [36], balancing security requirement for PHR can be a challenge. Advances in PHR technologies enable patients to contribute and share their medical information raise the security risk. The evolution of medicine as well as technology enforces PHR vendors to reconsider how they do business. For example, the advent of Web enabled medical devices that are available in the market today and/or is in use in humans. We can see a glimpse of how these devices fit in the picture and the challenges up ahead. Vuorimaa et al [8] built a portal-based home care platform called Active Life Home (ALH) figure 3 show ALH architecture.

Figure 3. Active Life Home Architecture [8]



Their idea is to build a portal-based home care platform that integrates multiple assistive devices in home setting such as medicine dispenser, safety bracelet, and safety monitoring gateway that help the elderly persons to live longer in their own homes. According to Vuorimaa et al [8], ALH portal is supported by several small and medium size businesses, a non-profit company Active Life Village [52], and two universities:

Aalto University and Laurea University of Applied Science. These organizations have integrated various devices, systems, and services in to ALH. Table 4 shows the different systems and products that are compatible with ALH. Even though some of these devices are incompatible with each other, the team built and tested ALH in lab environment. Figure 4 illustrates all the service model that ALH uses and figure 5 show the living lab environment.

Table 4. Systems and products supported by Active Life Home [8]

Organization	Product	Website
Addoz	Medication dispenser	www.addoz.com
ArctiCare Technologies	Active care monitoring	www.arcticare.com
Beddit	Smart bed sensor	www.beddit.com
Elsi Technologies	Safety floor	www.elsitechnologies.com
Everon	Safety bracelet	www.everon.fi
Helmivisio	Home safety monitoring	www.helmivision.fi
Innohome	Stove, washing machine, and dishwasher alarms	www.innohome.fi
Kira-Solution	Home control	www.kira-solution.fi
Oppifi	Recollection and life story service	www.oppi.fi
Playground	Activity and Health Record (PHR system)	www.anyplayground.com
Reslink Solution	Tracking of daycare visits	www.reslink.fi
Tandber/ VCG	Video conferencing	www.vcg.fi
Vivago	Wellbeing watch	www.vivago.fi
Wellness Foundry	Meal logger	www.wellnessfoundry.com
Aalto University	Valpas Safety Monitoring and Alarming Gateway	No website

Figure 4. The ALH portal integrates together existing devices and services, which have their own interconnectivity, customer record, and online service solutions [8].

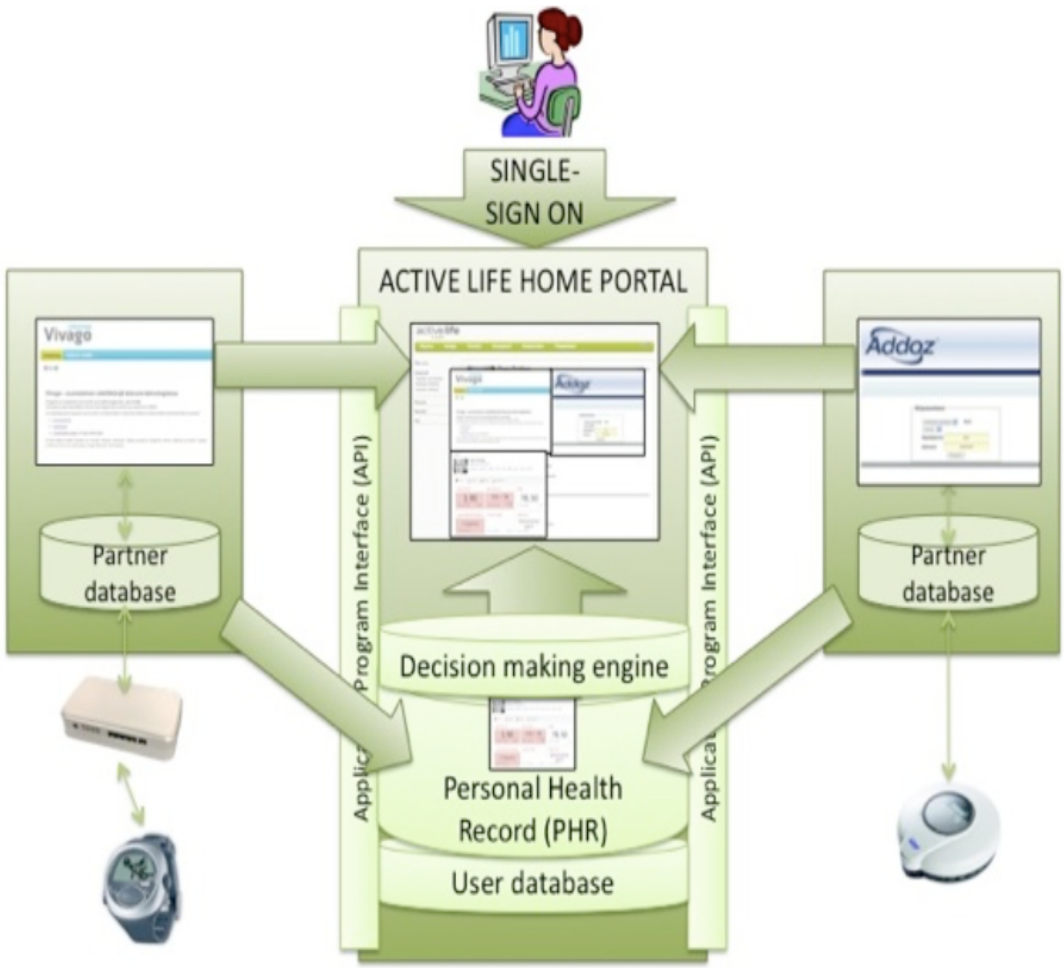


Figure 5. ALH portal living lab [8]

As shown in figure 3, there are three main layers to the implementation. Taking a bottom-up approach, the lower level is the gateway level. Vuorimaa et al [8] used a Linux based gateway called ThereGate. This gateway, which is shown in figure 6, has Wi-Fi, four USB ports, and integrated Z-Wave controller for wireless sensors. ThereGate is connected to the Internet either via an Ethernet port or optional 3G modem. The Ethernet ports can also be used for devices to connect to the gateway.

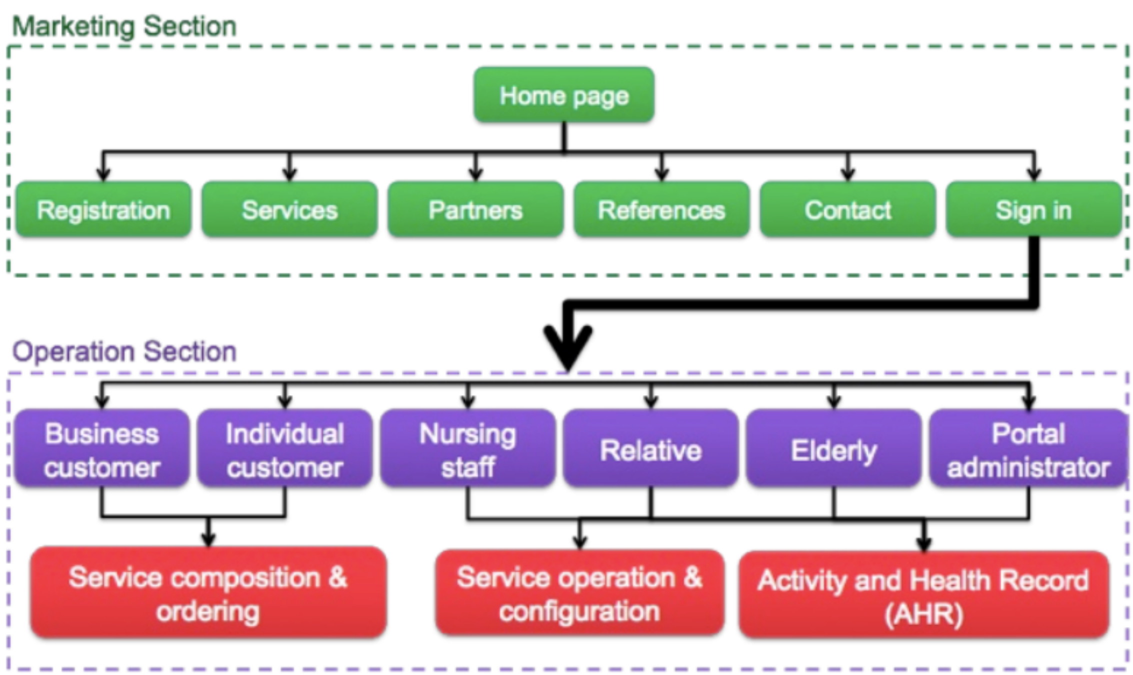
ThereGate provides an easy way to attach and connect new medical devices into ALH's ecosystem. Even non-medical devices such as home appliance can be attached and monitored via the portal due to the connectivity capabilities of ThereGate. There Gate can wirelessly connect and add new devices which provide an easy, fast, and effective setup.

Figure 6. ThereGate home server is used as an integration platform at home [8]

The middle service layer in ALH [8] model is where the personal health information gathered and stored. Personal Health Information is stored using a PHRS which is developed in consortium effort to enable recording of personal health, wellbeing and the successful integration of various health and wellbeing monitoring devices. According Playground [51], the ALH project involves Aalto University and number of companies with leading solutions in ageing care.

The top service level, portal level, is implemented using the Liferay portal platform [8]. Liferay extension environment provides portlets, which facilitates the management of the portal and the services that the portal provides. The portal has two main sections a marketing section, and an operation section. Figure 7 depicts those sections and the relationship between both.

Figure 7. The content of the ALH portal is divided into parts: Marketing Section and Operation Section [8]



Operation section is only available for registered users. ALH has six user groups:

- Business customer
- Individual customer
- Nursing staff
- Relatives
- Elderly
- Portal Administration.

Both business and individual customers can order and create a service package. Then, these orders are configured and used them. They also have access to PHRS. The result of their experiment shows that portals are suitable platforms for integrated home care solution. The security and the architectural issues of this particular implementation are very different from any other PHRS implementations. Given the different communication protocols and divers medical devices used to connect to the PHRS via the gateway and share the information via the portal. In order to secure the network, protect the transmitted information, and ensure the confidentiality of the personal health information encryption and other security measure, as mentioned, must be used internally and when communicating over the Internet.

Wearable Technologies (WT) such as smart watches, fitness/health trackers, or safety bracelets for Alzheimer patients [8] (see Figure 8a, 8b) can also provide a great resource of health information. New WT are able to track and transmit multiple key measurements such as blood pressure, oxygen saturation, and heart rate in real time. Even carry and track medical condition, chronic disease management, allergies, and contain emergency contacts [www.healthid.com]. WT can be divided into two different categories. The first, is passive wearable just like HealthID band which contains personal medical information stored in an emergency medical ID bracelet. HealthID includes a bracelet and HealthID card. The personal health information can be accessed in one of three ways:

1. Both have Near Field Communication capabilities to transmit information, and
2. HealthID card has a barcode which gives access to the reader to view the medical information on the card.

3. Through the Web using HealthID code. The HealthID card has a code written on it called Health ID Profile code (HIP). This code grants access to the medical information when used in Health ID website (www.healthid.com/emergency_summary_view).

Second, active wearable which is actively performing a preset task(s). The type of WT has the processing power and the connectivity to complete its task. For example, the Evron Vega is a solution for people with cognitive disorders such as Alzheimer's disease. The system consists of a wearable bracelet, home base station, and external service [8]. The Evron Vega has three main functions:

1. Manual alarm button for requesting assistance.
2. Location tracking via GPS and mobile networks.
3. Two-way speech communication.

According to Vuorimaa et al [8], *"when the alarm button is pressed, the bracelet determines its location using assisted GPS and GSM networks or connection to the home base station (RF). The bracelet sends the assistance request and location information to an external server, which routes the message to the mobile phone of the caregiver. The caregiver can then call the bracelet to determine necessary actions with the elderly person. In addition, predetermined safety zones can be set around the home base station. If the elderly moves outside the area, an automatic alarm is raised."*

Another challenging area is the Implantable Medical Devices (IMD) which are built to be embedded in the human body to do a specific job. They monitor and treat physiological conditions within the body and help manage a broad range of ailments. In the United

States, there are 25 million US citizens currently reliant on IMDs [35]. Some IMDs such as pacemakers or cardiac defibrillators have the ability to communicate with the outside world to transmit data. Verichip is an example of implantable chip that has been approved by the Food and Drug Administration (FDA), which uses Radio Frequency Identification (RFID) [34]. According to Tanne [34], *"this chip is the size of a grain of rice and is implanted under local anesthesia beneath the patient's skin in the triceps area of the right arm, where it is invisible to the naked eye. It contains a unique 16 digit identification number."* Doctors hope to use this chip in emergency situation when the patient is unconscious and unable to speak for himself/herself or when they lack medical records. Enforcing the security and privacy of new medical devices and technology that stores, manipulate, and transmits personal medical information and PHI is shared responsibility and an ongoing challenge.

Figure 8a. The Everon Vega and Vivago Care bracelets [8]

Figure 8b. HealthID card and band [54]

Figure 8c. Samsung Galaxy Gear Live, Android Wear smart watches [53]

As mentioned, there is an intersection between PHR security and privacy and healthcare security and privacy. Appari and Johnson [38] which surveyed the current state of research for information security and privacy in healthcare. Second, similar to Appari and Johnson [38], Avancha et al. [14] surveyed the literature for privacy in mobile technology for personal healthcare. These very wealthy great source of knowledge for research seeking security and privacy related issues.

3.7 Interoperability and PHR sharing

At the present time, not all patients have access to their medical records through a PHR. However, they do have the right to access the medical record in the digital format. Even though, they would get those records in digital format that does not mean that these records are interoperable and/or that other doctors would operate on them. Keep in mind that even with all the incentives programs that the United State government have put in place to boost interoperability and the use of interoperable EHR in small to medium-size healthcare practices has not reach its desired outcome. Patients still do not have access to their medical records, and interoperability is still limited [12].

Interoperability and access to medical records via PHR carries huge potential in terms of benefits. Major benefits that would have a great quality and economical impact on healthcare such as cost reduction, wasteful spending reduction, APE reduction, saving human lives, and achieving continuity of care. Reading and surveying the literature we came across so many publications that mentioned the human cost and death toll due to errors and other preventable events such as infections like the report we mentioned in section 3.1. Further, the Center for Disease Control and Prevention (CDC) more recently noted that 100,000 Americans die of infections [25]. We have to agree with Andel et al.

[25] “it is easy to forget when reviewing study after study, that what we are talking about are patients – real people – and their families.” Therefore, the promise of interoperability must be realized as soon as possible to achieve these goals that help save human life and reduce wasteful spending.

In addition, continuity of care and the empowerment of patients to manage and participate in their personal care via PHRS is an awaited innovation in the healthcare system. The current dire situation of healthcare requires joint efforts to achieve continuity of care as soon as possible. Kessls [13] states that in his article about patient’s memory for medical information that patient forget 40% - 80% of the medical information that is provided by a practitioner, which is necessary for good adherence, about recommended treatments, immediately. PHR can help patient by having 24/7 access to their up-to-date medical information including their treatment notes. A noteworthy example about continuity of care via PHRS is My HealtheVet [11]. My HelahteVet is a proprietary tethered PHRS. It belongs the Department of Veterans Affairs (VA). My HealtheVet track record is impressive. According to the VA, My HealtheVet lunched nationwide in 2003, and that more than 740,000 registered users 72% are VA patients (2009). Further, VA states that veterans own and track their medical records and can view their medication history, health history, contact information for health care providers, weight and blood pressure. In 2009, more than 6.5 million refills have been requested via My HealtheVet since 2005 [11].

Just as doctors need to be able to read understand the notes and conditions that other doctors wrote. Medical systems including PHR must be able to work together not against each other. Both interoperability and continuity of care require certain key component to activate interoperability. In healthcare, standardization reduces medical errors and sets rules on a common ways for the communications among medical personnel. Several standards exist today in healthcare to make Electronic Health Records (EHR) systems interoperable. For example, the Clinical Document Architecture (CDA) is the standard that is being used to exchange medical messages from one healthcare system to other [24]. Similarly, the Standardized Nomenclature for Medicine – Clinical Terminology (SNOMED-CT) is used and understood as a standardized medical terminology among all interoperating medical systems [24]. According to A.K. Sari et al. [46], to achieve full ‘share-ability’ requires two levels of interoperability: semantic interoperability and syntactic interoperability. Sematic interoperability defines the information that is going to be shared and understood by any of the other consuming services. Syntactic interoperability, on the other hand, sets the rules for how sets of words, messages, and symbols are going to be grouped together to produce meaningful information to be viewed, processed, or aggregated. Therefore, in order to integrate several healthcare systems and achieve interoperability we must achieve both semantic and syntactic interoperability.

As we mentioned before standardized HIT technologies do exists and could be utilized to achieve compatibility. Iakovidis [47] states that standardization issues could be group into the following categories:

1. Rerecord architecture (semantic).
2. Standardized terminology (semantic).
3. Standardized communication and exchange format (syntactic).
4. Standards for the security features (both: syntactic & semantic).

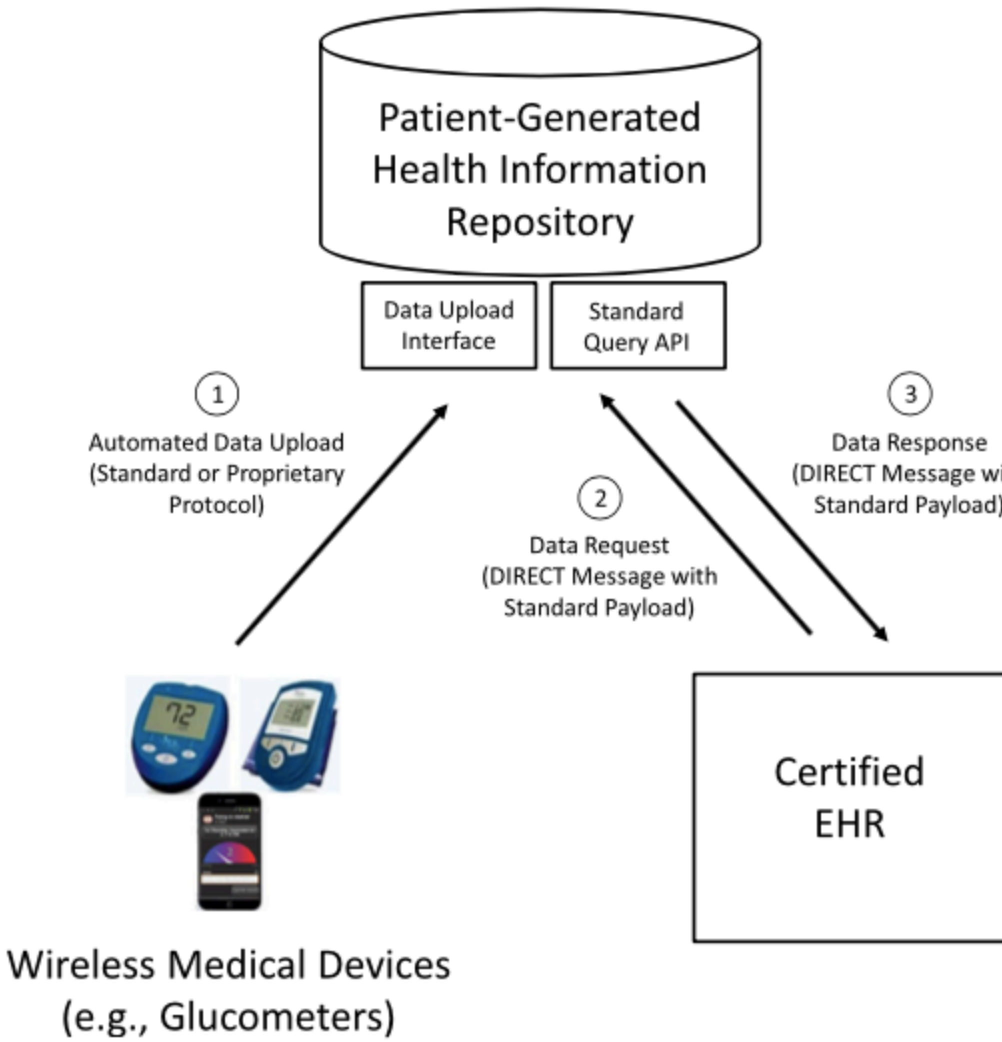
Iakovidis's focus is studying the implementations of EHRs and the issues that could affect the design of an interoperable EHR. But, our analysis takes into consideration the participation of the patient/citizen in the care process by supplying and recording key medical information about him/her via PHR as we mentioned before.

Similarly, Lee et al. [1] proposed a standardized Health Knowledge Sharing (HKS) PHRS that uses Integrating the Healthcare Enterprise (IHE) Cross-Enterprise Document Sharing (XSD) architecture standard to share and integrate to the PHRS. Lee et al. [1] PHRS combine simple health Web medical resources knowledge about medical condition from reputable sources and share it with other patients who have the same medical condition via the PHRS.

Personal Health Devices (PHD) that can connect and communicate with PHRS must use standardize communication protocols to be attach and integrate successfully with PHRS. Sujansky et al. [10] proposed model an automated collection of patient data through wireless medical devices and sharing it with EHRS using HIT widely accepted and recognized standard. Figure 9 illustrates Sujansky et al [10] proposed model. These PHD can upload personal health information using a standardized protocols such as:

1. Share that health information with EHRS via a secure transport layer based on the DIRECT Project's secure email standard.
2. The EHRS application data layer uses Health Level Seven (HL7 v2.5.1) query response message coupled with CDA release 2.0 personal healthcare monitoring report implementation guide to querying and receiving medical data from the patient-generated health information repository.

Figure 9. High-level architecture of the proposed model [10]



4. Conclusions and directions for future research

In this paper, we discussed the current the most relevant work done in the field of PHR. PHR and PHR literature there remains an ongoing research area and there is a need for future work. One area that needs more research is the use of proprietary PHR records and the interoperability of such systems. Also the use of standardized medical terminology such as the Systematized Nomenclature of Medicine (SNOMED) this area where research can study the impact of standardized medical terminology from different perspectives such as patient, medical provider, and other stakeholders. Furthermore, insurance companies nowadays joined other medical providers to develop PHR and other PHA more research is needed there to study the reimbursement review process how can patient file, approve, or raise a claim against certain claim. PHR implementations are limitless and the possibilities are endless for applications. Developers out there in the world take advantage of publicly available Application Programming Interface (API) to develop applications and creative use cases for PHR can dramatically influence the adoption. Just as cell phones nowadays have application stores to download and install applications easily to extend the system capabilities this area remains a fertile and relatively untouched because adoption has not yet reached a critical mass and some people do not know about PHR at all.

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6. Curriculum Vitae

Mohammed Alghareeb

[redacted]

Education

Towson University (In progress)

Towson, Maryland

Master of Science in Computer Science, expected graduation date May 2015

Southern Oregon University

Ashland, Oregon

Bachelor of Science in Computer Science, June 2011, 3.33 out of 4.0 GPA

Institute of Public Administration

Riyadh, Saudi Arabia

Diploma in Computer Programming, June 2006, 4.16 out of 5.0 GPA

Awards

- Scholarship from the Ministry of Higher Education to study Computer Science in USA, July 2007.
- Outstanding computer science student (2008-2009).

Experience

Sep 2014- Present Towson University

Towson, MD, USA

Towson University Computer Lab Assistant

Contact: Mr. Richard Webster, **Tel**. +1(410)-704-2424, rwebster@towson.edu

- Managing labs printer and lab's physical security.
- Opening and preparing classrooms.
- Closing and securing classrooms and labs at the end of day.

May 2007- Jul 2007 Royal Protocol Riyadh and Jeddah, Saudi Arabia

A branch of the Royal Courts that facilitates his majesty's the King visits and events.

Programmer assistant

Contact: Mr. Waleed Alsidiqi, **Tel**. +966-50-4226190

- Developed Applications using Oracle Data Base, and Oracle Forms.
- Worked as help desk and technical support technician.

Sep 2001- Aug 2005 Abdulrehman Algosaibi General Trading Bureau Riyadh, Saudi Arabia

A Leading healthcare company in the Kingdom of Saudi Arabia.

Data entry and secretary

Contact: Dr. Magdy R. Saidum, Ph.D, **Tel**. +966-1-4793000 Ext. 1116

- Worked as part time inventory data entry.
- Worked as a secretary in the Information Technology Department.

Skills

- **Computer literacy:** Windows OS, Linux OS, Unix OS, Mac OS X.
- **Operating System Administration:** Linux OS admin, managing system processes and user request such as granting privileges, managing Access Control List, and OS security.
- **Networks:** Operating, administrating, and maintaining, analyzing network traffic using packet analyzer, designing networks, implementing security and privacy tools and equipments for small and large networks.
- **Programming Languages:** C, C++, Java, PHP, Perl, Html, Ajax, XML, ASP, ASPX, Oracle Developer, Oracle DB, SQL, PL/SQL, Visual Basic, Ruby on Rails, ColdFusion on Wheels.

- **Databases:** Analyzing, designing, and implementing DBs using structured , and Object Oriented (OO) methodologies, building and managing DB documentation .
- **Software Engineering:** Involvement in different software process models, requirement engineering, modeling software design, and implementation, software evolution, testing, building and managing software documentation.
- **Software Testing:** Software testing activities, coverage criteria, writing and running test cases, using tools for automated software testing, building and managing software test document.
- **Requirement Engineering:** investigating the work, conducting interviews, data gathering and analysis, developing and evaluating system requirements, developing fit criteria for requirements, building and managing software requirement specification.
- **Security:** Identify threats and risks, finding solutions for exploits, securing operating systems, Firewalls, VPN's, Securing networks, and Servers.
- **Project Management:** Developing project lifecycle**,** developing project proposal and request for proposals, risk management, developing project schedules, resource utilization, project documentation.

- **Healthcare Information Security:** Understating of Health IT laws and requirements, HIT security governance, audit logging, health IT clouds security requirements, developing and implementing security strategies, identity management, identifying and implementing security framework.

- **Enterprise Architecture:** IT-Business alignment, ID and aligning business process, improving business process using Capability Maturity Model Integration, use of the Open Group Service Integration Maturity Model to asses and evaluate service maturity, using Business Process Model Notation to design and document business process.

- **Software Collaboration tools:** Git, Github, Subversion.

Languages

- Fluent in both: Arabic (Native language) & English (Second Language).

References

- References are available upon request.