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Evaluating Usability of Current Design Strategies for Web-based Personal Health Records

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Abstract

Background: Personal Health Records (PHRs) are becoming important tools for health management; the goal of PHRs is to assist individuals to electronically manage and control their health information (i.e. immunizations, allergy records, etc.) to improve health and wellness.

Objective: While it has been suggested that widespread PHR adoption is greatly influenced by its design and implementation, there is little understanding on the actual experience of people using PHRs at this time. The objective of this study is to evaluate the usability (i.e. efficiency and satisfaction) of existing, commercially available web-based PHRs.

Methods: For this research, usability test among five widely available web-based PHRs was conducted, specifically focusing on efficiency and satisfaction by lay consumers following a prescribed script of tasks simulating actual PHR use. Efficiency was measured based on three variables: number of clicks, keystrokes and time per task, while satisfaction was measured based on a post questionnaire. Efficiency and satisfaction data was collected from 41 subjects, 18 to 32 years old, college students, using a combination of online monitoring software while they manually entered a prescribed health profile into 5 chosen web based PHRs. Correlation between the chosen PHRs was determined by comparing average, standard deviation and using two weight factor schemes.

Results: For 4 of 8 common PHR tasks, Healthvault required the highest number of mouse clicks resulting from large window sizes, extra screens, and active links. Health vault also required the highest number of keystrokes for 6 of 8 PHR tasks. Google Health required the second highest number of keystrokes in 4 of 8 PHR tasks. By task completion time, Vital Chart had the highest time to complete all 8 required PHR tasks 12.2 min, 26-58% higher than the other PHRs tested. Vital Chart PHR had the lowest usability rating in the usability questions when compared to the other PHRs. Overall scores were only affected slightly by the test case (i.e. chronic, acute) type in two of the PHRs tested.

Conclusions: The findings of this research suggest that the design interface and strategy of a PHR has a direct effect on the satisfaction of and efficiency by end-users. Allowing for flexibility of data entry by users may enhance PHR usability by reducing the number of clicks, keystrokes, and time required to complete common tasks.

Keywords: *Personal Health Records; Electronic Health Records; Web Usability; User Interface Design; Web Design*

Introduction

Today, there are many issues forcing the U.S. health system to look for new and better ways to manage public health information.These include the incessant and rising cost of healthcare, lack of care coordination, administrative inefficiency, medical errors, etc. In terms of health care costs, the United States spends nearly $3.2 trillion or $9,990 per person annually in healthcare [1]. In 2015, total U.S. health expenditure was estimated at 17.8% of total GDP, with national health expenditure costs growing at an annual rate of 5.6 percent, and expected to reach approximately 20% of GDP by 2025 [2]. Lack of coordination among physicians and administrative inefficiency are the result of a fragmented health care system. In the current system, a comprehensive picture of an individual's health information (i.e. history, immunization record, allergies, medications, etc) is very difficult to obtain.This information is distributed among various data sources (i.e. primary care providers, hospitals, pharmacies, etc.) creating silos of information that often are not linked to one another. In order to solve some of these problems, the U.S. Department of Health and Human Services, the Office of the National Coordinator for Health Information Technology, and the Centers for Medicare and Medicaid Services have all identified PHRs as a strategic priority for improving the health and wellness of the nation as well as containing the rising cost of health care [3]. They advocate for more widespread adoption of Personal Health Records (PHRs) among the general public. While there are many definitions of what a PHR is, the Markle Foundation has described PHRs as "a set of computer-based tools that allow people to access and coordinate their lifelong health information, and make appropriate parts of it available to those who need it" [4]. At this time, many authors agree that PHRs are meant to be used individuals rather than healthcare professionals [5-6]. One of the main challenges for PHRs is increasing its level of

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adoption by the general population. In 2008, a national survey reported that 79% of U.S. consumers agreed that using electronic PHRs could provide significant benefits in managing their health and improving health care services. However, only 2.7% of adults have online PHRs [7].

There are different types of barriers hindering the adoption of PHRs. Some of them include education efforts in using this technology [8]. Some individuals may not be familiar with using technology and, therefore, may require extensive training or personal aids when using PHRs. Another key barrier relates to awareness of the availability and potential benefits of PHRs in facilitating health and wellness and/or management of chronic illness and acute events. Although, there is an overwhelming amount of evidence of the potential benefits of PHRs, there continues to be a lack of quantifiable, large-scale research supporting those benefits [9].

At this time, one of the challenges for researchers has been in trying to understand PHR usage among individuals; currently, "little work has been done on the usability of PHRs, on patient preferences for entering, maintaining, and disclosing portions of their record"-[11]. In a study by Emani et al. [12] studying patient perceptions of PHRs, the authors identified ease of use as a key barrier to PHR adoption. Other usability areas which need further study include evaluating the effectiveness of such interfaces [13]. There have been some studies evaluating the usability of PHRs. Wang, Matsen, and Kim [14] developed and implemented a study on a proprietary web-based PHR whose main functions were to collect some patient information and send self-referrals. Sixty-one (61) subjects participated in the study. The results indicated that 85% of the subjects were satisfied with the usability of the system and 94% of respondents were satisfied with the online referral experience. Another study conducted by the Geisinger Health System, a physician healthcare system in Pennsylvania, evaluated the user experience of their online health portal (MyChart) [15]. MyChart's main features included allowing patients to view portions of their electronic medical record and providing electronic communication with their providers. For this study, 1,421 active online users participated. Respondents rated the system favorable (range from 78 to 85) from a scale of 1(hard) to 100(easy). For communication with providers, patients preferred email for asking general questions (53%), getting prescription renewals (64%), and getting instructions for self-monitoring (46%). The majority of work in this area has been on evaluating provider-based PHRs, PHRs which are managed and controlled by a health care provider (i.e. hospital) who make their data available via an internet portal [16-17]. However, few attempts have been made to evaluate usability among current PHR market vendors, commercially available systems that are controlled by consumers. Czaja et al. performed a PHR usability analysis in underserved adult populations and reported high cognitive load in this population due to "low literacy, low health literacy, and limited technology skills" but suggested further study regarding human factors related PHR challenges [18]. The purpose of this study is conduct such a study to evaluate usability of 5 commercially available, web-based PHR systems.

Methods

A total of 5 web-based PHRs were chosen for this test based on their importance in the market and common features. Systems evaluated were Google Health (Google Inc., Mountain View, CA), Health Vault ® (Microsoft Corp., Redmond, WA), No More Clipboard (Ft. Wayne, IN), Vital Chart ® (Durham, NC), and Healthy Circles (Healthy Circles LLC, San Diego, CA).

For this study, reviewed by the Institutional Review Board at The Catholic University of America (Washington, DC) and deemed "exempt" as only de-indentified data is being collected, 43 college-aged (18-32 years old) students participated in the study. Seven (7) datasets were corrupted and later removed from analyses. Data was collected in two sessions. The first group (n=22) completed evaluation of two PHRs (Google Health, Health Vault), while the second group (n=21) evaluated three PHRs (No More Clipboard, VitalChart ,Healthy Circles). During each session, participants received a packet consisting of a brief description of the study, waiver form, basic demographic questionnaire, assigned tasks and a post-test questionnaire to be completed.

Subject Demographics

A total of 36 subjects (M: 58%; F: 42%) aged 20.8 ± 4.6 years old who were students at CUA were recruited for the study. 25% of the subjects had completed a bachelor's degree and 100% completed high school. Subjects had high computer literacy and regularly used computers (94% daily) and all had been using computers for 3 or more years. Common uses include EMAIL, news, academic needs, entertainment, shopping, and gaming.

The web-browser used for this research study of web-based PHRs was Firefox v1.5 by Mozilla as there were readily available monitoring add-ons for collecting key quantitative metrics of usability. These add-ons were pre-loaded onto each computer and included: Capture Fox 0.7.0 – web based screen capture for retrospective analysis of temporal events, Selenium IDE – an add-on that records and playback interaction in the browser for assessing mouse clicks, and Keylogger – for recording keystrokes.

Usability Analysis

For this study, each participant was given 8 PHR tasks to complete following a script. PHR tasks were intended to represent typical tasks required by consumers to upkeep their own PHRs. These tasks shown in Table 1 and include logging in/out of PHRs, entering allergies, recording medications and immunizations, and documenting hospital procedures. Once they completed all the tasks, participants were required to complete a post-test questionnaire asking them to rate their experience using each PHR and provide written feedback about their experience.

While performing each task, various monitoring software recorded different usability variables such as the number of mouse clicks (Selenium IDE), number of keystrokes (Keylogger), and time per task (Capture Fox). A text editor was used to count the number of clicks and keystrokes per task. Specific interface clues were used to determine the beginning and end of each task.

All PHRs had a button to save the data into the PHR. Once the "save" mouse click activity was detected, its time stamp was assigned to the end of the task. The next detected mouse click was assigned as the beginning of the next task. A record of keystrokes for a task indicated that participants had used the keyboard. If no keystroke was recorded, participants did not use the keyboard for that task (i.e. only required mouse click).

Table 1. Evaluated PHR Tasks	
Task 1	**Sign-in** to the assigned PHR website
Task 2	You are allergic to peanuts. Please add **peanuts allergies** toyour PHR. **Addlactose intolerance**and delete **peanuts** from your allergies.
Task 3	Your current **health condition** is that you suffer from **asthma.** Add **asthma**to the PHR**.**
Task 4	You just got an **x-ray** on your right hand today. Add **right hand x-ray procedure** to the PHR**.**
	You suffered an accident while playing basketball, it requires you to get an **x-ray** on your right ankle. **Add this event**to the PHR.
Task 5	You have high blood pressure and have to take the following medicines: **indapamicome**and **metolazone**.Add both **medications** to the PHR.
Task 6	You received immunizations for **tuberculosis** and **dengue fever.**Add both **immunizations**to the PHR
Task 7	A relative (uncle) suffered and died from **lung cancer**. Add this**history** to the PHR.
Task 8	Please**sign out**of website.

Questionnaire Analysis

A post-test survey included 5 questions. For the first four questions, participants had to rate their answer using a 5-point Likert scale (1=strongly disagree; 5=strongly agree), while the last question was an open-ended allowing for unstructured user comments. The questions asked were:

- Question 1: Was moving around the website difficult to you?
- Question 2: What was your level of difficulty completing the tasks? Both had a rate scale of 1(very difficult) to 5(very easy).
- Question 3: Were you satisfied with the number of steps to complete a task?
- Question 4: Was the website confusing?

Computation of Overall Usability Measure

As not all 8 tasks carry the same level of importance in utilization and maintenance of a PHR, analyses of overall usability measures is complex. For this study, usability scores were developed based upon 2 distinct schemas, one based upon test-case (TC) utilization and another based upon efficiency and satisfaction (ES) measure.

In the (TC) schema, a weight of importance of each task was assigned based upon a test case of a person managing either a chronic (i.e. hypertension, heart failure, etc) or acute illness (i.e. accidents, infections, common cold, etc.). To determine the TC score, the average (a) of each usability metric (i.e. time, mouse clicks, and keystrokes) was multiplied by the task weight(w) and summed for all tasks. The scores were normalized following:

$$\mathrm{N} = 1 - \left(\frac{(x_i - \bar{x})}{\bar{x}}\right) \mathrm{X}\ 100\% \qquad (1)$$

where xi is the TC score for a PHR and x represents the lowest TC score for that metric. To arrive at a final TC score, the following formula was used:

$$\text{Score} = \textstyle\sum_{i=1}^{n} wf * x_i \qquad (2)$$

Here, the usability weight factor (*wf*) was multiplied by the normalized score for each efficiency matrix. This was repeated for all efficiency metrics. The result for each multiplication for each efficiency metric was added together to get the final TC score.

In the ES schema, an ES score was computed from the quantitative data as well as subjective questionnaire information collected. First, the TC schema is used to get the TC score for each efficiency metric using the equations 1 and 2. In addition, an user satisfaction score is added to this scheme. To arrive at the user satisfaction (SAT) score, the following formula was used:

$$\mathrm{SAT} = \frac{\sum_{i=1}^{s} \mathrm{y_i} * \mathrm{x_i}}{\sum \mathrm{n_i}} \qquad (3)$$

where y is the average score for that specific answer in the questionnaire, x is the weight scale for that answer, and n is the number of participants. The average y is multiplied by the weight scale x for all the answer for that PHR which is sum together divided by the total number of participants (n) to get the SAT score. The final SAT score is produced by adding all the SAT scores for all the questions for that PHR.

For the ES scheme, weightings for clicks, keystrokes, time, and subjective measures were 20%, 20%, 40%, and 20%, respectively.

Results

A. Usability Variables

Mouse clicks, keystrokes and completion time observed for each task are given in Tables 2-4.

B. Usability Questionnaire

Table 5 summarizes post-test surveys of usability rankings for PHR by each subject. Results range from 1-5 (1=very difficult; 5=very easy). Table 6 provides a summary users' open-ended responses regarding each PHR tested.

C. Usability Scores

Test case (TC) scoresforchronic and acute illnesses are reported in [Tables 7 and 8], respectively. Usability scores, combination of efficiency and satisfaction scores, are provided in Tables 9 and 10.

Table 2: Mouse Clicks per Task (*avg ± stdev*)

	Tasks	Benchmark	PHRs				
			Google Heath	Health Vault	NoMore Clipboard	Google Heath	Healthy Circles
1	Sign in	3.2	3.1 ± .5	3.9 ± .2	2 ± 1.1	2.3 ± 1.7	2.2 ± 0.9
2	Add allergies	9.1	10.6 ± 4.1	10.27 ± 4.5	8.8 ± 6.7	9.3 ± 7.7	6.6 ± 4.3
3	Add condition	3.9	4.1 ± 3.8	4.87 ± 3.1	3.5 ± 2.7	3.7 ± 2.1	3.5 ± 2.2
4	Add surgery	8.1	8.1 ± 2.4	9.07 ± 3.0	7.3 ± 3.1	9.7 ± 6.1	8.1 ± 3.8
5	Add medication	5.2	5.5 ± 3.5	7.27 ± 2.9	3.8 ± 2.9	4.4 ± 2.4	4.9 ± 2.8
6	Add immunization	5.5	3.6 ± 1.8	6.33 ± 1.8	4.9 ± 6.6	5.7 ± 4.6	5.6 ± 3.9
7	Add family history	3.5	3.7 ± 8.1	4.53 ± 2.3	3.4 ± 1.5	2.7 ± 2.0	3.1 ± 1.8
8	Sign out	1.7	1.8 ± 1.6	1.33 ± 0.5	1.3 ± 1.5	1.2 ± 1.0	1.4 ± 2.3

Table 3: Keystrokes per Task (*avg + stdev*)

	Tasks	Benchmark	PHRs				
			Google Heath	Health Vault	NoMore Clipboard	Vital Chart	Healthy Circles
1	Sign in	17.4	19.8 ± 1.9	20.1 ± 3.1	15.2 ± 5.5	12.2 ± 7.7	14.6 ± 9.4
2	Add allergies	20.7	33.9 ± 20.4	26.8 ±13.2	11.7 ± 8.4	14.3 ± 11.4	17.0 ± 10.9
3	Add condition	7.1	6.0 ± 2.5	7.3 ± 2.4	6.5 ± 5.8	7.3 ± 8.7	8.6 ± 6.3
4	Add surgery	25.7	33.8 ± 15.5	43.7 ± 15.9	20.0 ±10.6	17.0 ± 12.6	14.0 ± 14.2
5	Add medication	20.3	30.5 ± 8.7	32.1 ± 15.8	15.4 ± 7.3	10.8 ± 7.7	11.3 ± 6.8
6	Add immunization	12.0	14.7 ± 7.1	9.9 ± 11.4	17.0 ± 7.7	7.6 ± 9.1	10.7 ± 7.0
7	Add family history	8.0	4.5 ±13.8	15.4 ± 4.9	7.8 ± 6.3	3.3 ± 4.1	8.8 ± 6.8
8	Sign out	0.0	0 ± 0.0	0 ± 0.0	0.0 ± 0.0	0.0 ± 0.4	0.0 ± 5.9

Table 4: Completion Time per Task (*avg + stdev*)

	Tasks	Benchmark	PHRs				
			Google Heath	Health Vault	NoMore Clipboard	Vital Chart	Healthy Circles
1	Sign in	0.50	1.1 ± .3	1.1 ± .2	1.0 ± 0	1.0 ± .3	1.0 ± 1
2	Add allergies	1.46	2.5 ± 1.4	1.4 ± .4	1.8 ± 1	1.9 ± .8	1.7 ± 1
3	Add condition	0.44	0.3 ± .2	0.5 ± .4	1.0 ± .3	1.4 ± .7	1.1 ± .6
4	Add surgery	1.12	1.2 ± .7	1.3 ± .6	2.5 ± 1	2.9 ± 1.4	2.4 ± 1.7
5	Add medication	0.76	1 ± .4	1 ± .5	1.0 ± .2	1.3 ± .6	1.1 ± .5
6	Add immunization	0.78	0.5 ± .2	1.5 ± .9	1.3 ± 1.1	1.6 ± 1.5	0.9 ± .4
7	Add family history	0.34	1 ± .9	0.6 ± .5	0.9 ± .4	1.0 ± .7	0.8 ± .6
8	Sign out	0.15	0.4 ± .4	0.1 ± .1	0.9 ± .4	0.8 ± .4	0.8 ± .6
		Avg. Total	**8.9**	**8.7**	**7.7**	**12.2**	**9.7**

Table 5: Questionnaire results average responses					
	Google Health	**HealthVault**	**NoMore Clipboard**	**VitalChart**	**Healthy Circles**
1Q: Navigating website	4 ± .7	3.7 ± .9	3.8 ± .7	**2 ± .5**	3.7 ± .9
2Q: Difficulty completing tasks	3.9 ± .6	3.7 ± .9	3.9 ± .7	**2 ± .7**	3.9 ± .9
3Q: Satisfied with number of steps to complete task	3.9 ± .6	3.7 ± .9	3.9 ± .7	**2 ± .7**	3.9 ± .9
4Q: Website confusing?	**2.5 ± .9**	**2.5 ± 1.2**	**2.4 ± 1.1**	4 ± .8	**2.5 ± 1.1**

Table 6: Users' Comments	
GoogleHealth	**HealthVault**
Liked most: Similar to Gmail easy, easy to use if familiar with Gmail. Liked least: No family history, family history was hard, couldn't find out family history, no family history, difficult finding x-ray and no family history, not user friendly. Recommendations: Should have family history.	Liked most: Very user friendly, very detailed, more organized, easier than Google. Liked least: Couldn't find immunizations. Recommendations: Didn't have family history as dropdown option, couldn't find immunizations, slow response medical term use.
NoMoreClipboard	**HealthyCircles**
Liked most:The website was easy, easy, very easy to move around website, actual submission of data was easy, website good if patient know what to enter in advance. Least liked: Family history was confusing; confusing but not frustrating; finding main page was hard. Recommendations: Make account button to enter data larger; nice to have a feature to correct misspelled medication; need navigation buttons to move around easily.	Liked most: Best one; layout was easy to use;easy to navigate; looks very professional; liked had it had a calendar to keep records. Least liked: It took some getting used to layout of website; immunization was confusing, too specific hard to enter information always ask for dates. Recommendations: could be a little more simple in finding tabs.
VitalChart	
Least liked: Very difficult to navigate around, very confusing, didn't like this one at all, didn't like it at all, too confusing too many steps, options to complete weren't option in website, difficult to locate areas, Limited checkboxes to enter information, website relied on clicking didn't provide option to add other information, sign out difficult to find, too many steps.	

Table 7.Test CaseScore: Chronic Illness						
Tasks weight Factor(w)			**Efficiency**			
Sign in	10%		**Click**	**Keystroke**	**Time**	**TC score**
Add allergy	10%	**PHR**	25%	25%	50%	
Add Health Condition	30%	NoMoreClipboard	1	.8	.7	69%
Add Surgery	8%	HealthyCircles	.95	.9	.8	**79%**
Add Medication	25%	VitalChart	.88	1	.4	58%
Add immunization	7%	GoogleHealth	.76	.1	1	**72%**
Add family history	3%	HealthVault	.5	0	1	51%
Sign out	7%					

Table 8: Test Case Score:Acute Illness						
Tasks weight Factor(*w*)			**Efficiency**			
Sign in	10%		**Click**	**Keystroke**	**Time**	**TC score**
Add allergy	5%	**PHR**	25%	25%	50%	
Add Health Condition	25%	NoMoreClipboard	1	.67	.56	**80%**
Add Surgery	15%	HealthyCircles	.93	.89	.67	**86%**
Add Medication	15%	VitalChart	.88	1	.22	67%
Add immunization	15%	GoogleHealth	.78	.11	1	72%
Add family history	5%	HealthVault	.5	0	.78	63%
Sign out	10%					

Table 9: Usability Score:Chronic Illness					
	Efficiency			**Satisfaction**	**Final Score**
PHR	Click (20% wt)	Keystroke (20% wt)	Time (40% wt)	Subjective (20% wt)	
NoMoreClipboard	1.00	0.80	0.70	1.0	**84%**
HealthyCircles	0.95	0.90	0.80	0.89	**87%**
VitalChart	0.88	1.00	0.40	0.76	69%
GoogleHealth	0.76	0.10	1.00	0.93	**76%**
HealthVault	0.5	0.00	1.00	0.77	65%

Table 10: Usability Score:AcuteIllness					
	Efficiency			**Satisfaction**	**Final Score**
PHR	Click (20% wt)	Keystroke (20% wt)	Time (20% wt)	Subjective (40% wt)	
NoMoreClipboard	1.00	0.67	0.56	1.00	**76%**
HealthyCircles	0.93	0.89	0.67	0.89	**81%**
VitalChart	0.88	1.00	0.22	0.76	62%
GoogleHealth	0.78	0.11	1.00	0.93	**76%**
HealthVault	0.5	0.00	0.78	0.77	57%

Discussion

The present findings are based on homogeneous population sample and results provide preliminary findings on the types of human factors problems individuals encountered when completing PHR tasks. By design, some PHRs required more text-based input where others implemented drop-down menus, radio buttons, and checkboxes for data entry. These contrasting strategies provided a trade-off between reducing data entry and potential input errors with flexibility of data to be entered. In many cases, if the system did not use common terminology as that provided by the test case scenario (i.e. medication type), this resulted in confusion by the user on what to do and how to enter required tasks into the PHR. Some users had to navigate back-and-forth between menu options to find desired tasks.

Tasks requiring the most mouse clicks and keystrokes (i.e. typing) related to adding allergies and surgical procedures to the PHR. Text-based PHRs such as Google Health and HealthVault required typing more manual typing for adding tasks such as allergies, surgeries, and medications as compared to other PHRs. While requiring more keystrokes, this was often faster for end-users than using dropdown menus which required more cognition and identification with fixed terminologies. In some cases, the desired tasks were not available in the PHR menus.

Test case (TC) scenarios (i.e. acute, chronic illness; Table 9 - 10) had only a slight impact on affecting final TC efficiency (i.e. clicks, keystrokes, time) scores. The top 3 PHRs remained the same for each TC, but due to the different weighting for entry of medications, #2 and #3 in the rankings exchanged places. Even when satisfaction (SAT) scores were added to efficiency scores, the top 3 remained the same. This may indicate a strong correlation between objective efficiency measures with subjective satisfaction scores.

Conclusion and Recommendations

Most research related to PHR usability has been done specifically on provider based PHRs and have focused on subjective satisfaction evaluations obtained through questionnaires. This study evaluated vendor-based PHRs using objective performance measures while users performed prescribed tasks along with satisfaction metrics. There is a high degree of correlation between the objective performance measures (i.e. clicks, keystrokes, task time) and satisfaction results. This study also suggests usability is potentially affected by end-user needs (i.e. chronic, acute illnesses).This effort also contributes a methodology and schema for future usability evaluations of PHRs.

Conflict of interest

The authors do not have financial relationships with any of the vendors mentioned in this article. There are no conflicts of interest.

References

1. David C K,Ashish K J, Douglas J b, Blackford M and David W B. A Research agenda for Personal Health Records (PHRs). J Am Med Inform Assoc. 2008; 15:729-736. [Crossref]
2. Keehan SP, Stone DA, Poisal JA, Cuckler GA, Sisko AM, Smith SD, et al. National Health Expenditure Projections 2016-25: Price increases, aging push sector to 20 percent of economy. Health Affairs. 2017; 35: 553-565. [Crossref]
3. Tang PC, Ash JS, Bates DW, Overhage JM and Sands DZ. Personal Health Records: Definitions, Benefits, and strategies for Overcoming Barriers to Adoption. J Am Med Inform Assoc. 2006; 12: 121-126. [Crossref]
4. The Markle Foundation. The Personal Health Working Group. Final Report . [accessed: 2012-10-31]. [Crossref]
5. The American Health Information Management Association. Personal Health Records. AHIMA American Health Information Management Association. U.S Department of Health and Human Services. 2010[accessed:2012-10-31]. [Crossref]
6. Tang PC and Lansky D.The missing link:bridging the patient provider health information gap.Health Aff (Millwood). 2005; 24:1290-1295. [Crossref]
7. Kuang-Yi Wen, Gary Kreps, Fang Zhu and Suzanne Miller. Consumers Perceptions About and Use of the Internet for Personal Health Records and Health Information Exchange: Analysis of the 2007 Health Information National Trends Survey. J Med Internet Res. 2010; 12: e73. [Crossref]
8. Thomas AH, Nathan EB and Richard JB. A Multidimensional View of Personal Health Systems for Underserved Populations. J Med Internet Res. 2010; 12: e32. [Crossref]
9. GoldmanJ. Personal Health Records: Employers proceed with caution. California healthcare Foundation.[accessed: 2012-10-31]. [Crossref]
10. Khan SJ, Aulakh V and Bosworth A. What it takes: Characteristics of the ideal personal health record. Health Aff. 2009; 28:269-276. [Crossref]
11. Kim MI and Johnson KB. Personal Health Records: Evaluation of Functionality and Utility. J Am Med Inform Assoc. 2002; 9:171-180. [Crossref]
12. Emani S, Yamin CK, Peters E, Karson AS, Lipsitz SR, Wald JS, et al. Patient Percepions of a personal health record: a test of the diffusion of innovation model. J Med Internet Res. 2012; 14:e150. [Crossref]
13. Marchionini G, Rimer BK and Wildemuth B. Evidence Base for Personal Health Record Usability, Final Report to the National Cancer Institute. Accessed: 2012-10-30. [accessed: 2012-10-30]. [Crossref]
14. Wang M, Lau C, Matsen FA and Kim Y. Personal Health Information Management System and Its Application in Referral Management. IEEE Trans Inf Technol Biomed.2004; 8:287-297. [Crossref]
15. Hassol A, Walker JM., Kidder D, Kim R, Young D, Pierdon S, et al. Patient Experiences and Attitudes about Access to a Patient Electronic Health Care Record and Linked Web Messaging. J Am Med Inform Assoc. 2004; 11:505-513. [Crossref]
16. Ralston JD, Carrel D, Reid R, Anderson M, Moran M, Hereford J, et al. Patient Web Services Integrated with a Shared Medical record: Patient Use and Satisfaction. J Am Med Inform Assoc. 2007; 14:798-806. [Crossref]
17. Frost JH and Massagli MP. Social Uses of Personal Health Information within PatientsLikeMe, an Online Patient Community: What Can Happen When Patients Have Access to One Another's Data. J Med Internet Res. 2008; 10. [Crossref]
18. Czaja SJ, Zarcadoolas C, Vaughon WL, Lee CC, Rockoff ML, and Levy J. The usability of electronic personal health record systems for an underserved adult population. Hum Factors. 2015; 57: 491-506. [Crossref]
19. U.S. Department of Health and Human Services. Usability.gov your guide for developing usable & useful websites. [accessed: 2012-10-30]. [Crossref]
20. Tran BQ and Gonzales P. Standards and Guidelines for Personal Health Records in the United States: Finding Consensus in a Rapidly Evolving and Divided Environment. J Health Med Informat. 2012; S6:001. [Crossref]