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EVALUATION OF USABILITY OF PICTURE ARCHIVING AND COMMUNICATION SYSTEM (PACS) IN CLINICAL SETTINGS BASED ON ISO 9241/10 FROM THE PERSPECTIVE OF END USERS

Ghasem Deimazar[1], Mehdi Kahouei[2, *], Yaser Norouzian[3], Mina Moslemi[3]

[1] Health information technology department of allied health school, Semnan University of Medical Sciences, Semnan, Iran.
[2] Health information technology department of allied health school, Semnan University of Medical Sciences, Semnan, Iran.
[3] Student Research Committee, allied health school, Semnan University of Medical Sciences, Semnan, Iran

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ABSTRACT

Introduction: Because of a supporting role in patient safety improvement through access to medical images of patients in the shortest possible time and accurate diagnosis and timely medical care, the high efficiency and effectiveness of digital medical picture archiving and communication system are clearly marked. Therefore, this study aims to evaluate the usability of the picture archiving and communication system with the assessment by workers of teaching hospitals.
Method: This study was performed in affiliated hospitals of Semnan University of medical sciences in Semnan, Iran, in 2016. In this study, a census method was used. The data collection tool was a researcher made questionnaire.
Results: The results related to suitability of PACS for tasks showed the highest average (3.74) was related to appropriate method of data entry done tasks. The results related to ability of user control showed the highest average (3.69) was related to the possibility of direct return to the main menu. There was a significant difference between the mean scores ($P<0.05$). The highest average score (3.65) was related to suitability of PACS for tasks and the lowest mean score (3.15) was related to the suitability of learning of the PACS.
Conclusion: According to survey results, the PACS was of good usability; of course, the PACS system developer company should have to pay more attention to functionalities such as learning systems, system errors, sufficient guides in the system and providing the necessary explanations to end users, so that the acceptance of the application in health care organizations becomes increasingly impressive.

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Introduction

Advances in digital communications and computer technology have had a major impact on medical imaging (1). Reduced medical errors is essential and the use of information technology to achieve this purpose is required (2, 3). There are numerous software applications and health information systems in the medical field designed to prevent or reduce medical errors, facilitate and expedite the activities, avoid duplication, reduce costs and ultimately to improve security patients (4-6). At present, imaging technology has made significant advances in storing, viewing and sending images and the process is improving. The digital picture archiving and communication system (PACS) can be considered as one of the recent developments (1). PACS concept was introduced in the early 1980s by the Radiological Society of America as a practical way

Corresponding Author: Mehdi Kahouei, Social Determinants of Health Research Center, Allied Health School of Semnan University of Medical Sciences, Semnan, Iran. Tel: +989127313543, E-mail: mkahouei@yahoo.com

of Radiology (7). This system was a computer tool that can provide the conditions necessary to create a center of medical imaging without films, along with other requirements (8). Today, with advances in medical information technology and computer networks, there is no need to old stereotypes for taking radiology images and the cost of purchasing and storing these films, because PACS has created the possibility of transmission, storage, retrieval and display of medical images at different points. Imaging devices, a computer network, databases or bank database and images display stations or Client are four main components that make up a PACS system in hospital. PACS is structured in such a way that it can manage databases on all patients in an intelligent way. This system is one of the subsystems for radiology information system and is also one of the essential requirements for the creation of electronic health records (9). Information systems in this sector should be free of usability problem in order to prevent any errors created by them. To achieve this goal, systems must be designed and used appropriately and in accordance with the scientific design principles (10). One way to ensure the proper design of systems is existing assessment regarding the usability of these systems (11). Usability is the extent to which a particular product can be used by specific users to achieve specific goals within a context characterized by effectiveness, efficiency and satisfaction (12). Usability deals with various software features including ease of learning, efficiency, ease of memorization, error prevention and customer satisfaction (11). Usability evaluation methods are divided into two major groups, including usability testing method and inspection usability inspection method (11, 13, 14). Therefore, ISO 9241 is one of the standards for judging the usability of standard software systems which has been developed by the International Organization for Standardization, covering lists of criteria for software compatibility with the needs of users (15). Part 10 of this standard provides a list of organizing and evaluating user interface. Topics included in this list are suitability for tasks, self-descriptiveness, controllability, compatibility with the needs and expectations of users, acceptance of error tolerance, suitability for customization and optimal training of users (15). According to what was said, because of a supporting role in patient safety improvement through access to medical images of patients in the shortest possible time and accurate diagnosis and timely medical care, the high efficiency and effectiveness of digital medical picture archiving and communication system are clearly marked.

To achieve this efficiency and effectiveness, continuous evaluation and measurement of this software are an indispensable process. Evaluation of the performance of these systems is of great importance. Therefore, this study aims to evaluate the usability of the picture archiving and communication system (PACS) with the assessment by users of hospitals affiliated to Semnan University of Medical Sciences, because assessing the views of end-users is one way of successful software systems implementation. In addition, by examining this system in hospitals of Semnan University of Medical Sciences, its strengths and weaknesses can be identified and it helps to improve the efficiency and effectiveness of the system.

Materials and Methods

This study was conducted in teaching hospitals affiliated to Semnan University of medical sciences in Iran. The research was done between April to December, 2016. The teaching hospitals are equipped with clinical information systems. Thus, no sampling procedure was used. A Likert-type questionnaire was used for collecting data. This instrument, which was designed based on the available literature, consisted of two sections: the first section included demographic items like age, gender and work experience. The second section consisted of seven subscales. The first subscale aimed at measuring the Suitability of PACS for tasks (5 questions), the second subscale, which tapped into self-descriptiveness of PACS includes 4 questions, the third subscale measured ability of user control (4 questions); the fourth subscale aimed at measuring PACS compatibility with the user's needs (4 questions); the fifth subscale measured fault tolerance of the PACS (5 questions); the sixth subscale measured suitability of PACS system for the personalization (3 questions); and the seventh subscale measured the suitability of learning of the PACS (3 questions). The answers on each item were measured on a 5-point Likert type scale, totally disagree =5, disagree =4, no idea=3, agree =2 and totally agree =1. In order to evaluate the validity, the primary questionnaire was reviewed by medical informatics and health information management experts. Utilizing the experts' suggestions, the questionnaire was rewritten and became more focused. Then we piloted the questionnaire on forty research community randomly selected from employees who were working in the teaching hospitals. Participants in the pilot study were excluded from the study. Cronbach alpha was used to calculate the reliability of the instruments of 0.921 Next, further revisions were made and some statements were rephrased. Lastly, the final version of the anonymous questionnaire was distributed among the employees in the hospitals and they were asked to complete the questionnaire. Furthermore, SPSS (version 16) was exploited to conduct descriptive and inferential statistics like Friedman test. First, we obtained ethical approval from the Medical Ethics Committee of Semnan University (IR.SEMUMS.REC.1394.153). Then, we prepared a cover letter describing the purposes of the study. The letter explained that responding to the survey indicated the participants' consent to take part in the research. It also assured the participants that all responses would be kept confidential.

Results

Table1. The study subjects' characteristics

characteristics	group	number	percent
sex	female	47	44.3
	male	59	55.7
job	physician	44	41.5
	Resident student	19	17.9
	Medical student	25	23.6
	Nurse	6	5.7
	Radiology technician	12	11.3
age	34.8±8.6		
Work experience	10.33±6.9		

106 people participated in the study. The findings showed that 59 people (55.7%) were males. 44 people (41.5%) were physicians. The mean age of participants was 34.81 years; the average work experience of participants was 10.33 years. (Table 1).

The results related to suitability of PACS for tasks showed the highest average (3.74) was related to appropriate method of data entry done tasks. There was a significant difference between the mean scores (P<0.05). The findings related to self-descriptiveness of PACS showed the highest average (3.58) was related to sufficient information about the data by the application. The results related to ability of user control showed the highest average (3.69) was related to the possibility of direct return to the main menu. There was a significant difference between the mean scores (P<0.05). The findings related to PACS compatibility with the user's needs showed the highest average (3.79) was related to miniaturizing and enlarging of images. There was a significant difference between the mean scores (P<0.05). The results related to of the fault tolerance of the PACS showed the highest average (3.46) was related to allowing easy return to previous work in the event of a mistake. There was a significant difference between the mean scores (P<0.05). The findings related to the suitability of PACS system for the personalization showed the highest average (3.38) was related to adjusting the displayed data on the screen in accordance with the requirements. The results related to the suitability of learning of the PACS showed the highest average (3.30) was related to providing auxiliary descriptions to user to create more skills to use of the PACS. (Table 2)

Table 2. Mean score of participants' attitudes towards Usability of PACS

Criteria	questions	mean	SD	Mean rank	p-value
Suitability of PACS for tasks	The software dose not impose me responsibilities other than my own	3.18	1.00	4.18	0.002
	I can put the images in the correct place	3.70	0.97	4.67	
	Data input methods, fit the responsibilities I have to do.	3.74	0.82	4.56	
	I can measure easily	3.52	0.89	4.41	
	I can match the software with my new duties easily	3.47	0.89	4.36	
self-descriptiveness of PACS	The software explains me the necessary items	3.33	0.89	4.22	0.172
	I can understand the massages displayed in the monitor easily	3.55	0.92	4.47	
	Retrieving information of a special field is possible for the user, easily	3.50	1.07	4.57	
	The software gives me enough information about authorized data	3.58	0.98	4.56	
ability of user control	I can switch between different menus easily	3.41	0.99	4.4	0.001
	The help menu in the software has adequate information	3.14	0.98	4.12	
	I can move easily between previous displayed pages and next ones.	3.38	0.91	4.29	
	The software allows me to return to main menu directly	3.69	0.95	4.64	
PACS compatibility with the user's needs	I can compare the images easily	3.50	1.17	4.67	0.001
	I can predict the results during the operation	3.30	0.90	4.2	
	I can zoom in and out the images	3.79	0.89	4.68	

	Massages of each page are displayed in that page	3.63	0.72	4.35	
fault tolerance of the PACS	I can retrieve the previous information in case of making mistakes	3.42	1.01	4.43	0.001
	This software needs confirmation for manipulating operations. (e.g. data elimination)	3.41	0.97	4.38	
	In the case of making mistake while working with the software, it is possible to return to the previous duty I was doing easily.	3.46	0.98	4.44	
	The software informs me about the place of happened problems.	3.08	0.99	4.07	
	While working with the software, system errors (e.g. mess) do not happen.	3.02	1.4	4.42	
suitability of PACS system for the personalization	This system has the capability of changing the order titles, topics and responsibilities according to my idea.	3.31	0.94	4.71	0.725
	It is possible for me to change forms, displayed pages and menus.	3.36	0.98	4.34	
	I can adjust the amount of displaying data with my requirements.	3.38	0.99	4.37	
the suitability of learning of the PACS	This system has additional explanations for user to gain more skills in using software	3.30	0.96	4.26	0.082
	Learning and using this system need a lot of time	3.12	1.13	4.25	
	I can use the software without asking my colleagues.	3.03	1.23	4.26	

The highest average score (3.65) was related to suitability of PACS for tasks and the lowest mean score (3.15) was related to the suitability of learning of the PACS. (Figure 1)

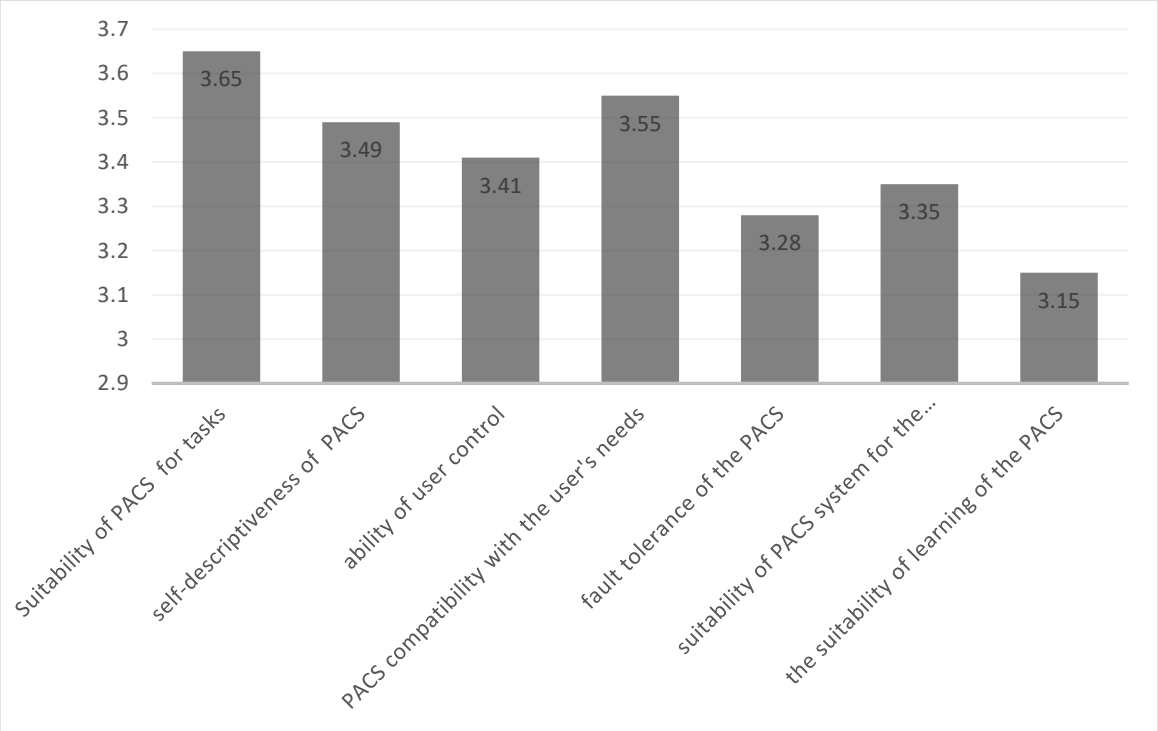

Figure 1. Mean score of participants' attitudes towards the criteria of the PACS usability

Discussion:

Suitability for tasks:

The findings of the study showed that the average suitability of software for tasks was 3.65. In this regard, in the study conducted by Hamborg and his colleagues, the average suitability of hospital information system software for tasks was 3.84 (16). It seems that the PACS software system designers in Iran have paid special attention to the suitability of PACS software that is not enough, of course. Some studies have shown that lack of attention to suitability of the software to perform tasks will increase the number of errors, which have negative effects on the tasks of software systems (10, 17). According to the results of this study, the suitability criterion of software for tasks has the highest average among the seven proposed criteria.

Self-descriptiveness of software:

The findings of the study in conjunction with software self-descriptiveness from the perspective of end users revealed that the evaluation criteria had an acceptable mean. It seems that PACS Software Manufacture Company has had an emphasis on providing appropriate information to users, clarity of the buttons and menus in the system as well as understandability of the messages displayed to users. In this regard, in the study carried out by Hamborg and his colleagues, the self-descriptiveness mean for hospital information system software was 3.84 (16).

User controllability:

The results regarding the user controllability by PACS systems software used in Semnan hospitals showed that end users could work easily with the software system and carry out their tasks with the least trouble. In the study by Thyvalikakath et al., it was shown that 27% of users were unable to perform their tasks while using the system. Moreover, in 31% of cases, tasks were mistakenly performed (18). Therefore, the results of the system in question are of acceptable design, which has resulted in the acceptance of this software system in hospitals in Semnan by end users. In this regard, in the study by Garavand et al., (2015), it was shown that the attitude towards the usefulness and the easy use of PACS system plays a very important role in the acceptance of its use (9). The other results also showed that users were able to move easily between different levels of menus and tabs in the software. In addition, the study by Jorritsma et al., (2016) showed that users could move from a menu or tab to other menus or tabs (19).

Software compatibility with the user's needs:

The findings of the study related to software compatibility with user requirements in the PACS system used in hospitals in Semnan showed that users can easily retrieve and compare new and old medical images of the patients and also could maximize or minimize pictures to suitable dimensions. The study by Jorritsma et al., (2014) showed that among the four studied PACS systems, users are able to retrieve patient images in all systems. Of course, one of these systems had better and easier image retrieval than other systems by users (20).

Error tolerance system:

The findings of the study showed that the average error tolerant system from the user perspective was 3.28. Although the mean is relatively positive, it is only slightly higher than average, so the upgrading of this part by PACS software system designers is necessary. In the study carried out by Hamburg et al., the average error tolerance in hospital information systems was 3.63 (16). Additionally, the study conducted by Safdari et al., (2012) showed that the average error-tolerant system in four studied hospital information software systems was equal to 2.95 (21). The other results of the study show that the current PACS systems used in hospitals in Semnan suffer system errors and the system will not notify users of the errors occurred properly. Thus, it seems that PACS software Manufacture Company has paid less attention to these issues.

Suitability of the software for customization:

Findings in relation to the suitability of PACS system for customization showed that users were able to change the desired forms, screens and menus and also able to adjust the amount of information displayed on the screen according to their needs. The study by Jorritsma et al (2016) also showed that PACS system users could disable temporarily function or unusable information displayed on their screen as well as maximize or minimize their screen profile (19).

Suitability of the software for users' learning:

The findings of the study showed that the mean attitude of the statistical population about the appropriateness of PACS system to learn the software was 3.15. Of the seven criteria studied in this research, the criteria had a lowered mean. In this regard, the study by Safdari et al., (2016) on usability assessment of four hospital information systems showed that the average suitability for hospital information systems for the user's learning was 2.97 (21). The other results of this study showed that used PACS system needs continuous attention from software producing companies to help guide users and easy to use software in terms of suitability for user learning. Also, the study by Rezaei Hachesu et al., (2016) showed that in the reviewed radiology information systems, software designers did not pay special attention to insert a guide to help users (22), and similar results in different studies were approved (4, 12).

Limitation

The results of this study should be interpreted with caution because the study was conducted using a researcher made questionnaire. Also, non-generalizable results of the study because of being done in a university of medical sciences, is of the other limitations of this study. But, however, the study results were in line with other studies in this field**.**

Conclusion

According to survey results, PACS systems used in hospitals in Semnan were of good usability; of course, the PACS system developer company should have to pay more attention to functionalities such as learning systems, system errors, sufficient guides in the system and providing the necessary explanations to end users, so that the acceptance of the application in health care organizations becomes increasingly impressive.

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