

# Investigating the satisfaction level of physicians in regards to implementing medical picture archiving and communication system (PACS)

**Reza Abbasi**

Kerman University of Medical Sciences

**Monireh Sadeqi Jabali**

Kashan University of Medical Sciences

**Hamidreza Tadayon** (✉ [tadayon1363@gmail.com](mailto:tadayon1363@gmail.com))

Kashan University of Medical Sciences <https://orcid.org/0000-0003-0888-1108>

---

## Research article

**Keywords:** Picture Archiving and Communication System (PACS), Satisfaction, Usability, Health Information Systems

**Posted Date:** March 19th, 2020

**DOI:** <https://doi.org/10.21203/rs.2.17033/v2>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

**Version of Record:** A version of this preprint was published on August 5th, 2020. See the published version at <https://doi.org/10.1186/s12911-020-01203-0>.

# Abstract

Background: User's satisfaction with PACS is considered as one of the important criteria for assessing success in using PACS. The objective of this study is to determine the level of satisfaction in PACS' users and also comparing its functional features with traditional film-based systems. Methods: This analytical study was conducted in 2017. Residents at three large university hospitals in Kerman city were included. We used self-administered questionnaire that was consisted of three parts include: demographic information, individuals' satisfaction, comparing features of the two digital and traditional imaging systems. Validity of this questionnaire was approved by specialists and its reliability was obtained as 86%. Data analysis was done with using descriptive statistics and after checking the normality of data, data compared with the spearman, the Mann Whitney U and the Kruskal-Wallis statistical tests. Results: The mean of the participants' ages 31.4 ( $\pm 4.4$ ) years old and 59% of the participants were females. Mean of overall physicians' satisfaction with PACS' score has no significant relationship with the variables of age ( $P=0.611$ ), experience in using PACS ( $P=0.301$ ), type of specialty ( $P=0.093$ ), level of interpretation of images using PACS ( $P=0.762$ ), however it did show a significant relationship with their computer skills ( $P=0.022$ ). Conclusions: The mean for physicians' satisfaction with PACS was at a moderate to high level, yet there are still problems in successfully implementing these systems and establishing interoperability between them . PACS has not fully met all the demands of physicians and has not achieved its predetermined objectives such as all-access from different locations .

## Background

Using modern technologies has led to the optimization of the quality and productivity of the health care systems [1, 2] and the Picture Archiving and Communication System (PACS) is one of these modern technologies, and because of the high costs of radiology films and their storage, their retrieval problems, and problems with the distribution and display of traditional radiology film-based pictures [3, 4], this technology has become the heart of medical imaging centers [5].

The PACS as a module integrated with the radiology information system, not only is it a centralized source for all imaging data, yet it also creates and transfers digital radiology pictures and their reports [6]. This system helps users so that through establishing communication with their workstation computer, to change picture display parameters such as quality, zoom, and contrast and compare pictures against each other [7, 8]. Having many advantages such as optimizing image quality and their accessibility [3, 7, 9, 10], increasing physicians' productivity and efficiency [3, 9], optimizing the connection between clinical units and radiology department [7], reducing the number of lost images [3], reducing the time of reports and sending radiology reports [3, 11, 12], lowering the need to physical space for picture archiving [13], reducing personnel costs and expenses related to films and relevant chemical substances [4, 12, 14], decreasing the need for re-imaging and patients' exposure to harmful rays[3, 14, 15], and reducing the average waiting time for patients [9, 16, 17], PACS has become an alternative for traditional film-based imaging since the 1980's [1].

Despite the significance and advantages of PACSs for healthcare centers and relevant financial investments, the launch and use of these systems are accompanied by some challenges [16]. Therefore, successful implementation of this system should be taken seriously [18]. One of the effective factors in successfully executing information systems is users' satisfaction with these systems [19-21]. So that users' resistance towards using these systems will turn these systems into inefficient systems [22] and eventually causes users to stop using this system [23, 24]. Users' satisfaction with using information systems leads to employees' productivity [25] and their continuous use of this system [19]. Thus, identifying and resolving issues related to users' dissatisfaction regarding healthcare information systems seems necessary. Many studies have investigated users' satisfaction with PACS [10, 15, 17, 26, 27] and have concluded different findings. The results of one study revealed that only 8% of radiologists believed that using PACS was easier than film-based imaging [17]. However, another study showed users' satisfaction with the quality of information and images produced by PACS and had a positive approach towards using this technology compared to the traditional systems [10].

During recent years, several Iranian hospitals have taken action in launching and using the PACS to advance their activities and use this system's benefits. In Iran, there are 5 PACSs, which are accordant with the DICOM standard, and the Iranian Ministry of Health has approved their use for healthcare organizations. Those systems being studied in the present research have different capabilities including, measurement of lesions, ability to measure Hounsfield units, ability to make visual changes such as brightness, contrast, resolution, and zooming in and out, viewing images in different slices, archiving images on database or CD, communicating images with workstations at the centers and ability to retrieve images on workstations. There are also studies concerning the challenges and issues in implementing the PACS [28, 29], effective factors in use, successes and failures of this system [16, 30, 31], evaluation of usability [32, 33] and investigating the impact of its launch [11]. However, according to our knowledge, there has not been any study conducted in Iran to assess physician users' satisfaction with the PACS. Physicians are one of the primary groups of PACS users, thus, this study was conducted to determine the physicians' level of satisfaction with the Picture Archiving and Communication System and compare this system's functional features to the traditional film-based imaging system.

## Methods

### Research Setting

The present analytical study was conducted in 2017. All available senior residents (59 residents) with experience in using PACS at three large university hospitals in Kerman city were included in this study. Kerman University of Medical Sciences is the largest medical university in southeast Iran and has three large general hospitals (Afzalipour, Shafa, and Bahonar), which have 462, 420 and 252 active inpatient beds; respectively. These hospitals have various inpatient wards such as emergency, orthopedic, internal medicine, neurology, pediatrics, obstetrics and gynecology, rheumatology, infectious, ENT, dermatology, nephrology, cardiology, endocrinology, dialysis, burn, general surgery, ICU, CCU.

## Data Collection

To collect data, we used a self-administered questionnaire. This researcher-made questionnaire was developed based on the review of relevant studies [1, 9, 15, 34]. This questionnaire consisted of three parts;

- 1) The first part included questions related to demographic information including age, gender, type of specialty, experience in using the PACS, computer skills (self-report) and also the level of radiology images' interpretation by physicians.
- 2) The second part included 14 specialty questions regarding the individuals' satisfaction with the PACS using a 7-choice Likert scale (from "completely disagree" to "completely agree").
- 3) The third part included 8 questions related to comparing features of the two digital and traditional film-based imaging systems using a 5-choice Likert scale (from score 1 to 5).

Also, to gain other positive and negative aspects of the PACSs, there were two open questions at the end of the questionnaire.

The face and content validity of this questionnaire was reviewed and approved by five specialists in the field of medical informatics (n=2), radiology (n=2), and health information management (n=1). The reliability of the questionnaire was reviewed through questionnaires filled out by 12 random residents using Cronbach's alpha ( $\alpha=0.86$ ). The researchers referred to three hospitals and after presenting some description regarding the study's aim, questionnaires were distributed amongst physicians who had consented to take part in the study and then questionnaires were collected after being completed.

## Data Analysis

Data analysis was done through SPSS.18 software using descriptive statistics. Also, after checking the normality of the data, the spearman statistical tests were used for assessing the relationship between the mean score of the overall satisfaction level with the PACS and age and experience in using the PACS; the Mann Whitney U was used for assessing the relationship with individuals' gender and also, the Kruskal-Wallis test was used for assessing the relationship with the type of specialty, level of images' interpretation with PACS and skills in using the computer. Physicians' satisfaction level in using the PACS was obtained based on the questionnaire's second part. For this reason, as in another study [35], after calculating the minimum and maximum scores, which could be earned in this section of the questionnaire (14 and 98) and after their differential, we classified the overall satisfaction level with the PACS into three categories: low, moderate, and high. The ranges of scores were considered: low, 14-42; moderate, 43-70; and high satisfaction, 71-98.

## Results

As shown in table 1, a total of 46 physicians participated in this study. The mean of the participants' ages was 31.4 ( $\pm$  4.4) years old and approximately 59% (n=27) of the participants were females. About 30% (n=14), 26% (n=12) and 20% (n=9) of the participants in this study were consisted of emergency medicine residents, internal residents and radiology residents, respectively. Almost 67% (n=31) of the physicians stated having an intermediate level of computer skills. The mean of experience in using the PACS among physicians ( $\pm$ 10.5) was 13.3 months. About 77% (n=35) of the physicians stated that they interpret more than half of the medical images using PACS. Results of this study showed that the mean of physicians' overall satisfaction level with PACS' score has no significant relationship ( $P>0.05$ ) with the variables of age, experience in using PACS, type of specialty, level of interpretation of images using PACS. However, results showed a significant relationship with their computer skills ( $P<0.05$ ).

Table 1: Mean of participants' satisfaction based on demographic information

Contextual Data		Frequency (percent)	Mean score of satisfaction	P-value
Sex*	Female	27(59%)	4.02 $\pm$ 1.61	0.126
	Male	19(41%)	4.65 $\pm$ 1.86	
Type of specialty**	Emergency Medicine	14(30%)	4.09 $\pm$ 1.9	0.093
	Internal Medicine	12(26%)	3.35 $\pm$ 1.73	
	Radiology	9(20%)	5.71 $\pm$ 1.07	
	Orthopedics	4(9%)	4.28 $\pm$ 1.62	
	Cardiology	3(7%)	4.09 $\pm$ 1.13	
	Pediatrics	2(4%)	3.78 $\pm$ 1.01	
	Urology	1(2%)	4.85	
	Neurology	1(2%)	6.14	
Computer skills**	Low	7(15%)	3.38 $\pm$ 1.92	0.022
	Intermediate	31(67%)	4.13 $\pm$ 1.7	
	High	8(18%)	5.62 $\pm$ 0.45	
Percent of images interpretation with PACS**	(1-25) %	1(2%)	4.57	0.762
	(26-50) %	9(20%)	3.6 $\pm$ 1.42	
	(51-75) %	14(31%)	4.71 $\pm$ 1.09	
	(76-100) %	12(26%)	4.39 $\pm$ 2.11	
	100%	9(20%)	4.15 $\pm$ 2.4	

\* Mann-Whitney U

\*\* Kruskal-Wallis

Approximately 58% of the physicians agreed that using the PACS is a great achievement for their hospitals. Also, 50% of the participants believed that using PACS reduces images' interpretation time and 59% of them also stated that reviewing images with this system is easy. About 76% of physicians believed that the quality of PACS images is higher than radiography films. Over 60% of the physician agreed that PACS leads to less time in searching for images, accelerates diagnosis time and reduces any confusion in the images. Also, the same number of physicians believed that this system leads to

optimization in the work process and training. About 56% of physicians believed that PACS has led to an optimization in the quality of treatment care. Close to 52% of the participants believed that PACS has not reduced the patients' admission time in the hospital. Over 50% of the physicians also believed that PACS leads to a reduction in costs and also this system has met the users' expectations.

As displayed in table 2, the satisfaction level of 41% (n=19) of the physicians with the PAC was at a high level and overall, the satisfaction level of 72% of the physicians was moderate to high.

Table 2- Overall satisfaction level with PACS

Overall Satisfaction with PACS	Satisfaction Level	Frequency (percent)
	Low	13(28%)
	Moderate	14(31%)
	High	19(41%)

Based on table 3, the mean satisfaction level of physicians with the simplicity of editing images, contrast and or presentation of details, pathological status clarity, ability to zoom, trustworthiness of the system and images' results, ability to compare previous and new images of a patient and system's user-friendliness in PACS was higher than traditional radiology systems, however, there was no significant difference between the two systems in the above components (table 3).

Table 3: Mean score of satisfaction level with PACS versus traditional radiology

Features	Mean score of satisfaction with digital imaging system (PACS)	Mean score of satisfaction with analogue imaging (film)	P-value
Easy to Editing Images	0.97 ±4.37	1.35 ±2.53	0.061
Contrast or Presentation of image's details	0.87 ±4.49	1.09 ±2.33	0.46
Pathological status clarity	1.29 ±3.98	1.16 ±2.74	0.464
Ability to zoom images	0.89 ± 4.45	1.1 ±2.27	0.854
System's reliability	1.34 ±3.71	1.33 ± 2.69	0.205
Reliability of images' findings	1.12 ±3.98	1.18 ±2.73	0.95
Possibility to compare patient's previous and new images	1.13 ±4.36	1.4 ±2.97	0.514
Easy to use the system	1.29 ±4.05	1.42 ±2.57	0.084

The major weakness points of PACS for physicians included waste of time in looking at images on computer systems (n=6), inability to print images and inability to use these images at any medical

centers outside the hospitals such as physician's office and followed by that, increase in patients' costs for being forced to go through the imaging process again and being exposed to x-ray again (n=5), inability to use this system at the bedside of patients and increase of images search time (n=4). The ability to change color and edit images, especially images of the brain (n=1) is one of the most important strengths of this system.

## **Discussion**

The results showed that most of those using the Picture Archiving and Communication System, were satisfied with this system. In this study, radiologists and also those who had higher computer literacy were more satisfied with PACS. Physicians believed that because of having different features such as edit, ability to apply different changes to the images and also the ability to compare patients' previous and new images, this system, and its findings are more reliable. Despite all of PACS's advantages, several physicians believed that this system somewhat wastes their time. Currently, considering the inability to use PACS images at imaging centers outside the hospital, this system can increase patients' costs for re-imaging and also the risk of being re-exposed to x-ray.

### **Optimization in work process, efficiency and quality of service**

The results of the present study showed that more than half of the physicians believed using PACS led to the optimization of the work process, quality of treatment care and also training. In line with this finding, Tan's [15] study also revealed that more than two-thirds of users believed that the PACS had led to optimization in their performance and compared to the traditional system of hard copies, this system has improved physicians' performance. The findings of two other studies [7, 10] also showed that users consider PACS to be effective in improving the quality of their services and believed that this system has led to an improvement in productivity, efficiency, and quality of their services.

### **System's Ease of Use**

More than half of the physicians in this study believed that reviewing images with this system is easy and the PACS has met their expectations. A study by Buabbas and colleagues [10], findings showed that more than three-quarters of the radiologists and technologists, consider using PACS as positive and being user-friendly. Also, Jorwekar and colleagues [36] in their study addressed the easiness in using PACS in users' viewpoints and reported that 85% of the users believed that PACS was very easy to use for them. The results of the mentioned studies are consistent with the present study. The PACS ease of use is one aspect that is addressed in many studies and therefore we can say that most likely, PACS is a system that despite its variety of tools and menus, it is highly easy to learn for users and can meet users' expectations for this matter.

### **Reducing hospital-stay time**

In this study, more than half of the physicians believed that PACS had no influence in reducing the patients' length of hospital stay [5]. Despite these results, Al-Alawi's study showed that about two-thirds of PACS users agreed that this system leads to reducing patients' hospital stay [9]. Some studies have reviewed the impact of PACS on the patients' hospital stay time. The findings of these studies [37-39] showed that this system has been able to lead to reducing patients' hospital stay time. However, a study in Australia [40] showed PACS not affecting the patients' length of stay in the hospital.

The reason for different findings amongst studies can be due to a variety of reasons. However, one of the most important reasons may be the difference in the population of studies. The difference among patients in different wards or hospitals can present different findings. Also, users with different standpoints that are being studied can lead to different results. Leastwise, all being said that in Iran the PACS is still considered a relatively new system and maybe physicians' approach towards this system's clinical advantages has not fully developed yet and they may need more time.

### **Reducing Costs**

According to the present study's findings, more than half of the physicians believed that using PACS leads to a reduction in costs. PACS-related costs are divided into two categories of direct and indirect costs. Direct costs are expenses related to implementing the PACSs such as system purchase cost, maintenance, and equipment purchase. While the indirect costs include increasing patients' hospital stay, repeating similar imaging, reducing productivity and physician's performance for the lack of access to images and reports [41].

Regarding PACS-related costs, there are different perspectives. While some studies address the high cost of purchase, implementation, and maintenance of the PACS [42-45], other studies suggest the effectiveness of this system and also consider the reduction of indirect costs as PACS's advantages [12, 46].

When launching the PACS, indirect costs reduce and can compensate for the direct expenses inflicted on the hospital and can even lead to the reduction of general expenses [41].

Fang et al. study [47] showed that an appropriately designed PACS can save and reduce costs compared to film-based imaging due to the increasing productivity of devices and technicians, ability for online phone consultation, ability to save time for physicians and radiologists and the decreasing need for more personnel all of which are indirect costs.

Physicians' different approaches towards the PACS maybe for their different standpoints regarding direct and indirect costs [41]. Presumably, some physicians fail to take into consideration the reduction in PACS's indirect costs in the long-term, and therefore they believe that PACS leads to an increase in costs. This is while indirect costs in the PACS are significantly lower compared to the traditional system.

### **Patients' Safety**

According to 10% of physicians, because of the inability to print images or use these images at other treatment centers outside the hospital such as physicians' offices, the patients are forced to go through the imaging again, which this matter leads to patients' further exposure to rays and finally decreases safety for patients. Despite the findings of the present study, Modrak and colleagues [14] conducted a study that showed after implementing PACS, patients' exposure to x-rays reduces, considering the decrease in repeat imaging. Also, other studies have shown that implementing the PACS can lead to a reduction in re-imaging and patients' dose of x-rays and increase patient safety [48, 49].

This difference could be because of the different network infrastructure used. In Iran, images are only transmitted within an organization and there is no communication among different organizations. In Iran, interoperability of information among health information systems such as hospital information systems does not exist with the PACS. For this reason, physicians believe that patients will have to go through imaging and exposure to x-rays again at other treatment centers. However, if the capability of establishing communication and transferring images between health information systems used at governmental and private health care centers develops, while reducing repeated imaging, the PACS can lead to decreasing patients' exposure to rays and finally increase patient safety.

### **PACS versus Traditional Radiology**

The results of the present study show that most physicians believe that because the PACS has different features such as image edit, ability to apply changes to images such as contrast, clarity, and zoom, and also the ability to present details, this system is more satisfying for them compared to traditional radiology. However, there was no significant difference in the ease of use in both systems. In Abuabbas and colleagues' [10] study, most participants suggested that the system was user-friendly. Also, Al Yafei and colleagues [50] in their study reported 90% user-friendliness for the PACS. The results of the mentioned studies are consistent with the present study's findings. However, the present study's results about comparing the ease of use in PACS and the traditional system differ somewhat from Jorwekar and colleagues' study [36] in which system users described the PACS as being very user-friendly. Perhaps this level of difference in opinions about the easiness in using PACS compared to traditional film-based systems is related to the computer literacy level of the users and or the lack of interoperability of PACS with other health information systems. Probably the more users are computer literate and the more proper the system's interoperability with other systems the system's ease of use and users' satisfaction level increase.

Also, another reason for the difference in opinions about the system's user-friendliness and its ease of use could be the users' level of involvement during the system analysis phase before the design phase. If users' needs are properly assessed, and the system is accordingly designed, then the system would probably meet users' satisfaction.

### **Relationship between Satisfaction Level and Demographic Information**

The results showed that factors such as age, experience in using PACS, and physicians' type of specialty had no significant relationship with the level of satisfaction; however, physicians' computer literacy affected the level of their satisfaction. In line with these findings, Buabbas's study [10] showed that none of the demographic information and also users' computer literacy does not affect their level of satisfaction.

One reason for the differences amongst studies in terms of the relationship between satisfaction and computer literacy is probably because the computer literacy variable was measured in the form of self-report. We suggest that for a more precise investigation of the relationship between these two variables, a standard computer literacy questionnaire along with the satisfaction questionnaire to be used.

Although the sample size in the present study is not very large, this study is the first study in Iran conducted that concerns the assessment of users' satisfaction with PACS, and those physicians who took part in this study had experience in working with PACS and were interested in completing the questionnaire. These findings can help those healthcare centers' directors who are considering purchasing or implementing the PACS, that besides considering the strong and weak points of this system, to attempt resolving some issues. Also, communications technology policymakers with the aid of information system developers can attempt to develop data communication standards for inter-informational systems so that the communication between these systems could be possible from anywhere.

## Conclusions

The results revealed that although the mean for physicians' satisfaction level with PACS was at a moderate to a high level, yet there are still problems in successfully implementing this system and establishing interoperability between them at different treatment centers. The results showed that PACS did not fully meet all the demands of physicians and did not achieve its predetermined objectives such as all-access from different locations. We recommend that to overcome the mentioned obstacles, to increase the number of workstations for these systems or to use a personal digital assistant (PDA) to reduce time waste and facilitate the care at patients' bedside and also, to add the feature for printing.

## List Of Abbreviations

**LOS:** length of stay

**PACS:** Picture Archiving and Communication System

**PDA:** Personal Digital Assistant

## Declarations

**Ethics approval and consent to participate**

This study was approved by the Research Ethics Committee of Kashan University of Medical Sciences Research Council (Number: 1398.049) and conducted following the guidelines of the Declaration of Helsinki. In accordance with the opinion of the above mentioned Ethics Committee and given the fact that no information about participants is provided in this paper, participants who participated in this study gave verbal consent to participate in this research.

### **Consent for publication**

Not applicable.

### **Availability of data and materials**

The data generated and analyzed during this study are available from the corresponding author on reasonable request.

### **Competing interests**

The authors declare that they have no competing interests.

### **Funding**

No funding was obtained for this study.

### **Authors' contributions**

RA, MSJ, and HT designed the study. HT supervised the project. RA and MSJ performed the experiments. HT and RA analyzed the data. All authors discussed the results and reviewed and approved the final manuscript. RA, HT wrote the final manuscript.

### **Acknowledgements**

Special thanks to all participants of the university hospitals in Kerman city (Shafa, Afzalipour and Bahonar) for their contributions to this study.

## **References**

1. Goodarzi H, Khatami S-M, Javadzadeh H, Mahmoudi S, Khajepour H, Heidari S, Khodaparast M, Ebrahimi A, Rasouli H, Ghane M: **User acceptance of picture archiving and communication system in the emergency department.** *Iranian Journal of Radiology* 2016, **13**(2).
2. Tavakoli N, Jahanbakhsh M, Mokhtari H, Reza Tadayon H: **Opportunities of electronic health record implementation in Isfahan.** *Procedia Computer Science* 2011, **3**:1195-1198.
3. Arora D, Mehta Y: **Use of picture archiving and communication system for imaging of radiological films in cardiac surgical intensive care unit.** *Journal of anaesthesiology, clinical pharmacology* 2014, **30**(3):447.

4. Moghadam A, Khorsha H, Abasi HN, Hossein S: **Evaluation of PACS system with economic interests approach in 5th Azar Educational Hospital in Gorgan.** 2015.
5. Ribeiro LS, Costa C, Oliveira JL: **Clustering of distinct PACS archives using a cooperative peer-to-peer network.** *Computer methods and programs in biomedicine* 2012, **108**(3):1002-1011.
6. Faggioni L, Neri E, Castellana C, Caramella D, Bartolozzi C: **The future of PACS in healthcare enterprises.** *European journal of radiology* 2011, **78**(2):253-258.
7. Aldosari H, Sadik B, Al Kadi K: **Impact of picture archiving and communication system (PACS) on radiology staff.** *Informatics in Medicine Unlocked* 2018, **10**:1-16.
8. Weiss DL, Siddiqui KM, Scopelliti J: **Radiologist assessment of PACS user interface devices.** *Journal of the American College of Radiology* 2006, **3**(4):265-273.
9. Alalawi ZM, Eid MM, Albarrak AI: **Assessment of picture archiving and communication system (PACS) at three of ministry of health hospitals in Riyadh region—Content analysis.** *Journal of infection and public health* 2016, **9**(6):713-724.
10. Buabbas AJ, Al-Shamali DA, Sharma P, Haidar S, Al-Shawaf H: **Users' Perspectives on a Picture Archiving and Communication System (PACS): An In-Depth Study in a Teaching Hospital in Kuwait.** *JMIR medical informatics* 2016, **4**(2).
11. Hasani N, Hosseini A, Sheikhtaheri A: **Effect of Implementation of Picture Archiving and Communication System on Radiologist Reporting Time and Utilization of Radiology Services: A Case Study in Iran.** *Journal of Digital Imaging* 2020:1-7.
12. Hurlen P, Østbye T, Borthne A, Gulbrandsen P: **Introducing PACS to the late majority. A longitudinal study.** *Journal of digital imaging* 2010, **23**(1):87-94.
13. Duyck P, Pynoo B, Devolder P, Voet T, Adang L, Ovaere D, Vercruyssen J: **Monitoring the PACS implementation process in a large university hospital—discrepancies between radiologists and physicians.** *Journal of digital imaging* 2010, **23**(1):73-80.
14. Modrák M, Modrák V: **The Effect of a PACS on Patient Radiation Doses and Operating Costs in a Radiology Department: A Practical Study.** *Procedia Technology* 2013, **9**:1282-1287.
15. Tan SL, Lewis RA: **Picture archiving and communication systems: A multicentre survey of users experience and satisfaction.** *European Journal of Radiology* 2010, **75**(3):406-410.
16. Abdekhoda M, Salih KM: **Determinant factors in applying picture archiving and communication systems (PACS) in healthcare.** *Perspectives in health information management* 2017, **14**(Summer).
17. Moodley I, Moodley S: **A comparative cost analysis of picture archiving and communications systems (PACS) versus conventional radiology in the private sector.** *SA Journal of Radiology* 2015, **19**(1).
18. MacDonald D, Neville D: **Evaluating the implementation of picture archiving and communication systems in Newfoundland and Labrador—a cost benefit analysis.** *Journal of digital imaging* 2010, **23**(6):721-731.

19. Tilahun B, Fritz F: **Comprehensive evaluation of electronic medical record system use and user satisfaction at five low-resource setting hospitals in Ethiopia.** *JMIR medical informatics* 2015, **3**(2):e22.
20. Tzeng WS, Kuo KM, Lin HW, Chen TY: **A Socio-technical assessment of the success of picture archiving and communication systems: the radiology technologist's perspective.** *BMC Med Inform Decis Mak* 2013, **13**:109.
21. Farzandipour M, Meidani Z, Sadeqi Jabali M, Dehghan Bnadaki R: **Designing and evaluating functional laboratory information system requirements integrated to hospital information systems.** *J Eval Clin Pract* 2019, **25**(5):788-799.
22. Aldosari B: **User acceptance of a picture archiving and communication system (PACS) in a Saudi Arabian hospital radiology department.** *BMC medical informatics and decision making* 2012, **12**(1):44.
23. Farzandipour M, Meidani Z, Riazi H, Jabali MS: **Nursing information systems requirements: a milestone for patient outcome and patient safety improvement.** *CIN: Computers, Informatics, Nursing* 2016, **34**(12):601-612.
24. Wong B, Arjpru C: **A Study of How User Satisfaction and User Dissatisfaction Affect the Success of an Information System.** *ACIS 2007 Proceedings* 2007:121.
25. Norfazlina G, Akma AS, Adrina SN, Noorizan M: **Customer information system satisfaction and task productivity: The moderating effect of training.** *Procedia Economics and Finance* 2016, **37**:7-12.
26. Srinivasan M, Liederman E, Baluyot N, Jacoby R: **Saving time, improving satisfaction: the impact of a digital radiology system on physician workflow and system efficiency.** *Journal of healthcare information management : JHIM* 2006, **20**(2):123-131.
27. Wong TY, Shih DH, Chen JC, Tsai SY: **A discrepancy model examining the determinants of user satisfaction with the PACS systems in the Radiology departments of Taiwan hospitals.** In: *2012*; 2012: 2255-2258.
28. Bahador F, Sharifian R, Farmani A: **The assessment of Picture Archiving and Communication System based on Canadian Infoway PACS Opinion Survey in Teaching Hospitals of Shiraz University of Medical Sciences.** *Journal of Health Management & Informatics* 2017, **4**(4):120-124.
29. Khajouei R, Jahromi ME, Ameri A: **Challenges of Implementing Picture Archiving and Communication System in Multiple Hospitals: Perspectives of Involved Staff and Users.** *Journal of medical systems* 2019, **43**(7):182.
30. Ahmadi M, Mehrabi N, Sheikhtaheri A, Sadeghi M: **Acceptability of picture archiving and communication system (PACS) among hospital healthcare personnel based on a unified theory of acceptance and use of technology.** *Electronic physician* 2017, **9**(9):5325.
31. Saghafi F, Heshmati Z, Heydari M, Khansari M: **Critical Success factors for implementing PACS Technology in Iran's Hospitals.** *International Journal of Information and Communication Technology Research* 2017, **9**(2):45-52.

32. Deimazar G, Kahouei M, Norouzian Y, Moslemi M: **Evaluation of usability of picture archiving and communication system (PACS) in clinical settings based on ISO 9241/10 from the perspective of end users.** *PHARMACOPHORE* 2017, **8**(6).
33. Zahiri Esfahani M, Khajouei R, Baneshi MR: **Augmentation of the think aloud method with users' perspectives for the selection of a picture archiving and communication system.** *Journal of Biomedical Informatics* 2018, **80**:43-51.
34. Top M: **Physicians' views and assessments on picture archiving and communication systems (pacs) in two turkish public hospitals.** *Journal of medical systems* 2012, **36**(6):3555-3562.
35. Khajouei R, Abbasi R: **Evaluating nurses' satisfaction with two nursing information systems.** *CIN: Computers, Informatics, Nursing* 2017, **35**(6):307-314.
36. Jorwekar GJ, Dandekar KN, Baviskar PK: **Picture Archiving and Communication System (PACS): Clinician's Perspective About Filmless Imaging.** *The Indian journal of surgery* 2015, **77**(Suppl 3):774-777.
37. Lindsay R, McKinstry S, Vallely S, Thornbury G: **What influences clinician's satisfaction with radiology services?** *Insights into imaging* 2011, **2**(4):425-430.
38. Nitrosi A, Borasi G, Nicoli F, Modigliani G, Botti A, Bertolini M, Notari P: **A filmless radiology department in a full digital regional hospital: quantitative evaluation of the increased quality and efficiency.** *Journal of Digital Imaging* 2007, **20**(2):140.
39. Watkins JR, Bryan S, Muris NM, Buxton MJ: **Examining the influence of picture archiving communication systems and other factors upon the length of stay for patients with total hip and total knee replacements.** *International journal of technology assessment in health care* 1999, **15**(3):497-505.
40. Crowe B: **Overview of some methodological problems in assessment of PACS.** *International journal of bio-medical computing* 1992, **30**(3-4):181-186.
41. Becker SH, Arenson RL: **Costs and benefits of picture archiving and communication systems.** *Journal of the American Medical Informatics Association* 1994, **1**(5):361-371.
42. Bryan S, Weatherburn G, Buxton M, Watkins J, Keen J, Muris N: **Evaluation of a hospital picture archiving and communication system.** *Journal of health services research & policy* 1999, **4**(4):204-209.
43. Hood MN, Scott H: **Introduction to picture archive and communication systems.** *Journal of Radiology Nursing* 2006, **25**(3):69-74.
44. Pratt HM, Langlotz CP, Feingold ER, Schwartz JS, Kundel HL: **Incremental cost of department-wide implementation of a picture archiving and communication system and computed radiography.** *Radiology* 1998, **206**(1):245-252.
45. Sarbaz M, Hosseini N, Kimiafar K: **Views of Users Towards the Quality of Picture Archiving and Communication System (PACS) in a Developing Country.** In: *EFMI-STC: 2019*; 2019: 100-104.
46. Macyszyn L, Lega B, Bohman L-E, Latefi A, Smith MJ, Malhotra NR, Welch W, Grady SM: **Implementation of a departmental picture archiving and communication system: a productivity and**

- cost analysis.** *Neurosurgery* 2013, **73**(3):528-533.
47. Fang YC, Yang MC, Hsueh YS: **Financial assessment of a picture archiving and communication system implemented all at once.** *J Digit Imaging* 2006, **19 Suppl 1**:44-51.
48. Collin S, Reeves BC, Hendy J, Fulop N, Hutchings A, Priedane E: **Implementation of computerised physician order entry (CPOE) and picture archiving and communication systems (PACS) in the NHS: quantitative before and after study.** *Bmj* 2008, **337**:a939.
49. Duncan LD, Gray K, Lewis JM, Bell JL, Bigge J, McKinney JM: **Clinical integration of picture archiving and communication systems with pathology and hospital information system in oncology.** *The American Surgeon* 2010, **76**(9):982-986.
50. Al Yafei SA, Abuzaid MM, WiamElshami J, Noorajan Z: **A survey analysis of the user's perspective to newly implemented PACS system at Dubai hospital.** 2015.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [questionnaire.docx](#)