Original Article

A study of picture archiving and communication system adoption in one hospital: Applying the unified theory of acceptance and use of technology model

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Abstract:

CONTEXT: The advent of picture archiving and communication system (PACS) as medical image information system represent a major change of work pattern for radiologists and physicians and has proved to be a substantial challenge to the organization.

AIMS: The study aimed to investigate the factors affecting the use of PACS through the unified theory of acceptance and use of technology model.

SETTINGS AND DESIGN: It was an applied and analytical study.

SUBJECTS AND METHODS: Ninety questionnaires were distributed in Kashani hospital of Esfahan which implemented web-based PACS, and 45 usable questionnaires were returned. The questionnaire consists of scales for performance expectancy (PE), effort expectancy, facility condition, social influences, and behavioral intention (BI) and was developed by the author comparing the similar studies in which validity was confirmed by a committee of experts and the reliability was calculated using a Cronbach's α ($\alpha = 0.946$).

STATISTICAL ANALYSIS USED: Data were analyzed using SPSS version 20. The statistical tests for data analysis were Pearson's correlation and multiple regression analysis.

RESULTS: The findings suggested a direct correlation between BI and factors of PE ($P < 0.001$, $r = 0.788$), effort expectancy ($P < 0.001$, $r = 0.564$), social influences ($P = 0.001$, $r = 0.472$), and facility condition ($P < 0.001$, $r = 0.477$).

CONCLUSIONS: According to the findings, only the PE is sufficient for predict and evaluation of user behavior toward PACS. The results could be useful in terms of designing new systems and understanding users' need.

Keywords:

Picture archiving and communication system, technology acceptance model, unified theory of use and acceptance model

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Introduction

There are various types and areas of telemedicine, covering pathology, consultation, surgery, and radiology. Teleradiology refers to send electronic images for medical specialists and doctors to make diagnosis and interpretation.[1] The images generated by imaging equipment such as computed tomography scan and magnetic resonance imaging are stored electronically. An electronic image

management system is required for the e-images to be used by radiologists and clinicians.[2] Picture archiving and communication system (PACS) is a medical image management information system capable of storing images in a web-based database. The files and images are managed, retrieved, and distributed through a server, an intranet, or the Internet.[3] The PACS has replaced the old-fashioned methods and eliminates the need for the storage and use of X-ray films. Moreover, the physicians can view images through the web at any time and any geographical location.[4] Similar to other technologies in the health-care system, the PACS can make major changes in the health sector, challenging the health organizations. It may lead to several problems at different stages of modern technology implementation at any level such as technical, organizational, and individual. These problems, if not solved, would jeopardize the success in implementation, recognition, and application of the program. Management over such changes so as to overcome the resistance of clinical staff and adoption of modern technologies by users is one of the strategies to deal with obstacles against the application of PACS. The most sophisticated and expensive information system would prove ineffective if left off by the users.[3] Acceptance of technology refers to the end-users voluntarily demanding or adopting the technology.[5] In their study on acceptance of telemedicine technology, Chau and Jen-Hwa Hu argued that physician acceptance plays an important role in implementation and deployment process of new technologies in a health-care institution. Compared with other users, the model of technology acceptance among doctors varies, since they have great capacity for learning and are yet insufficiently informed about the advantages of modern technology. That is why, it is essential to examine the factors contributing to the adoption of technology by physicians.[6] In the last two decades, various models have been established and approved so as to assess factors associated with technology. The adoption of information technology by the users can be surveyed from various aspects. In this respect, each of these models involved different criteria for assessing the adoption and application of technology. At first, the social-psychological perspective, the tendency of users was assessed so as to determine the level of adoption and application of the system. In these models, emphasis was on the criteria influencing behavioral intention (BI) of the users. In the second group of models, the main focus was on the diffusion of innovation and factors contributing to the development of a modern technology in organizations.[2]

Venkatesh *et al*. evaluated eight of the most important models in this area, finding out that these models were explained between 17% and 53% of the variance in user intention to use information technology. That was how an integral and comprehensive model was devised known as use of technology (UTAUT). Then, UTAUT was tested and found to outperform the eight individual models.[7] This model has been successfully tested in information technologies concerning health care.[5,8] It entails four core criteria comprising performance expectancy (PE), effort expectancy, social influence, and facility condition.[2,9] Each of these criteria has been organized with the aim to examine barriers to the application of a modern system in an organizational environment. In the new model proposed by Venkatesh *et al*., it was concluded that the criteria related to organizational infrastructure as the core of facility conditions have been considered for effort expectancy (i.e., system convenience and ease of use), where two concepts of effort expectancy and facility conditions are closely interconnected.[7] As a result, the facility conditions in UTAUT model directly affect the use of the system. According to a study by Duyck *et al*., the impact of facility condition on BI was measured and results different from those of Venkatesh *et al*. were achieved.[2] Furthermore, Chau and Jen-Hwa Hu concluded that compatibility and behavioral control are two constructs tightly associated with the facility conditions, thus providing a good indicator for measuring the BI.[6]

As the simplified version of teleradiology in practice, the web-based PACS has been applied in Isfahan only at Ayatollah Kashani Hospital. Before the survey carried out by the researcher, there were no similar work on the factors associated with adoption and application of this technology in Isfahan. Since human factors such as user adoption of the system are one of the critical factors to success of the program,[10-12] an investigation into the attitudes and perceptions of the users concerning the system could lead to a systematic implementation of the program and increasing the efficiency of the health-providing organization. Therefore, this study intended to explore how the web-based PACS was adopted and performed by doctors at the hospital based on UTAUT. The results can help managers and system designers to better understand the success criteria of a new technology at health-care organizations.

Subjects and Methods

This cross-sectional study was conducted in 2014. The population included a total of 90 physicians and residents at Ayatollah Kashani Hospital in Isfahan. Due to the limitation of the population and the feasibility of a census, there was no need for sampling. The inclusion criterion covered doctors working with the web-based PACS. Data were collected through a questionnaire formulated based on relevant studies.[8,2,13-16] The questionnaire included a total of 54 items in two sections. The first section contained 11 items regarding

demographic data and history of technology application. The second section contained 43 items based on the relevant studies covering the followings.

PE: (15 items) The user's belief in the usefulness of an information system in increasing the efficiency of the profession.[17] Effort expectancy: (7 items) It is defined as the ease of operation with obtained as a result of using the system and information technology. Social influence: (7 items) The belief of a person as a result of the impact of significant figures and their beliefs about the use or nonuse of information technology such as information systems. Facility conditions: (9 items) The belief and understanding of a person about availability of technical and organizational structures for system support.[7] BI: (5 items) It refers to the intensity of the user's desire for using technology. In other words, the mental attitude of a person to show a particular behavior that is an important factor in its actual adoption of that behavior.[18] These items were measured based on the 5-point Likert scale: strongly disagree (0), somewhat opposed (1), neutral (2), somewhat agree (3), strongly agree (4). The questionnaire items were scored out of 100 through the following equation based on each sphere including PE, effort expectancy, social influence, facility condition, and BI:

The score of each sphere out of 100= (total scores of spheres) × 100/(the number of items within that sphere × 4).

The validity of the instrument was assessed through content validity based on the comments of several university instructors in administration, health-care information management and technology, and medical informatics, while its reliability was measured by Cronbach's alpha. Cronbach's alpha was calculated for each component of the questionnaire, which was $\alpha = 0.946$. The questionnaire was distributed among the users (doctors) at Kashani hospital. Of the 90 questionnaires distributed, 45 were collected. The response rate was 50%. The data collected through questionnaires were analyzed through descriptive and inferential statistics. Moreover, the IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp was used for data analysis.

The statistical tests for data analysis were Pearson's correlation and multiple regression analysis.

Results

In this study, 84.1% of the participants ($n = 37$) were male and 15.9% were female ($n = 7$). There was one case of nonspecified gender. According to the findings, the highest frequency of participants (44.18%) ranged between the age group of 20–29 years, while the lowest frequency was over 50 years of age (2.32%). The highest frequency of expertise among the participants was orthopedic (20%, $n = 9$). The findings indicated that 75.6% ($n = 34$) of the participants had worked with the PACS in the past, while 24.4% of the participants ($n = 11$) had no previous experience, regarded as a new user of the web-based system.

In evaluating the frequency distribution of questions related to the importance of the criteria of unified theory of acceptance and UTAUT model, it was revealed that the mean score for all the elements was higher than 60%. Table 1 displays the score for each criterion separately.

The results of calculating the correlation between the criteria and BI showed there was a direct relationship between the score of PE and BI ($P < 0.001$), effort expectancy and BI ($P < 0.001$), social influence and BI ($P = 0.001$), and facility conditions and BI ($P < 0.001$) [Table 2].

The linear regression equation for the score of BI was obtained in terms of the criteria scores (PE, EE, FC, SI) through multiple correlation coefficient, which was 0.81 between the BI and the abovementioned criteria. The linear regression equation for BI was achieved according to the criteria as follows:

BI = −2/25 + 0/83 PE + 0/23 EE + 0/06 SI + 0/01 FC.

Discussion

One of the most important success factors of information technology in the health-care sector is the user's acceptance and application rate. More than 40% of investments of information technology in health-care sectors have failed. One of the major causes for

Table 1: Distribution of the percentage of importance for adoption and application model of information technology unified theory of acceptance and use of technology

Criteria	Score (%)						
	Strongly disagree	Somewhat opposed	Neutral	Somewhat agree	Strongly agree	Mean	SD
PE	0	4.4	4.4	40	51.1	78.9	16.6
EE	0	6.7	4.4	28.9	60	81.9	18.26
SI	0	8.9	28.9	44.4	17.8	65.16	17.15
FC	4.4	11.1	35.6	28.9	20	60.55	20.4
BI	4.4	0	2.2	26.7	66.7	85.66	20.87

PE=Performance expectancy, EE=Effort expectancy, SI=Social influences, FC=Facilitating conditions, BI=Behavioral intention, SD=Standard deviation

Table 2: Pearson correlation coefficients between behavioral intention and other criteria

Criteria	BI	
	r	*P*
PE	0.788	<0.001
EE	0.564	<0.001
SI	0.472	0.001
FC	0.477	<0.001

PE=Performance expectancy, EE=Effort expectancy, SI=Social influences, FC=Facilitating conditions, BI=Behavioral intention

such failure has been inadequate knowledge about different aspects of information technology, including sociotechnical aspects.[19] Numerous studies on affecting factors on technology acceptance have proposed a variety of models and theories.[20]

The results of this study suggested that PE can be a good indicator for the UTAUT model. In fact, 51.1% of users gave scores to the items regarding PE within the very high range. Moreover, the mean score of PE was 78.9 out of 100, while the standard deviation was 16.6. In their study, Duyck *et al.* achieved similar results, calculating the mean value of PE for PACS to be 5.14.[2] In their study, Tavakoli *et al.* achieved similar results for perceived usefulness, which is a measure equivalent to PE.[21] According to the findings, 60% of users selected very much for items related to effort expectancy, where the mean score was 81.9 and the standard deviation was 18.26. This result suggests that effort expectancy provided a main measure for the UTAUT model. Duyck *et al.* assessed the effort expectancy among users of PACS, concluding that the mean value of effort expectancy is above average. They argued that effort expectancy could provide a desirable measure for the UTAUT model.[2] The mean score of social influence according to the findings was 65.16 out of 100, while the standard deviation was calculated to be 17.15. In fact, 44.4% of users selected "high" in items dedicated to that category. Moreover, 28.9% selected "moderate," which indicates that social influence criteria and related items are ideal for the UTAUT model. Similarly, in their study, Duyck *et al.* found that social influence is higher than average and equal to 4.45, which indicated that social influence is ideal for assessment in the UTAUT model.[2] As for the facilitating condition, 84.5% of total users gave above-average scores to the items. The mean score was calculated to be 60.55, and standard deviation was 20.4, demonstrating it could be an ideal measure for the UTAUT model. As for BI, 66.7% of users selected "very much" for the items. The mean score was calculated to be 85.66, while the standard deviation was 20.87. In their study, Dwight *et al.* calculated the mean value of BI to be 6.25,[2] where both studies suggest the appropriateness of the measure.

According to the results, the Pearson's correlation coefficient revealed that PE is correlated with behavioral intention ($r = 0.788$, $P > 0.001$). In other words, this measure could provide an ideal predictor for the measurement of users' willingness to accept and apply modern technology. Duyck *et al.*[2] and Phichitchaisopa and Naenna[22] obtained similar results. In another study, acceptance of radiology PACS was examined through the technology acceptance model (TAM) model in Saudi Arabia, where it was reported that understanding of usefulness equivalent to PE is among the key criteria involved in predicting the acceptance and application of PACS technology by users.[4] The results demonstrated that effort expectancy is directly correlated with behavioral intention ($r = 0.564$, $P < 0.001$). In other words, effort expectancy could provide an ideal predictor for the measurement of users' willingness to accept and apply modern technology. In their study entitled "Factors Contributing to Acceptance of PACS through the UTAUT Model," Dwight *et al.* figured out that effort expectancy is directly correlated with BI. In this study, however, it was stated that effort expectancy is not a prominent measure for evaluating the effort to examine factors associated with acceptance of technology by the user as compared to other factors.[2] Phichitchaisopa and Naenna found that effort expectancy is one of the factors contributing to the user's desire to accept and adopt information technology.[22] Langarizadeh *et al.* argued that there is a positive correlation between perceived system ease of use (equivalent to effort expectancy in the UTAUT) and user's behavioral intention.[23]

The results demonstrated that social influence is directly correlated with behavioral intention ($r = 0.472$, $P < 0.001$). In other words, social influence could provide an ideal predictor for the measurement of users' willingness to accept and apply the PACS. In their study, Phitchaisopa and Naenna concluded that social influence is directly correlated with behavioral intention, even though it left no significant effect on predicting behavior and analysis of accepting technology by employees at health-care organizations.[22] In their study, similarly, Chau and Jen-Hwa Hu argued that subjective norms in the TAM, equivalent to the concept of social influence in the UTAUT model, have an insignificant impact on the assessment of BI, i.e., physicians are oblivious to the effects of the environment and other individuals for application of a technology.[6]

According to the results, the Pearson's correlation coefficient revealed that facilitating condition is directly correlated with behavioral intention ($r = 0.477$, $P < 0.001$). In other words, facilitating condition could provide an ideal predictor for the measurement of users' willingness to accept and apply the PACS. In the original UTAUT model, the impact of this factor on use is measured. According to

the study by Dwight *et al.*,[2] however, this was one of the factors in the assessment of BI. According to the study by Chau and Jen-Hwa Hu,[6] who concluded that facilitating condition could solely be an appropriate measure for assessing the BI, the current study also evaluated the effect of facilitating condition on BI. It was proved that this measure is directly correlated with BI. In their study, Langarizadeh *et al*. concluded that facilitating condition and decision to use information technology are not correlated.[23]

According to the results of this study, all four predictor criteria are effective in the acceptance of PACS technology. However, PE has the greatest correlation ($r = 0.788$) followed by effort expectancy, social influence, and facilitating condition. The more r value is close to 1, there will be stronger predicting power, reflecting higher importance of this criterion in examining the factors associated with acceptance and application of PACS. Using the multiple linear regression, the following equation was obtained.

$$BI = -2/25 + 0/83 \, PE + 0/23 \, EE + 0/06 \, SI + 0/01 \, FC$$

According to the obtained equation, it can be concluded that the other three criteria compared with PE are not very effective. Regarding the high correlation between the criteria, the PE can even be adopted with only 2% less accuracy for predicting acceptance and application of PACS technology. As such, the equation would be as follows:

$$BI = 7/55 + 0/99 \, PE$$

Similarly, the study by Dwight *et al*. indicated that PE is strong and significant predictor for the acceptance of PACS by physicians, arguing that effort expectancy and social influence have no significant impact on acceptance of technology.[2] In the study by Phichitchaisopa and Naenna, it was revealed that affecting factors on acceptance of technology by employees at several health-care organizations include PE, effort expectancy, and facilitating condition, which are consistent with the results obtained by the current study.[22] In their paper entitled "Contributing Factors to Acceptance of Information Technology by Employees at Medical Record Department Based on TAM," Abdekhoda *et al*. concluded that perceived ease of use equivalent to effort expectancy in UTAUT model and perceived usefulness of information technology (equivalent to PE) are two important factors in the acceptance of information technology.[24] In this study, similar results were obtained.

Conclusion

In this study, it was demonstrated that PE alone can predict BI, which leads to the application of PACS.

Moreover, the role of effort expectancy, social influence, and facilitating condition is less important than that of PE.

Conflicts of interest

There are no conflicts of interest.

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