Determinant Factors in Applying Picture Archiving and Communication Systems (PACS) in Healthcare

by Mohammadhiwa Abdekhoda, PhD, and Kawa Mirza Salih, MA

Abstract

Objectives: Meaningful use of picture archiving and communication systems (PACS) can change the workflow for accessing digital images, lead to faster turnaround time, reduce tests and examinations, and increase patient throughput. This study was carried out to identify determinant factors that affect the adoption of PACS by physicians.

Methods: This was a cross-sectional study in which 190 physicians working in a teaching hospital affiliated with Tehran University of Medical Sciences were randomly selected. Physicians' perceptions concerning the adoption of PACS were assessed by the conceptual path model of the Unified Theory of Acceptance and Use of Technology (UTAUT). Collected data were analyzed with regression analysis. Structural equation modeling was applied to test the final model that was developed.

Results: The results show that the UTAUT model can explain about 61 percent of the variance on in the adoption of PACS ($R^2 = 0.61$). The findings also showed that performance expectancy, effort expectancy, social influences, and behavior intention have a direct and significant effect on the adoption of PACS. However, facility condition showed to have no significant effect on physicians' behavior intentions.

Conclusions: Implementation of new technology such as PACS in the healthcare sector is unavoidable. Our study clearly identified significant and nonsignificant factors that may affect the adoption of PACS. Also, this study acknowledged that physicians' perception is a key factor to manage the implementation of PACS optimally, and this fact should be considered by healthcare managers and policy makers.

Keywords: picture archiving and communication systems (PACS), Unified Theory of Acceptance and Use of Technology (UTAUT), physician, structural equation modeling

Introduction

Picture archiving and communication systems (PACS) are databases of medical records in digital form that are used to store diagnostic images and appendix documents across a hospital information system and deliver them to other healthcare professionals. PACS are technology-based systems that provide healthcare staff with quality information to support the diagnosis and treatment of patients and have considerable benefit, such as the elimination of lost radiographic films.[1] Digital image and related documents are deposited within a digital database and network in PACS, enabling healthcare staff to view images synchronously.

Applying PACS in healthcare settings changes the workflow to improve performance. The system can reduce the number of unread, retaken, and lost films in radiology departments.[2, 3] The quality of emergency patient care is affected by PACS through improved radiology examination turnaround and faster diagnostic radiology document processing.[4] Also, meaningful use of PACS can change the workflow in access to digital images throughout the medical center, lead to faster turnaround time, reduce tests and examinations, and increase patient throughput.[5, 6]

In spite of the high potential and abundant benefits of PACS, the literature shows that nationwide implementation of PACS is comparatively low because of some considerable challenges, such as cost, the requirement of sufficient capacity to deal with the necessary computer infrastructure, the need to make changes in the healthcare staff workflow, and lack of users' adoption.[7–10] Nonacceptance of new technology such as PACS is a considerable obstacle that should be eliminated to adopt this technology. Also, healthcare organizations require comprehensive information regarding the impact of modern information technology to deal with implementation optimally.

A small but growing body of studies have recognized the effect of the end user's behavior intention on the adoption of PACS. Aldosari (2012) reported that "compared with the increasingly widespread use of picture archiving and communication systems (PACSs), knowledge concerning users' acceptance of such systems is limited."[11] Goodarzi et al. (2016) acknowledged that "in spite of the abundant benefits of employing PACS, there are some challenges in implementing this technology like users' resistance to accepting the technology, which has a critical role in PACS success."[12]

However, the researchers have found no studies evaluating factors affecting physicians' perception concerning the adoption of PACS according to the Unified Theory of Acceptance and Use of Technology (UTAUT), especially in Iran. This study aims to examine physicians' perceptions regarding PACS' adoption. Additional aims of this study include identifying the determinate factors that affect the adoption of PACS, analyzing the relationship between constructs in the proposed model for applying PACS (see Figure 1), and evaluating the applicability of the UTAUT model to explain physicians' behavior in adopting PACS.

Theory and Hypotheses

Various theoretical models have been applied to explain and reveal the determining factors that affect the adoption of information technology, such as PACS. Efforts are in progress to present a suitable model to explain the end user's intention in the implementation of new technology.[13] The Technology Acceptance Model (TAM),[14] the Theory of Planned Behavior (TPB),[15] and the Unified Theory of Acceptance and Use of Technology (UTAUT)[16] are some of the models for elucidating the applying new technology.

The literature shows that successes and failures of new technology adoption have been elucidated by using technology acceptance models such as UTAUT.[17–19] For example, UTAUT has been applied to enable a better understanding of the determinate factors that may affect end users' behavior in adopting PACS.[20]

UTAUT is based on eight related models, such as TAM and Innovation Diffusion Theory (IDT), and it has the potential capacity to explain the user's behavior when the acceptance and adoption of new technology is considered.[21] Venkatesh et al. (2003) developed UTAUT on the basis of three direct determinants of intention to use new technology: performance expectancy (PE), effort expectancy (EE), and social influence (SI), and two indirect determinates of behavior, intention to use and facility conditions (FC).[22]

PE was defined by Venkatesh et al. (2003) as "the degree to which an individual believe that using the system will help him or she attain gains in job performance."[23] In this study, the following hypothesis regarding PE was set:

H_1. PE has a direct and significant effect on physicians' perception for applying PACS.

Venkatesh et al. (2003) defined EE as "the degree of ease associated with the use of the system." Alrawashdeh et al. (2012), Tan (2013), and Usoro et al. (2014) found that EE has a direct and significant effect on end-user adoption of new technology. Thus, the following hypothesis was put forth:

H_2. EE has a direct and significant effect on physicians' perception for applying PACS.

SI has been defined as "the degree to which an individual perceives that important others believe he or she should use the new system."[24] Tan (2003),[25] Torres Maldonado (2011),[26] Nassuora (2012),[27] and Alrawashdeh et al. (2012)[28] acknowledged that SI has a significant effect on users' perception regarding new technology adoption; therefore, the following hypothesis was set:

H_3. SI has a direct and significant effect on physicians' perception for applying PACS.

Venkatesh et al. (2003) defined FC as "the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system."[29] Some studies found that FC has no significant effect on end users' perception concerning new technology adoption,[30–32] whereas Venkatesh et al. (2003),[33] Wang et al. (2009),[34] and Moran et al. (2010)[35] reported the significant effect of FC on users' perception in adopting new technology, such as Web-based Trianing(WBT), Web 2.0, and mobile learning. Based on this literature, the next hypothesis was as follows:

H_4. FC has a direct and significant effect on physicians' perception for applying PACS.

Venkatesh et al. (2003) reported that intention to use has direct and significant effect on end users' behavior.[36] Similarly, Alrawashdeh et al. (2012),[37] Tan (2013),[38] and Bassam (2013)[39] found that behavioral intention had a direct and significant effect on the implementation of new technology. Thus, the last hypothesis of this study (H_5) was as follows:

H_5. The behavioral intention has a direct and significant effect on physicians' behavior in adopting PACS.

The proposed conceptual model of the study based on these hypotheses is presented in Figure 1.

Materials and Methods

In Iran, applying new information technology (IT) such as electronic medical records and PACS is continuously encouraged, and comprehensive efforts for the successful implementation of IT in healthcare services must be taken into consideration. This cross-sectional study was conducted from February to June 2016 in a teaching hospital affiliated with Tehran University of Medical Science (TUMS). TUMS was selected because it is the first-ranked medical university in Iran and considerable progress regarding IT adoption has been made in this university.

The population of this study consisted of all physicians working in hospitals affiliated with TUMS. As a sample, 190 of them were selected by stratified random sampling. A researcher developed a questionnaire as the tool for data collection, based on the studies by Alrawashdeh et al. (2012),[40] Jan et al. (2012),[41] Nassuora (2012),[42] and Abdekhoda et al. (2016).[43] A faculty member in the heath information management department confirmed the content and face validity of the questionnaire. Also, the test-retest reliability of the questionnaire was measured ($\alpha = 91.2$).

The survey instrument consist of structured questions on PE, EE, SI, FC, BI, and user behavior. Also, a number of demographic questions were included in the questionnaire. A five-point Likert scale ("totally agree," "agree," "neutral," "disagree," and "totally disagree") was applied in the questionnaire and formed the item responses. The items used to measure the various constructs of the proposed model are presented in Table 1.

The survey was performed by using the TUMS webmail service. An introductory email explaining the objective of this study was sent to inform the participants of the study. The TUMS ethical committee approved study, indicating that no human subjects were involved. From 190 questionnaires, 172 were returned, of which 9 were not appropriate for analysis because of incomplete responses or uncorrect information. The analysis was therefore based on 163 completed questionnaires. To determine the

correlation between the UTAUT variables and to simplify the module prior to testing, a correlation matrix was made.

The collected data were analyzed. To measure the variables' correlation, Pearson and regression tests were applied. Also, structural equation modeling (SEM) was used to analyze the paths of the proposed model, and finally the modified model was developed with the use of SPSS Amos 16.0 SEM software.

Results

Table 2 shows the demographic information of the participants. The data from this table showed that the majority of participants are female (57.0 percent). Also, the mean age of respondents was 32.6 years, and 50 percent of physicians were in the age range of 36 to 45 years. About 41 percent of physicians were general practitioners. The data also showed a mean of 7.03 years for the participants' work experiences, while about 32 percent of them have more than 15 years of work experience.

The correlations between the variables in the proposed model are shown in Table 3. This table shows a positive and significant correlation of PE with EE, SI, FC, BI, and PACS usage. Also, EE has a positive and significant correlation with SI, FC, BI, and PACS usage. Data from this table also show a positive and significant correlation between SI and FC, BI, and PACS usage. Moreover, BI has a direct and significant correlation with PACS usage. However, no significant correlation of FC with BI and PACS usage was found.

The results of the authors' proposed conceptual path model are presented in Figure 2. It is clear that behavior intention has a direct and significant effect on PACS usage. The data in this figure also show that PE, EE, and SI have a direct and significant effect on behavior intention. Nevertheless, FC has no significant effect on behavior intention. Moreover, Figure 2 shows that the UTAUT model explains 61 percent of the variance in PACS usage ($R^2 = 0.61$). Also, PE, EE, and SI together explain 56 percent of the variance for BI ($R^2 = 0.56$).

Table 4 shows the recommended goodness of fit-measure. In this table, a relative χ^2 value was 1.8, which is acceptable. Also, other suggested indexes, such as the Tucker-Lewis index, comparative fit index, normal fit index, and root mean squared error of approximation values presented in Table 4, were favorable.

Discussion

This study was conducted to determine the factors that may affect physicians' perceptions when comprehensive implementation of PACS is considered. Implementation of new technologies such as PACS in healthcare is the unavoidable because of their role in promoting healthcare quality, leading to considerable reduction in medical errors, and decreasing the cost of imaging services.[44, 45]

The results of this study clearly revealed that applying UTAUT is an appropriate method to analyze physicians' behavior in adopting new technology, such as PACS, because UTAUT has considerable potential in explaining and identifying determinant factors that affect end users' perception in applying PACS. Figure 2 shows that the UTAUT can explain 61 percent of the variance for PACS adoption. Also, this figure revealed that 65 percent of physicians' behavior intention is controlled by PE, EE, and SI.

Concerning the association between PE and behavioral intention toward applying PACS, the standard coefficient of PE and behavioral intention was found to be 0.78 with a *p*-value of .001; thus, H_1 was supported, indicating that PE has a direct effect on physicians' perceptions for applying PACS. This result has supported the findings of Alrawashdeh et al. (2012),[46] Tan (2013),[47] Echeng et al. (2013),[48] Nassuora (2012),[49] and Abdekhoda et al. (2016),[50] which showed that PE has a direct and significant effect on users' behavior intention in adopting new technology.

Regarding the association between EE and behavioral intention toward applying PACS, the standard coefficient of PE and behavioral intention was 0.34 with a *p*-value of .001, supporting H_2. This finding is

in line with the findings of Alrawashdeh et al. (2012),[51] Tan (2013),[52] Nassuora (2012),[53] and Abdekhoda et al. (2016),[54] who reported that EE had a direct and significant effect on new technology adoption.

As for the relationship between SI and behavioral intention toward applying PACS, the standard coefficient of SI and behavioral intention was found to be 0.39 with a *p*-value of .001; thus, H_3 was supported, suggesting that SI will have a direct effect on physicians' perceptions in applying PACS. Likewise, Torres Maldonado (2011),[55] Alrawashdeh et al. (2012),[56] Tan (2013),[57] Nassuora (2012),[58] and Usoro et al. (2014)[59] found that SI has a direct and significant effect on end users' perception regarding new technology adoption.

In terms of the relationships between FC and behavioral intention toward applying PACS, the findings shown in Figure 2 suggest that FC had no significant effect on behavioral intention ($\beta = 0.04$, $p = .007$). Hence, H_4 was not supported. Similarly, Tan (2013)[60] and Usoro et al. (2014)[61] found that FC had no direct and significant effect on IT acceptance. However, Alrawashdeh et al. (2012),[62] Echeng et al. (2013),[63] and Nassuora (2012)[64] reported that FC had a significant effect on end users' perception when applying new technology is considered.

Finally, in terms of the relationships between behavioral intention and applying PACS, the standard coefficient of BI and PACS usage was found to be 0.52 with a *p*-value of .001; thus, H_5 was supported, suggesting that behavioral intention will have a direct effect on physicians' behavior in applying PACS. Likewise, Alrawashdeh et al. (2012),[65] Tan (2013),[66] and Nassuora (2012)[67] reported that behavioral intention had a direct and significant effect on end users' perception in applying new technology.

The results of this study offer a significant contribution to both theory and practice in three ways. First, comprehensive adoption of new technology such as PACS is dependent on end users' perception, and users' behavioral intentions play an important role in applying new systems. Applying new systems such as PACS may be unsuccessful because of the lack of adoption by end users. Thus, in the system development life cycle, users' demands should be considered. Second, this study clearly revealed that physicians' behavior intentions can be explained by applying the UTAUT model. Finally, the determinant factors in the adoption of PACS based on physicians' perceptions were identified.

However, the limited setting of this study in just the teaching hospital of TUMS, the use of self-reported data on the use of PACS instead of measurement of the actual use of it, and self-selection biases related to the items in the survey are some of the limitations of this study that need to be addressed in future studies.

Conclusion

Implementation of new technology such as PACS in the healthcare sector is unavoidable. Meaningful use of PACS changes the workflow in access to digital images, leading to faster turnaround time, reductions in tests and examinations, and increased patient throughput. In order to fulfill comprehensive interoperability and recognize the benefits of PACS, end users' attitudes toward using and applying this system must be recognized. Users' perception is the key factor to manage the implementation of PACS optimally, and this fact should be considered by healthcare managers and policy makers.

The results from this study show that the UTAUT model provides helpful insights regarding the perception, elucidation, and anticipation of physicians' behavior in adopting PACS technology. In this study, determinant factors that may affect physicians' behavior intention toward the adoption of PACS (i.e., PE, EE, SI, and behavior intention) are clearly acknowledged. Also, the results show that FC has no direct and significant effect on physicians' behavior intention. In future studies, developing a model for PACS adoption by other healthcare staff, such as nurses and radiologists, and testing adoption of PACS by means of another model, such as TAM or TPB, is recommended.

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Notes

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Figure 1

Proposed Conceptual Model for the Application of Picture Archiving and Communication Systems (PACS) by Physicians, Based on the Unified Theory of Acceptance and Use of Technology

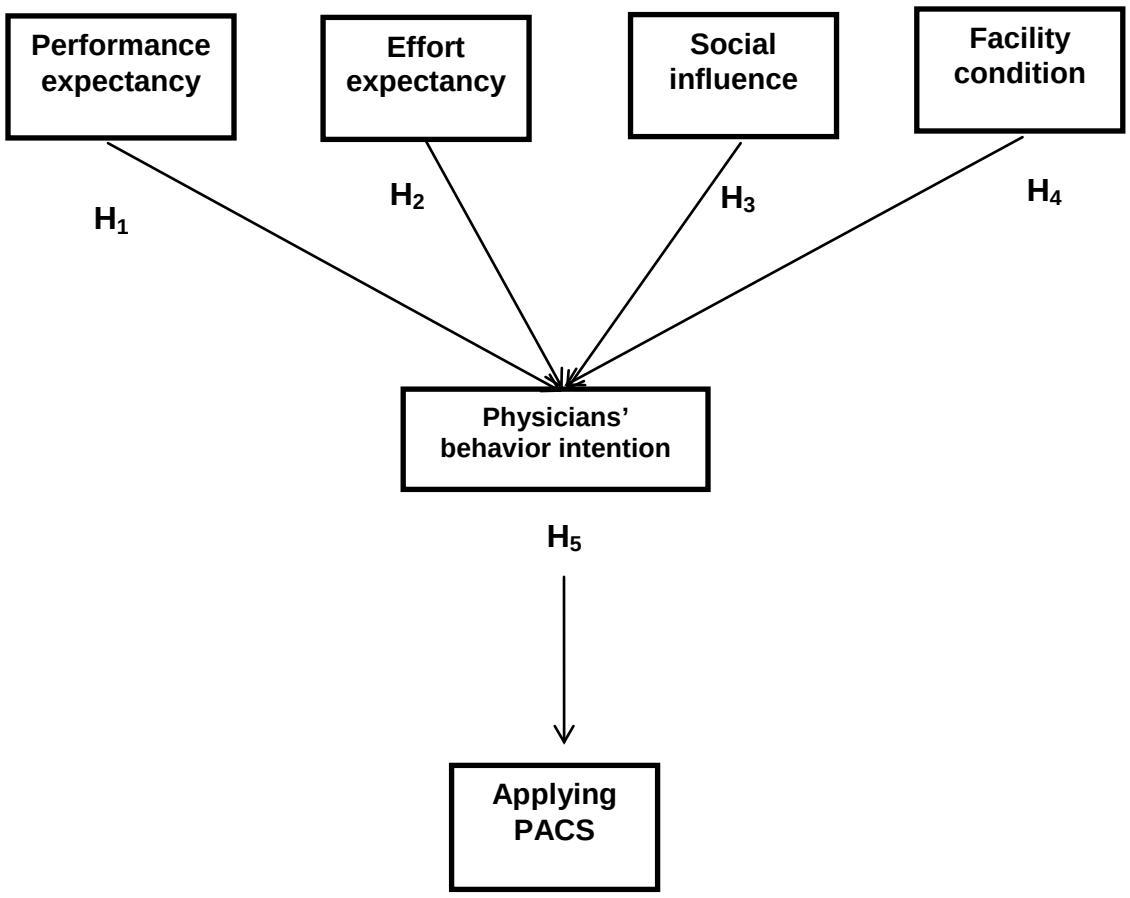

Figure 2

Results of the Proposed Conceptual Path Model

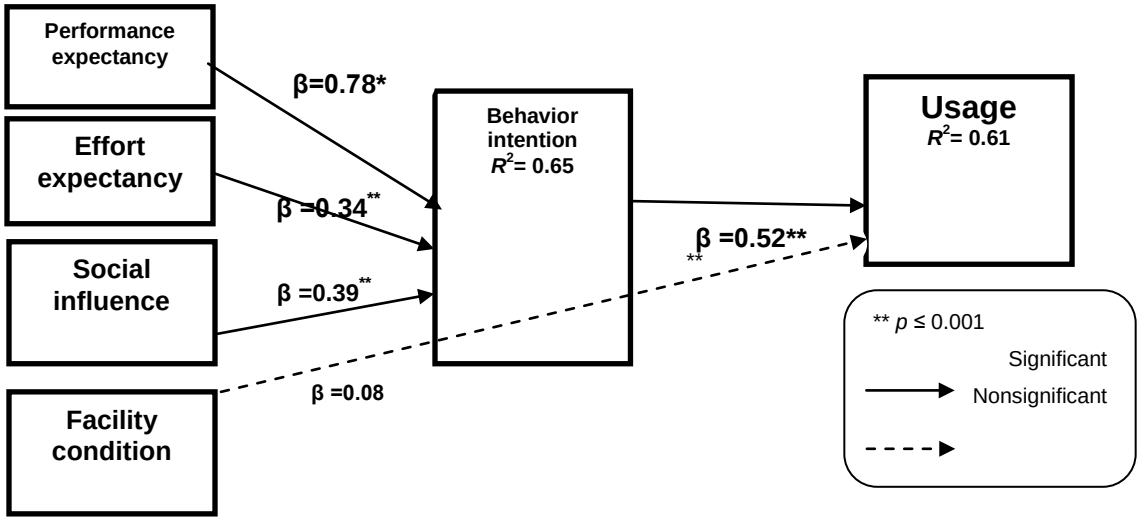

Table 1

Items Used to Measure the Various Constructs in the Proposed Model

Construct	Item Number	Item
Performance expectancy	1	I would find picture archiving and communication systems (PACS) useful in my work.
	2	Using PACS enables me to do my tasks more quickly.
	3	Using PACS increases my work productivity.
	4	If I use PACS, I will increase my chances of getting a promotion.
Effort expectancy	5	My interaction with PACS would be clear and understandable
	6	It would be easy for me to become skillful at using PACS.
	7	I would find PACS stress-free to use.
	8	Learning to operate PACS is easy for me.
Social influences	9	People who influence my behavior think that I should use PACS.
	10	People who are important to me think that I should use PACS.
	11	The senior management of this business has been helpful in the use of PACS.
	12	In general, the organization has supported the use of PACS.
Facility condition	13	I have useful resources to use PACS.
	14	I have enough information to use PACS.
	15	PACS is not compatible with other systems I use.
	16	A specific person or team is available to support with PACS difficulties.
Behavior intention	17	I intend to take PACS in the future.
	18	I plan to take PACS in the future.
	19	In the future, I predict I would take PACS.
Usage	20	PACS makes work more fascinating.
	21	Applying PACS is a good idea.
	22	Working with PACS is a pleasure.
	23	I like working with PACS.

Table 2

Demographic Information of the Participants

Characteristic	Category	Frequency	Percentage	Mean	SD
Gender	Male	65	43.0		
	Female	86	57.0		
	Total	151	92.6		
	Missing	12	7.4		
Age	25–35 years	41	28.9	32.6	4.6
	36–45 years	50	35.2		
	46–55 years	48	33.8		
	56 years or older	3	2.1		
	Total	142	87.1		
	Missing	21	12.9		
Degree	General practitioner	68	41.7		
	Specialist	52	31.9		
	Fellowship	43	26.4		
	Total	163	100.0		
Work experience	1–5 years	57	35.0	7.03	4.2
	5–10 years	25	15.3		
	11–15 years	28	17.2		
	More than 15 years	53	32.5		
	Total	163	100.0		

Table 3

Correlation between Variables of Proposed Conceptual Path Model

Constructs	**PE**	**EE**	**SI**	**FC**	**BI**	**Usage**
PE	1					
EE	0.586**	1				
SI	0.325**	0.336**	1			
FC	0.243*	0.613**	0.395**	1		
BI	0.705**	0.425**	0.416**	0.125	1	
Usage	0.423**	0. 432**	0.472**	0.095	0.689**	1

Abbreviations: PE, performance expectancy; EE, effort expectancy; SI, social influences; FC, facility condition; BI, behavioral intention.
Notes:

** *p*-value is significant at 0.01 level.

* *p*-value is significant at 0.05 level.

Table 4

Recommended Goodness-of-Fit Measure

Fit Index Category	**Suggested Index**	**Suggested Value**	**Obtained Value**
Absolute fit	Relative χ^2	Relative $\chi^2 < 3.0$	1.8
Incremental fit	Tucker-Lewis index	.90 or above for acceptable fit	.95
Incremental fit	Comparative fit index	.90 or above	.93
Incremental fit	Normal fit index	.90 or above	.91
Parsimonious fit	Root mean squared error of approximation	≤0.1	.02