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Toward a multidimensional assessment of picture archiving and communication system success

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Objectives: Based on a prevalent framework in the information systems field, this study proposes and describes an integrated model for evaluating picture archiving and communication system (PACS) success from multiple users' perspectives.
Methods: Our study details the validation process of the proposed model at a large tertiary-care teaching hospital in Canada. Both qualitative and quantitative data were collected to assess the psychometric properties of the measurement instrument and test the research hypotheses.
Results: Our findings clearly reveal that radiologists, technologists, and clinicians have different views regarding the factors influencing PACS success. For instance, the results for radiologists show that their concern with efficiency and productivity is best guaranteed by a system that is reliable and easy to use. Furthermore, that only perceived system usefulness influenced clinicians' satisfaction with PACS is a reflection of the primary impact that technology has on their work, namely, the ability to have instant access to images from any point in the hospital. Even though, overall, all three groups view the adoption of PACS positively, the mean scores indicate that radiologists and technologists seem to be more satisfied and their expectations to be met at a higher level than clinicians.
Conclusions: We believe the measurement instruments developed in this study can be used as a diagnostic tool by project managers interested in better understanding the extent to which different groups of stakeholders perceive the deployment of PACS as being successful and how factors influencing perceptions of PACS success vary across user types.

Keywords: PACS, Success model, Evaluation study

PACS (picture archiving and communication system) has become an important component of many radiology departments and hospitals around the world (8). A large number of studies have attempted to identify those factors that contribute to PACS success (e.g., 20;24). Results from these studies (e.g., 2;18) clearly reveal that the ultimate success of PACS requires health-care organizations and managers to adequately address various types of challenges: technological (e.g., integration with other information systems), managerial (e.g., project management), organizational (e.g.,

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availability of resources), behavioral (e.g., change management), and political (e.g., alignment among key participants).

However, the dependent variable in these studies—PACS success—has been an elusive one to define. Different researchers have addressed different aspects of success, making comparisons difficult and the prospect of building a cumulative tradition for research similarly elusive. Most investigations have considered a single or at best a small number of factors, contributing to a fragmented view of PACS success. Some researchers have chosen to focus on the desired attributes of the PACS itself. For instance, Cox and Dawe (5) examined the speed of image availability, the ease of use of the system, and the frequency of system breakdown. Rather than measure the quality of the PACS performance, other researchers have preferred to focus on the quality of the information that the PACS produces, primarily in the form of images and reports. For instance, Lou (11) considered the data integrity and completeness of acquired images. High-quality images in terms of timeliness, accuracy, completeness, etc., were also considered to be a key success factor in several evaluative studies (e.g., 3;5;15;16). Fundamentally, the use of a PACS is central to its success. Users' expectations and satisfaction also have been studied widely. Undeniably, impacts, whether at the individual or the organizational level, represent the most widely used construct of PACS success. A vast majority of researchers have been interested in the influence that the PACS has on the users. For instance, Bryan et al. (4), Kato et al. (10), and Reiner et al. (20) investigated the impact of PACS on radiologists' productivity and report/interpretation time. Other researchers have studied the influence of PACS on technologists' productivity. As an example, Reiner and Siegel (19) assessed the impact of filmless operation and computed radiography on technologist's examination times compared with conventional film-screen radiography.

In short, past empirical studies have provided limited discussion of conceptual frameworks for holistic or comprehensive understanding of PACS success. To organize this diverse research, as well as to present a more integrated view of PACS success, a comprehensive success framework is introduced. Our aim is to synthesize previous research into a more coherent body of knowledge and to provide guidance to managers and clinicians. Importantly, the model proposed in this research evaluates PACS success from a user's perspective and does not include factual or objective success measures referring to individual productivity (e.g., time to dictation), organizational efficiency (e.g., image reject rates), and economic outcomes.

AN INTEGRATED MODEL OF PACS SUCCESS

Evaluation of system success or effectiveness has been a fundamental issue and dominant focus in information system (IS) research over the past 30 years. Because PACS is a particular or specialized form of system, a logical and reasonable departure point for evaluating PACS success is the relevant IS literature. From this perspective, the proposed multidimensional model of PACS success is based on DeLone and McLean's IS success framework (6;7) which has emerged to be a dominant model for system evaluation research. Since its publication in 1992, approximately 300 articles in refereed journals have referred to, and made use of, this IS success model. Several empirical studies explicitly tested the relationships among the variables identified in the original model (e.g., 12;17;22). Yet, other studies have implicitly tested the model by investigating multiple success dimensions and their interrelationships (e.g., 9;23). Taken as a whole, these studies gave strong support for the proposed associations among the IS dimensions and helped to confirm the causal structure in the model. Judged by its frequent citations in articles published in leading IS journals, this framework has become a dominant evaluation model in IS research.

Based on research contributions since the publication of the model, DeLone and McLean have updated their original success framework in 2003. The model indicates that success of an information system is multidimensional and can be represented by the quality characteristics of the system itself (SYSTEM QUALITY); the quality of the output (INFORMATION QUALITY); the quality of the technical support or service (SERVICE QUALITY); the consumption of the output of the system (USAGE); the user's response to the system (USER SATISFACTION); and, ultimately, the impacts the system has (NET BENEFITS).

Two constructs were added to DeLone and McLean's model to recognize complementary research findings in the IS field. DeLone and McLean are primarily concerned with acceptance behaviors, namely, use (or intention to use). Although usage represents an important indicator of system success, long-term viability and its eventual success depend on its continued use. As explained by Battacherjee (1), IS continuance is not an alien concept in IS research. Indeed, many studies have acknowledged the existence of a postacceptance stage when IS use transcends conscious behavior and becomes part of normal routine activity. In line with such reasoning, we think it is important to differentiate between acceptance and continuance behaviors, and hence, we include SYSTEM CONTINUANCE INTENTION as the ultimate dependent variable in our own success model.

The model tested by Battacherjee (1) is based on expectation-confirmation theory (14), which stipulates that users' intention to continue using a system is determined primarily by their satisfaction with prior system use and their perceived usefulness of IS use (perceived net benefits). Therefore, as shown in Figure 1, both user satisfaction and net benefits are associated with system continuance. Lastly, we posit that PACS continuance intention is influenced (both directly and indirectly) by another construct, namely, CONFIRMATION OF EXPECTATIONS after actual use of the system. Confirmation is positively related with system continuance (and user satisfaction) because it suggests the

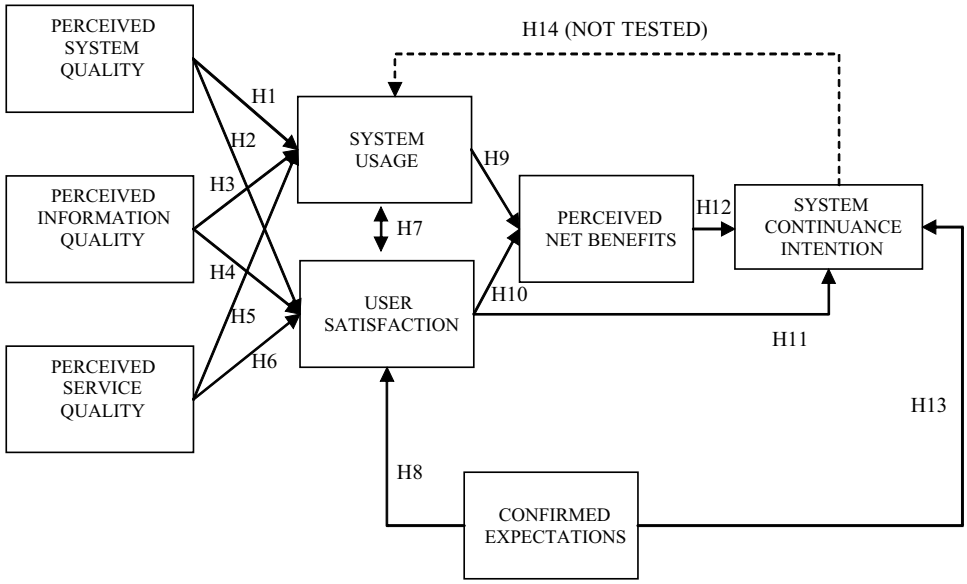

Figure 1. An integrated model of picture archiving and communication system success. H, hypothesis.

Table 1. Research Hypotheses

		R	T	C
H1	Use of PACS is positively associated with perceived quality of the system	•		•
H2	Users are more satisfied with PACS of higher perceived system quality	•	•	•
H3	Use of PACS is positively associated with perceived information quality	•		•
H4	Users are more satisfied with PACS of higher information quality	•		•
H5	Use of PACS is positively associated with perceived service quality	•		•
H6	User satisfaction is positively associated with PACS service quality	•	•	•
H7	Levels of user satisfaction and levels of PACS use are mutually and positively associated	•		•
H8	Users' extent of confirmation is positively associated with their satisfaction with PACS use	•	•	•
H9	Perceived net benefits are positively associated with PACS use	•		•
H10	Perceived net benefits are positively associated with user satisfaction	•	•	•
H11	Users' level of satisfaction with PACS usage is positively associated with their PACS continuance intention	•	•	•
H12	Perceived net benefits are positively associated with users' PACS continuance intention	•	•	•
H13	Users' extent of confirmation is positively associated with their PACS continuance intention	•	•	•

PACS, picture archiving and communication system; H, hypothesis; R, radiologists; T, technologists; C, clinicians.

realization of the expected benefits of IS use, whereas disconfirmation denotes failure to achieve expectation (1).

As depicted in Figure 1, the resulting model comprises eight interrelated dimensions of PACS success. As mentioned earlier, three groups of users are most affected by the introduction of PACS in a hospital environment, namely, radiologists, clinicians, and radiology technologists. The interaction of each group with PACS, as well as the impact of PACS on each group differs. The radiologists represent the group whose entire work environment and work practices are changed by PACS. The same can be said of clinicians, when analyzed from the perspective of their interaction with the radiology department and their use of medical images. Of course, clinicians perform many other tasks that are not related to medical imaging, but in their use of images for diagnosis and treatment, the tools at their disposal have been replaced. On the other hand, technologists interact with PACS in a more limited way. Specifically, only that part of their work involved in the production and handling of film is replaced by PACS. Technologists are not involved in image interpretation, except at the level of ensuring minimal quality assurance standards. This statement explains why certain research hypotheses listed in Table 1 do not apply to them.

METHODOLOGY

To test the content validity of the proposed research model, a series of in-depth interviews were first conducted with representative respondents at the Centre Hospitalier de l'Université de Montréal (CHUM) where a PACS was implemented throughout the year 2002. CHUM is a multi-site tertiary teaching facility composed of Hôtel-Dieu, Hôpital Notre-Dame, and Hôpital St-Luc. The academic medical

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center has over 1,400 licensed beds and produces over 365,000 radiology exams each year.

Given that different stakeholders, having different needs and interests, may attribute different outcomes to the PACS, may ignore outcomes they do not want to think about, and may evaluate the "same" outcomes differently, interviews were then conducted with twelve representatives from the three user groups. Conclusively, the overall success model shown in Figure 1 appeared to characterize well the reality of PACS success in the hospital context.

Next, a full-scale survey was conducted at the CHUM to assess the reliability and validity of our success measures as well as the strength of the relationships between the various constructs. A distinct questionnaire was then built for all radiologists ($n = 47$) and technologists ($n = 160$) and for those physicians who request exams from the radiology department ($n = 649$). A total of 232 questionnaires were returned to the researchers (27 percent response rate). Among the returned questionnaires, 24 were completed by radiologists, 77 by technologists, and 131 by attending physicians. Note that 14 questionnaires returned by physicians were removed from our database due to missing data, leaving us with a final sample of 218 responses. Of these usable questionnaires, 36.4 percent were received from Saint-Luc Hospital, 36.9 percent from Notre-Dame Hospital, and 26.6 percent from Hôtel-Dieu Hospital. The age of the respondents follows a normal distribution, and the sample was equally constituted of men and women. As expected, only 10.6 percent of the sample had prior experience with PACS.

DATA ANALYSIS AND FINDINGS

Data analysis began with an examination of the measurement model in terms of its reliability and discriminant validity. Table 2 presents the results associated with the assessment of the internal consistency of each scale. The composite reliability coefficients of all the measurement scales but two satisfied Nunally's guidelines (13). Only *integration* and *scope of use (radiologists only)* showed a weak reliability coefficient of 0.66. For integration (in the radiologist and technologist questionnaires), the low alpha is a result of the scale not having enough variability. Based on the results of the reliability analysis and the inter-item correlation coefficients matrix (not shown here), no item was removed from the measurement instruments.

Following the assessment of the measurement model, descriptive statistics were computed. Table 2 presents the means and standard deviation of the main constructs in the study for the three groups of respondents and provides the results of the Mann-Whitney *U*-test, which tested differences between the populations of respondents on these constructs.

Table 2. Internal Consistency Results and Descriptive Statistics

Construct	Variable	No. of items	Alpha	Radiologists		Technologists		Clinicians		Mann-Whitney or Kruskal-Wallis test	
				Mean	SD	Mean	SD	Mean	SD	Chi-squared	Asymp. Sig.
System quality	Ease of use	8	0.91	5.5	0.9	—	—	5.1	1.0	2.266	.132
	Usefulness	3	0.83	4.8	1.2	—	—	4.7	1.2	.166	.684
	Integration	2	0.66	2.8	1.7	5.1	1.2	3.3	1.6	66.976	.000
	Reliability	5	0.86	5.6	1.0	4.4	1.1	4.9	1.1	23.685	.000
	Ease of access	3	0.79	4.5	1.4	—	—	4.2	1.4	.404	.525
	Interface quality	6	0.78	4.5	1.0	—	—	3.9	1.1	5.185	.023
	Rapidity	6	0.78	4.4	1.2	—	—	3.9	1.1	2.430	.119
Information quality	Information quality	6	0.91	5.3	1.1	—	—	5.2	1.0	.180	.671
	Image quality	8	0.91	5.8	0.5	—	—	5.0	1.0	13.360	.000
Service quality		13	0.97	5.0	1.3	5.1	1.2	4.9	1.3	1.781	.410
Usage	Intensity[a]	2	0.83	25.5	12.2	—	—	5.6	8.3	45.696	.000
	Frequency	1	—	6.7	0.8	—	—	5.3	1.9	13.313	.000
	Scope[b]–Radiologists	8	0.66	4.9	1.0	—	—	—	—	—	—
	Scope–Physicians	6	0.72	—	—	—	—	2.2	0.8	—	—
User satisfaction		4	0.94	5.6	0.9	5.4	1.0	5.0	1.2	7.241	.027
Net benefits[c]	Radiologists and physicians	19	0.80	5.1	1.0	—	—	5.0	0.9	0.24	.877
	Technologists	6	0.92	—	—	5.1	0.8	—	—		
Confirmed expectations		2	0.77	5.3	1.0	5.3	1.0	4.9	1.2	8.601	.014
System continuance intention		3	0.82	6.7	0.6	6.2	1.0	6.2	0.9	12.385	.002

[a] Scales for all constructs, but intensity of use, are 1 (low value) to 7 (high value). Scale for "Usage Intensity" refers to the average number of hours per week spent working with the PACS.
[b] Scales for "Usage Scope" differed between groups; hence, comparisons of means were not computed for these constructs.
[c] A combined measure was developed to satisfy the usual requirement of at least five times as many respondents as items (reference 13, page 262). We intend to validate the success model in Figure 1 in other hospital settings and collect sufficient data to test the reliability of our original measures (radiologists, 23 items; physicians, 27 items).

Table 3. Linear Regression of Independent Variables on System Continuance Intention, Perceived Net Benefits, and User Satisfaction (Radiologists)

Criterion variable	Independent variable	Parameter estimate	SE	Standardized coefficients	*t*-value	*p* value <
System continuance intention	Intercept	5.071	0.687		7.377	.000
	User satisfaction[b]	0.498	0.143	**0.668**	3.474	.003
	Confirmed expectations[a]	0.308	0.125	**0.525**	2.467	.025
	Net benefits			0.149	−.622	.543
	Overall model: $F = 12.068$; $p < .005$; $R^2 = 0.446$; **adjusted $R^2 = 0.409$**					
Net benefits	Intercept	2.951	0.862		3.423	.003
	User satisfaction[a]	0.367	0.148	**0.528**	2.484	.024
	Overall model: $F = 6.172$; $p < .05$; $R^2 = 0.278$; **adjusted $R^2 = 0.233$**					
User satisfaction	Intercept	0.303	0.932		0.326	.750
	Reliability[c]	0.801	0.128	**0.851**	6.245	.000
	Ease of use[b]	0.609	0.172	**0.591**	3.545	.004
	Information quality			0.115	0.569	.580
	Interface quality			0.086	0.329	.748
	Rapidity			0.114	0.543	.597
	Confirmed expectations			0.252	1.503	.159
	Image quality			0.230	1.733	.121
	Usefulness			0.230	1.678	.132
	Integration			0.258	1.857	.100
	Ease of access			0.206	1.194	.267
	Rapidity			0.114	0.702	.503
	Service quality			0.229	−2.104	.069
	Overall model: $F = 38.996$; $p < .001$; $R^2 = 0.812$; **adjusted $R^2 = 0.792$**					

[a] $p < .05$.
[b] $p < .005$.
[c] $p < .001$.

Next, hypothesis testing was evaluated using linear (stepwise) regression coefficients. More advanced statistical approaches such as structural equation modeling could not be used because of the small number of radiologists and technologists in our sample. The regression results are shown in Tables 3 through 5 for radiologists, technologists, and clinicians, respectively. Note that gender and age were not found to be correlated with any of the constructs in our research model and, hence, were not included in the regression analyses.

Table 3 presents results pertaining to the relationships of the predictors of system continuance, perceived net benefits, and user satisfaction for radiologists. First, findings reveal that user satisfaction and, to a lesser extent, confirmed expectations, have significant positive effects on radiologists' intention to continue PACS usage. On the other hand, the data show that perceived net benefits were not found to have a significant and direct effect on system continuance intention for this group of professionals. The study variables explained 41 percent of the variance in system continuance intention. Second, 23 percent of the variance in perceived net benefits was explained by the only hypothesized predictor, namely, user satisfaction. Third, a linear regression of predictors on radiologist's satisfaction with the usage of PACS was conducted. The model explains 79 percent of the variance in the criterion variable, although only two of the twelve predictors were statistically different from zero. The standardized regression coefficients show that system reliability and ease of use had significant and positive effects on radiologists' satisfaction with the PACS. On the other hand, all of the other system quality variables (rapidity, usefulness, integration, and ease of access) as well as the quality of the information, the quality of the technical service, and the extent to which expectations were met had no significant direct effect on user satisfaction.

Table 4 reports the results pertaining to the determinants of system continuance intention, perceived net benefits, and user satisfaction for technologists. First, as expected, user satisfaction and perceived net benefits were found to have significant and positive effects on system continuance intention among technologists ($R^2 = 0.47$). On the other hand, the relationship between confirmed expectations and system continuance intention was not supported for this group of professionals. Second, 40 percent of the variance in perceived net benefits was explained by the only hypothesized predictor, namely, user satisfaction. Third, the standardized regression coefficients show that, as expected, confirmed expectations, system reliability, and service quality had significant and positive influence on technologists' satisfaction with the PACS ($R^2 = 0.59$). However, results indicate that system integration had no significant direct effect on satisfaction for this group of professionals.

Lastly, Table 5 summarizes the results pertaining to the relationships of the predictors of system continuance intention, perceived net benefits, and user satisfaction for

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Table 4. Linear Regression of Independent Variables on System Continuance Intention, Perceived Net Benefits, and User Satisfaction (Technologists)

Criterion variable	Independent variable	Parameter estimate	SE	Standardized coefficients	*t*-value	*p* value <
System continuance intention	Intercept	2.719	0.483		5.634	.000
	User satisfaction[b]	0.380	0.114	**0.390**	3.333	.001
	Net benefits[b]	0.325	0.100	**0.380**	3.243	.002
	Confirmed expectations			0.151	1.160	.251
	Overall model: $F = 29.671$; $p < .001$; $R^2 = 0.485$; **Adjusted $R^2 = 0.469$**					
Net benefits	Intercept	1.232	0.604		2.039	.046
	User satisfaction[c]	0.724	0.110	**0.636**	6.587	.000
	Overall model: $F = 43.387$; $p < .001$; $R^2 = 0.404$; **Adjusted $R^2 = 0.395$**					
User satisfaction	Intercept	−0.009	0.602		−0.155	.877
	Confirmed expectations[c]	0.594	0.108	**0.540**	5.483	.000
	Reliability[b]	0.271	0.089	**0.266**	3.028	.004
	Service quality[a]	0.193	0.092	**0.199**	2.098	.040
	Integration			0.020	0.194	.847
	Overall model: $F = 28.940$; $p < .001$; $R^2 = 0.608$; **Adjusted $R^2 = 0.587$**					

[a] $p < .05$.
[b] $p < .005$.
[c] $p < .001$.

Table 5. Linear Regression of Independent Variables on System Continuance Intention, Perceived Net Benefits, and User Satisfaction (Clinicians)

Criterion variable	Independent variable	Parameter estimate	SE	Standardized coefficients	*t*-value	*P* <
System continuance intention	Intercept	3.178	0.082		7.632	.000
	Net benefits[c]	0.617	0.088	**0.662**	7.013	.000
	Confirmed expectations			0.039	0.349	.728
	User satisfaction			−0.088	−0.778	.439
	Overall model: $F = 49.184$; $p < .001$; $R^2 = 0.438$; **Adjusted $R^2 = 0.430$**					
Net benefits	Intercept	2.395	0.444		6.288	.000
	User satisfaction[c]	0.473	0.083	**0.595**	5.713	.000
	Intensity of use[b]	0.002	0.008	**0.240**	2.303	.025
	Frequency of use			0.144	1.186	.241
	Scope of use			0.101	0.812	.421
	Overall model: $F = 17.175$; $p < .001$; $R^2 = 0.360$; **Adjusted $R^2 = 0.339$**					
User satisfaction	Intercept	0.885	0.618		1.433	.162
	Confirmed expectations[c]	0.503	0.142	**0.535**	3.534	.000
	Usefulness[a]	0.305	0.149	**0.310**	2.047	.049
	Service quality			0.219	0.1537	.135
	Information quality			0.099	0.671	.508
	Image quality			0.027	0.184	.856
	Ease of use			0.037	0.155	.878
	Integration			0.104	0.670	.508
	Reliability			0.117	0.752	.458
	Ease of access			0.006	0.049	.961
	Interface quality			0.142	1.131	.267
	Rapidity			0.058	0.451	.656
	Intensity of use			0.174	1.491	.148
	Frequency of use			0.072	0.555	.584
	Scope of use			0.011	0.097	.924
	Overall model: $F = 22.075$; $p < .001$; $R^2 = 0.654$; **Adjusted $R^2 = 0.641$**					

[a] $p < .05$.
[b] $p < .005$.
[c] $p < .001$.

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clinicians. First, the model explains 43 percent of the variance in system continuance intention for this group of professionals. Contrary to radiologists, clinicians' intention to pursue PACS usage was exclusively influenced by perceived net benefits, whereas user satisfaction and confirmed expectations had no significant positive effects on the criterion variable. Second, as expected user satisfaction and, to a lesser extent, intensity of use, were found to have a significant positive effect on perceived net benefits ($R^2 = 0.34$). On the other hand, the other two dimensions of usage, namely, frequency of use and scope of use, had no influence on the extent of perceived benefits. Third, like technologists, clinicians' satisfaction with usage of the PACS was explained first and foremost by the extent to which their expectations regarding the impacts of the PACS were initially met. Clinicians' satisfaction was also influenced by one of the system quality dimensions, namely, usefulness. Both variables explained 64 percent of the variance in the criterion variable. On the other hand, the data show that, contrary to our expectations, all other six dimensions of system quality as well as information/image quality, service quality, and all three dimensions of PACS usage had no significant and direct effect on clinicians' satisfaction with the technology.

DISCUSSION

Several research hypotheses were fully or partially supported in the present study. For one thing, user satisfaction strongly influenced the perceived net benefits of the PACS on all three categories of users, namely, radiologists, technologists, and clinicians. In this study, the more satisfied the users were with the PACS, the more strongly they agreed the system helped them perform well in the context of their job. Again, this result is consistent with the results of prior studies in the information technology domain (e.g., 12).

Next, DeLone and McLean (7) suggested that user satisfaction might be interpreted as a response to three types of user aspirations for a system: system quality, information quality, and service quality. Battacherjee (1) further suggested that confirmed expectations were directly related to user satisfaction. Perceptions of system quality, information quality and service quality as well as confirmed expectations should then explain a large proportion of variance in user satisfaction. As explained in detail below, the results from the PACS implementation that was the object of our study only provide partial support for this proposition, and factors influencing user satisfaction strongly varied across user types.

First, only three dimensions of system quality directly influenced users' satisfaction. PACS reliability was found to influence both radiologists' and technologists' satisfaction with the system. Radiologists' satisfaction was also influenced by the ease of use of the system, while perceived system usefulness, which captures the instrumentality of PACS use, was the only system quality variable that strongly influenced clinicians' satisfaction with the PACS. That only perceived system usefulness significantly influenced clinicians' satisfaction with PACS is a reflection of the primary impact of PACS on their work. Indeed, the ability to have instant access to images from any point in the hospital is the greatest perceived advantage, avoiding time wasting trips to the radiology department or the inconvenience of lost films. The results for radiologists show a concern with efficiency and productivity, because this aspect is best guaranteed by a system that is reliable and easy to use. As mentioned earlier, technicians are not, in actual fact, users; nevertheless, they benefit from the implementation of PACS because the system eliminates the tasks of physically producing and manually handling films. From this perspective, the quality of the system is less important than its reliability. It is surprising that reliability was not significantly linked to clinician satisfaction, because in the implementation studied, all film-based images were eliminated and the PACS assumed the role of a mission critical application. That since the early implementation period there has not been a prolonged and generalized failure of the system, at least in part, may explain this result.

Second, contrary to our expectations, neither perceived information quality nor perceived image quality generated or produced by the PACS influenced radiologists' and clinicians' satisfaction with the system. Image quality was a much more important issue in the early years of PACS deployment. Today, the technology has matured and images of excellent quality are the norm.

Third, it was hypothesized that user satisfaction was positively associated with PACS technical service quality. As reported in the preceding section, this result was supported but for technologists only. In the servicing agreement concluded with the PACS provider, technical service at the end-user level, be it PC related or application related was under the responsibility of the hospital technical staff. The PACS provider was responsible for the enterprise servers, a layer often transparent to the users. For clinicians and radiologists, the system has, in general, performed well, possibly explaining why service has not been an issue in the satisfaction expressed by these two groups. In a particular aspect of the technologists' work that required integration between the PACS and another application used routinely by them, some problems have persisted. The ability of the service team to fix this recurrent issue has made service quality an important parameter influencing their degree of satisfaction.

Lastly, satisfaction with PACS was also predicted by users' confirmation of the realization of expectations in relation to PACS usage. However, this result was significant for only two of three groups of respondents, namely, technologists and clinicians. The larger effect size of confirmation, relative to perceived usefulness (for clinicians) and reliability (for technologists), suggests that technologists and clinicians view the realization of their expectations as more salient than instrumentality and reliability of PACS in forming affect and, ultimately, intention about system continuance intention. For

the primary users of PACS, the radiologists, satisfaction—which, at the onset of implementation, might have been influenced by whether or not expectations had been met—2 years after deployment, appears to be solely dependent on the system's reliability and efficiency.

The next series of research hypotheses concern the antecedents of PACS continuance intention. The model in Figure 1 posits that continuance intention is influenced by three variables, namely, user satisfaction, perceived net benefits, and confirmed expectations. All three variables were found to be positively associated with continuance intention, but none of the variables was significant for all three groups of PACS users. On one hand, results of the study provide additional support for the expectation-confirmation theory's contention that satisfaction with PACS use is the strongest predictor of users' continuance intention. Indeed, a strong association was found between satisfaction and actual continuance behaviors for both radiologists and technologists. To a much lesser extent, radiologists' continuance intention was also influenced by the confirmation of expectations, whereas that of technologists was also related to the perceived net benefits. On the other hand, clinicians' intention to continue using PACS in the future was significantly and positively influenced by a single variable, namely, the perceived net benefits from PACS usage. Contrary to our expectations, continuance intention for the latter group was neither influenced by their satisfaction with prior usage of the technology nor by the extent to which their initial expectations had been met. Clinicians plan to continue using PACS regardless of the level of satisfaction because of the advantages that PACS affords them in their practice. As mentioned earlier, the possibility of instantaneous access to images anywhere in the hospital has a significant positive impact on productivity and the quality of their practice. Satisfaction with PACS may be more related to the particular commercial product chosen, resource management at the hospital level, or other issues that are not related to the concept of electronic management and distribution of medical images.

Lastly, contrary to our expectations, most hypotheses concerning the antecedents and consequences of PACS usage (actual use) were not supported. Indeed, no significant relationship was found between use (in terms of frequency, intensity, and scope) and system quality, information quality, and service quality. Similarly, with only one exception (see Table 5), actual PACS usage was not related to user satisfaction and perceived net benefits. Contrary to Seddon (21), who posits that use is not an indicator of IS success but that user satisfaction is because it is related to perceived impacts, we are not rejecting usage as an appropriate measure of PACS success. In our view, the problem in the present study is more methodological than conceptual. On one hand, simply measuring the frequency and amount of time a PACS is used by radiologists and clinicians may not properly capture the relationship between usage and other constructs such as user satisfaction and perceived net benefits. On the other hand, as suggested by DeLone and McLean (7), it can be argued that declining usage may be an important indication that the anticipated benefits are not being materialized and that users are not satisfied. Consequently, enriching our understanding of use may position us to better understand individual and organizational outcomes of PACS usage.

Policy Implications

Rapidly, PACS technology is becoming a reality in many North American, European, and Asian hospitals. Amid the growing interest in and implementation of PACS around the world, it is essential to address the challenge of evaluating PACS success. The research reported here signifies an important first step toward a comprehensive and holistic understanding of PACS technology success in the hospital setting. We believe the measurement instrument developed in this study can be used as a diagnostic tool by project managers interested in better understanding the extent to which different groups of stakeholders perceive the deployment of PACS as being successful and how factors influencing perceptions of PACS success vary across user types. For instance, our results clearly indicate that radiologists, which constitute the primary user group, are concerned with issues of efficiency and productivity and, hence, expect a PACS to be highly reliable and easy to use. Project managers must then make sure that both hardware and software components of the system are being tested thoroughly and that adequate security procedures are in place. Those responsible for PACS deployment must also be sensitive to the ease of learning the system, the adjustment to ergonomic factors, the system response time, and the users' reactions to system feedback, including what happens when an error message is received. In short, any concerns with regard to the reliability and/or the ergonomic aspects of the system need to be adequately addressed before PACS deployment.

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