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Determinants of Clinical Information System Post-Adoption Success

Jean-Marc Palm[ac], Andrew Grant[a], Jean-Marie Moutquin[b], Patrice Degoulet[c]

[a] *Collaborative Research for Effective Diagnostics, Sherbrooke University, Québec, Canada*
[b] *Department of Obstetrics and Gynaecology, Sherbrooke University, Québec, Canada*
[c] *Pompidou University Hospital, Paris Descartes University, and INSERM UMR-S872 Eq.20, Paris, France*

Abstract

The diffusion of information technology (IT) in healthcare systems to support clinical processes makes the evaluation of physician and nurse post-adoption an important challenge for clinical information systems (CIS). This paper examines the relationships between the determinants of success of a CIS based on an expectation-confirmation paradigm in a cross-sectional survey performed at the Sherbrooke University Hospital (CHUS). 32.2% (161) of physicians and 27.1% (352) of nurses responded to the survey questionnaires. Results suggested that physician and nurse satisfaction is determined differently according to post-adoption expectations: compatibility, confirmation of expectations, usefulness, ease of use, and support. The best predictor of physician satisfaction was perceived usefulness (r=.25, p=.0003) whereas for nurses it was ease of use (r=.18, p=.0003). Confirmation of expectations was strongly associated with each post-adoption expectation and positions its importance in CIS design and redesign. This study draws attention to the differences between physician and nurse perceptions of information technology and emphasizes post-adoption evaluation to measure CIS success. Physicians and nurses post-adoption expectations were key factors to warn again potential discontinuance.

Keywords:

Clinical information system, Post-adoption behavior, Success dimension, Confirmation of expectation, Satisfaction

Introduction

Clinical Information Systems (CIS) have significant potential to improve clinical processes and patient satisfaction [1]. Analysis of the success factors is essential in assuring the initial success and survival of a system in clinical routines in order to achieve the health system objectives [2]. Many factors affect the CIS post-adoption process by health professionals; the understanding of a successful CIS implementation is critical to the improvement of health care services and future development of CIS. Furthermore, it is essential to integrate analysis of health professional expectations and satisfaction in post-adoption models, and to investigate the relationship between user characteristics, compatibility, perceived usefulness, ease of use, and user support. Several studies have shown the driving role of the compatibility [3], perceived usefulness and ease of use [4,5], and user support [2] in the evolution of the adoption process and IT diffusion in organizations. This integrative approach is supported by the combining of relevant constructs of these IS research models [4-6].

The CIS of the "Centre Hospitalier Universitaire de Sherbrooke" (CHUS) was developed relatively early, but has, from time to time, encountered resistance by professionals. The levels of use were very different from one unit to another, even though CIS aims to improve health care processes and the quality of health care systems at the CHUS. In this study, we attempt to integrate user characteristics, perceived ease of use, compatibility and support, into the expectation model in order to analyse the mechanisms through which physicians and nurses achieve their post-adoption decisions and satisfaction.

The choice of dimensions is aligned with managerial perspectives and, by their relevance and compatibility, with the action plans for the evolution of CIS at the CHUS. Each CIS success dimension was assessed in terms of the different viewpoints of physicians and nurses.

Materials and Methods

Clinical Information System and Setting

This study was conducted at CHUS, a 712-bed affiliate of the Faculty of Medicine, Sherbrooke University. The CHUS' healthcare organization is divided into 11 client programs. The electronic clinical information system (ARIANE) was installed in 1989 with a progressive implementation strategy. ARIANE is an integrated system, and supports the following clinical processes: (1) admissions, discharge and transfer (ADT), (2) electronic health records (EHR): laboratory, radiology and imaging, diagnostic test results, (3) partial computerized provider-order entry (CPOE) including laboratory and radiology tests, (4) clinical documentation (CD): patient demographic characteristics, (5) appointment and patient scheduling (APS). In clinical practice, physician notes, problem lists, medication lists, discharge summaries and nursing assessments are achieved on paper, as well as orders for medications. In general, the nurse's processes are less developed than physician's processes in the ARIANE

system. The clinician notes, medication orders and discharge summaries are digitized and made available through ARIANE. According to Jha *et al*, ARIANE is a system that evolves between "Basic EHR System without Clinician Notes" and "Basic EHR System with Clinician notes" [7].

Survey instrument

The survey was designed to measure user characteristics, CIS compatibility, CIS support, confirmation of expectations, perceived CIS usefulness, perceived CIS ease of use, and user satisfaction. A seven-point Likert-type (1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither disagree nor agree, 5=Somewhat agree, 6=Agree, 7=Strongly agree) survey measured each dimension. All measurements were adapted from the previously validated instruments and modified based on the Clinical Information System. *User characteristics* asked users for personal information such as gender, age, whether working full or part-time, CIS training sessions and prior CIS experience. Items under *Compatibility* were adapted from Rogers and Moore [3,8,9]. *User Support* assessed the availability of CIS, help to access and understand CIS data, availability of assistance and training [2,9,10]. Items for measuring *Confirmation of Expectations* were adapted from Bhattacherjee and Van Der Meijden [2]. Four items were used to measure CIS expectations: compatibility, ease of use, usefulness and overall quality of the CIS [2,5]. *User Satisfaction* asked respondents to indicate their general satisfaction with the experience of using CIS, clinical information quality, reliability and user support quality. [2]. Scales for perceived CIS *Usefulness* and *Ease of Use* were adapted from previous studies on TAM [4,5,9].

Research model

According to the theoretical model used (Figure 1), the post-adoption user satisfaction is determined by the users' confirmation of expectations *(H3a)*, perceived usefulness *(H2a)* and ease of use *(H4a)*, compatibility *(H1a)*, support *(H5a)* and user characteristics *(H0)*. The perception of the usefulness is influenced by confirmation of expectations *(H3b)*, perceived ease of use *(H4b)*, compatibility *(H1b)* and support *(H5b)*. The confirmation of expectations *(H3c)*, compatibility *(H1c)* and support *(H5c)* directly influences perceived ease of use. In this model, the degree to which health professional expectations are confirmed is affected by both compatibility *(H3d)* and user support *(H3e)*.

Administration procedure

A cross-sectional field survey was conducted at the CHUS. We selected the CHUS to perform this study because its organization is positioned in the Post-Adoption phase for the last 5 years. The study targeted physicians and nurses working part-time or full-time at the CHUS, and used one component of CIS to support a clinical process. The survey questionnaires were anonymous and sent out to all program clients, between December 2007 and January 2008. Participants systematically received bi-monthly response reminders. In all, 1800 survey questionnaires were sent to physicians (500) and nurses (1300). 32.2% (161) of physicians and 27.1% (352) of nurses responded.

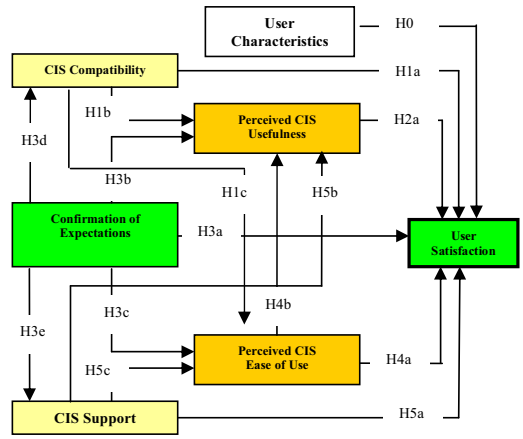

Figure 1- Theoretical Model

Data analysis methods

In the pre-test phase, the questionnaire was administered to a small target group (4 physicians, 8 nurses), in order to verify clarity of the questions. The reliability and validity of the items measuring the various elements was evaluated using Cronbach's alpha [11]. As shown in Table 1, the values were either close to or above 0.70. These results were acceptable [12]. For each dimension, we computed an aggregated variable and presented descriptive statistics, with mean and standard deviation. The mean deviation for physicians and nurses were compared by F tests. To address our research hypothesis, we performed separate multivariate regression analysis, as recommended by *Gefen* when the sample size is too small to use advanced statistical approaches such as structural equation modeling [13]. Analyses were performed using the statistical packages Statview® and Stata®.

Table 1-Validity of the instrument (Cronbach's Alpha)

Dimensions *(Items Number)*	**Physicians** (n=161)	**Nurses** (n=352)	**Total** (n=513)
Compatibility *(3)*	0.80	0.78	0.92
Confirmation of expectations *(4)*	0.96	0.93	0.95
User support *(4)*	0.80	0.78	0.74
Perceived CIS ease of use *(4)*	0.94	0.93	0.93
Perceived CIS usefulness *(4)*	0.94	0.89	0.91
User satisfaction *(4)*	0.82	0.79	0.80

Results

Users' characteristics

The sample consisted of 118 physicians, 43 residents, 324 nurses and 28 auxiliary nurses (table 2). Only 25.0% ($p<.0001$) of the respondents were male, working full time 74.5% ($p<.0001$) and having received prior CIS training 80.9%. The respondents averaged 40.1±11.4 ($p<.0001$) years of age and seniority at work at the CHUS of 14.1±10.5 years ($p<.0001$). The perception of CIS experience differed between physicians and nurses ($p=.0138$).

Compatibility

The items concerning CIS compatibility received very good scores (4.59±1.38) without any difference between health professionals (Table 2).

Table 2- Factors describing the compatibility dimension - Means (SD)

Using CIS is compatible with or (fits into)…	**Physicians** (n=161)	**Nurses** (n=352)	**Total** (n=513)
All aspects of my work	4.76(1.58)	4.66(1.45)	4.69(1.50)
My Work habits	4.55(1.56)	4.62(1.45)	4.60(1.49)
Organization of my work	4.39(1.60)	4.53 1.41)	4.49(1.47)
CIS Compatibility§	**4.57(1.51)**	**4.60(1.32)**	**4.59(1.38)**

§= Aggregated variable; Scale: 1=Strongly disagree to 7=Strongly agree

Confirmation of expectations

The post-adoption expectations such as compatibility (4.38±1.30) and perceived usefulness (4.64±1.27) did not differ, while perceived ease of use (4.60±1.21, p=.0085), quality of the CIS (4.54±1.27, p=.0199) and aggregated variable (4.54±1.18, p=.0230) scored higher on the scale for nurses (Table 3).

Table 3- Factors describing the expectations dimension - Means (SD)

The CIS…..was better than what I expected	**Physicians** (n=161)	**Nurses** (n=352)	**Total** (n=513)
Compatibility	4.25(1.55)	4.45(1.16)	4.38(1.30)
Perceived ease of use*	4.38(1.43)	4.70(1.09)	4.60(1.21)
Perceived usefulness	4.48(1.45)	4.71(1.18)	4.64(1.27)
Overall quality of the CIS*	4.34(1.50)	4.63(1.14)	4.54(1.27)
Expectations§*	**4.36(1.42)**	**4.62(1.04)**	**4.54(1.18)**

*§= Aggregated variable; * p<.05; Scale: 1=Strongly disagree to 7=Strongly agree*

User support

CIS support (4.44±1.07, p=.0002) was relatively low according to the CHUS IT objectives (Table 4). However, physician perception in appreciation of availability of assistance (p=.0028) and training (p<.0001) ranked higher than nurses.

Table 4- Factors describing the user support dimension - Means (SD)

	Physicians (n=161)	**Nurses** (n=352)	**Total** (n=513)
CIS availability when I need it	4.38(1.38)	4.41(1.41)	4.40(1.40)
Help to access and understand CIS data	4.74(1.33)	4.62(1.34)	4.66(1.34)
Availability of assistance*	4.86(1.36)	4.43(1.46)	4.56(1.44)
Training*	4.65(1.44)	3.92(1.46)	4.15(1.49)
CIS Support§*	**4.66(1.03)**	**4.34(1.07)**	**4.44(1.07)**

*§= Aggregated variable; * p<.05; Scale: 1=Strongly disagree to 7=Strongly agree*

Perceived CIS ease of use

The aggregated variable physician (5.17±1.24) perceived CIS ease of use seemed slightly higher than that of the nurses (5.09±1.18). Overall, the items of this dimension were relatively high and not significantly different among health professionals (Table 5).

Table 5- Factors describing the ease of use dimension - Means (SD)

	Physicians (n=161)	**Nurses** (n=352)	**Total** (n=513)
Simplicity	5.19(1.30)	5.23(1.18)	5.22(1.22)
Comfortable	5.19(1.30)	5.10(1.26)	5.13(1.27)
Learning	5.22(1.29)	5.08(1.33)	5.12(1.32)
Overall, perceived easy to use	4.92(1.41)	4.90(1.29)	4.90(1.32)
CIS Ease of Use§	**5.17(1.24)**	**5.09(1.18)**	**5.12(1.20)**

§= Aggregated variable; Scale: 1=Strongly disagree to 7=Strongly agree

Perceived CIS usefulness

Table 6 illustrates the CIS impact on performance, effectiveness and ability to make good decisions that were similar for physicians and nurses.

Table 6- Factors describing the usefulness dimension - Means (SD)

Using CIS…	**Physicians** (n=161)	**Nurses** (n=352)	**Total** (n=513)
Improves performance	4.78(1.76)	4.45(1.37)	4.55(1.51)
Improves effectiveness	4.72(1.86)	4.57(1.37)	4.61(1.54)
Improves ability to make good decisions	4.41(1.62)	4.16(1.44)	4.24(1.50)
Overall, CIS usefulness	5.25 (1.54)	5.18(1.28)	5.21(1.37)
CIS Usefulness§	**4.79(1.57)**	**4.59(1.20)**	**4.65(1.33)**

§= Aggregated variable; Scale: 1=Strongly disagree to 7=Strongly agree

User satisfaction

Physicians (4.79±1.28) were more satisfied with the quality of support than nurses (4.36±1.30, p=.0006). Overall, all professionals at the CHUS were satisfied with their CIS experience (4.76±1.04). For the other parameters, such as quality and reliability, both groups ranked similar (Table 7).

Table 7- Factors describing CIS user satisfaction dimension - Means (SD)

I am satisfied with…..	**Physicians** (n=161)	**Nurses** (n=352)	**Total** (n=513)
Clinical information quality	4.92(1.36)	4.91(1.13)	4.92(1.21)
Reliability	4.65(1.41)	4.67(1.22)	4.67(1.28)
User support quality*	4.79(1.28)	4.36(1.30)	4.50(1.30)
Overall experience of using CIS	4.75(1.33)	4.92(1.09)	4.87(1.17)
User satisfaction§	**4.83(1.13)**	**4.72(1.00)**	**4.76(1.04)**

*§= Aggregated variable; * p<.05; Scale: 1=Strongly disagree to 7=Strongly agree*

Model testing results

The regression results shown in Table 8 corresponded to the

model shown in Figure 2, based on the whole group of users (n=513). The model explained 68%, 53% and 59% of the variance of satisfaction for physicians, nurses and the whole group, respectively.

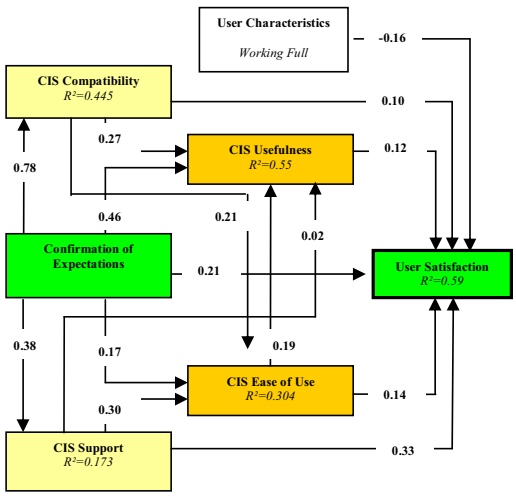

Figure 2- Model Testing Results (Total n=513)

The perceived usefulness (r=.25, p=.0003) was associated with physician satisfaction while perceived ease of use (r=.18, p=.0003) and compatibility (r=.10, p=.009) influenced nurses satisfaction. User support and confirmation of expectation were strongly correlated with physicians' and nurses' satisfaction. Compatibility, confirmation of expectation and ease of use were significant determinants of perceived usefulness. The explained percentage of variance was relatively high (≥48%). Compatibility (r=.21, p<.0001), confirmation of expectations (r=.17, p<.0001) and support (r=.30, p<.0001) explained 30.4 percent of the variance of perceived ease of use. Confirmation of expectations explained 63 percent of the variance in CIS compatibility for physicians. Furthermore, confirmation of expectations was most strongly correlated with CIS support for nurses.

Discussion

This study examined relationships between post-adoption expectations and satisfaction based on a model of confirmation of expectations. Results suggested that the confirmation of expectations was a relevant determinant of perceived usefulness, ease of use, compatibility and user support and the explained variances were relatively acceptable. The best predictor of a physician's satisfaction was perceived usefulness whereas for nurses it was perceived ease of use. Paré *et al* showed that clinician satisfaction was correlated with confirmation of expectations regarding the impacts of a PACS and perceived usefulness [14]. Thus, physicians are satisfied when the CIS provides desirable utility to their practice, and nurses when the CIS is easy to use in the nursing processes [15]. In a previous study we found that perceived CIS usefulness, perceived CIS quality and service quality had a significant effect on physician and nurse satisfaction [10]. Lee *et al*. reported that physician satisfaction was associated with ease of use, frequency of use, response times, and user characteristics [16]. Results also demonstrated

Table 8- Linear regression analysis of post-adoption model

Dimensions	H	**Physicians** (n=161)	**Nurses** (n=352)	**Total** (n=513)
		r (p)	*r (p)*	*r (p)*
*Regression 1: Stepwise multiple regressions analysis on **user's satisfaction***				
User characteristics				
Physicans	H0			.06(NS)
Male sex	H0	.09(NS)	-.04(NS)	-.00(NS)
Age	H0	.00(NS)	.00(NS)	.00(NS)
Working full time	H0	-.16(NS)	-.17 (.0494)	-.16 (.0379)
Prior CIS training	H0	.17(NS)	-.08(NS)	.010(NS)
CIS experience	H0	.00(NS)	-.03(NS)	-.020(NS)
CIS compatibility§	H1a	.09(NS)	.10(.009)	.10(.0023)
CIS usefulness§	H2a	.25(.0003)	.06(NS)	.12(.0008)
Expectations§	H3a	.16(.0349)	.21(<.0001)	.21(<.0001)
CIS ease of use§	H4a	.06 (NS)	.18 (.0003)	.14 (.0002)
CIS support§	H5a	.34 (<.0001)	.32 (<.0001)	.33 (<.0001)
Adjusted R² (p)		***.68 (<.0001)***	***.53(<.0001)***	***.59(<.0001)***
*Regression 2: Stepwise multiple regressions analysis on **CIS usefulness***				
CIS compatibility§	H1b	.35 (<.0001)	.23 (<.0001)	.27 (<.0001)
Expectations§	H3b	.56 (<.0001)	.40 (<.0001)	.46 (<.0001)
CIS ease of use§	H4b	.08(NS)	.25 (<.0001)	.19 (<.0001)
CIS support§	H5b	.04(NS)	.00(NS)	.02 (NS)
Adjusted R² (p)		***.70 (<.0001)***	***.48 (<.0001)***	***.55 (<.0001)***
*Regression 3: Stepwise multiple regressions analysis on **CIS ease of Use***				
CIS compatibility§	H1c	.28 (.0017)	.20 (.0001)	.21 (<.0001)
Expectations§	H3c	.06(NS)	.23 (.0005)	.17 (<.0001)
CIS support§	H5c	.33(.0001)	.28 (<.0001)	.30 (<.0001)
Adjusted R² (p)		***.31 (<.0001)***	***.30 (<.0001)***	***.304 (<.0001)***
*Regression 4: Stepwise simple regression analysis on **CIS compatibility***				
Expectations§	H3d	.84 (<.0001)	.74 (<.0001)	.78 (<.0001)
Adjusted R² (p)		***.63 (<.0001)***	***.34 (<.0001)***	***.445 (<.0001)***
*Regression 5: Stepwise simple regression analysis on **CIS support***				
Expectations§	H3e	.28 (<.0001)	.49 (<.0001)	.38 (<.0001)
Adjusted R² (p)		***.14 (<.0001)***	***.23 (<.0001)***	***.17 3(<.0001)***

CIS= Clinical Information System; NS p>0.05 §= Aggregated variable; H=Hypothesis

the importance of perceived ease of use in mediating the relationship of user support, compatibility and confirmation of expectations on satisfaction. For the nurse group, perceived ease of use had positive effects on perceived usefulness, according with TAM in pre-adoption [4]. As shown by Chismar *et al*, this relationship had no significant effect among the physicians, especially in post-adoption [15,17]. These findings showed that physicians and nurses at the CHUS are not experiencing the same dependence on CIS in their daily tasks. Currently, the description of the nursing processes was not electronically documented in the CIS [18]. CPOE functions are available for the laboratory and radiology orders; medication orders are input by pharmacy staff but are not yet introduced into the clinical processes. The implementation of clinician notes and medication orders associated with clinical decisions supporting (CDS) faced significant challenges for the IT practices at the CHUS in particular as well as the province of Québec as a whole. Another plausible explanation might be that nurses were considering CIS to be easy to use in their clinical processes and that they depended more on user support than physicians [10]. The compatibility influenced user satisfaction toward perceived ease of use. Chau *et al* found that compatibility was a significant determinant of perceived usefulness but not of perceived ease of use [15]. Several limitations of our study have to be emphasized. The response rate was low by physicians (<15%) and nurses (<24%). The relatively low R^2 values of CIS support and perceived ease of use compared with prior studies suggested the potential limitations and possible omission of factors important to the healthcare post-adoption context.

Future perspectives of this work could be the consolidation of the CIS post-adoption model and then evaluating its applicability in other academic hospital contexts using structural equation modelling to test and analyse post-adoption network causalities.

Conclusion

The findings of the study provide insights and implications relevant to CIS post-adoption research, communication and articulation of salient post-adoption expectations and health IT management.

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Address for correspondence

Jean-Marc Palm ing, M.ing, PhD
Sherbrooke University
Collaborative Research for Effective Diagostics (CRED)
3201, rue Jean Mignault
Sherbrooke (Québec), Canada, J1E 4K8
sie.jean.marc.palm@usherbrooke.ca