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Clinical Factors and Technological Barriers as Determinants for the Intention to Use Wireless Handheld Technology in Healthcare Environment: An Indian Case Study

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CLINICAL FACTORS AND TECHNOLOGICAL BARRIERS AS DETERMINANTS FOR THE INTENTION TO USE WIRELESS HANDHELD TECHNOLOGY IN HEALTHCARE ENVIRONMENT: AN INDIAN CASE STUDY

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Abstract

Traditional technology adoption models identified 'ease of use' and 'usefulness' as the dominating factors for technology adoption. However, recent studies in healthcare have established that these two factors are not always reliable on their own and other factors may influence technology adoption. To establish the identity of these additional factors, a mixed method approach was used and data were collected through interviews and a survey. The survey instrument was specifically developed for this study so that it is relevant to the Indian healthcare setting. We identified clinical management and technological barriers as the dominant factors influencing the wireless handheld technology adoption in the Indian healthcare environment. The results of this study showed that new technology models will benefit by considering the clinical influences of wireless handheld technology, in addition to known factors. The scope of this study is restricted to wireless handheld devices such as PDAs, smart phones, and handheld PCs.

Keywords: healthcare, wireless technology, adoption factors

1 INTRODUCTION

Technology Acceptance Model (TAM) asserted 'perceived ease of use' and 'perceived usefulness' as the determinants in predicting the acceptance of technology in a given setting. These constructs were found reliable in many information systems studies. However, when TAM was tested in a healthcare environment, perceived ease of use was not found to be significant (Chismar and Wiley-Patton, 2006, Spil and Schuring, 2006) . Further, other studies also established that perceived ease of use was not a significant predictor of technology acceptance in a clinical domain (Jayasuriya, 1998, Chau and Hu, 2002, Hu et al., 1999b) . While studying the dynamics of IT adoption in a major change process in health delivery, TAM was found to be inadequate (Lapointe et al., 2006). In introducing electronic patient records into hospitals, it was found that relative advantage, strong network availability and rich availability of information through different communication channels influenced technology adoption (Suomi, 2006). While measuring physicians' understanding of online systems use, physicians' behaviour, their workflow practices, and their perceptions regarding the value of specific information systems were found to be more significant than perceived ease of use and perceived usefulness (Horan et al., 2006). Therefore, there is a need to revisit the factors that determine the intention to use the wireless handheld technology in the healthcare environment.

A previous Australian study revealed that clinical usefulness of wireless technology is far more significant than the ease of use factor as established in TAM (Gururajan et al., 2005). Another focus group discussion with Western Australian senior health managers also indicated that aspects of clinical usefulness, such as integration of clinical data, may be a more significant factor than 'ease of use' (Gururajan et al., 2005b). This variation requires further empirical investigation to identify the

common key determinants of adoption of wireless handheld technology in the healthcare environment. One reason for this variation could be the settings, within which initial validity of TAM was predominantly established, i.e., by testing the model with students as surrogates in a generic software application domain.

Prior models of technology adoption come with criticism. For example, in terms of the Theory of Reasoned Action (TRA), irrational decisions, habitual actions and other unintentional behaviours are not explained (Fishbein and Ajzen, 1975, Ajzen and Fishbein, 1980). TRA is also limited by its reliance on self reported information to determine the subject's attitude and the data reported may be subjective in nature (Ajzen and Fishbein, 1980, Farhoomand et al., 1990, Fredricks and Dossett, 1983, Tan and Teo, 2000)

The Theory of Planned Behaviour (TPB) is limited in that it describes the attributes of adoption at the individual unit of analysis rather then at the organisational level. This precludes its use when dealing with an adoption based on primarily, organisational units (Ajzen, 1985, Ajzen, 1991, Ajzen and Madden, 1986) (Ajzen and Driver, 1992, Cheung et al., 1999, Madden et al., 1992, Randall and Gibson, 1991).

Technology Acceptance Model (TAM) was predominantly tested with students who have limited computing exposure, administrative and clerical staff who do not use all ICT functions found in software applications. Applicability of TAM to specific disciplines such as medicine appear to have not yet fully established (Davis, 1989, Davis et al., 1989) (Burton-Jones and Hubona, 2005, Darsono, 2005, Legris et al., 2003, Riemenschneider et al., 2003, Venkatesh and Brown, 2001, Venkatesh et al., 2003) (Hu et al., 2002, Hu et al., 1999a).

In terms of Unified Theory of Acceptance and Use of Technology (UTAUT), three additional reported indirect determinants such as self-efficacy, anxiety and attitude towards using technology need further study (Venkatesh et al., 2003) Li and Kishore (2006) (Carlsson et al., 2006, Cody-Allen and Kishore, 2006, Lubrin et al., 2006, Robinson, 2006).

The Diffusion of Innovation (DOI) -Model is limited, process not uniform, may not hold true due to its linearity, unstructured, emergent phenomenon and complex to be expressed in a step-like model. Diffusion processes focused on describing observed diffusion patterns in terms of pre-specified trend or distribution functions. And no references to technical, organisational or social context. Industry context is different. (Moseley, 2000) (Baskerville and Pries-Heje, 2001). Rogers (1983, , 1995, , 2003) (Vuarin and Rodriguez, 1994). Rogers (1995) (Hamblin et al., 1973) (Mahajan and Peterson, 1985)Van de Ven et al., 1989).

In terms of handheld adoption for healthcare, studies between 2000 and 2003, discussed a number of potentials of wireless technology in clinical domains. For example the use of broadband (Wisnicki, 2002), addressing the staff crisis with intelligent solution using agent and wireless technology (Davis, 2002), compliance with the rigorous regulatory framework (Wisnicki, 2002), reduction in medication errors and hence the benefits that can be realised was discussed by (Turisco, 2000), provision for greater flexibility and mobility of healthcare workers in performing their work was portrayed by (Athey and Stern, 2002), effective management of the increasingly complex information challenges and improved access to those information from anywhere at anytime was discussed by (Stuart and Bawany, 2001). Our review clearly identified that all these studies were only implying the potential of wireless technology and did not provide any empirical evidence. We hypothesise that the economic and cultural context has a significant bearing on rate of and approach to adoption of ICT. The healthcare environment is complex, sensitive and time critical and, hence, TAM could have behaved differently. However, this proposition needs testing.

In order to identify the common determinants of technology adoption in a healthcare environment, this study selected India. The rationale is that India is a leader in developing software technologies, especially medical applications. India is emerging in the domain of 'health tourism' due to the advancement in medical technology and reduction in cost in offering high quality health services.

India employs medical systems that are polar opposites in the areas of payment options, standards and government regulations. Therefore, any common factors of wireless technology adoption identified in India will be also be applicable to other countries. Collectively, these aspects led to the research question, 'What are the main determinants of wireless handheld technology within the Indian healthcare environment'?

2   RESEARCH PROBLEM

The main problem investigated in this study was the role of various factors that influence the 'Intention to Use' wireless technology applicable to handheld devices within the Indian healthcare environment. This research initially identified potential challenges in accepting wireless technology in a healthcare environment due to the rapidly changing nature of technology and associated legislative framework. Based on the initial literature reviewed, the following research question was raised in this study:

What are the factors that determine the intention of the healthcare professional to use wireless handheld devices in the Indian healthcare environment?

3   RESEARCH DESIGN

Taking into account the suggestions that a combined approach (mixed methodology) of qualitative and quantitative methods would strengthen the research outcome, and that there is a need to include a qualitative approach to study the human social and psychological factors (Remenyi et al., 1998), this study investigated human psychological factors using interviews and quantified these factors using a survey instrument. The data were collected from healthcare professionals involved in patient care and focused on their behavioural patterns of acceptance and usage of wireless handheld technologies, and their opinion on the usage of these technologies. The hospitals were derived from government, private and regional sectors respectively. The qualitative method employed in this study included semi-structured in-depth interviews to gain a sufficient understanding on the topic from healthcare professionals using wireless handheld technology in hospital settings. These interviews helped to identify any unknown factors that affect the adoption of wireless technology.

The data collection involved three specific stages. In the first stage we reviewed the existing literature in order to identify various issues impacting the healthcare domain where handheld devices can be used. This was the 'exploratory' stage. The main purpose of this stage was to identify factors in order to derive an interview instrument. The second stage involved actual data collection through interviews. The third stage included administering a specific questionnaire developed from the previous stages. These three stages are explained below.

Stage 1 – Literature Review (exploratory)

Extensive literature review was carried out at this stage to integrate the materials available into the interview questionnaire. The questionnaire consisted of over 20 themes and an information sheet was prepared after this comprehensive literature review. The specific purpose of this was to ensure that healthcare professionals were comfortable in answering the technical aspects of wireless technology as appropriate to their working environment. This stage did not identify any mediating factors and only main factors influencing the acceptance of technology were the focus of this stage.

Stage 2 – Interviews (evaluative)

In order to extract opinions about technology in a specific domain such as healthcare, the choice of sample is crucial. This is because the opinions expressed by healthcare professional should be unbiased and should pertain only to technology—and not the effects of technology on their current workflow. The samples for this project were drawn from the health departments of both public and

private healthcare facilities in India, where each participant is currently holding a practising licence. Further, the participants chosen were working in wards. People in administrative roles were eliminated from the interviews.

While information systems research identifies a range of sampling techniques such as random and clustering, the sampling technique used for this study is classified as 'purposive' sampling. In order to target healthcare staff with special knowledge of technology, this approach was followed in this study. The samples were chosen through the local medical district on their advice as their opinions on wireless technology was extracted based on their knowledge. Therefore, the samples needed to exhibit certain attributes related to technology adoption.

In the second stage of the research a set of 30 interviews were undertaken in the Indian healthcare environment. In order to ensure the interviews were conducted on time, the local health district was approached through one of the authors of this paper, and suitable candidate groups were identified. After obtaining ethical clearance from both the principal university and the health district, a research associate from the health district was contracted to undertake the interviews. The interviews were conducted in such a fashion as to minimize any disruption to participants' work schedule, ensure comfort in answering questions, minimize any travel time by interviewees, synchronise the 'interview' language with participants and to prompt participants when unknown aspects were encountered by participants.

Prior to the interviews, the line managers were approached for permission to release staff for interviews. Participants for the interviews were selected from the healthcare professionals from public and private healthcare facilities located in the southern region in India. The participants were initially screened for suitability, and those working with technology were considered for this purpose. Staffs involved with 'administration only' were eliminated from the interviews to avoid any unforeseen bias. As the healthcare professionals belonged to the Health Department, no further screening was employed for sampling.

The instruments of this research consisted of two broad categories of questions. The first category related to the adoption and usage of wireless devices in hospitals for data collection purposes. The second category consisted of demographic variables. Open-ended questions were included in the instrument to obtain unbiased and non-leading information. Prior to administering the questions, a complete peer review and a pilot study were conducted in order to ascertain the validity of the instrument.

Stage 3 – Survey (confirmatory)

This study developed a survey instrument from the interview data. The main reason for this behaviourist approach was that previously tested instruments were found to be inadequate for healthcare settings in India. The data from the interviews were used to develop a specific range of questions to gather more detailed views from the wider population. This survey instrument was pilot tested to capture the information reflecting the perceptions and practice of those using the wireless handheld technology in the Indian healthcare system, and particularly focussed on what internal and external environmental factors shape the adoption of wireless, and the extent of influence.

This survey was then randomly distributed to over 300 healthcare professionals in Southern India. A cover letter explained the objectives and goals of the research. In order to improve the response rate, a telephone reminder occurred two weeks after the initial date of survey distribution. A total of 200 surveys were received from India. The survey responses were then transcribed into a spreadsheet file. A Visual Basic interface was written to generate numerical codes for various elements of the survey for data analysis using SPSS. The coded spreadsheet file was then copied into a SPSS file format.

4   RELIABILITY AND FACTOR ANALYSES

The data were initially analysed for reliability through SPSS. The reliability tests returned a reliability value of 0.86 (Cronbach Alpha) for the survey instrument. This value indicates that the instrument was reliable and further statistical tests can be conducted.

Description	Cronbach's Alpha	No of Items
All the items in the survey questionnaire	.861	58
Items filtered through factor analysis	.895	37
Only survey questionnaire items selected in the first component (Clinical Performance) of factor analysis	.951	19
Only survey questionnaire items selected in the second component (Clinical Data Management) of factor analysis	.826	14
Only survey questionnaire items selected in the third component (Technological Barrier) of factor analysis	.819	3

Table 1: Individual component reliability analysis

The data were then analysed for factor analyses (varimax, rotated solution with factor loading set at 0.5) in order to identify groupings. These resulted in three main factor groupings. We titled these factors as *clinical performance*, *clinical data management* and *technological barriers*, as shown in Table 2 below.

Indian healthcare items descriptions	Clinical Performance	Clinical Data Management	Technological barriers
Reduce-workload	.650		
Improve-public-image	.685		
Improve-clinical-performance	.695		
Attract-more-practitioners	.596		
Save-time	.760		
More-training	.705		
Save-effort	.753		
Tech-support	.769		
Reduce-overall-cost	.633		
Reduce-medical-errors	.644		
More-contact-time-with-patients	.721		
Improve-clinical-workflow	.801		
Efficiency-in-communication	.729		
Better-quality-of-service	.747		
Improved-delivery-of-information	.741		
Delivery-of-high-qual-info	.763		
Reduce-inaccuracies	.660		
Easy-access-to-data	.693		
Positive-impact-on-patient-safety	.688		
Time for training barrier			.603
Poor technology barrier			.707

Tech expertise barrier			.616
Medical database referral		.607	
Daily scheduling of appointment		.618	
Obtain lab results		.565	
Billing and accounting		.556	
Disease state management		.566	
Administrative purpose		.608	
Patient education		.738	
Note taking		.768	
Drug administration		.620	
Communication with physicians		.684	
Communication with colleagues		.605	
Communication with patients		.525	

Table 2: Results of factor analysis on the Indian Survey data

5   RESEARCH MODEL

The factor analysis indicated that the above three group of factors appear to influence the intention in using wireless handheld technology. This is envisaged as our research model. The three factors as identified by the factor analysis are the independent variables influencing the intention to use technology as shown in Figure 1 below.
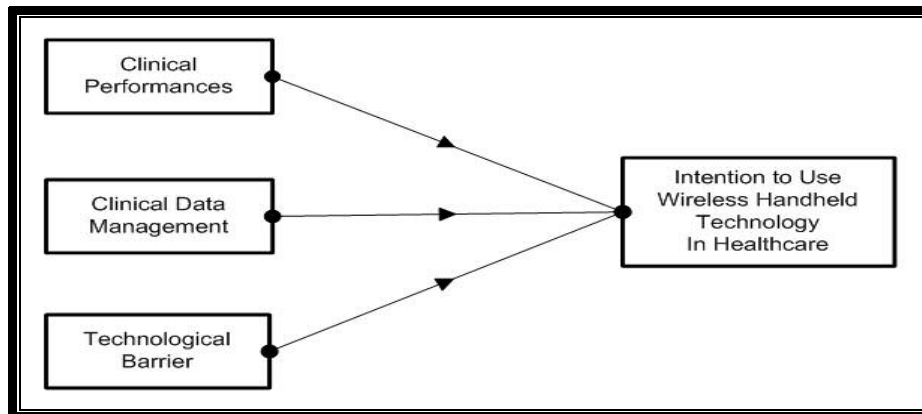
Figure 1: Research Model

Through the factor analysis, it is clear that the factors, clinical preferences, clinical data management and technological barrier will help to explain the variation in the factor 'intention to use' the wireless handheld technology in the healthcare environment. Therefore, these three factors (clinical preferences, clinical data management, and technological barrier) would be considered as independent variables for the dependent variable 'Intention to Use' as shown above. In order to test the provisional research model, we formed the following three hypotheses.

> H1: Clinical preferences will have influence on the intention to use wireless handheld technology in the Indian healthcare setting

> H2: Process of clinical data management will influence the intention to use wireless handheld technology in the Indian healthcare setting.

> H3: Technological barrier of the existing wireless handheld technology will influence the intention to use wireless handheld technology in the Indian healthcare setting.

Pearson correlation analysis was conducted among the predictors of the dependent variable, "Intention to Use". The independent factors namely clinical performance (CP), clinical data management (CDM), and technological barriers (TB) were used to analyse the correlation, as it can been seen from the table below the correlation between the predictors, "CP and TB is not significant as r = .037, with p > .05, for CP and CDM not significant as r = -.037, with p>.05, for CDM and TB is significant as r = .15 with p >.05.

Even though the correlation between CDM and TB is positive, the actual value of r=.145 is low and P > .05. This prompted us to conduct the multicollinearity analysis before proceeding to multiple regression analysis. Multicollinearity exists when there is a strong relationship between two predictors (Field, 2003). If the correlation between the predictors is between 0.80 and 0.90, then such a predictor should not be included for the multiple regression analysis. Therefore, we can be confident that all the three predictors (CP, TB, and CDM) are contributing to explain the variation in the predictor variable "Intention to use". This is also confirmed by "Variance Inflation Factor" (VIF). The value of VIF also confirms that all the three predictors are contributing in explaining the variation in the predictor variable (Myers, 1990).

Correlations		Clinical Performance	Technologi calBarriers	ClinicalData Management
ClinicalPerformance	Pearson Correlation	1	.037	-.037
	Sig. (2-tailed)		.611	.725
TechnologicalBarriers	Pearson Correlation	.037	1	.145
	Sig. (2-tailed)	.611		.162
ClinicalDataManagement	Pearson Correlation	-.037	.145	1
	Sig. (2-tailed)	.725	.162	

Figure 2: Correlations analysis of predictors

A standard multiple regression analysis (enter method) for the three independent predictors (CP, TB. CDM) was performed with "intention to use" as the dependent variable. Figure 3 below shows the model summary.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.979[a]	.959	.958	.23422

[a]. Predictors: (Constant), ClinicalDataManagement, ClinicalPerformance, TechnologicalBarriers

Figure 3: Multiple correlation coefficient Summary

The multiple correlation coefficient "R" for the three predictors (CP, TB. CDM) represents the combined correlation of these three predictors with the dependent variable (R = .979). The adjusted r-square (R^2 = .959) clearly indicates that 0.959 of the variations in the dependent variable ITU can be explained by the three (CP, TB. CDM) combined predictors.

ANOVA[b]					
Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	113.799	3	37.933	691.470	.000[a]
Residual	4.828	88	.055		
Total	118.627	91			

a. Predictors: (Constant), ClinicalDataManagement, ClinicalPerformance, TechnologicalBarriers

b. Dependent Variable: IntentionToUse

**Figure 4: ANOVA analysis**

Coefficients[a]							
	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1 (Constant)	-1.625	.114		-14.220	.000		
ClinicalPerformance	.048	.030	.034	1.585	.117	.997	1.003
TechnologicalBarriers	.391	.095	.089	4.110	.000	.977	1.023
ClinicalDataManagement	1.079	.024	.963	44.263	.000	.977	1.023

a. Dependent Variable: IntentionToUse

Figure 5: Coefficients and Variance Inflation Factor analysis

From the above figure (Figure 5), it can be seen that both independent variables 'Clinical data Management' and 'Technological barriers' were found to be significantly and uniquely contributing to the prediction of dependent variable 'Intention to use' (t = 44.3, p <.05, and t = 4.1, p <.05) . The independent variable 'Clinical Performance' was found not to provide any significant unique contribution to the prediction of dependent variable "Intention to use" (t = 1.6, p >.05). Thus, the standardized coefficient of multiple regression analysis describes the relationship of three determinants for the adoption of wireless handheld technology for the Indian healthcare setting as shown below.
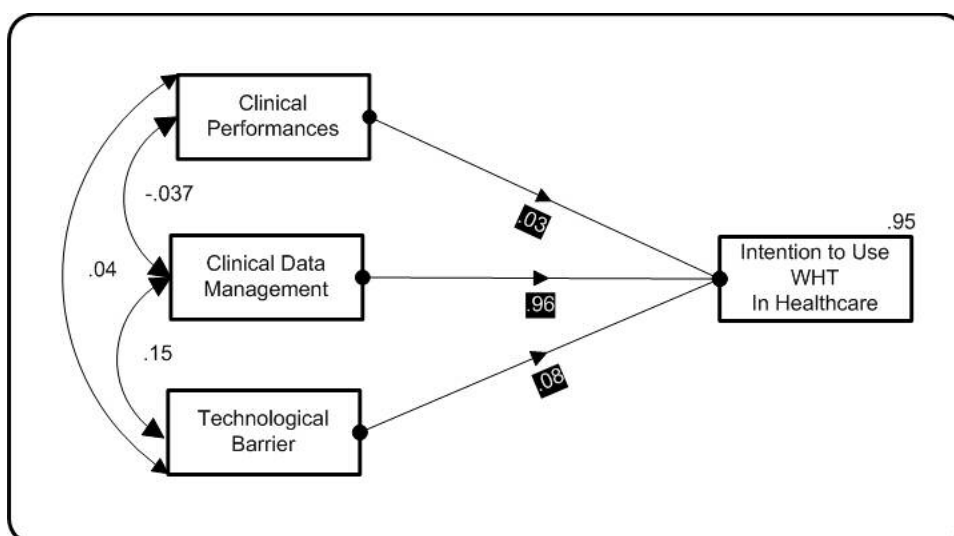
Figure 6: Initial framework confirmation

The above model clearly shows the low level of correlation between the independent variables, all the independent variable, CP, CDM, and TB are uniquely contributing to explain the variation in the dependent variable ITU. The portion of variation in the dependent variable ITU by CP and TB is quite low in the context of Indian healthcare systems. As discuss previously "Clinical Data Management" is the dominant factor for explaining the variation in the dependent variable "Intention to Use". This model clearly shoes that Indian healthcare professionals are quite concerned with the flow and availability of high quality clinical data in a healthcare facility for the adoption of wireless in healthcare setting.

6   DISCUSSION

The first order regression, as well as the second order regression, tests clearly indicate that both clinical data management and technological barriers were influencing the intention to use wireless technology in the given context. Further, our correlation analyses show that these two factors are well correlated, indicating the cohesive link between these two factors in order for the technology to be used in a given context. There is initial indication to this in the factor analysis conducted.

What transpires from the data analysis, especially the second order regression analysis, is that in order for physicians to accept the technology and for them to use it, the technology should be able to help them in the clinical management domain. This aspect is essential in order to realise benefits offered by the technology. These benefits may include cost and time savings, reduced consultation time, etc. While wireless technology may not help directly with clinical performance, the data associated with such clinical procedures can be managed with wireless technology, thus providing better access to data.

However, in order to realise this, the barriers must be minimised. This is even more important for physicians who may not have the expertise in comprehending the intricate details of wireless technology at enterprise levels. As identified in the factor analysis, the barriers fall under the technological barriers and aspects of this barrier should be properly addressed to ensure the uptake of technology in a clinical domain.

The implication of the data analysis is that the technology with reduced technical barriers is useful, as efficiency gains can be attained. While the ease of using a technology is crucial, in the clinical domain, physicians are quite conversant with using a variety of medical technologies and, hence, this factor is assumed to be available. However, usefulness is quite different because usefulness has a direct bearing on various management and attitude measures. If the technology is useful in a clinical setting, then users will be inclined to use the technology more, leading to technology acceptance. This is reflected in the regression analyses.

While some healthcare organizations are aware of the potential benefits they could gain by using mobile technologies, they encounter problems in adopting them and realizing the anticipated benefits. The success of innovative mobile applications in healthcare, however, depends not just on the soundness of the technology, but also on the organization's ability to embrace that technology to gain real benefits and enabling and encouraging the healthcare workers to use them.

Often transformation or adoption from existing systems to new systems is approached on piece-meal basis, without adequate consideration all relevant factors such as those identified in this study, it may be difficult to comprehend the intention to using such a new system. The technological barriers identified in this study should also be integrated with functional and non-functional requirements, security needs, users' profile and their needs and preferences, regulatory requirements, level of the quality of service required, integrity of data/information, the healthcare (organizational) policies and procedures and the constraints they impose, and current and future healthcare practices. Further, the risks of adoption of handheld technology initiatives require organisational wide assessment

Thus we recommend that a proper identification of clinical performance be undertaken by organisations so that mobile technologies could yield significant benefits to the organization, healthcare workers and the patients. This identification should consider aspects of data management so that appropriate technologies/platforms and mobile devices and networks available within the organisation can support data management at clinical level with security and privacy concerns properly addressed, new or modified healthcare practices, procedures and workflow that embrace the capabilities and potentials of mobile applications be thought of, and design an appropriate IT infrastructure and information systems, that includes integration with existing systems, and implement them. This would enable healthcare organisations to keep the quality of care, efficiency and effectives of healthcare delivery, and stakeholder needs – not the technology - at the centre of the usage of wireless technology.

7 CONCLUSION

This study merely identified the factors that contributed to the usefulness of wireless technology in a clinical setting. The data gathered was based on perceptions. We did not measure the actual usefulness. It would be worthwhile to measure this aspect to correlate the perceived feelings and actual use. The study also empirically established that clinical performance and reduction of technology barriers associated with technology in a clinical setting are determinants to the intention to use the technology. The study also, perhaps for the first time in the Indian context, identified specific factors that contribute to the acceptance of wireless technology specific to clinical setting. These factors require further validation as this study captured only perceptions. Real time measurement in a clinical domain of using wireless technology would provide insights as to the validity of the factors identified in this study. Future research should look into the use of multi-group analysis. The issues of sample size should also be addressed. This research has reported how a ground up research is undertaken in order to establish factors influencing technology adoption in a given context.

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