Confirmatory factor analysis on critical success factors of healthcare management IS in India

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Abstract

An instrument, based on the developed conceptual framework to identify variables that are critical for the success of Healthcare Information Systems adoption in India, is tested for reliability and validity. This research uses Confirmatory Factor Analysis to establish and confirm the fitness of the model using Structural Equation Modeling.

Keywords: Information and Communications Technology, Critical Success Factors, Healthcare Management Information Systems.

INTRODUCTION

Information and Communication Technology (ICT) has the potential to address many of the challenges that healthcare systems are currently confronting, mainly, universal access to healthcare services (Health Canada, 1999). It is reported that several ICT applications remain underused by healthcare professionals (Berner et al. 2005, Brooks et al. 2006). Healthcare organisations are lagging behind in the adoption of ICT (Yarbrough et al. 2007). Human and Organisational factors are in the fore front in causing ICT implementation failure (Aarts et al. 2007, Lorenzi et al. 1997, Pagliari et al. 2005). The number of studies which stress upon the identification of critical success factors of healthcare Information Systems (IS) adoption are practically absent or are too less in number in the literature and the same is absent for the adoption of HMIS in India. This explains the relevance and need for the current research.
This research is aimed at conceptualizing a framework for the identification of variables that are critical to the success of Healthcare Management Information Systems (HMIS) adoption and use in India. Suitable scale is developed, tested for its reliability and validity and Confirmatory Factor Analysis is carried out to confirm the fitness of the model using Structural Equation Modelling. Thus, the objectives of this research are:

- To identify the variables associated with HMIS adoption, use and other variables related to emerging technologies based on literature review;
- To develop a conceptual framework for the HMIS adoption study in India based on the variables identified;

- To develop a suitable scale using constructs to study the variables involved;
- To conduct a confirmatory factor analysis using structural equation modelling to establish the fitness of the model.

LITERATURE REVIEW

Healthcare Management Information System (HMIS)

This HMIS mentioned in this study is synonymously known as healthcare information system, healthcare planning system and hospital information system. The application of ICT technologies in HMIS has resulted in high-quality and efficient healthcare (Hauxe, 2006). In the past four decades, three different generations have evolved in the case of HMIS. Paradigm shift towards computerised information processing and storage about some forty years ago resulted in HMIS implementation in small hospitals with limited features and at only certain departments of these hospitals. HMIS of First Generation managed the digitalized form of medical documents, such as images or reports created by means of editing programs such as Radiology Information System (RIS) for storing and managing radiology-related documents (Huang, 2004). This later on led to Electronic Medical Records (EMR) in the 1990s. This transition from first to second generation HMIS as seen in DIOGENE project that seamlessly integrates all patient-related information (Borst et al. 1999). The innovative trend of the present is to integrate all the hospital-size HMIS to form regional HMIS, and federating all the regional HMIS to have national and trans-national National Healthcare System (NHS) of the third generation.

Adoption Theory

The approach in this research is based on revised Technology Adoption Model (TAM) proposed by Venkatesh and Davis (2000) which includes Perceived Usefulness, Perceived Ease-of-Use and Intention of Use. This theory has been tested and validated in non-healthcare settings and is found apt in present research as ICT is being used widely in adding value through redesign in healthcare solutions.

Critical Success Factors

Critical success factors (CSF) are important to identify and understand as they focus the attention on vital few against (Stahl et al. 2001). The purpose of this research is to identify the CSF that influences the adoption of Healthcare Information Systems used in India. The rationale is justified by the fact that India is a leader in developing information systems and is emerging in 'Health Tourism' due to the advancement in medical technology which help offer high quality health services at reduced cost.

CSF for HMIS

This section reviews empirical studies done previously on information system implementation success factors which support the current research theoretically to arrive at the critical success factors for the HMIS. Perceived usefulness was the most frequent success factor encountered in

prior studies (29 studies). Ease of use was the second most commonly used success factor (17 studies) Attitude also has been of high relevance to HMIS success in many researches (9 studies). Scholars have established that self efficacy and Training have a significant effect on HMIS success (7 studies each). Factors such as top management support (8 studies) and facilitating conditions (9 studies) are also having an impact on the success of HMIS. System Reliability, Information quality, Service care quality (5 studies each) and Social Influence (4 studies) are other identified factors affecting the behavioural intention of use of technologies as per literature. Summary of reviewed articles can be obtained from authors upon request and is not included due to shortage of space.

DEVELOPMENT OF CONCEPTUAL MODEL

The conceptual framework

Based on the literature review and considering the emerging technologies that pave way for the redesign of HMIS, a conceptual model to describe HMIS success factors has been developed as discussed below. In this model, the critical success factors identified grouped in to five categories. They are individual characteristics, organizational characteristics, system characteristics, environmental characteristics, redesign characteristics and TAM elements.
The conceptual model is shown in Figure 1.

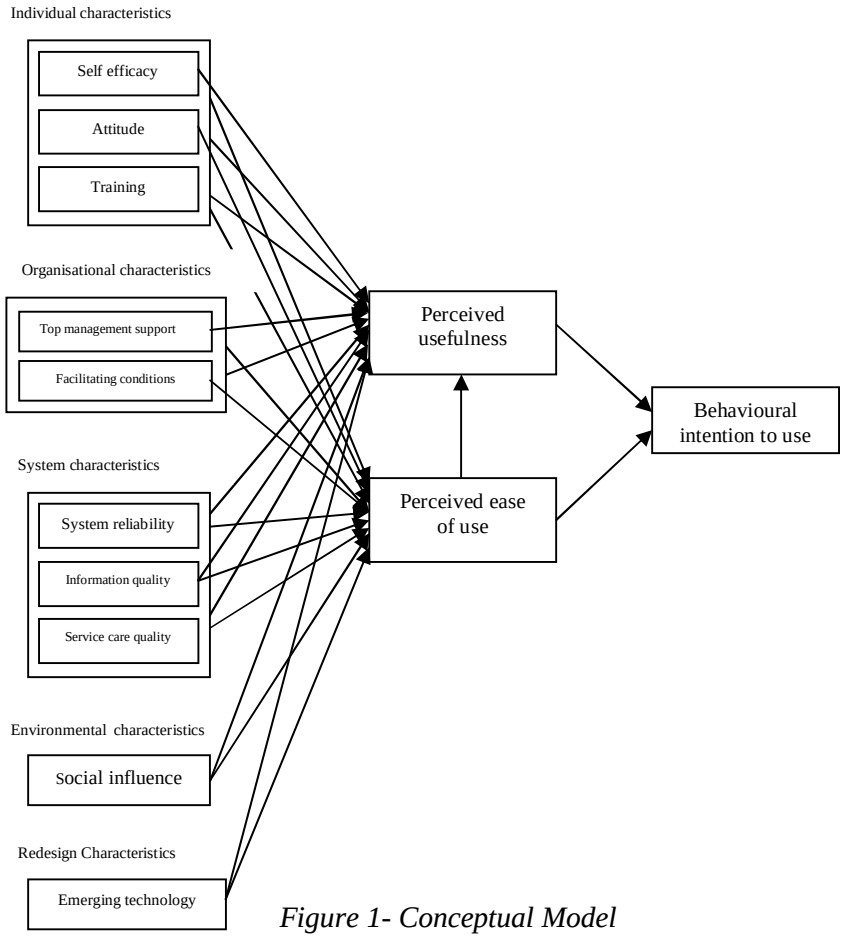

Figure 1- Conceptual Model

The arrows indicate either regression relationships or information flow. It consists of nine exogenous variables, namely, Self efficacy, Attitudes, Training, Top management support, Facilitating conditions, System reliability, Information Quality, Service care quality, Social influence and Emerging technologies, and, three endogenous variables, namely, Perceived usefulness, Perceived ease of use and Behavioural intention to use.

Development of the instrument

A five-point Likert scale from "strongly disagree (1)" to "strongly agree (5)" based structured questionnaire is used to measure each variable in the model. The operational definition of the variables used in the constructs along with their reference resources are presented in Table 1. The reliability and validity of the scale items are explored and relevant items related to each variable that make the scale more relevant are only included in the instrument.

Table 1- Description of Constructs and Source of Measurement Instrument

Variable	Definition	Number of items in the construct	Source
Self Efficacy	An individual's perception of his or her ability to use a computer system in accomplishing a job task.	3	Chau (2001)
Attitude	User's affection, or liking, for HMIS and for using them.	3	Venkatesh et al. (2003)
Training	Extent to which an individual has been trained about HMIS through courses, training, manuals, and so on	2	Goodhue and Thompson (1995)
Top management support	Top-management support for, and favourable attitude towards HMIS, in general	3	Igbaria and Iivari (1995)
Facilitating conditions	The adequacy of the deployment of IT infrastructure in an organisation to support job performance and to improve the quality of the users' job.	3	Thompson et al. (1991) Bhattacherjee and Hikmet (2008),
System reliability	The extent to which a system is dependable for the completion of a task without problems and breakdowns.	3	Sutirtha Chatterjee et.al (2009
Information quality	Degree to which information produced has the attributes of accuracy, format, completeness, understandability, and report timeliness for the user.	3	Seddon and Kiew (1996)
Service care quality	Perception of how a HMIS provider delivers the service to user	3	Brady, Cronin, and Brand (2002)
Social Influence	Social influence is defined as the degree to which an individual perceives that it is important that he or she should use health IT.	3	Boonchai Kijsanayotin et.al (2009)
Perceived usefulness	The degree to which a person believes that using a particular computer system would enhance his or her job performance.	4	Venkatesh and Davis (2000)
Perceived ease of use	The degree to which a person believes that using a particular computer system would be free of effort.	5	Venkatesh and Davis (2000)
Behavioural intention to use	The degree to which a healthcare professional's motivation intend to use the HMIS	5	Chau (2002) Gangnon, (2003)
Emerging Technology	Novel information and communication technologies, namely, social media, biometric identification, business intelligence and the like which help improving HMIS	8	Authors own

Development of a Structural Equation Model

The model consists of nine exogenous variables, namely, Self efficacy, Attitudes, Training, Top management support, Facilitating conditions, System reliability, Information Quality, Service care quality, Social influence, and Emerging Technology, and, three endogenous variables, namely, Perceived usefulness, perceived ease of use and Behavioural intention to use. There are forty eight indicators (q1 to q48) and 51 residual errors (e1 to e51).

Descriptive Statistics of Demographic Variables

The six demographic variables, that represent the demographic characteristics of the respondents, namely, gender, age, educational level, experience, rank and income, are included in this research. These variables represent the demographic characteristics of the respondents. Table 2 presents the percentage distributions and frequencies of each demographic variable.

Table 2 - Demographic characteristics of the sample

Items	Characteristics	Frequency	Percent
Gender	Female	176	57.33
	Male	131	42.67
	Total	307	100.00
Age	Up to 30 years	222	72.32
	31 - 40 Years	22	7.17
	41 - 50 Years	41	13.35
	51 - 60 Years	22	7.17
Education level	Higher secondary/ Pre-degree	17	5.54
	Diploma	71	23.13
	Bachelors	198	64.50
	Masters	8	2.60
	Ph. D / DM	13	4.23
Experience	Up to 5 years	198	64.50
	6 - 10 Years	51	16.61
	11 - 15 Years	4	1.30
	More than15 years	54	17.59
Organizational level	Doctor	115	37.46
	Nurse	151	49.19
	Technician	23	7.49
	Pharmacist	18	5.86
Income	Less than Rs.10000	11	3.58
	Rs. 10001 – 20000	173	56.36
	Rs. 20001 – 30000	27	8.79
	Rs. 30001 – 40000	81	26.38
	Rs. 40001 – 50000	11	3.58
	Above Rs. 50001	4	1.31

Construct Validity and Reliability analysis

The individual item loadings from factor analysis results are shown in Table 3. The extracted common factors have factor loading varying from 0.786 to 0.986 which show that they are well above the critical value of 0.50. The extracted common factors also accounted for variance ranging from 66.96% to 95.95% of the total variances providing good explanation on the associated factor. The construct reliability level assessed based on Cronbach's Alpha ranging from 0.752 to 0.979 showed good instrument reliability level. KMO index are varying from 0.5 to 0.972, which are either equal to or above 0.50, depicted sufficient sampling adequacy.

Based on the result of exploratory factor analysis and further reduced set of variables in the proposed model, confirmatory factor analysis was carried out using AMOS^{TM} program. Confirmatory factor analysis is used here to provide a confirmatory test of how measured variables from the survey results agreed with the theoretical model.

Table 3 - Reliability and Validity of the instrument

Construct		Cronb-ach's α	Kaiser Mayer Olkin, KMO	Factor Loadings,FL	Variance Extracted Estimate, AVE %
Self Efficacy (SE)		**0.947**	**0.766**		**90.5**
SE1	I could use HMIS without external help or experience.			0.955	
SE2	I am confident enough to handle unforeseen situations.			0.939	
SE3	It is easy for me to accomplish goals in HMIS.			0.960	
Attitude (ATT)		**0.765**	**0.500**		**81.00**
ATT5	I fully support the use of HMIS which is new technology			0.900	
ATT6	I feel that HMIS is beneficial for patient care management.			0.900	
Training (TRG)		**0.752**	**0.500**		**80.11**
TRG7	I consider the training given for this HMIS is adequate.			0.895	
TRG8	I completely accept the training duration and approach for this HMIS.			0.895	
Top Management Support (TMS)		**0.955**	**0.765**		**91.80**
TMS9	Top management commitment is felt in HMIS adoption.			0.960	
TMS10	User assistance for HMIS is assured.			0.968	
TMS11	New feature adoption is encouraged in HMIS by top management.			0.946	
Facilitating conditions (FC)		**0.909**	**0.755**		**84.68**
FC12	This hospital has sufficient computer software and hardware resources for HMIS.			0.918	
FC13	This hospital has paid ample attention in integrating and managing the related IT resources for HMIS.			0.913	
FC14	This hospital provides sufficient user support to sort out operational problems.			0.929	
System Reliability (SR)		**0.975**	**0.785**		**95.18**
SR15	HMIS functioning is reliable.			0.975	
SR16	HMIS is sufficiently quick in providing response.			0.978	
SR17	HMIS rarely faces screen hang or system fault.			0.973	
Information Quality (IQ)		**0.979**	**0.711**		**95.95**
IQ18	HMIS is secured using user ID and password.			0.974	
IQ19	The data provided by the system is accurate and timely.			0.986	
IQ20	Online help available in HMIS is useful.			0.979	
Service Care Quality (SCQ)		**0.978**	**0.766**		**95.86**
SCQ21	HMIS of this hospital is from a professional vendor.			0.969	
SCQ22	The system has required level of sophistication.			0.986	
SCQ23	The system problems are recovered quickly.			0.982	
Social Influence (SI)		**0.832**	**0.719**		**75.93**
SI24	Use of online referral system is encouraged.			0.868	
SI25	Encouragements from colleagues persuade my use of HMIS.			0.894	
SI26	Social media plays a strong role in promoting my use of HMIS.			0.851	
Perceived Usefulness (PU)		**0.836**	**0.798**		**67.13**
PU27	I feel like using the system frequently.			0.794	
PU28	With new features of HMIS, I see new potential benefits for my practice.			0.798	
PU29	The use of HMIS improves my efficiency.			0.819	
PU30	The use of HMIS improves the quality of medical service.			0.865	
Perceived Ease Of Use (PEOU)		**0.860**	**0.732**		**78.11**
PEOU31	HMIS is easy to use.			0.882	
PEOU33	HMIS is flexible enough to accommodate minor changes.			0.871	
PEOU34	Searching and getting the required information from HMIS is easy.			0.899	
Behavioural intention to use		**0.834**	**0.797**		**66.96**
BI37	I expect that future versions of HMIS will be more useful.			0.808	
BI38	I plan to use more features from HMIS.			0.885	
BI39	I prefer electronic mode than physical mode for my day to day transactions.			0.786	
BI40	I intend to adopt electronic patient identification system.			0.791	
Emerging Technology (ET)		**0.973**	**0.972**		**90.25**
ET41	I prefer highly secure Biometric system for HMIS access.			0.965	
ET42	Online imagery for scans and X-rays are used here instead of physical photographs in HMIS.			0.957	
ET45	Telemedicine capability in HMIS helps geriatric care and rural care as it improves accessibility at reduced costs.			0.974	
ET46	I use Personal Digital Assistant (PDA)/Mobile devices for daily work			0.978	
ET48	Disease spread among various parts of the country can be predicted by using new internet technologies.			0.871	

The structural equation model and fit indices for structural model are shown in Figure 2 and Table 4 respectively.

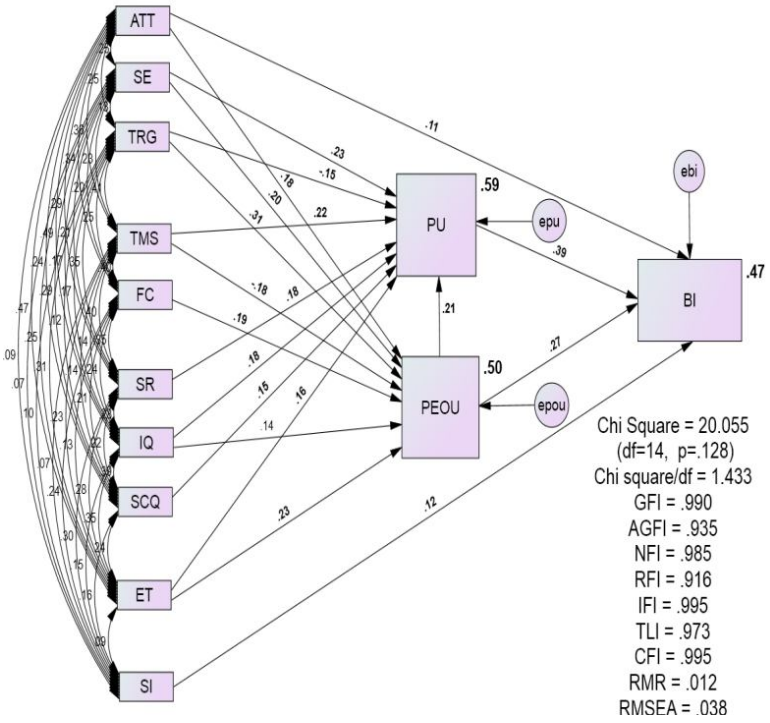

Figure 2 - Structural equation model

Table 4 - Fit indices for structural model

Index	Criterion	Final Model
Chi-square (χ^2)	Low	20.055
Degrees of freedom (df)	≥ 0	14
Probability (p-close)	≥ .05	.128
Normed Chi-squared (NC=χ^2 /df)	< 2.0	1.433
Goodness of Fit Index (GFI)	>.90	.990
Adjusted Goodness of Fit Index (AGFI)	>.90	.935
Normed Fit Index (NFI)	>.90	.985
Relative Fit Index (RFI)	>.90	.916
Incremental Fit Index (IFI)	>.90	.995
Tucker Lewis Index (TLI)	> 0.90	.973
Comparative Fit Index (CFI)	> 0.90	.995
Root Means Square Residual (RMR)	≤ .05	.012
Root Mean Square Error of Approximation (RMSEA)	≤ .08	.038

The statistical significant levels based on the regression weights (Estimate) and critical ratios (CR) are checked. Table 5 shows the results of path analysis for the generic structural equation model of the study. It is imperative from the evaluation of the structural equation model that the model fit is satisfactory as per Goodness of fit statistics. In Table 5, as all critical ratios of the various items are significant at the .05 level, it can be inferred that all the items of the

measurement model and nineteen regression paths out of the twenty three regression paths remained in the structural equation model.

Table 5 - Results of path analysis of revised SEM

Path link				Estimate	SE	CR	P	Results
H1:	SE	→	PEOU	.179	.038	4.764***	.001	Supported
H2:	ATT	→	PEOU	.191	.057	3.356***	.001	Supported
H3:	TRG	→	PEOU	.381	.056	6.781***	.001	Supported
H4:	TMS	→	PEOU	-.140	.039	-3.624***	.001	Supported
H5:	FC	→	PEOU	.174	.043	4.075***	.001	Supported
H7:	IQ	→	PEOU	.112	.037	3.002**	.003	Supported
H9:	ET	→	PEOU	.174	.037	4.674***	.001	Supported
H10:	SE	→	PU	.159	.029	5.532***	.001	Supported
H12:	TRG	→	PU	-.148	.044	-3.363***	.001	Supported
H13:	TMS	→	PU	.141	.027	5.173***	.001	Supported
H15:	SR	→	PU	.106	.025	4.227***	.001	Supported
H16:	IQ	→	PU	.114	.027	4.224***	.001	Supported
H17:	SCQ	→	PU	.098	.027	3.577***	.001	Supported
H18:	ET	→	PU	.100	.027	3.717***	.001	Supported
H19:	PEOU	→	PU	.170	.040	4.273***	.001	Supported
H20:	ATT	→	BI	.099	.043	2.283*	.022	Supported
H21:	SI	→	BI	.079	.027	2.944**	.003	Supported
H22:	PEOU	→	BI	.224	.043	5.233***	.001	Supported
H23:	PU	→	BI	.404	.053	7.677***	.001	Supported

MANAGERIAL IMPLICATIONS

This research has high practical implication as it is useful for the HMIS developing firms as the study has identified and confirmed redesigning possibilities. CSF studies on HMIS available in the literature are less compared to other types of IS in the global scenario and, as far as India is considered, studies in this direction are practically nil. The results of this study will shed light on certain aspects which will help healthcare IS professionals identify the required capabilities in future systems development. Also resource allocation proportionate to the importance of the capability could lead to gain and sustain competitive advantage by developing more useful and productive HMIS rather than chasing the trivial aspects/factors. Technology driven HMIS enable hospitals to improve contemporary measures of performance like quality, service, speed at reduced costs, and facilitate coordination of care across multiple facilities / organisations through seamless integration.

CONCLUSION

The purpose of this research is to make HMIS more beneficial for the healthcare sector by examining a multitude of factors critical to use, acceptance and redesign of such systems as these are important concern for professionals. The overall research goal is to provide new insight for predicting major variables such as criterion measures of technology use, acceptance and redesign. Additionally, this research sought to introduce and evaluate critical variables that have not been explained by prior studies on TAM with respect to IS, especially, in connection with the healthcare sector or HMIS. In addition to, CSF identified from the literature review, namely, Perceived usefulness, Perceived ease of use, Self efficacy, Attitudes, Training, Top management support, Facilitating conditions, System reliability, Information Quality, Service care quality and Social influence, Emerging Technologies that help redesign of HMIS has been incorporated in this study which is quite new to the literature.

High quality patient care achieved using optimal imaging at minimal cost and time factors, to improve patient outcomes, form the priority goal of this research. Thus, it is imperative to understand the impact and effect of technology on those aspects which provide patient care and produce the final output. Factors which favour quick and economic service delivery are explored in this research. Further, the authors believe that this research can contribute to an increased understanding by academic researchers as well as organisational management teams on these unique professional user attributes and perceptions that impact and effect technology use, acceptance and redesign. Moreover, longitudinal studies might provide further empirical validity, reliability and generalization with this type of technology research.

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