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Reengineering Healthcare using Information and Communication Technology: Structural Equation Model for Healthcare Information Systems

Nizar Hussain M, Suresh Subramoniam
Associate Professor, Department of Mechanical Engineering, Thangal Kunju Musaliar College of Engineering, Kollam (Kerala). India.
Associate Professor, College of Engineering, Trivandrum, Thiruvananthapuram (Kerala). India.

ABSTRACT: *It is claimed that reengineering healthcare using Information and Communication Technology (ICT) can bring many benefits to the healthcare organisation. Many ICT applications remain underused by healthcare professionals and healthcare organisations. Human and organisational factors have frequently been identified as the main causes of ICT implementation underuse. Therefore, it is very important to identify the Critical Success Factors (CSF) necessary for the implementation of Healthcare Information Systems (HIS). Existing models of CSF on information systems related to healthcare sector are practically less, globally, and almost nil with respect to India. Hence, the purpose of this research is to develop a conceptual model of CSF especially for HIS adoption, use and redesign in India. Such identified factors for redesign will also have international bearing as redesign possibilities discussed are mainly based on emerging technologies. The rationale of the purpose is justified by the fact that India is a leader in developing information systems, especially medical applications. Further, India is emerging as an international destination for healthcare due to the advancement in medical technology and is offering high quality health services at reduced cost.*

Index Terms: *Information and Communications Technology, Critical Success Factors, Healthcare Information Systems, Structural Equation Model.*

I. INTRODUCTION

Reengineering healthcare using Information and Communication Technology (ICT) has the potential to address many of the challenges that healthcare systems are currently confronting. ICT applications could improve information management, universal access to healthcare services, quality and safety of care, continuity of services, and costs containment [1]. It is reported that several ICT applications remain underused by healthcare professionals [2], [3]. Healthcare organisations, particularly physician practices, are often pointed out as noticeably lagging behind in the adoption of ICT [4]. Human and Organisational factors have frequently been identified as the main causes of ICT implementation failure [5]-[7]. 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 HIS in India. Hence, the researcher has decided on the above theme for carrying out the research. The following sections are organized as follows. Section 2 presents an extensive literature review on the topic. The conceptual model details and relationship between the variables involved along with their definition and corresponding constructs are discussed in Section 3. Implications of this study are enumerated in section 4. Finally, the research is summarized in Section 5.

II. LITERATURE REVIEW

A. Critical Success Factors

Critical Success Factors (CSF) can be defined as key areas of performance that are essential for the organization to accomplish its mission. Critical success factors are those that must be accomplished by the individual or the organization which are considered successful by important stakeholders. Critical success factors are important to identify and understand as they focus the attention on vital few against trivial many that consume most of the manager's time [8].

A broad range of factors that can influence the success of Healthcare Information Systems (HIS) have been

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mentioned in the literature. 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, especially, medical applications. Further, India is emerging in 'Health Tourism' due to the advancement in medical technology and offering high quality health services at reduced cost.

B. CSF for HIS

This section consists of the empirical studies done previously on success factors area which support the current research theoretically to derive the critical success factors for the HIS. Perceived usefulness was the most frequent success factor encountered in the literature (29 studies). Ease of use was the second most commonly used success factor (17 studies) Attitude also has been considered highly relevant to HIS success in many studies (9 studies). Scholars have established that self efficacy and Training have a significant effect on HIS 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 HIS. 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 is shown in Table 1.

TABLE 1. SUMMARY OF REVIEWED ARTICLES

Factors	Number of studies	References
Perceived usefulness	29	[7], [9-36]
Perceived ease of use	17	[7], [10], [13], [15], [21], [28], [29], [31], [32], [34--41]
Attitude	9	[13], [14], [16], [23], [27], [33], [38], [42], [43]
Self efficacy	7	[14], [44], [45], [46], [47-49]
Training	7	[18], [21], [24], [38], [44], [50], [51]
Management support	8	[17], [21], [22], [27], [29], [38], [52], [53]
Facilitating conditions	9	[9], [18], [19], [28], [32], [38], [40], [54], [55]
System reliability	5	[10], [15], [18], [22], [56], [57]
Information quality	5	[12], [40], [51], [57], [58]
Service care quality	5	[59-63],
Social influence	4	[22], [51], [64], [65]

This research is aimed at conceptualizing a framework for the identification of variables that are critical to the success of HIS adoption and use in India. Suitable scale is to be designed using constructs to study the variables and their relationships in the study. Scale developed is to be tested for its reliability and validity. Confirmatory Factor Analysis is planned to establish and confirm the fitness of the model using Structural Equation Modelling. Thus, the objectives of this research are:

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

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- To develop a suitable scale using constructs to study the variables involved;
- To develop a structural equation model with the constructs identified.

III. DEVELOPMENT OF CONCEPTUAL MODEL

A. The conceptual framework

Based on the literature review and considering the emerging technologies that pave way for the redesign of HIS, a conceptual model to describe HIS 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. The arrows indicated are either regression relationships or just the information flow. It consists of nine exogenous variables,

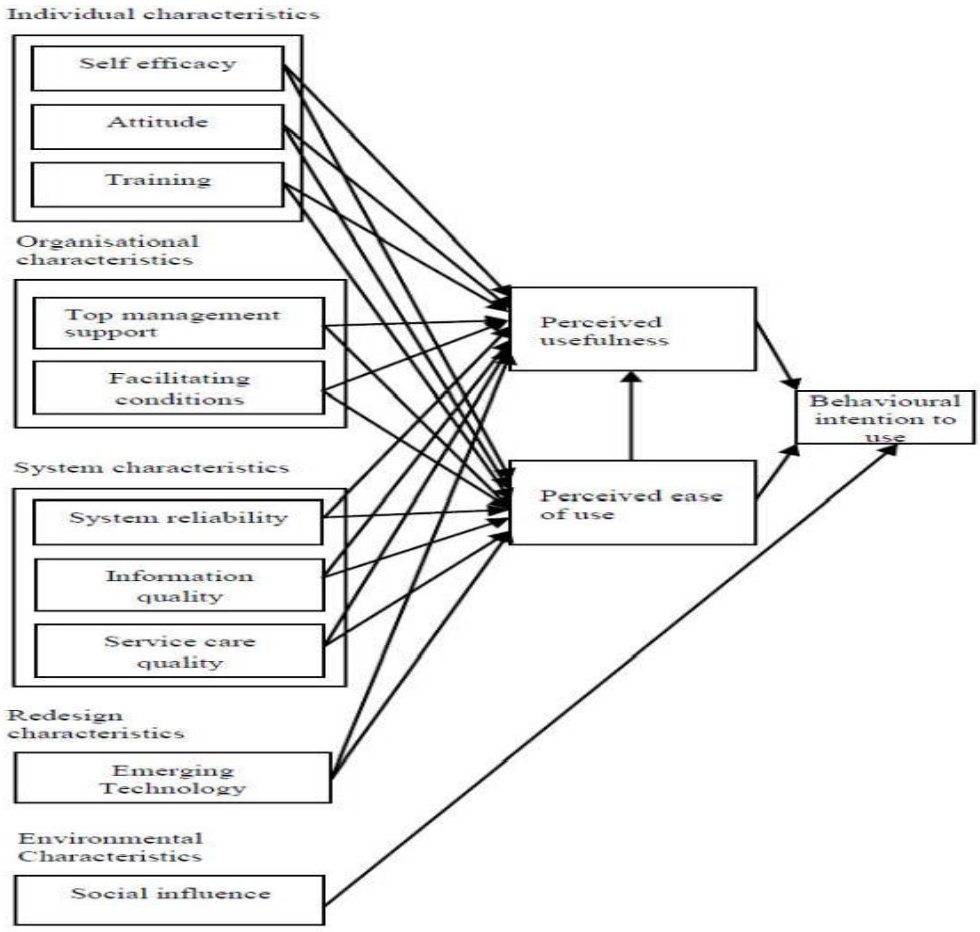

Figure 1. Conceptual model

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.

B Development of the instrument

This section describes the development of the construct for the proposed model. All measures used in the survey instrument are either adapted from existing studies or based on expert opinion. In this study, all variables are measured using multiple items which are developed based upon the theoretical considerations suggestions in prior studies and author's contributions. With regard to the HIS characteristics, the questionnaire is further adapted and modified. Several scholars in the fields of healthcare information technology and Management Information System (MIS) reviewed the content of questionnaire. In addition, a group of public healthcare professionals also contributed for the revision of the questionnaire for ensuring the suitability and appropriateness of every measurement item. A five-point Likert scale from "strongly disagree

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(1)" to "strongly agree (5)" in a structured questionnaire is used to measure each variable in the model. The operational definition of variables used in the constructs, and the corresponding reference resources are presented in Table 2. The reliability and validity of the scale items are to be explored and relevant items related to each variable that make the scale more relevant are only planned to be included in the instrument.

TABLE 2. 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	[66]
Attitude	User's affection, or liking, for HIS and for using them.	3	[67]
Training	Extent to which an individual has been trained about HIS through courses, training, manuals, and so on	2	[68]
Top management support	Top-management support for, and favourable attitude towards HIS, in general	3	[69]
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	[70]
System reliability	The extent to which a system is dependable for the completion of a task without problems and breakdowns.	3	[71]
Information quality	Degree to which information produced has the attributes of accuracy, format, completeness, understand ability, and report timeliness for the user.	3	[72]
Service care quality	Perception of how a HIS provider delivers the service to user	3	[73]
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	[74]
Perceived usefulness	The degree to which a person believes that using a particular computer system would enhance his or her job performance.	4	[75]
Perceived ease of use	The degree to which a person believes that using a particular computer system would be free of effort.	5	[75]
Behavioural intention to use	The degree to which a healthcare professional's motivation intend to use the HIS	5	[76], [77]
Emerging Technology	Novel information and communication technologies, namely, social media, biometric identification, business intelligence and the like which help improving HIS	8	Author's own

C. Development of a Structural Equation Model

Structural Equation Modelling (SEM) is defined as a collection of statistical techniques similar to factor analysis, path analysis, or multiple regression that takes into account the modelling of interactions, nonlinearities, correlated independent variables, measurement error, correlated error terms, multiple latent independent variables each measured by multiple indicators, and one or more latent dependent variables with multiple indicators. The advantages of SEM compared to multiple regression include the following: a) more flexible assumptions, such as the allowance for interpretation even in the presence of multi-collinearity; b) use of confirmatory factor analysis to reduce measurement error by having multiple indicators per latent variable; c) the appeal of testing overall models rather than individual coefficients; d) the capacity to test models with multiple dependent variables; e) the ability to model mediating variables; f) the capacity to model error terms; g) the usefulness to test coefficients across multiple between- subjects groups; and, h) the capability to handle non-normal data and incomplete data. Additionally, most SEMs consist of two parts, namely, the measurement model and the structural equation model. The measurement model specifies how the latent constructs are measured in relation to the observed variables, and further, it describes the

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measurement properties such as validities and reliabilities of the observed variables. Measurement models often suggest ways by which the observed measurements can be improved. Several conventions are used in developing SEM path diagrams. Measured variables, also called observed variables, indicators, or manifest variables, are represented by squares or rectangles. Factors have two or more indicators and are also called latent variables, constructs, or unobserved variables. Factors are represented by circles or ovals in path diagrams. Relationships between variables are indicated by lines; lack of a line connecting variables implies that no direct relationship has been hypothesized. Lines have either one or two arrows. A line with one arrow represents a hypothesized direct relationship between two variables, and the variable with the arrow pointing to it is the Dependant Variable (DV). A line with a two-headed arrow indicates an unanalyzed relationship, simply a covariance between the two variables with no implied direction of effect. As in multiple regressions, nothing is predicted perfectly; there is always residual error termed as "e". In SEM, the residual variance is the variance unexplained by the Independent variable (IV).

The SEM model for CFA on CSF related to HIS adoption, use and redesign is shown in Figure 2. 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 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).

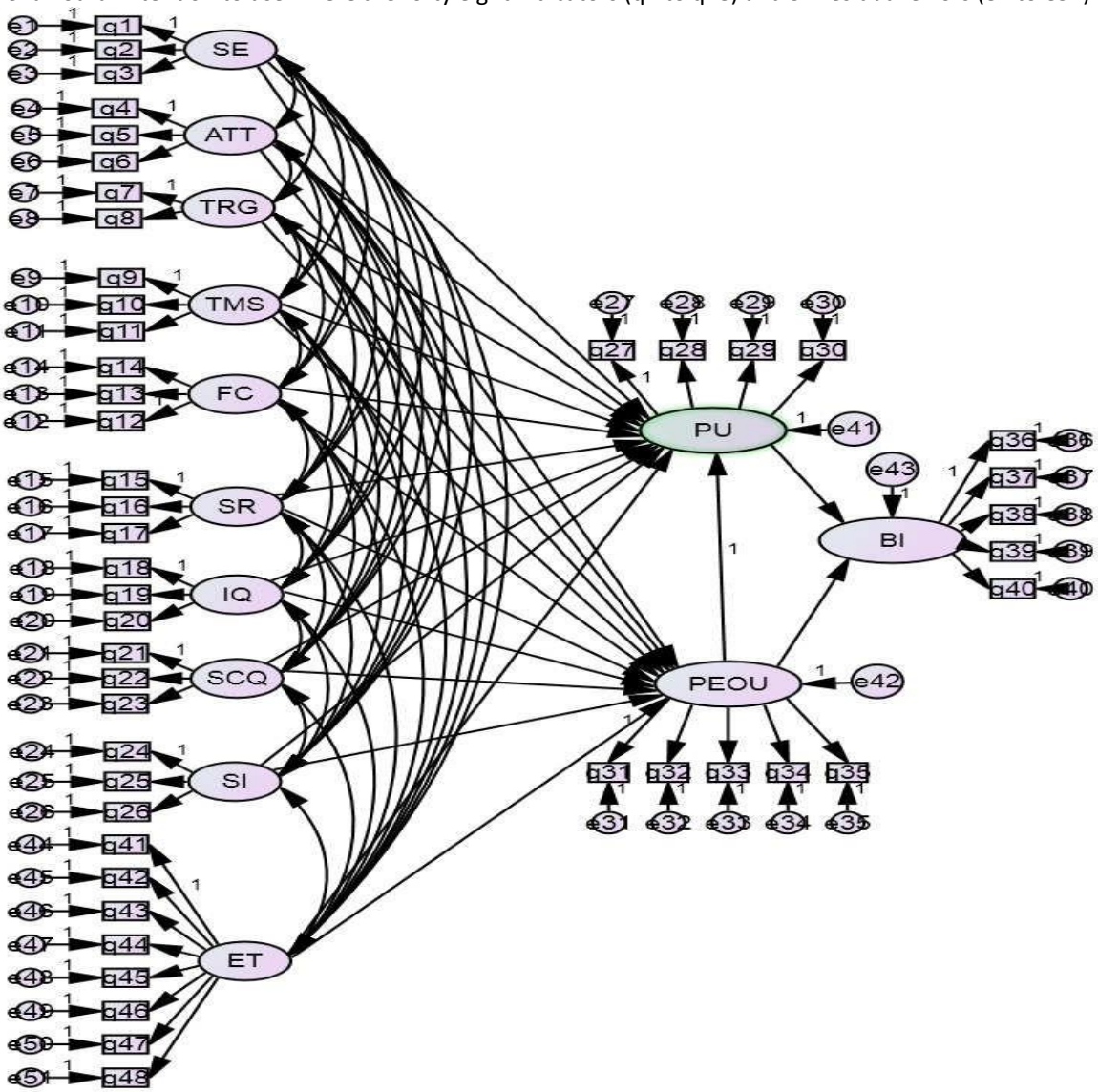

Figure 2. SEM model

It has been found that the return loss is reduced by 35.791 dB, directivity is increased by 3.947 dB & the efficiency is increased by 25% of the proposed structure. The Figure 8 & 9 obtained from Microsoft Excel Software shows the negative value of permittivity & permeability [16] at the operating frequency of 0.909 GHz, and Table 2 & 3 shows the numeric value of corresponding figure at the required operating frequency [15]. This proves that the proposed Design of media with a negative refractive index is a Metamaterial Structure.

IV. IMPLICATIONS

The practical implications of the study are enumerated below. This research is definitely useful for the HIS developing firms as the study identifies and confirms redesigning possibilities. CSF studies on HIS available in literature are less compared to other types of IS, globally, and as far India is considered studies in this direction are practically absent. The healthcare professionals will also get benefitted from this CSF study while planning and executing HIS. Using the results from this study, the healthcare IS professionals will be able to identify the required capabilities and allocate necessary resources in order to gain and sustain competitive advantage by developing more useful and productive HIS rather than chasing trivial factors. Technology driven HIS enable hospitals to improve quality, service, speed at reduced costs, and facilitate coordination of care across multiple facilities / organisations.

IV. CONCLUSION

In order to make HIS more beneficial for the healthcare sector, examination of a multitude of factors critical to use, acceptance and redesign of such systems have become a prime concern for professionals. The overall research goal is to provide new insight for predicting major variables 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 HIS. The CSF identified through literature review are 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. In addition to the above, Emerging Technologies that help redesign of HIS have been incorporated in this study.

Previous research findings suggested that professional users and common users subtly differ in their usage behaviour and acceptance of technology. Thus, as there is great disparity and diversity in terms of technology users, there has been a push for researchers to look at real-time technology trends and practices in the work environment that may impact or influence professional users. As noted by other researchers, there is always a need for additional empirical support to validate proposed models and research frameworks across various geographical locations in India. Moreover, longitudinal studies might provide further empirical validity, reliability and generalization with this type of technology research.

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