Factors Affecting the Use of a Medical Material Management Cloud - A Case Study of Telecommunications Company C

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Abstract

Combining the revised Technology Acceptance Model with the Information System Success Model as a theoretical framework, this study employed experts and scholars to examine the factors affecting a medical device management cloud. Convenience sampling was used to examine the factors affecting the willingness of employees in four teaching hospitals in the Central Taiwan and their medical device suppliers to use Chung Hwa Telecom's medical device management cloud. Statistical descriptions, relevant analyses, confirmatory factor analysis, and structural equation modeling were conducted to verify the model. Regarding the medical device management cloud, the results showed: relationship quality has a significant positive effect on perceived usefulness (PU) and usage intention; information quality does not have a significant positive effect on PU but does have a significant positive effect on perceived ease-of-use (PEOU); system quality does not have a significant positive effect on PU but does have a significant positive effect on PEOU; service quality has a significant positive effect on PU and PEOU; usage intention has a significant positive effect on PU; PU has a significant positive effect on PEOU; PU and PEOU have a significant positive effect on usage intentions。 A medical device management cloud provided by Telecom Company C to each major medical institution and device supplier would be an excellent tool to improve service quality, reduce medical treatment costs, create immediate feedback information on patient safety, and continue to increase the net benefit to medical institutions.

Keywords: cloud computing, medical device management cloud, Technology Acceptance Model, Information System Success Model

Introduction

The new era of cloud computing not only represents a trend in interdisciplinary applications of research and development but also has created a new business service model and lifestyle. By integrating clinical services with digital technology, the medical device management cloud has revolutionized conventional medical equipment supply systems. In the conventional clinical model of symptom treatment, medical devices that can track patient care after an invasive implantation treatment and can be used to immediately recall a patient to the hospital for safety concerns is exceptionally rare. Article 13 of the Pharmaceutical Affairs Act in the Republic of China defines medical devices as apparatuses, appliances, instruments and their accessories, fittings, and parts, which are used to diagnose, cure, alleviate or directly prevent human diseases or may have an effect on the structure and function of human bodies. Li (2012) in particular pointed out that future medical devices should integrate information with information communication technology.

Through the diversified service technology of cloud computing, hospitals can use the massive computing support of the online cloud to compute and access medical device data or conduct online medical services. Specifically, the Software as a Service (SaaS) model platform in cloud computing would provide patients and their families with 4P medicine (personalization, participation, prediction, and prevention), compensate for the lack of electronic medical records tracking patients after invasive implants, accelerate the informationization of the medical industry and the digitalization of medical records and operations data, as well as improve medical care quality and patient safety. According to Hsu (2011), medical device suppliers combine SaaS platforms provided by telecom companies with cloud infrastructure applications to vastly improve the original medical device management. Applications can then be used to connect various client devices through a thin client, such as a medical treatment web browser, eliminating the need for hospitals to manage or control low-level cloud infrastructure, such as networks, servers, operating systems, storage space, or even individual application functions, thereby accelerating the configuration and transfer of information and vastly decreasing the cost of care. Therefore, this study examined four regional teaching hospitals in Central Taiwan along with their medical device suppliers by combining the Technology Acceptance Model (Davis, 1989) with the Information System Success Model (DeLone and McLean, 1992; 2003) to analyze the correlation between relationship quality, information quality, system quality, service quality, perceived usefulness, perceived ease-of-use, usage intentions, and net system benefits. In addition, the mediating effect of perceived usefulness, perceived ease-of-use, and usage intentions on the correlation between relationship quality, information quality, system quality, service quality, and net system benefits, the mediating effect of usage intentions on the correlation between perceived usefulness and net system benefits, as well as the mediating effect between perceived usefulness, usage intentions, and net system benefits are investigated.

2. Literature Review

Medical Device Management Cloud

Cloud computing is an Internet computing model that allows users to conveniently access shared services through the Internet at any time (NIST, 2013). Cloud technology is an extension of the conventional data centers, using automation, standardization, virtualization, and data computation technology to integrate an organization’s entire work flow with its information system (NIST, 2010). The basic concept of the medical device management cloud is storing digitally-processed individual patient medical records and health information in a cloud storage platform. Cloud technology has gradually affected the healthcare industry, even providing patients with safer hospital environment and creating a new generation of patient safety information systems. The medical device management cloud uses SaaS functions to allow clients to use applications run on the telecom company’s cloud infrastructure. These applications can connect various client devices through a thin client, such as a medical treatment web browser (for example, a web-based email system).Hospitals do not need to manage or control low-level cloud infrastructure, such as networks, servers, operating systems, storage space, or even individual application functions. The system’s initial indicator collection remains dual-tracked, synchronizing information systems with manual collection. Three collection methods (manual, semi-automatic, and automatic) are used. First, the indicator collector discusses each indicator element from the Healthcare Information System, Laboratory Information System, Nursing Information System, or Clinical Information System before the “cloud computing” technology automatically extracts and cleans up the useful data from these medical information systems, ensuring data accuracy.. Wang (2014) used the SaaS platform with medical device cloud technology to not only reduce indicator collection time, but more crucially helped medical institutions effectively balance efficient care with quality service and created immediate clinical recall to continue to improve medical quality and patient safety. Of the factors affecting the Chunghwa Telecom cloud-based medical device management, perceived usefulness is an actor’s perceived response to the system after trial use and could be related to the assessed relationship quality, information quality, system quality, and service quality during use, thereby affecting the usage intentions and the development of subsequent system benefits.

Technology Acceptance Model

Developed by Davis (1989), the Technology Acceptance Model (TAM) is based on the Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980) and is used in the information system/computer technology field to explain and predict people’s acceptance of information technology. TAM is founded on two key beliefs: perceived usefulness (PU) and perceived ease-of-use (PEOU).

TAM contends that external variables affect user acceptance of information technology by first affecting attitudes toward using and behavioral intention to use through PU and PEOU before producing the actual system use behavior. More simply, PU and PEOU are the independent variables while attitude toward using, behavioral intention to use, and actual system use are the dependent variables. The subsequent research of Agarwal and Prasad (1998) demonstrated that PU and PEOU alone are insufficient to completely explain attitude. In addition, other perceived beliefs will affect attitudes toward technology. Due to the effect of usage intentions, the subjective norms neglected by TAM will provide more specificity to factors related to the net benefit of the medical device management cloud.

Information System Success Model

The Information System Success Model (ISSM) was first presented by DeLone and McLean (1992) in a 180-page article based on Shannon and Weaver (1949) and Mason (1978) and was revised in DeLone and McLean(2003) to incorporate six major constructs: system quality, information quality, service quality, system use, user satisfaction, and net system benefits. The revised ISSM (DeLone and McLean, 2003) divides information systems into the six concept indicators defined below:

1.**System quality** refers to an evaluation of the information system itself, which includes ease of operation, reaction time, easy-to-use functions, system flexibility, ease-of-use, storage convenience, ease of learning, extent of understanding user needs, system precision, system reliability, system integrity, system accuracy, system efficiency, resource usability, response time, and system adjusted response time.

2. **Information quality** refers to an evaluation of the information system's output (production), which includes the accuracy, completeness, timeliness, relevance, fluidity, clarity, comprehensibility, usefulness, reliability, newness, objectivity, and brevity of the output data.

3. **Service quality** refers to service quality of the advisory staff. The evaluation indicators come from the SERVQUAL scale (Parasuraman et al., 1988), which includes five indicators: tangibles, reliability, responsiveness, assurance, and empathy. Zeithaml, Berry and Parasuraman (1996) studied the relationship between service quality, behavioral intentions, and financial performance and found that service quality has a "positive correlation" effect on behavioral intentions: behavioral intentions were strongest when service quality was good, and next strongest when issues occurred but were taken seriously; the weakest behavioral intentions that followed an issue not receiving proper attention will affect customer behavior, thereafter affecting the financial performance of the company.

4. **System intention and use** is a type of attitude. Users with positive usage intentions will use the information system. The status of use for the information system include frequency of use, time of use, and voluntary use, which are used to measure system intention and use.

5. **User satisfaction** refers to a certain level of relationship based on past research findings that exist between user attitude toward and satisfaction with a system. Research examining computer user satisfaction will help establish an implication or item to measure the system's service quality. Oliver (2013) contended that the construct measuring satisfaction must express the client's feelings toward a product or service.

6. **Net system benefit** is an effect on organizational performance. Profit is the most crucial measurement for success and can be used to measure the positive or negative effects of e-commerce on employees, companies, customers, and the entire market supply chain.

3. Methodology

1. Research Framework

Based on the literature review, this study developed a research framework theoretically founded on the revised TAM and ISSM to examine the effects of relationship quality, information quality, system quality, and service quality on PU, PEOU, and usage intentions, as well as the effects of PU, PEOU, and usage intentions on net system benefits. The research framework diagram is presented in Fig. 3.

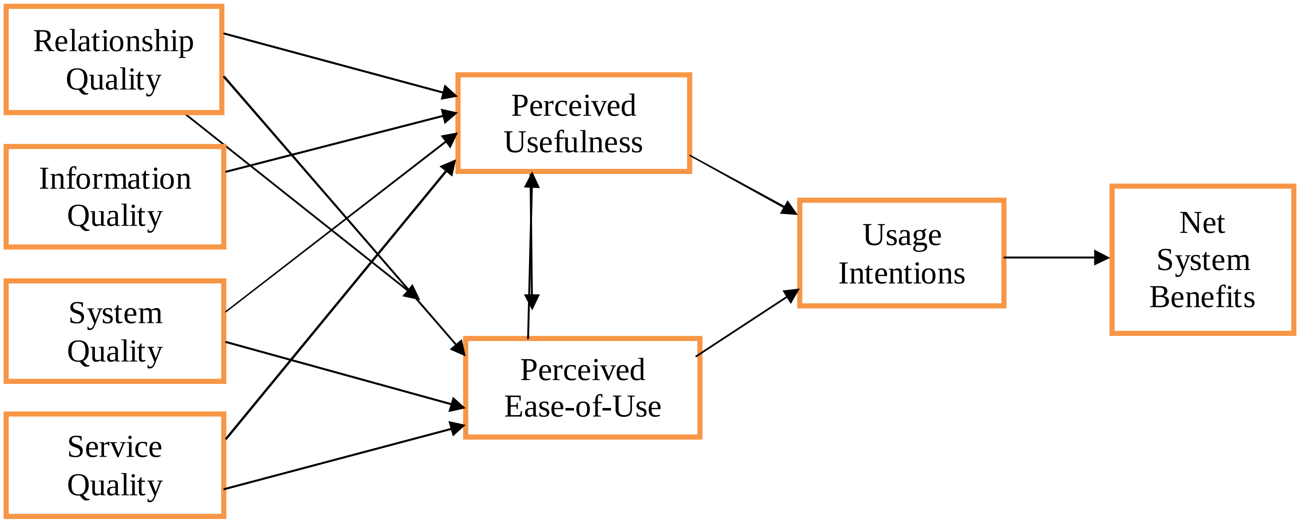

Fig.1 Research framework

2. Research Subjects

This study used convenience sampling to select 256 research samples from four teaching hospitals in Central Taiwan and their medical device suppliers. A total of 256 responses were received for a 100% response rate. Of those respondents, 240 questionnaires (93.8%) were valid.

3. Research Instruments

This study used the questionnaire "A Study on the Key Factors of Success for Chung Hwa Telecom's Development of a Medical Device Management Cloud" to collect relevant data. This questionnaire comprised three parts: the first part contained basic demographic information; the second part contained 26 statements about the four constructs, i.e., relationship quality, information quality, system quality, and service quality; and the third part contained 18 statements about the other four constructs, i.e., PU, PEOU, usage intentions, and net system benefits. Respondents scored each statement according to their degree of agreement using a Likert seven-point scale, ranging from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*).

4.Data Analysis and Processing

Each of the valid questionnaire responses were coded and filed using SPSS21.0 statistical software. After obtaining the numbers and percentages for the questionnaire response data, AMOS18.0 was used to analyze the impact factors for Chung Hwa's development of a medical device management cloud.

4. Research Results

Confirmatory Factor Analysis

This study used confirmatory factor analysis (CFA) to test the convergent validity and discriminant validity of the factors in this study. The composite reliability and average variance extracted (AVE) were calculated based on the standardized regression weights (the standardized factor loading) of the observed variables and assisted the determination of construct validity. First, confirmatory factor analysis was conducted on the eight constructs developed in the research framework to determine the internal and external quality of the model. The analysis showed that the reliability for each variable in the model (Cronbach's α) surpassed the required value of 0.7 or above, while the level of composite reliability value (CR value) also surpassed the required value of 0.6 or above. Those constructs whose decision value (CR value) was significant ($P<0.05$) were retained (Rigdon, 2005). The factor loading and AVE mostly satisfied the 0.5 or greater threshold, indicating that the model achieved an ideal level of internal quality.

Overall Model Analysis

Table 4.1 shows the results for each part of the overall model analysis, including the Chi-square (χ^2) test, the χ^2 per degree of freedom, Goodness of Fit Index (GFI), Amended Goodness of Fit Index (AGFI), average Root Mean Squared Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Precise Comparative Fit Index (PCFI).

This study satisfied the standard for each of these tests: χ^2 per degree of freedom was 2.20 (standard <3); GFI was 0.90 (>0.90); AFGI was 0.82 (>0.80); RMSEA was 0.07 (<0.80); CFI was 0.94 (>0.90); and PCFI was 0.82 (>0.50). These results indicate that this study developed an acceptable model (Wu, 2009).

Table 4.1 Model fit analysis

Fit Indices	Allowable Standard	Model (Revised)	Model Fit
χ^2	Less = better	2.36	Fit
χ^2per Degree of Freedom	<3	2.40	Fit
GFI	>0.90	0.91	Fit
AGFI	>0.80	0.86	Fit
RMSEA	<0.08	0.06	Fit
CFI	>0.90	0.92	Fit
PCFI	>0.50	0.71	Fit

As the results in Table 4.2 demonstrate, the effects of system quality on PU and usage intentions, of information quality on usage intentions, of usage intentions on PU, of PU on usage intentions, of PEOU on PU, of PEOU on usage intentions, and of usage intentions on net system benefits were all significant, verifying H1, H2, H4, H7, H8, H10, H11, H12, H13, H14, H15, and H16. However, the effects of information quality on PU, of system quality on PU, and system quality on PEOU failed to achieve a level of significance; thus, H3, H5, and H6 were not supported.

Table 4.2: Experimental validation results for the research hypotheses

Hypothesis	Path Relationship	Path Value	Support Hypothesis
H1	Relationship Quality→ PU	0.53*	Yes
H2	Relationship Quality→ Usage Intentions	0.50*	Yes
H3	Information Quality→ PU	-0.24	No
H4	Information Quality→ PEOU	0.49*	Yes
H5	System Quality→ PU	-0.21	No
H6	System Quality→ PEOU	-0.2*	No
H7	Service Quality→ PU	0.29*	Yes
H8	Service Quality→ PEOU	0.24*	Yes
H9	PEOU→ PU	0.09	Yes
H10	PU→PEOU	0.68*	Yes
H11	PU → Usage Intentions	0.92*	Yes
H12	PEOU → Usage Intentions	0.94*	Yes
H13	PU and PEOU →Relationship Quality and Net System Benefits	0.61*	Yes
H14	PU and PEOU → Information Quality and Net System Benefits	0.64*	Yes
H15	PU and PEOU → System Quality and Net System Benefits	0.63*	Yes
H16	PU and PEOU → Service Quality and Net System Benefits	0.67*	Yes

5. Conclusion and Recommendations

1. Conclusion

This study combined TAM with ISSM by using the four primary constructs of the revised ISSM (relationship quality, information quality, system quality, and service quality) as the external variables affecting PU and PEOU in the revised TAM to further elucidate the actual effects of using medical device management cloud of Telecommunication Company C on usage intentions and net system benefit. The results of this study are described below:

This study examined four medical institutions in Central Taiwan using linear structure verification to evaluate the causal relationship of relationship quality, information quality, system quality, service quality, and net system benefit, and determined the fitness of the overall model. Of the 16 path hypotheses in the model, 13 were significant. The analysis results demonstrate that this model is a theoretical model with favorable goodness of fit.

Additionally, the results of this study demonstrated that relationship quality, information quality, system quality, and service quality all exhibited a significantly positive effect on net system benefit, proving that the active promotion of cloud applications in medical device management by Taiwan's medical device providers could achieve net system benefits for medical institutions by improving relationship quality, information quality, system quality, and service quality.

2. Recommendations

As shown by the research results above, while user-friendly operating interfaces in general medical information systems help users perceive that the systems are useful, the information and service qualities provided by these systems may fail to satisfy user demands, negating effects created by their usefulness. Therefore, this study recommends that medical device management focus on improving information and service quality and strengthening the expansion of the application of the Internet of Things to medical device technology to other medical institutions (beyond medical institutions in Central Taiwan). Accordingly, suppliers can satisfy the user demand for information and service in this information age with a medical device management cloud. Furthermore, this study primarily examined hospital staff and their medical device suppliers, all of whom may not be voluntary users (such as, medical managers, medical device suppliers, or physicians). Users who are forced to use the medical management cloud might care more about the extent to which system applications can facilitate their daily work. Therefore, future research could strengthen deficiencies in this study by further examining the relationship quality, system quality, information quality, and service quality satisfaction and the effect on PU, PEOU, usage intentions, and net system benefit for users with different characteristics.

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