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Research Article
Factors Influencing the Adoption of Cloud Telehealth Systems Based on the TAM and Perceived Risk

[1,2]Po-Chung Chen, [3]Che-Fu Chang, [4]Chen-Ying Su, [5]Cheng-Min Chao and [6]Chou-Yuan Ko

[1]Attending Physician, Division of Family Medicine, Department of Community Medicine, Taoyuan Armed Forces General Hospital, Taiwan, Republic of China
[2]National Defense Medical Center, Republic of China
[3]Division of Family Medicine, Department of Community Medicine, Taoyuan Armed Forces General Hospital, Taiwan, Republic of China
[4]Department of Nursing, National Quemoy University, Taiwan. 1 University Road, Jinning Township, Kinmen Hsien, Taiwan
[5]Department of Business Administration, National Taichung University of Science and Technology, Taiwan, 129 Sec. 3, San-min Rd., Taichung, Taiwan, 40401, Republic of China
[6]Kaohsiung Armed Forces General Hospital, Taiwan, Republic of China

Abstract

Background and Objective: This study was conducted to investigate the factors influencing the adoption of telehealth systems by hospital staff. Specifically, perceived risk, computer self-efficacy and the technology acceptance model were incorporated into a theoretical model that explains and predicts the behavioral intentions of users operating a telehealth system. **Materials and Methods:** This study obtained data from hard copy survey responses to self-report questionnaires administered to staff at a hospital in Taoyuan, Taiwan. This study distributed 1,100 questionnaires of which 1,068 were retrieved. After invalid responses were removed, 1,018 questionnaires remained, yielding an effective retrieval rate of 93.7%. Using structural equation modeling (SEM). **Results:** The results showed that the perceived risk negatively affected perceived usefulness, computer self-efficacy positively affected perceived usefulness and perceived ease of use, perceived usefulness positively affected perceived ease of use; perceived usefulness and perceived ease of use positively affected attitude and attitude positively affected behavioral intention. The path coefficients of perceived risk on perceived ease of use were non significant ($p>0.05$). **Conclusion:** The study contributes to the application of health care systems in hospitals by investigating multiple variables. The findings may assist hospitals in consider which information technology to invest in when implementing a new telehealth system.

Key words: Telehealth systems, perceived risk, computer self-efficacy, technology acceptance model (TAM)

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Corresponding Author: Cheng-Min Chao, Department of Business Administration, National Taichung University of Science and Technology, Taiwan, 129 Sec. 3, San-min Rd., Taichung, Taiwan, 40401, Republic of China

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

As medical technology advances, population aging has become a global trend. Statistics published by the Ministry of the Interior of Taiwan in 2015[1] displayed an upward trend with an aging index of 61.51% compared with the population ratio of other countries among people aged 65 years and above. This trend demonstrated rapid growth in the elderly population, indicating an aging population structure. To provide medical treatment and health care services to elderly people, various countries have begun to integrate new types of information technology (IT) into long-term care, in other words, health care. The objective of health care is to reduce medical expenses and allow elderly people to age in place and live their last years[2]. in a more humane and dignified. Furthermore, health care is a crucial direction of development for the emerging industry and how to use new types of IT to assist elderly people in obtaining industries related to health care. Real-time monitoring of health care status as well as the intention to use management services and early warning systems in health management have also become crucial research topics in the health care domain.

With the continuous enhancement of IT, the proportion of elderly people using the Internet, IT, or information systems (ISs) in the long term is also increasing. For instance, E-mail is used for receiving critical messages, the Internet is employed to search for products and smart home technology, the health care system and digital learning is also utilized[3-7]. Additionally, elderly people use E-mail or instant messaging to communicate with family members and friends[4,5]. Evidently, IT has been integrated into the daily lives of elderly people. The medical industry is information intensive. The study of key factors affecting the success of ISs is a subject of concern for various information intensive industries. User attitude toward ISs is the key factor that determines the success of ISs. The technology acceptance model (TAM) proposed by Davis *et al.*[8] is the most widely used and representative theory among theories regarding the intention to use new technology. The basis of the theory is the theory of reasoned action (TRA) proposed by Fishbein and Ajzen[9]. The TAM integrates two decisive variables, perceived usefulness (PU) and perceived ease of use (PEOU) to measure the level of user acceptance[8,10] toward new systems or technology.

Perceived risk was first proposed by Bauer in 1960 in a study on consumer behavior. It was defined as any purchase behavior of a consumer generating unanticipated consequences. Therefore, consumer purchase behavior can be perceived as a type of risk-taking. Cox and Rich[11] elaborated on the study of perceived consumer behavior and defined perceived risk as occurring when a consumer believes that the purchased product or result may not meet expectations. However, adverse consequences generated before and after the purchase affect the extent of the perceived risk. When a consumer uses an Internet-related system or completes purchases through this system, privacy problems such as a violation of personal data[12] can be a concern. Hence, determining the perceived consumer risk and understanding the source of perceived risk is considerably crucial[13,14]. Because cloud technology and the health care market are still in the developmental stage in Taiwan and cloud technology is a recently developed type of IT, rampant Internet fraud and Internet hackers have caused consumers to fear leakage of personal data while they are using online applications, particularly leakage resulting from hacker intrusion. Consequently, risk concerns for new types of technology have been generated[13,15]. Scholars have emphasized that computer self-efficacy (CSE) is the key variable[16-18] in the study of user behavior regarding ISs. Bandura[19] asserted that belief in individual self-efficacy can affect action, choice, individual effort in work or tasks and individual attitude regarding difficulties and setbacks. Previous research has indicated that an increase in CSE can help improve user enthusiasm and persistence in relation to computer usage, resulting in enhanced usage outcomes and expectations, this result included attitude and behavioral intentions[20-22].

Summarizing, the two objectives of this study were as follows: (1) To integrate perceived risk, CSE and TAM to establish the critical factors for using telehealth systems, determine relevant assessment factors affecting the intention to use telehealth systems and (2) To analyze the relationship among the crucial factors affecting people's intention to use telehealth systems and provide hospital administrators with references for assessing the continuous development of telehealth systems.

MATERIALS AND METHODS

Instrumentation: Data were collected using two-part questionnaire surveys. The first part examined the respondents' perceived risk, computer self-efficacy and the factors of the technology acceptance model (TAM; i.e., perceived usefulness, perceived ease of use, attitude and behavioral intention) through a 5-point Likert scale with values ranging from 1 (strongly disagree) to 5 (strongly agree). Using a nominal scale, the second part was designed to obtain basic information on the respondents' characteristics, including their age, sex, formal education and monthly income.

Our scale was developed following the recommendations of MacKenzie *et al.*[23] and the standard psychometric scale development procedures suggested by DeVellis[24]. The measurement items for the perceived risk construct were adapted from several previous studies[14,25,26] that have investigated financial risk (six items), time risk (four items) and psychological risk (four items). The items for the computer self-efficacy construct were adapted from several previous studies[27-29] comprising a total of 10 items. The items for the TAM constructs were adapted from several previous studies[9,10,22,30,31], specifically, the constructs used in this study were perceived usefulness (seven items), perceived ease of use (six items), attitude (five items) and behavioral intention (four items).

To ensure that the survey questionnaires were concise and understandable, this study conducted in-depth interviews and a pilot study. The initial questionnaires were administered to seven researchers who specialized or were interested in community health and hospital management. A convenience sampling approach was adopted in administering 250 questionnaires to telehealth system users in Taoyuan, Taiwan. Subsequently, the initial questionnaire was administered to 208 hospital staff with experience using telehealth systems. Reliability was evaluated using Cronbach's alpha for behavioral intention. These results implied that the scales used in this study satisfactorily measured the constructs of interest. According to the pilot study results, the questionnaire was revised twice. The final survey contained 50 items in addition to a series of demographic and self-reported usage items.

Research hypotheses: The proposed theoretical model incorporated the variables of perceived risk, computer self-efficacy, perceived usefulness, perceived ease of use, attitude and behavioral intention as crucial determinants of the intention to use telehealth systems. This study proposed 9 hypotheses for the adoption of telehealth systems as follows (Fig. 1):

- **Hypothesis 1:** Perceived risk negatively affects perceived usefulness
- **Hypothesis 2:** Perceived risk negatively affects perceived ease of use
- **Hypothesis 3:** Computer self-efficacy positively affects perceived usefulness
- **Hypothesis 4:** Computer self-efficacy positively affects perceived ease of use
- **Hypothesis 5:** Perceived usefulness positively affects perceived ease of use
- **Hypothesis 6:** Perceived usefulness positively affects attitude
- **Hypothesis 7:** Perceived ease of use positively affects attitude
- **Hypothesis 8:** Attitude positively affects behavioral intention

Sample and descriptive statistics: To fulfill our research objectives, this study administered hardcopy interview surveys to staff at a hospital in Taoyuan, Taiwan. This study distributed 1,100 questionnaires to telehealth system users who were selected through convenience sampling and 1,086 questionnaires were returned. Responses with 1/3 of the items unanswered or incompletely answered were excluded from the analysis. After 68 responses fulfilling the exclusion criterion were discarded, the remaining 1,018 valid responses (effective retrieval rate, 93.7%) were statistically analyzed. The general characteristics of the participants (Table 1) show that their average age was 39.1 years (SD, 9.2 years), 50.6% were men and 49.4% were women, 73.8% had attended college and the largest group by monthly income (37.5%) was in the NT$20,001-NT$40,000 range.

Data analysis: This study comprehensively combined the analysis of both the measurement and structural models through structural equation modeling (SEM). Subsequently,

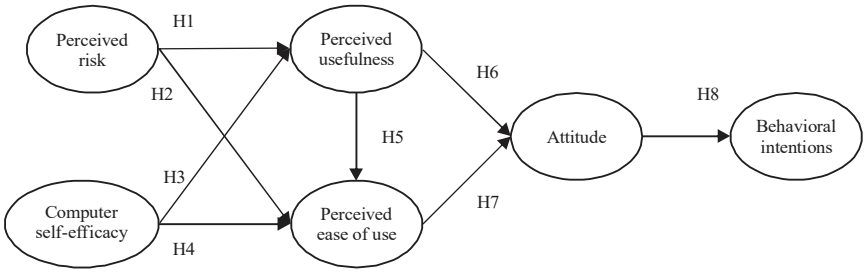

Fig. 1: Research model and hypotheses

Table 1: Demographic profile of sample (N=1018)

Factors	Level	N	%	Factor	Level	N	%
Gender	Male	515	50.6		Elementary school	24	2.4
	Female	503	49.4		Junior high school	43	4.2
Monthly income	<20,000*	326	32.0	Education	Senior high school	151	14.8
	20,001-40,000	382	37.5		College	751	73.8
	40,001-60,000	304	29.9		Master degree	49	4.8
	> 60,001	6	0.6				

Table 2: Construct reliability results

Constructs	Cronbach's α	AVE	CR
Perceived risk (PR)	0.935	0.681	0.864
Computer self-efficacy (CSE)	0.901	0.579	0.905
Perceived usefulness (PU)	0.853	0.500	0.799
Perceived ease of use (PEOU)	0.888	0.623	0.891
Attitude (A)	0.840	0.593	0.853
Behavioral intentions (BI)	0.924	0.754	0.925

Table 3: Discriminant validity using average variance extracted

Variables	PR	CSE	PU	PEOU	A	BI
PR	0.681					
CSE	0.210*	0.579				
PU	0.295*	0.478*	0.500			
PEOU	0.406*	0.451*	0.703*	0.623		
A	0.277*	0.479*	0.708*	0.645*	0.593	
BI	0.241*	0.427*	0.681*	0.607*	0.825*	0.754

*Average variance extracted (AVE). Convergent validity: AVE$\geq$0.5. Discriminant validity coefficient: AVE/(Correlation)^2, where (Correlation)^2 = highest (Correlation)^2 between factor of interest and remaining factors

the maximum likelihood method was applied to the sample data by using LISREL Version 8.72. Furthermore, this study analyzed the psychometric properties of the variable measurement scales and handled the missing data through leastwise deletion. Specifically, this study analyzed 6 variables (2 dependent and 4 independent variables).

RESULTS AND DISCUSSION

Measurement model evaluation: The relationships between the observed variables (i.e., manifest variables or indicators) and the latent variables (i.e., constructs being measured) were specified using the measurement model. The convergent and discriminate validity of the constructs were evaluated to verify the suitability of the construct measures[32,33]. Convergent validity refers to the consistency that multiple items exhibit in measuring the same construct. The criteria used for assessing convergent validity[34-36] were (1) Reliability coefficients (Cronbach's alpha) should be larger than 0.60, (2) Composite reliability (CR) coefficients for each latent construct should be larger than 0.70 and (3) average variance extracted (AVE) for each latent construct should be larger than 0.50.

Table 2 lists the indices of reliability and convergent validity scores. The standardized item loadings ranged from 0.70-0.91 and were significant at the 0.01 level[36]. The Cronbach's alpha coefficients ranged from 0.840-0.935, indicating that the survey instrument attained high internal consistency (Table 2). As shown in the Table 2, all values were above the suggested 0.6 level for ensuring scale robustness[36].

CR is a set of latent construct indicators for ensuring that constructs are consistent in their measurement; in other words, it is the degree to which a set of two or more indicators in a construct measurement[36]. The CR coefficients for all constructs ranged from 0.799-0.925 (Table 2), which is above the 0.70 benchmark recommended by Fornell and Larcker[34]. The test for construct validity was conducted because it is crucial to stabilizing the measure dimensionality when conducting measure development[24].

Convergent and discriminant validity were evaluated by calculating the AVE for each factor within each model. Convergent validity was established where the shared variance accounted for at least 50% of the total variance. Discriminant validity refers to the degree to which measurements of a concept are distinct, implying that correlations among items in the same scale should be higher than those among items across different constructs. Discriminant validity was evident where the AVE of each construct was greater than the squared correlation between a construct and any other construct in the model[34]. All constructs attained AVE values between 0.500 and 0.754 (Table 2), which were above the 0.5 benchmark recommended by Fornell and Larcker[34]. Overall, the items demonstrated satisfactory convergent and discriminant validity.

Table 3 shows results of the discriminant validity test. The correlation matrix between the constructs shows that the square roots of the AVEs were higher than the correlations coefficients of other constructs. Thus, the constructs demonstrated satisfactory convergent validity and discriminant validity.

Structural model estimation: The proposed model comprised one exogenous variable (perceived risk) and four endogenous

variables (perceived usefulness, perceived ease of use, attitude and behavioral intention). The constructs and their hypothesized relationships in our structural model were tested simultaneously. The SEM of the theoretical model involved the chi-square goodness-of-fit test, chi-square to degrees of freedom (df) ratio, goodness- of-fit index (GFI), adjusted goodness-of-fit index (AGFI), root-mean-square error of approximation (RMSEA) and comparative fit index (CFI)[35-37]. Table 4 provides the fitness measurement indices of the structural model. The SEM results obtained from the theoretical model are as follows: c 2/df = 6.803, GFI = 0.865, AGFI = 0.838, RMSEA = 0.076 and CFI = 0.971.

The chi-square p-value did not meet its recommended 0.000 value because of the relatively large sample (n = 1,018). A chi-square to df ratio below 5:1 is considered an acceptable fit and the chi-square value should be as small as possible. Although GFI and AGFI values exceeding 0.90 are preferable, the more liberal cut-off value of 0.80 has been used to indicate a good model fit[36]. An RMSEA value of 0.08 or lower is preferable. However, Raykov[38] argued that RMSEA values ranging from 0.08-0.10 are moderate. An RMSEA index value below 0.8 is preferable. The results of the current study indicate a reasonable fit of the data to the structural model used in this study.

Interpretation of structural model results: Figure 2 shows the model path coefficients (loading and significance) and R^2 for each value, all of which support the hypothesized model. The model explains a substantial portion of variance for all of the endogenous variables as follows: 38.2% for perceived usefulness, 57.6% for perceived ease of use, 64.2% for attitude and 73.8% for behavioral intention.

Table 5 shows the standardized beta coefficients from the estimated structural model in addition to the associated t-values for each construct. Nine causal paths were specified in the hypothesized model, seven of which were statistically significant and thus supported; however, one was rejected. As posited in Hypothesis 1, the estimated negative coefficient estimates for the paths from perceived risk to perceived usefulness are significant (standardized beta coefficient = -0.34, t = −9.84, p<0.05). However, Hypothesis 2 was not supported because the relationship between perceived risk and perceived ease of use was non-significant. Regarding hypothesis 3, computer self- efficacy on perceived usefulness was statistically significant (standardized beta coefficient = 0.44, t = 12.49, p<0.05). For hypothesis 4, the positive relationship between computer self-efficacy and perceived ease of use was also significant (standardized beta coefficient = 0.09, t = 2.75, p<0.05); thus, both hypotheses 3 and 4 were supported. Perceived usefulness was significantly

Table 4: Measures of model fit and reported values for the structural model

Fit index	Recommended values	Model values	Model fit
χ^2 (Chi-square)	p≥0.05	0.000	Poor fit
Chi-square/df	≤5	6.803	Moderate fit
GFI	≥0.9	0.865	Moderate fit
AGFI	≥0.9	0.838	Moderate fit
RMSEA	≥0.08	0.076	Good fit
CFI	≥0.9	0.971	Good fit

Table 5: Estimation results for hypotheses 1-9

Hypotheses	Path from/to	Standardized coefficient	t-value	Test results
1	PR→PU	-0.34*	-9.84	Accepted
2	PR→PEOU	-0.05	-1.53	Rejected
3	CSE→PU	0.44*	12.49	Accepted
4	CSE→PEOU	0.09*	2.75	Accepted
5	PU→PEOU	0.73*	15.26	Accepted
6	PU→A	0.48*	9.87	Accepted
7	PEOU→A	0.37*	8.10	Accepted
8	A→BI	0.86*	26.17	Accepted

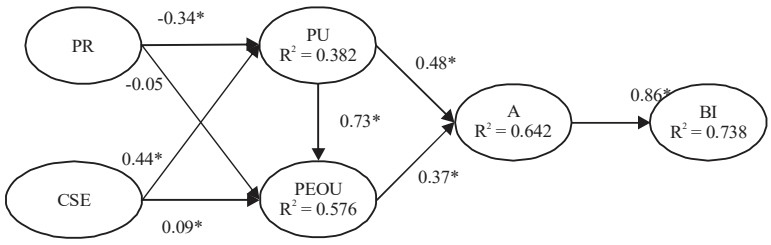

Fig. 2: Structural model. *p<0.05

influenced by perceived ease of use (standardized beta coefficient = 0.73, t = 15.26, p<0.05) supporting hypothesis 5. Contrary to our expectations, the constructs of perceived usefulness (standardized beta coefficient = 0.48, t = 9.87, p<0.05) and perceived ease of use (standardized beta coefficients = 0.37, t = 8.10, p<0.05) were significant determinants of attitude supporting both hypotheses 6 and 7. Finally, attitude was a crucial antecedent of behavioral intention (standardized beta coefficient = 0.86, t = 26.17, p<0.05), thus supporting Hypothesis 8.

Rapid population aging and IT advancements in recent years have prompted many countries to actively integrate IT with health care to enable elderly people or citizens of remote areas to age in place and live their final years in a more humane and dignified manner. Thus, application software and regional ISs for remote and long-term care management are gradually being built and people's intention to use the systems has become a substantial topic. This study combining computer self-efficacy and perceived risk with TAM theory, this study formulated a new model to explore the telehealth systems usage intentions of people. The data were collected through a questionnaire survey and verified using SEM, with an acceptable overall structural model being created (Fig. 2). The results indicated that this study exhibited satisfactory reliability, validity, path coefficients and explained variances (R2), which increased our confidence in the study results. This study's test results can be used as references by telehealth system manufacturers to adjust these systems and enhance people's intention to use them. As shown by the empirical results in this study, the variance explained by the proposed model's dependent variables were 0.738 for behavioral intention (R2 = 73.8%), 0.642 for attitude (R2 = 64.2%), 0.382 for PU (R2 = 38.2%) and 0.576 for PEOU (R2 = 57.6%). The aforementioned data demonstrated that the theoretical framework proposed in this study can adequately explain people's intention to use telehealth systems.

Empirical results did not display any significant correlation between perceived risk and PEOU, this differs from previous research results[13,15]. Because users did not understand the system, fear of personal data leakage and violation of privacy generated feelings of insecurity toward the system. Although the telehealth system is a considerably convenient and crucial type of technology for people in remote areas, insecurity generated among users has resulted in a non-significant use of such technology. Additionally, a lower perceived risk indicates a higher user PU regarding a system and a greater CSE signifies a higher PU and PEOU. Thus, the attitude and intentions of the people to use the telehealth system were also enhanced. The path coefficient of relationship between attitude and intentions to use the telehealth system was the highest, a result that matches the findings of previous studies. However, an analysis of the results indicated that if telehealth systems can be explained to the people of the Taoyuan region, then people's intentions to use the telehealth system can be enhanced. Thus, higher path relationship between attitude and intentions to use the telehealth system was generated.

CONCLUSION

Although this study analyzed the key elements that affected people's intentions to use telehealth systems, it had a number of research limitations and numerous topics in this domain remain unexplored. First, the research results indicated that perceived risk has a significantly adverse effect on PU. Thus, hospitals or developers or managers of telehealth systems should first educate users regarding system and information security, reducing insecurity among users regarding the risks generated by the telehealth system to enhance people's intentions to use this system. Additionally, the participants in this study were limited to people of the Taoyuan region and this study therefore could not adequately represent the perspective of the people of Taiwan. Subsequent researchers should extend their studies to people of various regions to conduct comparisons in order to understand the differences between people in various regions. This study employed a questionnaire survey method to determine respondents' level of perception and understanding of the questions. However, in the discussion of this paper, the research findings were characterized and compared only with the results of previous studies. The discussion thus lacks circumspection and depth and cannot determine people's desire to use the telehealth system or the factors affecting their intentions to use this system. Finally, subsequent researchers should thus adopt qualitative research methods such as in-depth interviewing after data analysis to obtain a better understanding of people's feelings regarding their research topics to comprehensively improve their research results.

SIGNIFICANCE STATEMENT

The TAM is one of the most cited theories applied to understand and predict the process of user acceptance and the use of new IT/IS. However, the external variables affecting TAM have not been determined. This study discovered that the computer self-efficacy and perceived risk are external variables factors that affect TAM. The perceived risk negatively affected perceived usefulness; computer self-efficacy

positively affected perceived usefulness and perceived ease of use. The perceived usefulness positively affected perceived ease of use; perceived usefulness and perceived ease of use positively affected attitude and attitude positively affected behavioral intention. In addition, the study contributes to the application of health care systems in hospitals by investigating multiple variables. The findings may assist hospitals in consider which information technology to invest in when implementing a new telehealth system.

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