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Understanding the Determinants of Implementing Telehealth Systems: A Combined Model of the Theory of Planned Behavior and the Technology Acceptance Model

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ABSTRACT
This study investigated the factors that affect the adoption of telehealth systems by users belonging to hospitals. This research involved synthesizing the perceived service availability, Technology Acceptance Model (TAM) and Theory of Planned Behavior (TPB) to hypothesize a theoretical model for explaining and predicting user behavioral intentions toward using telehealth systems. For this study, self-report questionnaires in the form of hardcopy interview surveys were distributed in Taiwan. Of the 1,500 distributed questionnaires, 1,274 responses were received which yielded a response rate of 84.9%. The responses were analyzed using descriptive statistics, confirmatory factor analysis and structural equation modeling methods and suggested that perceived service availability positively affects perceived usefulness and perceived ease of use, perceived ease of use positively affects perceived usefulness, perceived usefulness and perceived ease of use positively affect attitude and attitude, subjective norm and perceived behavioral control positively affects behavioral intention. In addition, the path coefficients of perceived usefulness on behavioral intention were nonsignificant. This study contributes to the application of health care systems in hospitals through using a wide range of variables. The findings can also help hospitals consider their information technology investments when implementing novel telehealth systems.

Key words: Telehealth systems, theory of planned behavior, technology acceptance model, structural equation model

INTRODUCTION

The internet has dramatically changed work and leisure-time communication and interaction worldwide (Beutel *et al*., 2011) and has become an indispensable tool for socializing, academic research, obtaining information, entertainment and health care issues. Rapidly developing information technologies have been growing pervasively in various applications of the medical sector, such as electronic health services, telehealth systems, smart home technologies, health information systems and health care-related information (Mitzner *et al*., 2010; Wagner *et al*., 2010; Simsim, 2011; Dunnebeil *et al*., 2012). Hospital information systems have the potential to substantially improve the quality of health care.

Information Technology (IT) in health care has been proven to reduce the incidence of adverse events (Dunnebeil *et al*., 2012). Moreover, telehealth systems were developed to provide home-based monitoring and support for patients with chronic diseases. Relevant studies have indicated that the current trend of using telecare services plays a crucial role in advancing patient self-care and management of chronic illnesses as well as reducing hospital stays and emergency room visits (Schwartz and Britton, 2011; Dunnebeil *et al*., 2012). Fitzmaurice (1998) defined telehealth as "applying information, computing and telecommunications technologies to offer" health-related services when health professionals and patients are separated by long distances. Wyatt and Liu (2002) defined telehealth as conducting clinical consultations through an electronic medium (e.g., e-mail and telephones). Briefly, the goal of telehealth is to efficiently furnish medical care at a distance through numerous media (Adeogun *et al*., 2011). In addition, telehealth was developed from telemedicine but has extended to health promotion and disease prevention (Koch, 2006). To analyze the acceptance of telehealth systems and improve future adoption, understanding the issues that affect the intentions of using e-health is necessary. Thus, this study investigated the process of adopting the technology and identified the factors affecting telehealth adoption among hospitals in Taiwan. Understanding the factors that are associated with and predict telehealth system usage is critical. Psychological theories primarily focus on behavioral explanation and prediction.

A framework based on a conventional sociopsychological theory and recently developed technological learning models facilitated investigating the factors that affect users to use (or not to use) health IT. Several sociopsychological theories are frequently cited, validated and applied: The theory of reasoned action (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975), theory of planned behavior (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975) and the technology acceptance model (Davis, 1989). In this study, we synthesized the expectation-perceived service availability, Technology Acceptance Model (TAM) and Theory of Planned Behavior (TPB) to hypothesize a novel model to explain telehealth system usage. The TPB and TAM were developed based on the Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975). The TRA and TPB can be used to measure various human behaviors in more general terms. The TAM examines usage and adoption behaviors in specialized contexts, such as the context of information systems and new media technologies (Lee, 2010). The TRA argues that both behavioral attitude and subjective norm affect behavioral intention and consequently affect actual behavior. The TAM principally focuses on the technological aspect and the strengths of the model are its parsimony and strong explanatory power (Wu *et al*., 2011). The TAM suggests that when users are presented with a new technology, numerous factors (e.g., perceived usefulness, perceived ease of use, attitude and behavioral intention) can influence their decision about how and when they will use it. The TAM proposes that perceived usefulness and perceived ease of use are two fundamental beliefs which are key factors for technology acceptance and primary motivations for user acceptance of a specific type of system. Perceived ease of use is defined as the degree to which a person believes that using a particular system would be free of physical and mental effort and perceived usefulness is defined as "the degree to which a person believes that using a particular system would improve his or her job performance" (Davis, 1989). The TAM model has been used successfully in the context of e-learning (Lee, 2010; De Smet *et al*., 2012), mobile health care (Wu *et al*., 2011; Dunnebeil *et al*., 2012; Xue *et al*., 2012) and customer relationship management systems (Pai and Tu, 2011).

This study applied frameworks from the TAM and TPB to develop and validate an adoption model for telehealth systems in hospitals. The primary contributions of this research are its examination of the integration of perceived service availability, TAM and TPB in explaining the behavioral intention of telehealth system usage and an empirical evaluation of the crucial factors that affect this behavioral intention. The findings of this study might help bridge the current gap between acceptance and continuing use of telehealth systems. The telehealth service affects the patient-provider relationship and the design for special users must be further explored. Establishing a decision support system for caregivers and users to provide further assistance to achieve local-and community-based health care should be considered. This study also established associated facilitators and inhibitors, providing system developers, innovation service providers and telehealth systems operators with references to development targets and investment roadmaps.

MATERIALS AND METHODS

Instrumentation: This study had two primary objectives. The first objective was to construct a theoretical model to predict and explain the user behavioral intention in hospitals to investigate the telehealth system adoption issue. The second objective was to test the empirical model. In this study, the theoretical model incorporated the perceived service availability, perceived usefulness, perceived ease of use, attitude, subjective norm, perceived behavioral control and behavioral intention variables as essential determinants for the intention to use telehealth systems. The instruments were developed based on a review of previous research on the TAM, TPB and perceived service availability. Scales pertaining to the perceived usefulness, perceived ease of use, attitude and behavioral intention were adopted from the TAM scale (Davis, 1989; Venkatesh and Davis, 1996, 2000; Lee, 2010; Wu *et al*., 2011) and the TPB (attitude, subjective norm, perceived behavioral control and behavioral intention) were adopted from (Taylor and Todd, 1995a, b; Lee, 2010; Wu *et al*., 2011). In addition, the items measuring perceived service availability was adopted from (Venkatesh, 2000;

Table 1: Demographic profile of sample

Factors	Number	Percentage
Gender		
Male	721	56.6
Female	553	43.4
Education		
Elementary school	38	3.0
Junior high school	53	4.2
Senior high school	351	27.6
College	671	52.7
Master degree	161	12.6
Monthly income		
<20,000*	464	37.1
20,001-40,000	305	24.4
40,001-60,000	389	31.1
60,001-80,000	76	6.1
80,001-100,000	15	1.2
>100,001	3	0.2
Missing value	22	

*NT dollars

Hong and Tam, 2006). All of the items were measured using a 5-point Likert-type scale ranging from 5 (strongly agree) to 1 (strongly disagree). To reduce a potential ceiling (or floor) effect inducing monotonous responses to items designed to measure the same construct.

To ensure that the questionnaires were concise and understandable, we conducted an in-depth interview and a pilot study. The initial questionnaires were administered to five researchers who specialized or were interested in the community health and hospital management field.

The initial questionnaire was then administered to 132 subjects who had used telehealth systems. The reliability scores were based on Cronbach's alphas ranging from 0.881 for perceived service availability to 0.957 for perceived usefulness. The results implied that the scales used in this study satisfactorily measured the constructs of interest. Based on the pilot study results, the questionnaire was revised twice. The final survey comprised 56 items and a series of demographic and self-report usage items.

Research hypotheses: The theoretical model incorporated the perceived service availability, perceived usefulness, perceived ease of use, attitude, subjective norm, perceived behavioral control and behavioral intention variables as essential determinants of the intention to use telehealth systems. Therefore, we proposed nine hypotheses for the adoption of telehealth systems:

Hypothesis 1: Perceived service availability positively affects perceived usefulness
Hypothesis 2: Perceived service availability positively affects perceived ease of use
Hypothesis 3: Perceived ease of use positively affects perceived usefulness
Hypothesis 4: Perceived usefulness positively affects attitude
Hypothesis 5: Perceived ease of use positively affects attitude
Hypothesis 6: Perceived usefulness positively affects behavioral intention
Hypothesis 7: Attitude positively affects behavioral intention
Hypothesis 8: Subjective norm positively affects behavioral intention
Hypothesis 9: Perceived behavioral control positively affects behavioral intention

Sample and descriptive statistics: In this study, questionnaires were administered to offline consumers who had experience with online purchasing. To meet our objectives, 1,500 questionnaires in the form of hardcopy interview surveys were distributed to users (selected using convenience sampling) who adopted telehealth systems in Taiwan. Questionnaires with up to one third of items unanswered or incompletely answered were excluded. Finally, 1,274 valid responses were obtained. Table 1 shows the general characteristics of the 1,274 subjects.

RESULTS

We conducted a comprehensive, combined analysis of both measurement and structural models by using Structural Equation Modeling (SEM). The SEM was estimated using the maximum-likelihood method and was applied to the sample data through the linear structural relational model (partial least-squares, PLSs). The psychometric properties of the variable measurement scales were also analyzed. In addition, missing data were handled using listwise deletion. An analysis using PLSs exhibits five primary advantages: (a) Smaller sample, (b) More accurate prediction, (c) Larger number of constructs and indicators, (d) Few demands on residual distributions and (e) Testing theories at earlier stages of development (Chin, 1998; Terzis and Economides, 2011). In this study, data analyses using PLSs were conducted to verify the hypotheses. This technique provided the analyses of both a structural model (assessing relationships among theoretical constructs) and a measurement model (assessing the reliability and validity of measures). Additionally, PLSs were used to analyze the research model.

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. Construct convergent and discriminate validity were both provided to verify the construct measures (Chen, 2010; Komiak and Benbasat, 2006). Convergent validity refers to the consistency that multiple items exhibit in measuring the same construct. Three criteria were used for assessing convergent validity (Fornell and Larcker, 1981; Bagozzi and Yi, 2012; Hair *et al*., 2010): (a) Reliability coefficients (Cronbach's alpha coefficients) should be greater than 0.60, (b) Composite Reliability (CR) coefficients for each latent

construct should be greater than 0.70 and (c) Average Variance Extracted (AVE) for each latent construct should exceed 0.50.

Internal consistency was assessed using Cronbach's alpha coefficients and CRs. Cronbach's alpha coefficients ranged from 0.867 to 0.949. Table 2 shows the high instrument internal consistency. As shown in Table 2, all of the values exceeded the suggested level of 0.6 for scale robustness (Hair *et al*., 2010).

The CR is a set of latent construct indicators consistent in their measurement. That is, reliability is the degree of a set of two or more indicators in a construct measurement (Hair *et al*., 2010). The CR coefficients ranged from 0.910-0.955 (Table 2). In addition, all constructs displayed a higher composite reliability than the 0.70 benchmark recommended by Fornell and Larcker (1981). The construct validity test is central to stabilizing the measure dimensionality when conducting measure development (DeVellis, 2003).

Convergent and discriminant validity were evaluated by calculating the Average Variance Extracted (AVE) for each factor within each model. Convergent validity is established if the shared variance accounts for 0.50 or more of the total variance. Discriminant validity refers to the degree of distinctive concept measurements. It implies that in the same scale, correlations among items should be higher than those of items across various constructs. Discriminant validity is evident when the AVE for each construct is greater than the squared correlation between that construct and any other construct in the model (Fornell and Larcker, 1981). All constructs demonstrated AVE values between 0.623 and 0.801 (Table 2) which were higher than the 0.5 benchmark recommended by Fornell and Larcker (1981). Overall, the items demonstrated satisfactory convergent and discriminant validity.

Table 2: Construct reliability results

Constructs	CR	AVE	Cronbach's α
Perceived service availability	0.910	0.716	0.867
Perceived usefulness	0.955	0.623	0.949
Perceived ease of use	0.924	0.636	0.904
Attitude	0.933	0.667	0.916
Subjective norm	0.947	0.747	0.932
Perceived behavioral control	0.913	0.637	0.886
Behavioral intention	0.941	0.801	0.917

Hypotheses testing: Based on the adequate convergent and discriminant validity, the hypotheses were empirically tested. Table 3 presents the results of the structural model. Figure 1 shows the PLS analysis results and the standardized coefficients for each hypothesized path in the model and the R-squared values for each dependent variable. All standardized path coefficients were statistically significant except for the weights of perceived usefulness to behavioral intention; therefore, Hypothesis 6 was rejected. Moreover, the R-squared values were used as a goodness-of-fit measurement in the PLS analysis (Hulland, 1999). The model explained 58.5% of the variance regarding behavioral intentions of adopting telehealth systems of general residents in Taiwan. Furthermore, the perceived ease of use and perceived usefulness explained 72.0% of the attitude which is indicative of a considerably strong explanatory power. The perceived ease of use and perceived service availability explained 61.2% of the perceived usefulness. The perceived service availability explained 45.1% of the perceived ease of use. The results revealed a high prediction rate in forecasting user behavioral intention. The structural model of this research yielded excellent results for perceived usefulness, attitude and behavioral intention with 50% of explained variance for each construct. However, perceived ease of use was low but acceptable at 45.1%.

The path significance of each hypothesized association in the research model for each path was examined. Table 3 shows the standardized path coefficients and path significances. The eight hypothesized associations were strongly significant at $p<0.05$ and supported, except for the link between perceived usefulness and behavioral intention (Hypothesis 6). The perceived service availability to the perceived usefulness and perceived ease of use (Hypotheses 1 and 2), perceived ease of use to perceived usefulness (Hypothesis 3), perceived usefulness and perceived ease of use to attitude (Hypotheses 4 and 5) and subjective norm and perceived behavioral control to behavioral intention (Hypotheses 7 and 9) were determined to be statistically significant at the $p<0.01$ level. The attitude to behavioral intention (Hypothesis 8) was determined to be statistically significant at the $p<0.05$ level. Conversely, perceived usefulness on behavioral intention was nonsignificant in the model. Thus, Hypothesis 6 was rejected.

Table 3: Estimation results for Hypotheses 1-9

Hypotheses	Path from/to	Standardized coefficient	t-value	Test results
Hypothesis 1	Perceived service availability→perceived usefulness	0.273	11.27**	Accepted
Hypothesis 2	Perceived service availability→perceived ease of use	0.671	36.42**	Accepted
Hypothesis 3	Perceived ease of use→perceived usefulness	0.573	19.22**	Accepted
Hypothesis 4	Perceived usefulness→attitude	0.615	18.93**	Accepted
Hypothesis 5	Perceived ease of use→attitude	0.282	7.86**	Accepted
Hypothesis 6	Perceived usefulness→behavioral intention	0.052	1.66	Rejected
Hypothesis 7	Attitude→behavioral intention	0.118	2.81*	Accepted
Hypothesis 8	Subjective norm→behavioral intention	0.342	8.00**	Accepted
Hypothesis 9	Perceived behavioral control→behavioral intention	0.334	11.29**	Accepted

*p<0.05, **p<0.01

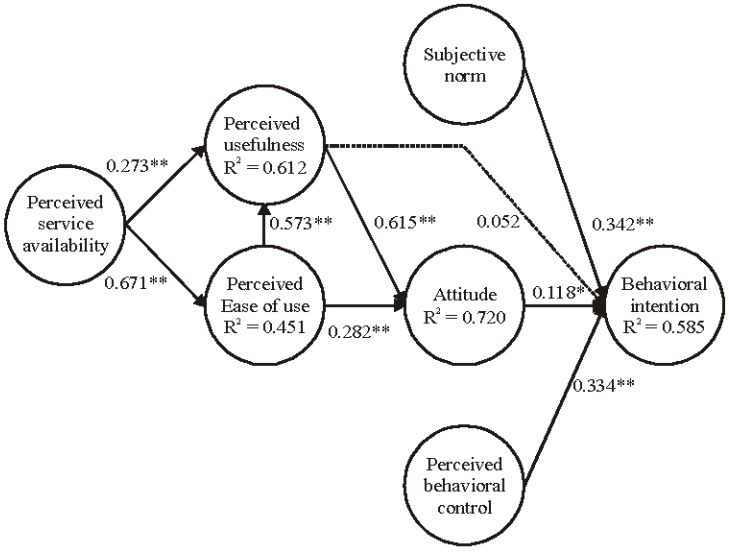

Fig. 1: Structural model, *p<0.05 and **p<0.01

DISCUSSION

This study proposes a conceptual model that investigates the factors that affect residents' intentions of using telehealth systems. In this study, the perceived service availability, TAM and TPB were synthesized to hypothesize a theoretical model for explaining and predicting user behavioral intentions toward telehealth systems. The results of this study provided support for the research model and for the hypotheses regarding the directional linkage among the model's variables. The overall explanatory power of our research model exhibited an R-square of 58.5% for behavioral intention of using telehealth systems, 72.0% for attitude, 45.1% for perceived ease of use and 61.2% for perceived usefulness which suggested that the extended perceived service availability model is capable of explaining a relatively high proportion of variation of continued intention to use telehealth systems. Several results can be summarized from our research framework.

The dimensions of perceived usefulness and perceived ease of use exerted significantly positive effects on attitude. Attitude, subjective norm and perceived behavioral control exerted significantly positive effects on behavioral intention. These results were consistent with those of previous studies (Lee, 2010; Wu *et al*., 2011; Xue *et al*., 2012). Whereas, the effect of perceived usefulness on behavioral intention was nonsignificant. This result differed from that of previous studies (Lee, 2010; Wu *et al*., 2011; Dunnebeil *et al*., 2012; Xue *et al*., 2012). Generally, most people consider telehealth systems to be useful but they are worried about unknown risks, such as leakage of private information. In addition, the cost of telehealth systems in Taiwan remains high; people would seldom spend money on the system installation without government support. Therefore, perceived risk toward telehealth systems exerts a significant influence on behavioral intention. We suggest that future research includes these two variables to explore the public's behavioral intention toward telehealth systems.

Finally, the results indicated that perceived usefulness and perceived ease of use can improve attitude toward using telehealth systems. Furthermore, the results also indicated that attitude, subjective norm and perceived behavioral control can improve behavioral intention of using telehealth systems. This study contributes to the literature by advancing theoretical discourse on the ability of perceived service availability, TAM and TPB to enhance our understanding of issues in telehealth care.

CONCLUSION

The findings of this study suggest that no significant evidence for the effect of perceived usefulness on behavioral intention exists. Additionally, perceived service availability exerted a significantly positive effect on perceived usefulness and perceived ease of use; perceived ease of use exerted a significantly positive effect on perceived usefulness; perceived usefulness and perceived ease of use exerted a significantly positive effect on attitude and attitude, subjective norm and perceived behavioral control exerted a significantly positive effect on behavioral intention. This study also determined that perceived usefulness, perceived ease of use and attitude play crucial mediating variable roles. Based on the results, we presented suggestions considering the limitation of our analysis for management and academy. We examined the effects of attitude, subjective norm and perceived behavioral control on the adoption of and behavioral intention toward telehealth systems. The results of this study suggested that subjective norm was the strongest predictor of user behavioral intention, followed by perceived behavioral control and attitude.

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