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Examining the Technology Acceptance Model Using Physician Acceptance of Telemedicine Technology

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ABSTRACT: The rapid growth of investment in information technology (IT) by organizations worldwide has made user acceptance an increasingly critical technology implementation and management issue. While such acceptance has received fairly extensive attention from previous research, additional efforts are needed to examine or validate existing research results, particularly those involving different technologies, user populations, and/or organizational contexts. In response, this paper reports a research work that examined the applicability of the Technology Acceptance Model (TAM) in explaining physicians' decisions to accept telemedicine technology in the health-care context. The technology, the user group, and the organizational context are all new to IT acceptance/adoption research. The study also addressed a pragmatic technology management need resulting from millions of dollars invested by health-care organizations in developing and implementing telemedicine programs in recent years. The model's overall fit, explanatory power, and the individual causal links that it postulates were evaluated by examining the acceptance of telemedicine technology among physicians practicing at public tertiary hospitals in Hong Kong. Our results suggested that TAM was able to provide a reasonable depiction of physicians' intention to use telemedicine technology. Perceived usefulness was found to be a significant determinant of attitude and intention but perceived ease of use was not. The relatively low R-square of the model suggests both the limitations of the parsimonious model and the need for incorporating additional factors or integrating with other IT acceptance models in order to improve its specificity and explanatory utility in a health-care context. Based on the study findings, implications for user technology acceptance research and telemedicine management are discussed.

KEY WORDS AND PHRASES: information technology acceptance, information technology management in health care, Technology Acceptance Model, telemedicine.

INFORMATION TECHNOLOGY (IT) HAS BECOME AN INTEGRAL, EVEN A PIVOTAL, PART of business activities and processes undertaken by an organization. As investments in IT by organizations all over the world continue to grow at a rapid pace, user technology acceptance has become an increasingly critical technology implementation and management issue [19, 26, 39, 47]. However, regardless of potential technical superiority and promised merits, an unused or underutilized technology cannot be effective [47, 48]. As Davis et al. [23] comment, "As technical barriers disappear, a pivotal factor in harnessing this expanding power of computer technology becomes our ability to create applications that people are willing to use."

User technology acceptance has received fairly extensive attention from information systems (IS) researchers and practitioners [2, 9, 10, 23, 30, 39, 47, 52]. The issue has been examined across assorted information technologies and user populations, and a fairly satisfactory empirical support for respective theories or models investigated has been accumulated. Of the models that have been proposed and examined, the Technology Acceptance Model (TAM), originated by Davis [20], appears to be the most promising. TAM is an intention-based model developed specifically for explaining and/or predicting user acceptance of computer technology. TAM has been used as the theoretical basis for many empirical studies of user technology acceptance/adoption [1, 11, 12, 21, 23, 48, 64, 65, 66] and has accumulated ample empirical support.

In spite of the documented empirical applicability of TAM, additional efforts are needed to validate existing research results, particularly those involving different technologies, users, and/or organizational contexts, in order to extend the model's theoretical validity and empirical applicability. This study emerged as a response to the call for more empirical validation of well-researched theories/models in different settings. In particular, we examined TAM in the context of physician acceptance of telemedicine technology. The study aims to make a contribution to IT acceptance/adoption research by advancing the understanding of user technology acceptance and extending the theoretical validity and empirical applicability of existing literature to health-care professionals, who have become increasingly dependent on IT [59]. Furthermore, addressing the issue of physicians' technology acceptance can fill a research void as well as meeting a pragmatic need for managing telemedicine technology by health-care organizations where considerable growth in IT investment and utilization has occurred [55].

Literature Review and Research Motivation

USER TECHNOLOGY ACCEPTANCE HAS RECEIVED FAIRLY EXTENSIVE attention from information systems (IS) researchers and practitioners [2, 23, 30, 39, 47]. Collectively, the literature has suggested that user acceptance is a critical success factor for IT adoption and can be sufficiently explained, accurately predicted, and effectively managed by means of a host of relevant factors. In particular, these factors include three important dimensions: characteristics of the individual, characteristics of the technology, and characteristics of the organizational context. Various frameworks and models have used these characteristics to investigate the nature and determinants of IT acceptance/adoption. Examples include Rogers's [57] diffusion of innovations model, Kwon and Zmud's [42] diffusion/implementation model, and Davis's [21] technology acceptance model (TAM). Saga and Zmud [59] reviewed prior IT acceptance studies and identified twenty empirical studies that aimed at investigating the nature and determinants of IT acceptance. Among these, TAM was found to be one of the most influential. Compared with other frameworks/models, TAM has advantages in parsimony, IT specificity, strong theoretical basis, and ample empirical support.

TAM and Related Empirical Studies

TAM was developed by Davis [20] to explain computer-usage behavior. The theoretical grounding for the model is Fishbein and Ajzen's [24] theory of reasoned action (TRA). According to TRA, beliefs influence attitudes, which in turn lead to intentions, which then guide or generate behaviors. TAM adapts this belief-attitude-intention-behavior relationship to an IT user acceptance model. The goal of TAM is to "provide an explanation of the determinants of computer acceptance that is general, capable of explaining user behavior across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified" [23, p. 985].

Many studies have examined TAM's overall explanatory power and measurement validity in different empirical settings characterized by user group, technology, and organizational context. For instance, quite a few empirical studies of TAM have tested the theory with students as the user group. Davis et al. [23] longitudinally investigated the validity of TAM and TRA in M.B.A. students' acceptance of a word processor application. Mathieson [48] compared the utility of TAM and Theory of Planned Behavior (TPB) [41], another theory that extends from TRA but does not specifically target IT acceptance/adoption behavior, in predicting intention of undergraduate students to use a PC-based spreadsheet application. In another longitudinal study, Taylor and Todd [65] examined the validity of TAM together with TPB in explaining and predicting the use of a computer resource center by business school students. Recently, Szajna [64] evaluated TAM in an investigation of acceptance of an e-mail system by graduate students at a business college.

The model has also been examined by nonstudent subjects. For example, Davis [21] tested TAM using acceptance of an e-mail system and a word editor by employees at a large commercial organization. Using an extended TAM, Chau [11] investigated acceptance of a newly released PC-based application suite by administrative and clerical staff at a university. In another study, Chau [12] examined a modified TAM using acceptance of computer aided software engineering (CASE) technology by system developers. Recently, Igbaria et al. [37] investigated personal computing acceptance factors in small firms using TAM as the theoretical basis.

Jointly, results from these and other studies suggest that TAM is capable of providing fairly adequate explanation and/or prediction of user acceptance of IT. While perceived usefulness has been identified as consistently important in attitude formation, support for perceived ease of use has been inconsistent and of less significance. As suggested by the literature, a plausible explanation for the observed differential is that the importance of perceived ease of use as a determinant of the intention to use a technology may become insignificant after users' prolonged exposure to the technology [11].

The validity of measurement scales for TAM has also been scrutinized. Adams et al. [1] examined the psychometric properties of the perceived usefulness and perceived ease of use scales employed by Davis [21] by replicating his study. Similarly, Hendrickson et al. [32] assessed the reliability of perceived usefulness and perceived ease of use by investigating user acceptance of two software packages. The reliability and validity of the measurement scales for TAM were also examined by Segars and Grover [60].[1] Collectively, the literature has suggested relatively high reliability and validity for both measurement scales.

Our literature review indicates that TAM would be valuable and useful for explaining or predicting user acceptance of IT, particularly among students and end users and executives in a university or business organization context. However, the validity of the model has rarely been tested with professionals such as physicians or attorneys in their own professional contexts. Conceivably, such professionals may differ from students or other subjects commonly studied by previous research due to a host of factors including general competence, intellectual and cognitive capacity, specialized training, and professional work and accomplishments. Hartwick and Barki [29] emphasize the increasing importance of theory testing for IS research, for which examination or validation of existing findings of user technology acceptance is desirable, particularly when the findings involve different technologies, user populations, or organizational contexts.

This study examined TAM in a professional setting, investigating the factors affecting physicians' acceptance of telemedicine technology. Choice of TAM over other IT acceptance/adoption models was made for the following reasons. First, TAM is general, parsimonious, IT-specific, and designed to provide an adequate explanation for and a prediction of a diverse user population's acceptance of a wide array of IT within various organizational contexts. Second, TAM has a well-researched and validated inventory of psychometric measurements, making its use operationally appealing. Finally, TAM is a dominant model for investigating user technology acceptance and has accumulated fairly satisfactory empirical support for its overall explanatory power, and has posited individual causal links across a considerable variety of technologies, users, and organizational contexts [11, 12, 23, 48, 64].

Telemedicine Acceptance Studies

Telemedicine is an IT-based innovation that has the potential to support and enhance physicians' patient care as well as to improve health-care organizations' competitiveness. The concept of telemedicine emerged almost four decades ago when rudimentary pioneering projects were under way, driven by futuristic quests that primarily focused on concept proving or feasibility evaluation [38, 71]. Most early telemedicine endeavors failed to meet expectations, however. Problems included nascent and mostly primitive IT infrastructure, immature technology and inefficient technology use, and premature funding termination [7]. As summarized by Bashshur et al. [7], the failure of the first-generation telemedicine projects demonstrated the need for detailed consideration and rigorous evaluation of the multitude of technological, social, cultural, and organizational dimensions accompanying the introduction of telemedicine. User technology acceptance is an essential organizational challenge facing health-care organizations considering or planning to provide telemedicine-enabled health-care services.

Previous telemedicine research has predominantly focused on technological developments or clinical applications [54, 62, 68, 69, 70] and thus offers limited discussion of physician technology acceptance. A handful of studies have investigated physician technology acceptance [3, 27, 45, 46, 50], but most of these were limited in scope and scale, as measured by medical specialty and sample size, respectively. As summarized by Mitchell et al. [50], earlier investigations of user acceptance of telemedicine technology typically had a small and restrictive sample size and tested hypotheses that were idiosyncratically formulated without theoretical foundation. Therefore, integrating user technology acceptance literature and telemedicine research and management needs represents a desirable and advantageous opportunity to validate the existing IT acceptance/ adoption literature by examining physician acceptance of telemedicine technology. One logical starting point is to use TAM, a dominant model in the literature, to provide a necessary theoretical basis. The choice of telemedicine technology acceptance by physicians as the research context was justified by the significance of the health-care sector in national and global economies, the fast-growing IT investment by health-care organizations, and the unique characteristics of health-care professionals, which in combination represent a desirable extension to existing research on user technology acceptance.

Research Model, Design, and Method

Research Model

Figure 1 depicts the research model employed in the study. It is a reduced TAM model, excluding actual behavior. Behavior intention is predicted by both attitude and perceived usefulness; the latter also influences attitude. Perceived ease of use influences both attitude and perceived usefulness. In our context, the model hypothesizes that the degree to which telemedicine technology is easy to use, as perceived by physicians, affects both their perception of the usefulness of the technology and their attitude toward using the technology in general. Attitude is also influenced by the level of the technology's usefulness, as perceived by physicians. Finally, the intensity of physicians' intention to use a technology can be explained or predicted jointly by their attitude toward using the technology and the technology's perceived usefulness.

Study Focus

In this study, technology acceptance was defined as "an individual's psychological state with regard to his or her voluntary or intended use of a particular technology" [31]. The targeted technology was telemedicine in general, rather than specific telemedicine programs/technologies. The rationale was that telemedicine is mostly in an early adoption stage, which makes it difficult to conduct large-scale investigations of user technology acceptance based on a specific telemedicine technology. Nevertheless, the findings of the study can provide insights and implications relevant to technology acceptance research and telemedicine management in general. Quite a few prior studies have adopted this "broad" technology approach. Recent examples include

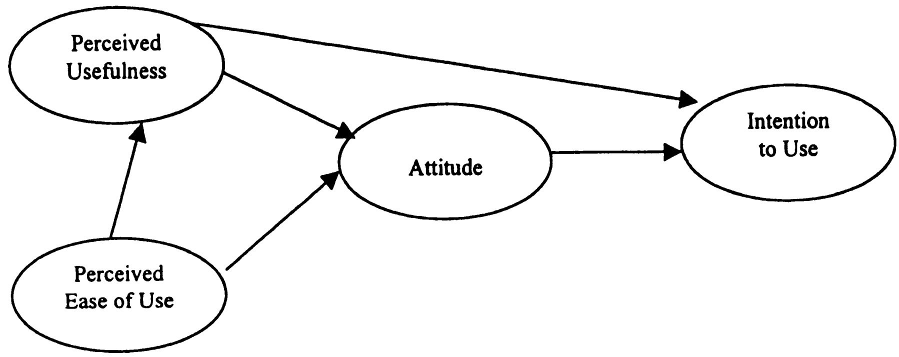

Figure 1. Research Model

Chau and Tam's [14] study on open systems and Arunachalam's [5] work on electronic data interchange.

User acceptance in this study was examined by intention to use the technology rather than actual usage [48, 64]. The decision was made primarily because telemedicine is still at an early development stage, characterized by limited technology adoption and use. The choice, however, was warranted from both research and managerial perspectives. On the research side, a number of prior empirical studies have reported a strong, significant causal link between behavioral intention and actual behavior [61]. Mathieson [48] has justified his use of behavioral intention as the dependent variable by stating that, given the strong causal link, "the fact that behavior was not directly assessed is not a serious limitation" (p. 186). On the management side, investigations of physician technology acceptance using a well-established theoretical foundation is of obvious importance and the use of behavioral intention as a dependent variable can be justified as a fast-growing number of health-care organizations interested in telemedicine are considering adopting or planning to adopt the technology.

Subjects

The study targeted physicians of preselected specialties who practiced in public tertiary hospitals in Hong Kong.[2] Choice of targeted physicians was based on the likelihood of their current or potential involvement with telemedicine programs in the foreseeable future. As a group, physicians at public tertiary hospitals have substantial interorganizational service needs that may be greatly supported by telemedicine technology. In effect, all existing Hong Kong–based telemedicine programs involve public tertiary hospitals, which collectively provide more than 90 percent of tertiary care in Hong Kong [34]. Common interinstitutional service collaborations include solicitation of a second or a specialist's opinion, patient transfer or admission assessment, team-based collaborative patient management, and urgent medical care needs. As a result, physicians at these hospitals usually have up-to-date knowledge of innovative technologies and medical techniques and often exhibit high interest in experimenting with new technologies and pioneering their use.

The choice of region was based on physician accessibility and the criticality of technology acceptance to program/project success. Compared with implementations elsewhere, physician technology acceptance appears to be increasingly important for Hong Kong–based programs [6, 43]. Relatively small geographic extent and acceptable resource requirements combined with emerging policies and regulations of telemedicine services and an across-the-board substantial government subsidy for health care reduce program implementation complexity and friction and have contributed to making physician technology acceptance increasingly important [44].

A total of nine specialty areas were included in the study, selected because of their frequent and appropriate utilization of telemedicine and documented satisfactory results [53]. They included internal medicine, obstetrics and gynecology, pediatrics, psychiatry, radiology, pathology, accident and emergency, intensive care, and surgery.

Instrument Development and Pretest

Use of TAM to investigate physician technology acceptance is advantageous because of its well-researched and validated measurement inventory [21, 48, 60]. Specifically, preliminary measurements for perceived usefulness, perceived ease of use, attitude, and behavioral intention were obtained from prior studies [21, 23, 48] to formulate the question items, using a seven-point Likert scale with anchors ranging from strongly agree to strongly disagree.

As most of the items were obtained directly from the literature, the validity of the instrument was reevaluated to ensure its applicability [18, 63]. A review panel consisting of three physicians from different specialties was formed to evaluate the face and content validity of the instrument using a card-sorting method suggested by Moore and Benbasat [51]. The results were satisfactory, as the physicians were able to categorize the question items presented with an accuracy rate of 90 percent or better. To ensure desired balance of the items in the questionnaire, half of the question items were suitably negated to invite the attention of respondents who, as a result, might become increasingly alert to manipulated question items. In addition, all the question items were arranged in a random order to reduce the potential ceiling (floor) effect that could induce monotonous responses to question items designed to measure a particular underlying concept. Finally, to anchor the responses properly [36], the questionnaire provided a working definition of telemedicine and included reference materials containing information on and common examples of telemedicine technology. The review panel that assisted with the face and content validation was again invited to examine the formatted survey instrument to ensure that its layout and wording were appropriate in a health-care context.

With satisfactory face and content validity established, the instrument was pretested for its reliability and construct validity [63]. A pretest was administered to thirty-five physicians from different specialties and hospitals. Results were fairly satisfactory, as manifested by acceptable Cronbach's alpha values (all above 0.70 [53]) and relatively higher covariances among measurements for the same construct than for different constructs. The overall analysis suggested that the instrument was of adequate reliability and construct validity. A list of the measurement items included in the formal instrument is provided in the appendix. As shown, multiple measurements were used for each construct, complying with Churchill's recommendation to use a minimum of two indicators for a latent variable [16]. Physicians who took part in the pretest were excluded from the subsequent formal study.

Data Collection Procedures

Data were collected using a user-reported self-assessment approach [17], deemed appropriate because of considerable literature support for its use in intention-based studies. Melone [49] suggested that the user-reported self-assessment approach was advantageous in situations where perceptual measures could cope with real-world constraints more effectively than could objective measures.

A total of seventy clinical departments at the target hospitals were contacted by means of an encounter letter that briefly described the intended study. Personal visits and phone calls were later made to the departments' chiefs of service to provide detailed study information and solicit their voluntary participation. Forty-one of the seventy (59 percent) departments agreed to participate.

Questionnaire packets were delivered to physicians who practiced with the participating departments. Each packet contained a cover letter stating the purpose of the study and intended use of the data, along with endorsement letters from the Hong Kong Telemedicine Association and the Hospital Authority, selected telemedicine technology references, and the questionnaire.[3] A letter soliciting internal promotion of the study was also faxed to chiefs of service of the participating departments immediately after questionnaire distribution to help promote the study and encourage participation. Subjects were asked to return the completed questionnaires to their department secretaries within two weeks of receiving the packet. Reminders and additional questionnaires were sent to physicians who failed to return a completed questionnaire before the specified deadline.

Data Analysis and Results

Sample Characteristics and Evaluation of Nonresponse Biases

OF THE 1,728 QUESTIONNAIRES DISTRIBUTED, 421 WERE COMPLETED and returned, showing a 24.4 percent response rate. Thirteen of the returned questionnaires were partially completed and therefore were excluded from the data analysis, resulting in an effective response rate of 23.6 percent. The respondents averaged 34.7 years in age and had 9.4 years of postinternship clinical experience in their respective specialty areas; the male-to-female ratio was approximately 4 to 1; 80 percent of the respondents received their medical education in Hong Kong. Distribution of the respondents was fairly balanced among the participating hospitals, ranging from 6.5 to 11.6 percent. Similarly, distribution among the investigated specialties was fairly balanced, with the exception of radiologists and neurosurgeons, who exhibited relatively high interest in the study.

Nonresponse is a potential source of bias in survey studies and therefore needs to be properly addressed [25]. The potential biases in this study were evaluated by comparing the responses between early and late respondents on the following two groups of measures: demographic data and responses to the question items for the four constructs in the research model. Early respondents were defined as those who had completed and returned the questionnaires within the initial two-week response window while late respondents were those who returned the questionnaires after the specified response period. Approximately half of the responses (203 out of 408) were from early respondents.

The average ages for the early and late respondents were 35.9 and 33.4, respectively. No significant differences in postinternship clinical experience were observed between the two groups, which were largely comparable with respect to distribution of medical specialty, gender, and country where they attended medical school. As for responses to question items for the four constructs, as shown in Table 1, the differences were not significant, suggesting that the threat of nonresponse bias is not serious.

Analysis of Measurement Validity

Measurement validity in terms of reliability and construct validity was evaluated. Specifically, reliability was evaluated using Cronbach's alpha. As shown in Table 2, the values were either close to or above 0.70. Although the numbers were not as high as those obtained in some prior studies that had used the same items, they were in a range that was deemed acceptable, based on common threshold values recommended by the literature [53]. Nevertheless, since the items in the instruments were mainly adapted from existing literature, care should be exercised in interpreting the results.

Construct validity of the instrument was evaluated by examining convergent and discriminant validity using both interitem correlation analysis and factor analysis.[4] As summarized in Table 3, correlation was considerably higher among items intended for the same construct than among those designed to measure different constructs. This suggested adequate convergent and discriminant validity of the measurements.

A principal component factor analysis was also performed. Four components were extracted, precisely matching the number of constructs included in TAM (Table 4). Furthermore, items intended to measure the same construct exhibited prominently and distinctly higher factor loadings on a single component than on other components, suggesting adequate convergent and discriminant validity of the measurement.

Jointly, the observed reliability and convergent/discriminant validity suggested adequacy of the measurements used in the study.

Model Testing Results

The utility of TAM to explain and/or predict physician acceptance of telemedicine technology was examined using structural equation modeling [8, 35]. LISREL 8 with

Table 1. Analysis of Nonresponse Biases

Dimension/measure	Early respondents ($n = 203$)	Late respondents ($n = 205$)	Significance
Perceived usefulness (PU)	3.12	3.05	$p = 0.488$
Perceived ease of use (PEOU)	3.24	3.18	$p = 0.515$
Attitude (ATT)	2.78	2.78	$p = 0.926$
Intention to use (ITU)	3.16	3.07	$p = 0.366$

Table 2. Analysis of Measurement Reliability: Descriptive Statistics and Cronbach's Alphas

	Mean	S.D.	Cronbach's alpha
Perceived usefulness (PU)			0.89
PU1	3.43	1.36	
PU2	2.80	1.17	
PU3	3.07	1.31	
PU4	3.04	1.20	
PU5	3.30	1.22	
PU6	2.91	1.16	
Perceived ease of use (PEOU)			0.79
PEOU1	3.02	1.30	
PEOU2	3.46	1.16	
PEOU3	3.18	1.12	
PEOU4	3.26	1.19	
PEOU5	3.10	1.60	
PEOU6	3.21	1.18	
Attitude (ATT)			0.69
ATT1	2.82	1.03	
ATT2	2.96	1.16	
ATT3	2.59	1.15	
Intention to use (ITU)			0.86
ITU1	2.71	1.06	
ITU2	3.47	1.28	
ITU3	3.23	1.41	
ITU4	2.98	1.26	
ITU5	3.07	1.11	
ITU6	3.23	1.26	

* See appendix for abbreviations in Tables 2–4.

Table 3. Analysis of Intermeasurement Correlation

	PU1	PU2	PU3	PU4	PU5	PU6	PEOU 1	PEOU 2	PEOU 3	PEOU 4	PEOU 5	PEOU 6	ATT1	ATT2	ATT3	ITU1	ITU2	ITU3	ITU4	ITU5	ITU6
PU1	**1.00**																				
PU2	**0.48**	**1.00**																			
PU3	**0.64**	**0.55**	**1.00**																		
PU4	**0.50**	**0.71**	**0.60**	**1.00**																	
PU5	**0.69**	**0.55**	**0.58**	**0.48**	**1.00**																
PU6	**0.52**	**0.69**	**0.53**	**0.63**	**0.55**	**1.00**															
PEOU1	0.07	0.10	0.07	0.10	0.08	0.07	**1.00**														
PEOU2	–0.03	0.06	–0.01	0.03	–0.04	0.01	**0.34**	**1.00**													
PEOU3	0.08	0.05	0.04	0.03	0.07	0.05	**0.35**	**0.42**	**1.00**												
PEOU4	–0.02	0.05	0.07	0.05	–0.01	0.06	**0.38**	**0.26**	**0.31**	**1.00**											
PEOU5	0.03	0.03	0.08	0.10	0.02	0.00	**0.54**	**0.29**	**0.29**	**0.36**	**1.00**										
PEOU6	0.07	0.00	0.04	0.00	0.04	0.00	**0.55**	**0.50**	**0.45**	**0.33**	**0.44**	**1.00**									
ATT1	0.32	0.30	0.33	0.30	0.33	0.36	0.15	–0.01	0.06	0.13	0.08	0.11	**1.00**								
ATT2	0.24	0.35	0.21	0.34	0.24	0.34	0.11	–0.03	0.04	0.07	0.06	0.07	**0.49**	**1.00**							
ATT3	0.26	0.35	0.31	0.32	0.28	0.28	0.08	–0.02	0.06	0.00	0.03	–0.02	**0.43**	**0.36**	**1.00**						
ITU1	0.30	0.32	0.29	0.28	0.31	0.32	0.19	0.08	0.22	0.19	0.01	0.07	0.28	0.22	0.24	**1.00**					
ITU2	0.36	0.41	0.36	0.36	0.39	0.40	0.10	0.05	0.12	0.08	0.03	0.04	0.34	0.26	0.22	**0.51**	**1.00**				
ITU3	0.37	0.40	0.35	0.38	0.32	0.39	0.09	0.09	0.16	0.11	0.04	0.08	0.24	0.30	0.27	**0.48**	**0.51**	**1.00**			
ITU4	0.31	0.35	0.25	0.34	0.26	0.35	0.09	0.04	0.15	0.15	0.04	0.00	0.21	0.31	0.22	**0.52**	**0.47**	**0.63**	**1.00**		
ITU5	0.36	0.35	0.25	0.31	0.36	0.34	0.16	0.10	0.14	0.09	–0.03	0.07	0.21	0.27	0.20	**0.48**	**0.52**	**0.36**	**0.43**	**1.00,**	
ITU6	0.40	0.38	0.35	0.35	0.40	0.39	0.07	0.02	0.20	0.12	–0.05	0.07	0.27	0.23	0.33	**0.50**	**0.62**	**0.54**	**0.50**	**0.47**	**1.00**

Table 4. Factor Analysis Results: Principle Component Extraction

	Component			
	1	2	3	4
Perceived usefulness (PU)				
PU1	**0.76**	0.25	0.01	0.07
PU2	**0.74**	0.26	0.02	0.21
PU3	**0.79**	0.16	0.03	0.11
PU4	**0.76**	0.19	0.04	0.20
PU5	**0.77**	0.23	-0.97×10^{-3}	0.09
PU6	**0.72**	0.26	-2.65×10^{-3}	0.22
Perceived ease of use (PEOU)				
PEOU1	0.06	0.03	**0.76**	0.15
PEOU2	0.01	0.07	**0.67**	–0.18
PEOU3	–0.01	0.24	**0.64**	–0.08
PEOU4	–0.06	0.14	**0.59**	0.10
PEOU5	0.07	–0.14	**0.71**	0.12
PEOU6	0.03	–0.01	**0.80**	1.30×10^{-3}
Attitude (ATT)				
ATT1	0.23	0.15	0.09	**0.75**
ATT2	0.15	0.20	0.03	**0.76**
ATT3	0.23	0.17	–0.02	**0.66**
Intention to use (ITU)				
ITU1	0.15	**0.73**	0.13	0.13
ITU2	0.29	**0.71**	0.03	0.19
ITU3	0.25	**0.70**	0.07	0.14
ITU4	0.14	**0.75**	0.04	0.15
ITU5	0.23	**0.65**	0.07	0.07
ITU6	0.27	**0.74**	0.02	0.11

maximum likelihood estimation, which is appropriate for testing structural equation models that have a well-developed underlying theory [8], was used. The structural model was examined in terms of model goodness-of-fit, overall explanatory power, and postulated individual causal links.

First, the overall model fit was assessed using multiple fit criteria, as suggested in the literature [30, 35, 60]. Specifically, seven goodness-of-fit indices were used, including chi-square/degree of freedom, goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), normalized fit index (NFI), nonnormalized fit index (NNFI), comparative fit index (CFI), and root mean square residual (RMSR). The chi-square statistic, which is also an intuitive index for measuring the goodness of fit between data and a model, was not used because of its sensitivity to sample size [13]. Table 5 summarizes the values observed in the study together with recommended values of common model fit indexes. As shown, even though some of them failed to meet the

Table 5. Analysis of Overall Model Goodness-of-Fit Using Common Fit Indexes

Model goodness-of-fit indexes	Recommended value	Results obtained from the study
Chi-square/degree of freedom	≤ 3.0	2.80
Goodness-of-fit index (GFI)	≥ 0.90	0.89
Adjusted goodness-of-fit index (AGFI)	≥ 0.80	0.86
Normalized fit index (NFI)	≥ 0.90	0.86
Nonnormalized fit index (NNFI)	≥ 0.90	0.89
Comparative fit index (CFI)	≥ 0.90	0.91
Root mean square residual (RMSR)	≤ 0.10	0.07

recommended minimum levels, they were close enough to suggest that the model fit was reasonably adequate to assess the results for the structural model.

The explanatory power of the model for individual constructs was examined using the resulting R^2 for each dependent construct. Together, perceived usefulness and perceived ease of use were able to explain 37 percent of the variances observed in physicians' attitudes toward incorporating telemedicine technology in their services (figure 2). Perceived usefulness appeared to have contributed more to the observed explanatory power than perceived ease of use. At the same time, the combination of perceived usefulness of and attitude toward telemedicine accounted for 44 percent of the variances observed in physicians' intention to use the technology.

The data also supported most of the individual causal paths postulated by TAM. Perceived usefulness had a significant direct positive effect on a physician's attitude as well as on his or her intention to use the technology, with standardized path coefficients being 0.45 and 0.36, respectively. Literally, these coefficients suggested that every unit increment in perceived usefulness would strengthen an individual's (positive) attitude by 0.45 unit and at the same time increase his or her intention to use telemedicine technology by 0.36 unit. Effects of attitude on intention were also significant and showed a 0.25 path coefficient. Thus, perceived usefulness had a direct as well as an indirect effect, through the mediating attitude, on intention to use, with a resulting total effect of 0.47. Perceived ease of use had positive effects on both attitude and perceived usefulness. However, neither of these was of statistical significance, contrary to what TAM suggests.

Discussion

THIS STUDY EXAMINED TAM USING PHYSICIAN ACCEPTANCE OF TELEMEDICINE technology. Based on data collected from 408 physicians, the utility of TAM for explaining acceptance of telemedicine technology by physicians was evaluated. The results suggested the general adequacy and applicability of TAM in this professional context as indicated by fairly reasonable goodness-of-fit indexes for the model. However, TAM's power to explain attitude and intention was limited compared with

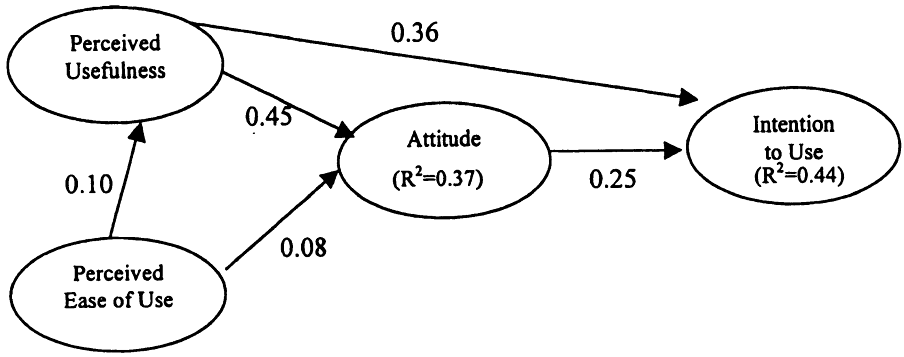

Figure 2. Model Testing Results

that reported by some prior studies that examined TAM in a "nonprofessional" context.

In agreement with what TAM postulates, perceived usefulness was found to have a significant and a strong influence on physicians' intention to use the technology. This may suggest that physicians are relatively "pragmatic" and tend to focus on the usefulness of the technology itself. Therefore, for telemedicine technology to be accepted by physicians, it will be necessary to demonstrate its ability to fill the needs of individual physicians, who tend to treat technologies as tools, acceptable only when desired utilities in their practices have been proven. In this connection, providing proper user training is essential for directing and solidifying physicians' perceptions of the usefulness of the technology.

Attitude was also found to be significant in influencing behavioral intention, though to a lesser extent than perceived usefulness. This suggests the relative importance of attitude in physicians' acceptance of telemedicine technology and its respective contribution in predicting behavioral intention.

Contrary to what TAM hypothesizes, perceived ease of use was found to have no significant effect on attitude and perceived usefulness. This might reflect limitations of TAM's applicability with respect to technologies, user populations, or both. Physicians are professionals and may exhibit considerable differences in general competence, adaptability to new technologies, intellectual and cognitive capacity, and the nature of their work. In this connection, they differ from students or subjects ordinarily examined in previous research, including end users, administrative and clerical staff, knowledge workers, and system developers. Conceivably, physicians can assimilate a new technology quickly and become familiar with its operation without as intense training as might be necessary for other user populations. Another plausible explanation is that physicians might not want to spend time learning a new technology, even if it is very easy to use. This is especially true when the adoption and use of the technology might interfere with their traditional practice routines [4]. Telemedicine may require physicians to change their traditional longstanding practice patterns and, as a consequence, its perceived ease of use may not be considered an important issue. As Keil et al. [40] opined, "no amount of EOU (ease of use) will compensate for low usefulness" (p. 89). The finding suggests that TAM may not be appropriate for user populations who have considerably above-average general competence and intellectual capacity or have constant and reliable access to assistance in operating technology. The explanatory power of TAM, particularly the perceived ease of use factor, may weaken as the competency of the users increases.

Compared with prior TAM studies, the model appeared to have relatively weaker utility for explaining physicians' attitude formation and intention development. Together, perceived usefulness and perceived ease of use accounted for only 37 percent of the variances in attitude, which is considerably less than that reported in Taylor and Todd (73 percent) [65] or Mathieson (73 percent) [48]. Similarly, combination of perceived usefulness and attitude explained 44 percent of the variances in intention to use the technology, which is also less than that reported by Szajna (52 percent) [64], Taylor and Todd (52 percent) [65], and Mathieson (70 percent) [48]. The observed relatively low R^2 values may have in part resulted from limited influence from perceived ease of use. However, the results also suggested that other factors should be added to the research model. TAM appears to lack adequate specificity to explain and enunciate attitude and intention of physicians, which may partially have been affected by characteristics of health care and/or the nature of their profession.

Limitations

THIS EMPIRICAL INVESTIGATION OF TAM IN A PROFESSIONAL CONTEXT has several limitations. First, operationalization of the constructs included in the research model was basically drawn from prior TAM studies. Despite the reported validity and reliability, the measurements used in the study exhibited relatively low reliability values, particularly those for attitude and perceived ease of use. The observed limited reliability may suggest potential "nonapplicability" of the same instrument to a very different context or group of target users. This responds to and reinforces the importance of instrument reevaluation, as suggested by Straub [63].

Second, responses to this study were voluntary and thus inevitably subject to self-selection biases. Conceivably, physicians who were interested in, had used, or were currently using telemedicine technology may have been more likely to respond. This might also explain why the response rate was not very high, even though support had been gained from the chiefs of service of participating clinical departments. The number of physicians interested in or currently using telemedicine technology may not be large, given the early technology adoption stage; but from the results of our nonresponse bias analysis it appears that the biases may not be significant.

Third, the relatively low R^2 values in our model compared with prior TAM studies suggest the potential limitations of TAM in this particular subject area and possible omission of factors important to individual technology acceptance in a professional context. A contingency approach that incorporates additional factors relevant to physicians' decisions to accept telemedicine technology might therefore be beneficial. Another promising approach is to use alternative intention-based theories, such as TPB, or to integrate TAM with such alternative theories to examine the physician technology acceptance issue. This study was intended as a starting point for investigations of technology acceptance by professionals using TAM as a theoretical model.

Fourth, cultural differences could represent another limitation of the study. Conceivably, physicians from different cultures may exhibit considerable differences in attitude formation and technology assessment. For instance, physicians from a culture characterized by relatively high uncertainty avoidance [33] may perceive usefulness and user friendliness of telemedicine technology differently from those whose culture is more tolerant of uncertainty. Rosenzweig [58] challenges the presumption of conceptual equivalence across language and cultural barriers in management research. More work is required on this aspect.

Conclusion

THEORY TESTING HAS BECOME INCREASINGLY IMPORTANT FOR IS RESEARCH [29], and therefore examination or validation of existing findings of user technology acceptance is desirable, or even essential, particularly when different technologies, user populations, or organizational contexts are involved. This study represents research in examining the applicability of TAM to explaining physicians' acceptance of telemedicine technology within the health-care context. The model was evaluated using data collected from more than 400 physicians practicing in public tertiary hospitals in Hong Kong. Several implications can be drawn from the findings of the study.

First, an important contribution to user technology acceptance research is the use of a preeminent intention-based model in a health-care context, which differs considerably in operational independence and individual autonomy from the business organizations ordinarily studied in previous research. On the one hand, we tested the "plausible" extension of the applicability of TAM and, on the other hand, we responded to a call for additional theory-testing efforts to validate research results accumulated from prior studies on IT acceptance/adoption.

From a managerial standpoint, the findings of this study reveal that, in order to foster individual intentions to use a technology, it is important to encourage and cultivate a positive attitude toward using the technology. In this connection, positive perception of the technology's usefulness is crucial, whereas the technology's ease of use may not be equally important for professionals. One logical implication is that the management of a health-care organization, upon decision to adopt a telemedicine technology, should strongly emphasize devising effective means to communicate the clinical utility of the technology to member physicians. Information sessions and training on telemedicine need to focus primarily on how the technology can help improve the efficiency and effectiveness of physicians' patient care and service delivery rather than on the steps or procedures of actual use of the technology.

Future research efforts are needed to address the limitations of this study. First, to expand the theoretical validity of the literature, reexamination of TAM with another professional population or a different IT application for a professional user group will be important. Ideally, this should be a series of studies in a variety of contexts including different technologies and professional user groups over a period of time. Longitudinal evidence obtained thereby might help us better understand the causality among variables and the applicability of TAM in the professional context.

Second, additional assessments on the psychometric properties and measurement validity for the constructs included in TAM are also needed. Attitude and perceived ease of use are two specific constructs whose measurement validity requires reevaluation, as suggested by the reasonable but not superior Cronbach's alphas observed in the study.

Third, the study did not test a full TAM. Actual technology use was not included in the research model, a constraint resulting from the early adoption stage of telemedicine technology. Continued studies that incorporate actual technology use into the research model would enable an increasingly complete examination of the applicability of TAM in explaining or predicting IT acceptance by professionals.

Finally, future studies should also not be limited by the original TAM. An extended model may be increasingly appropriate for our research context—IT acceptance/adoption by professionals. Several recent IT acceptance/adoption studies have extended TAM to include additional or mediating variables such as self-efficacy [65, 67], prior usage and experience [66], objective usability [67], and user characteristics [37]. Davis [22] also suggested additional factors to be included in the original TAM. Therefore, future studies should investigate the role of adding such variables to those originally used in the model. Exploring the applicability of alternative IT acceptance/adoption models may be essential as well. Candidate alternatives may include TPB [28] and Social Network Theory [56]. Such extended or integrated approaches may provide additional insights to our understanding of IT acceptance decision by professionals.

NOTES

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1. Segars and Grover [60] used confirmatory factor analysis with LISREL and identified potential weaknesses in the measures. Specifically, "perceived usefulness" was suggested to be split into two dimensions, "perceived usefulness" and "effectiveness." Chin and Todd [15] questioned this interpretation and reexamined data from Adams et al. [1] together with data from a new study to show that the original single dimension of "perceived usefulness" probably was more accurate.
2. In general, primary care refers to general care (provided by general practitioners or physicians), secondary care involves medical specialties that require fellowship training, (board) certificate exam, and licensure requirements to practice. Tertiary care involves subspecialties, which are "specialties within a specialty." Examples of tertiary care include neurosurgery (within surgery) and neuroradiology (within radiology). Thus, hospitals or care centers that offer tertiary care are often called tertiary hospitals or centers.
3. The Hong Kong Telemedicine Association was established in November 1996 by a group of health-care and IT professionals to promote awareness, understanding, and applications of telemedicine among health-care professionals and the general public in Hong Kong. The Hospital Authority, which was formally inaugurated in December 1990, is the supreme government organization that manages and coordinates all public health-care establishments in Hong Kong.
4. We used these techniques, rather than LISREL, because most readers are more familiar with the former than the latter.

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APPENDIX: Measurement Items Used in the Study

Perceived usefulness (PU)	
PU1:	Using telemedicine can enable me to complete patient care more quickly.
PU2:	Using telemedicine CANNOT improve my patient care and management.
PU3:	Using telemedicine can increase my productivity in patient care.
PU4:	Using telemedicine CANNOT enhance my service effectiveness.
PU5:	Using telemedicine can make my patient care and management easier.
PU6:	I would find telemedicine technology NOT useful for my patient care and management.

Perceived ease of use (PEOU)	
PEOU1:	Learning to operate telemedicine technology would NOT be easy for me.
PEOU2:	I would find it easy to get telemedicine technology to do what I need to do in my patient care and management.
PEOU3:	My interaction with telemedicine technology would be clear and understandable.
PEOU4:	I find telemedicine technology INFLEXIBLE to interact with.
PEOU5:	It is NOT easy for me to become skillful in using telemedicine technology.
PEOU6:	I would find telemedicine technology easy to use.

Attitude	
ATT1:	Using telemedicine technology in patient care and management is a good idea.
ATT2:	Using telemedicine technology in patient care and management is UNPLEASANT.
ATT3:	Using telemedicine technology is beneficial to my patient care and management.

Intention to use (ITU)	
ITU1:	I intend to use telemedicine technology in my patient care and management when it becomes available in my department or hospital.
ITU2:	I intend to use telemedicine technology to provide health-care services to patients as often as needed.
ITU3:	I intend NOT to use telemedicine technology in my patient care and management routinely.
ITU4:	Whenever possible, I intend NOT to use telemedicine technology in my patient care and management.
ITU5:	To the extent possible, I would use telemedicine to do different things, clinical or nonclinical.
ITU6:	To the extent possible, I would use telemedicine in my patient care and management frequently.