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Technology Acceptance among Physicians

A New Take on TAM

Amy K. Yarbrough
University of Florida, Gainesville
Todd B. Smith
University of Alabama at Birmingham

The proliferation of information technology has been a revolutionary force that has increased efficiency and effectiveness in many industries. However, health care organizations, particularly physician practices, are noticeably lagging in the adoption of such technologies. This article provides a systematic review of the literature on physician acceptance of information technology. An overview of the technology acceptance model (TAM) is discussed, and a modified version of this model is proposed. Finally, ideas for testing this new model in a physician setting are presented. By providing a better understanding of physician technology acceptance, this model will inform health care managers about barriers that make physicians hesitant to embrace new technologies designed to increase efficiency and improve quality in a health care setting.

Keywords: *technology acceptance model; physician technology acceptance; barriers to technology; electronic medical record*

In the current health care environment, many physicians are expressing frustration with various aspects of their practices (Mechanic 2003; Meyers 2003; Nixon and Jaramillo 2003), while many patients are not satisfied with their primary care interactions (Kassirer 2000). Physicians state they are "dissatisfied with large patient loads, burdened with administrative tasks, frustrated by reporting requirements, and angry about losing control of patient care decisions" (Kassirer 2000, 116). Patients complain that doctors spend too little time with them during appointments and do not listen well to their complaints (Kassirer 2000). Patients today are demanding better services from their physicians, including access 24 hours per day/7 days per week, immediate scheduling of appointments, electronic access to medical records, more time with physicians

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Please address correspondence to Amy K. Yarbrough, University of Florida, College of Public Health and Health Professions, Department of Health Services Research, Management, and Policy, P.O. Box 100195, Gainesville, FL 32610-0195; e-mail: ayarbro@phhp.ufl.edu.

during appointments, and less waiting time before appointments (Meyers 2003). Recent technological advances can aid in satisfying many of these requests, but few physician practices are actually using new types of technology to improve or alleviate such problems (Miller and Sim 2004). Additionally, as many patients are becoming much savvier with electronic communications (e.g., e-mail and interactions with service providers via the Internet), they are beginning to demand these types of electronic services from physicians (Kassirer 2000).

In 2001, the Institute of Medicine (IOM) recommended that both the public and private health sectors make commitments to end the practice of handwriting clinical information by the end of the decade (Bodenheimer and Grumbach 2003). Despite this recommendation, the health care community in the United States is making very slow progress in achieving this goal. Surveys indicate that only 25% of U.S. physicians routinely used electronic medical records (EMRs) in 2004 (Audet et al. 2004). From an institutional perspective, only 20% of U.S. hospitals had computerized physician order entry (CPOE) systems by 2002 (Ash et al. 2004), and physician resistance was cited as the greatest barrier to implementation (Poon et al. 2004).

With regard to electronic communication, only 6% of e-mail users had used the medium to communicate with their personal physicians as of 2003 (Bodenheimer and Grumbach 2003). The most common reason cited by physicians for resisting e-mail communication with patients is the lack of reimbursement for providing such a service (Kleinke 2000). Salaried physicians are much more likely to use information technology (IT; Audet et al. 2004), which suggests that physician compensation structure influences technology adoption. Another major impediment to physician technology utilization is the lack of documentation suggesting that available technologies do, in fact, increase quality of care. Although the benefits of technology adoption are widely prophesized, little to no empirical evidence to support such claims are offered in the literature (Berger and Kichak 2004). Finally, numerous other factors including fears about patient litigation, privacy/confidentiality, misinformation, and the lack of infrastructure or regulations to deal with such issues also serve as barriers to physician technology utilization (Kassirer 2000).

The proliferation of IT has been a revolutionary force that has increased efficiency and effectiveness in many industries. However, health care organizations, particularly physician practices, are noticeably lagging in the adoption of such technologies. The purpose of this report is to increase understanding of physician technology acceptance and barriers to such acceptance through the creation of a comprehensive theoretical framework rooted in both the information systems and health care management research.

New Contribution

This report reviews the literature on physician technology acceptance with the goal of providing a better understanding of barriers to physician adoption of

information systems. The technology acceptance model (TAM) is defined, and empirical studies of the TAM and its conceptual development during the last decade are discussed. Furthermore, the authors attempt to trace the model's evolution over time in different contexts with different populations. Literature on physician technology acceptance is then reviewed, and a modification to the TAM in a health care context is proffered. Finally, ideas for testing this new model in a physician practice setting are presented. The purpose of this report is to present an adaptation of the TAM customized for physician practices and to propose both a method and setting for testing this new model.

The TAM

An individual's intentional or voluntary use of a technology is referred to as technology acceptance (Davis, Bagozzi, and Warshaw 1989). Although other predictive models exist, the TAM is the most widely recognized model of behavioral intention in the information systems literature (Ma and Liu 2004). Another model widely used to predict the adoption of IT is the theory of planned behavior (TPB). The TPB model uses behavioral, normative, and control beliefs in addition to attitudes, subjective norms, and perceived control to predict behavioral intentions and in turn to predict behavior (Mathieson, Peacock, and Chin 2001). However, in comparisons between the TAM and the TPB as predictors of IT adoption, the TAM is a more parsimonious predictive model (Mathieson, Peacock, and Chin 2001; Venkatesh et al. 2003). The TPB model is more general than the TAM, and each construct in the TPB has to be reoperationalized when tested in a new setting (Mathieson, Peacock, and Chin 2001). Therefore, the TAM is the better choice when performing an approximate analysis of technology adoption.

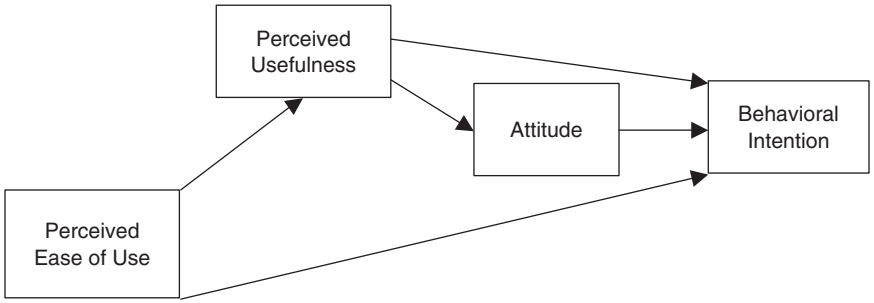
The TAM was derived from the theory of reasoned action (TRA). The TRA is a very general model of behavior that suggests beliefs influence attitudes, which determine intentions, and that intentions dictate behavior (Ajzen and Fishbein 1980). The original TAM suggests that an intention to accept technology is determined directly by attitude, perceived usefulness, and perceived ease of use. Additionally, perceived usefulness influences behavioral intention indirectly through attitudes, while perceived ease of use influences behavioral intention indirectly through both attitudes and perceived usefulness (Davis, Bagozzi, and Warshaw 1989). Perceived usefulness has been defined as an individual's perception that the utilization of a particular technology will be advantageous in an organizational setting over a current practice. Perceived ease of use is the perception by an individual that the utilization of the new technology will be relatively painless or effortless (Davis et al. 1989). The attitudinal component of the model measures an individual's affective response toward adopting a new technology, and the behavioral intention component of the TAM represents an individual's intentions to utilize a new technology (Davis, Bagozzi, and Warshaw 1989).

The TAM has proven to be a reliable and robust model through rigorous empirical testing. In the last decade, at least 45 empirical studies of the TAM have been conducted in many different contexts and have supported the validity of the model's constructs (King and He 2006; Ma and Liu 2004). Empirical tests of TAM prove the model to be applicable for individuals of all levels of IT competency (Lai and Li 2005; Yu et al. 2005), genders, and ages (Lai and Li 2005). The model holds across most cultures (Al-Gahtani 2001; McCoy, Everard, and Jones 2005; Rose and Straub 1998; Straub, Keil, and Brenner 1997), and it predicts technology acceptance among individuals in both mandatory and voluntary technology usage settings (Venkatesh and Davis 2000). Furthermore, the TAM has been successful at predicting acceptance of a wide variety of technologies (King and He 2006; Ma and Liu 2004). In general, the model has done a good job of predicting variance in technology acceptance in a wide variety of contexts for different types of users.

As researchers began empirically testing the TAM, the attitudinal construct was removed in efforts to achieve a more parsimonious model (Simon and Paper 2007). However, recent studies suggest that attitude does significantly influence behavioral intention and has a place in the model (Yang and Yoo 2004). Yang and Yoo (2004) tested the TAM inclusive of the attitudinal construct using structural equation modeling (SEM) and found support for the variable. Although the model fit met only minimum recommended requirements, their findings coupled with original empirical tests of the TAM confirm the importance of the attitudinal construct to the model. Therefore, the construct will remain in the model for the purposes of this report. However, the direct relationship between perceived ease of use and behavioral intention to accept technology has not proven its significance across various contexts (Hu et al. 1999; S. Lee et al. 2006; Liu and Ma 2005) or in meta-analysis results (King and He 2006; Ma and Liu 2004). Therefore, modern iterations of the TAM include a direct relationship between perceived usefulness and behavioral intention, with perceived ease of use influencing intention indirectly through both the usefulness and attitudinal constructs (see figure 1).

A limitation of the TAM is its inability to consider the influence of external variables and barriers to technology acceptance. Although the general TAM constructs consistently explain a large amount of variance in technology acceptance, the inclusion of variables customized to the sample population enhance the model's accuracy. The model's behavioral components were originally expected to fully mediate the influences that external variables have on behavioral intentions (Davis, Bagozzi, and Warshaw 1989), but studies suggest that external influences cannot be ignored in adequately assessing technology acceptance (Burton-Jones and Hubona 2006; James et al. 2006; McKechnie, Winklhofer, and Ennew 2006; Yi et al. 2006; Zhang, Prybutok, and Koh 2006). External variables often exert significant indirect influence on behavioral intention to accept technology through both the attitudinal, perceived ease of use, and perceived usefulness constructs (Amoako-Gyampah and Salam 2004; Burton-Jones and Hubona 2006; Hwang 2005; James et al. 2006; S. Lee et al. 2006; McKechnie, Winklhofer, and Ennew 2006; Robinson, Marshall,

Figure 1
Technology Acceptance Model



Source: Davis, Bagozzi, and Warshaw (1989).

and Stamps 2005; Schepers, Wetzels, and Ruyter 2005; Yi et al. 2006; Zhang, Prybutok, and Koh 2006). With regard to barriers, the TAM considers acceptance to be a purely voluntary behavior that cannot be impeded by traditional barriers to technology adoption, such as resource scarcity. Barriers to technology have been considered in only one empirical study (Mathieson, Peacock, and Chin 2001), which suggests that they are likely to influence behavioral intention to accept technology.

In summary, sufficient evidence exists to validate the TAM's ability to predict technology acceptance. The general constructs consistently explain a large amount of variance in technology acceptance, and customized variables enhance the model's accuracy. Although model development was largely informed through studies outside of health care, the model is worthy of consideration in a health care setting.

Method

The review presented in this report was started with the goal of critiquing the empirical research on physician technology acceptance and relating this to the TAM conceptual framework, which has been developed largely outside of health care. Because IT in health care is relatively new, only articles published in the past 10 years (January 1996–November 2006) were selected. Literature on physician technology acceptance was systematically reviewed using the following approach: (1) initial review results were generated by conducting PubMed and ABI Inform/Complete queries using the keywords "physician technology acceptance," "barriers to technology acceptance," and "TAM"; (2) general exclusion criteria for the abstract review process were determined; (3) published abstracts of articles generated during the initial searches were reviewed and reduced based on general criteria; (4) a secondary set of specific criteria for exclusion was determined based on the theory and

methodology used in the article; (5) a second review of the remaining published articles was conducted, and the sample was again reduced based on the secondary exclusion criteria; (6) remaining articles were categorized based on content and fully reviewed for relevant information; and (7) a compilation of resultant information was used to draw conclusions about extant research and aid in the development of a more comprehensive theoretical model.

The initial searches were conducted using Health Services Research queries in the PubMed and ABI Inform/Complete databases. Both databases were queried in an effort to include all technology acceptance research pertinent to health care contexts. The searches were limited to articles in English and peer-reviewed publications only, and the initial yield included 526 citations. The authors' initial criteria for exclusion of articles were determined based on the overarching goal of the research, which is to provide a physician-specific model of technology acceptance through the integration of health services and general information systems research. The first set of exclusion criteria disqualified articles not directly pertaining to (1) physician IT, (2) physician barriers to technology, or (3) the TAM. After a review of the abstracts, 114 published articles passed the preliminary screening process.

The authors determined their secondary criteria for exclusion based on the theory and methods used in the published literature. Nonphysician-specific technology acceptance articles were excluded. Physician-specific articles were excluded if the users targeted were not physicians, as the intent of this work is to determine factors influencing physician technology acceptance. Also, articles attempting to create typologies of physician users were excluded. Finally, articles were also excluded based on methodology. Although articles using both quantitative and qualitative research methodologies were considered appropriate for inclusion, those using specific types of qualitative methodologies were excluded in an effort to focus on studies using more rigorous methodologies. Therefore, case studies of organizations that were purely descriptive in nature and limited to less than two sites were excluded, as were review articles that only summarized research findings. However, qualitative studies of multiple organizations or multiple groups of technology users that used an inductive approach were deemed acceptable for inclusion, as were meta-analyses that used statistical methodologies to provide a review of prior research findings.

A second screening of the articles was conducted based on the secondary exclusion criteria, and the sample was further reduced to 18 published articles. The final set of articles was organized based on topic, findings, and conceptual framework and was reviewed to determine contributions relevant to the study.

Results

The authors fully reviewed a total of 18 published articles that represent the body of research on physician technology acceptance. These articles represent approximately

3.4% of the initial yield of the search (n = 526). Existent research indicates that while the TAM has the capacity to generally predict variance in technology acceptance, context-specific variables must be added to the model to increase its explanatory power. Eighteen empirical studies on barriers to physician technology acceptance and the TAM in a medical setting are now critically reviewed, presented in a tabular format, and summarized (see table 1).

Barriers to Technology Acceptance

Because of the professional training physicians receive, they may differ from users of technology in other industries. Although a scarcity of rigorous empirical evidence examining technology acceptance in the physician population exists, published studies do shed some light on potential barriers to technology acceptance. Eighteen empirical studies covering six different types of technology provide the starting point for a real understanding of factors contributing to physician technology acceptance (see table 1). Interruption of traditional practice patterns, lack of evidence regarding benefits of IT, organizational issues, and system-specific issues have all emerged as barriers to physician technology acceptance in the existent literature.

Often, doctors are hesitant to adopt technologies that require an interruption of their traditional practice patterns during implementation. The requirement of additional time is one of the major barriers to physician technology acceptance present in the literature. Evidence suggests that some information systems require more time per physician per patient than paper-based methods (F. Lee et al. 1996; Overhage et al. 2001).

F. Lee and colleagues (1996) surveyed physicians and nurses on satisfaction and usage of a recently implemented CPOE system in one large northeastern hospital. Study respondents indicated that CPOE was more time consuming than paper-based order entry. The report also suggests that physician satisfaction with CPOE is highly correlated with efficiency, which has a larger influence on physician satisfaction with technology than quality indicators do (F. Lee et al. 1996). While this early study does provide some baseline information on physician technology acceptance, it is a descriptive study that looks purely at correlations in one facility. A rigorous statistical analysis of the influences of additional time and satisfaction on technology usage was not conducted.

Additional support for physician time as a barrier to technology acceptance is offered by Overhage and colleagues (2001). These researchers performed a randomized, systemized trial of CPOE in 11 primary care clinics in the midwestern United States. The researchers observed 34 physicians in two groups: those just implementing CPOE and those with experience in using CPOE. Time and motion studies revealed that while the physicians do appear to spend considerably more time with patients due to CPOE, much of the additional time costs are attributed to duplicate efforts (maintaining paper-based systems) and administrative tasks. However, the study used a small sample of salaried physicians. Physicians who are paid in a more traditional way

Table 1
A Summary of Published Studies on Physician Technology Acceptance

Technology Evaluated	Author	Sample/Study Description	Model and/or Constructs Studied
CPOE	Lee et al. 1996	Descriptive study of 205 physicians and nurses (112 MDs and 93 RNs)	Perceived efficiency indicators, quality indicators, satisfaction, time costs, technology acceptance
	Overhage et al. 2001	Randomized trial following 34 salaried internal medicine physicians; time-motions studies for 764 patient encounters	Time, costs, technology acceptance
	Ash et al. 2003	Qualitative study of staff at three sites	Organization-specific issues, clinical issues, professional issues, system-specific issues, speed, organizational culture, technology acceptance
	Pare, Sicotte, and Jacques 2006	Cross-sectional study of 91 physicians currently using CPOE	TAM, psychological ownership
Telemedicine	Hu and Chau 1999	Cross-sectional study of acute care physicians, tertiary care hospital, Hong Kong	TAM
	Hu et al. 1999	Cross-sectional study of acute care physicians, tertiary care hospital, Hong Kong	TPB, attitude, perceived behavioral control
	Chau and Hu 2001	Cross-ectional study of acute care physicians, tertiary care hospital, Hong Kong	TAM, TAM/TPB
	Chau and Hu 2002a	Cross-sectional study of acute care physicians, tertiary care hospital, Hong Kong	TAM, TAM/TPB, decomposed TAM
	Chau and Hu 2002b	Cross-sectional study of acute care physicians, tertiary care hospital, Hong Kong	TAM

(continued)

Table 1 (continued)

Technology Evaluated	Author	Sample/Study Description	Model and/or Constructs Studied
	Gagnon 2003	Cross-sectional study of GPs and specialists at 32 hospitals in Quebec ($N = 519$)	Normative factors, self-identity factors, theory of interpersonal behavior
EMR	Dansky et al. 1999	Cross-sectional study of 67 MDs; 18 clinicians in ambulatory care centers	Demographic factors, PU, computer experience, perceived organizational support, computer anxiety, patient relationship
Internet-based applications	Chismar and Wiley-Patton 2002	Cross-sectional study of pediatricians, Hawaii	TAM
Handheld computers	McAlearney, Schweikhart, and Medow 2004	Qualitative study of practicing physicians' use of handheld computers; focus group (8) methodology	Reliability, dependency, questionable value, personal characteristics, technology acceptance
	Lapinsky et al. 2004	Prospective interventional study of four ICUs with 17 physicians; surveys and focus groups	Training, familiarity with technology, technology acceptance
	Horsley and Forster 2005	Cross-sectional study of 55 British physicians	Cost, interruption of practice, technology acceptance
	Yi et al. 2006	Cross-sectional study of 222 medical residents in eastern United States	Integrated model (TAM, TPB, innovation), external variables, behavioral control, subjective norms
Electronic mental health resources	Austin et al. 2006	Semistructured interviews of 27 Australian GPs	Familiarity of resources, knowledge of resources, technology acceptance
Medical error reporting system	Karsh et al. 2006	Longitudinal focus groups of (6) clinical assistants and (8) physicians	System's fit with work structure, time, choice of medium, confidentiality, organizational reporting issues, technology acceptance

Note: CPOE = computerized physician order entry; EMR = electronic medical record; PU = perceived usefulness; TAM = technology acceptance model; TPB = theory of planned behavior.

might behave differently with regard to time due to monetary incentives to see more patients (Overhage et al. 2001).

A more recent study of 55 British physicians also indicates time and cost as barriers to usage of handheld computers (Horsley and Forster 2005), but again the size of the sample used in the study makes it difficult to draw concrete conclusions. In a qualitative study by Karsh and colleagues (2006), a series of focus groups were conducted over a 9-month period with eight physician and six clinical assistant participants. Through a process of inductive analysis, barriers to system acceptance were collected. System fit with practice patterns and time were both cited as barriers to technology acceptance, but again sample size and the qualitative nature of the research limit the conclusions drawn from this study.

Although much of the additional physician time required to implement CPOE can be eliminated through the reduction of duplicate efforts and the acquisition of experience using a CPOE system, the cost of physician time appears to present a barrier to the acceptance of the technology in its initial implementation stages (Horsley and Forster 2005; F. Lee et al. 1996; Overhage et al. 2001). A number of studies confirm this barrier, but most of the research is limited to small sample sizes and is exploratory in nature. Additional research is indicated to determine the degree or level of influence that additional physician time has on technology acceptance.

Another potential barrier to technology acceptance among physicians is a lack of empirical evidence linking information systems to quality or financial improvements. A report on medical errors released by the IOM (Kohn, Corrigan, and Donaldson 1999) has increased pressure for physicians and health care organizations to adopt information technologies such as CPOE, error reporting systems, and EMRs. However, the evidence to support the claims that such technology increases the quality of care and decreases health care costs has come under some methodological scrutiny. Such systems do have the potential to decrease serious medical errors and reduce health care costs, but solid evidence simply does not yet exist to substantiate these claims (Berger and Kichak 2004). In fact, studies suggest that EMR implementation results in lower provider productivity and inconsistent error reduction (Sidirov 2006). The lack of support for the claim that IT decreases medical errors provides little incentive for physicians to embrace it, and the tremendous costs of adoption provide yet another barrier for physician technology acceptance. Still, no studies empirically indicate that this lack of evidence is a barrier to physician technology acceptance.

A recent qualitative study by Ash and colleagues (2003) identified themes causing physician resistance to technology acceptance. The qualitative study utilized clinical, administrative, and IT personnel at three hospital sites to garner information on barriers to successful implementation of CPOE. The categories of issues identified include organization-specific issues, clinical and professional issues, technical/implementation issues, and issues relating to the organization of information. Although the study provides some basic information on barriers to technology acceptance, the qualitative approach was limited to sites where CPOE was successfully implemented

(Ash et al. 2003). Perceived barriers might be different in a place where CPOE was not well received. Study conclusions were based on observations, focus groups, and interviews conducted on a total of 47 clinicians. An inductive approach was used to identify themes from the information garnered; however, due to the limited sample size, results might not be applicable to every provider (Ash et al. 2003). Despite study limitations, subsequent research lends support to some of the barriers to technology acceptance identified in the study, including organizational issues, personal/professional issues, and system-specific issues.

Four recent studies of physician technology acceptance have identified organizational issues as potential barriers. Dansky and colleagues (1999) studied physician perceptions prior to EMR implementation among 67 physicians and 18 mid-level clinicians in ambulatory care centers using a model derived from both the information systems and job design literatures. The following determinants of perceived usefulness of technology were evaluated: (1) individual characteristics such as age, computer experience, and patient care values; (2) computer anxiety; and (3) contextual factors such as office conditions and organizational support. Results indicate that demographic factors have no influence on perceived usefulness of technology. However, computer experience and perceived organizational support are positive predictors of perceived usefulness. In the context of this study, organizational support is representative of not only a supportive organizational culture, but also the presence of appropriate training and infrastructure needed for proper implementation of EMR (Dansky et al. 1999). The analysis used both descriptive statistics and regression analysis in testing the model, and although the sample size is relatively small, the analysis is elegant and straightforward.

In a second study, Audet and colleagues (2004) surveyed a national random sample of physicians and found consistent patterns of technology acceptance for numerous types of medical technologies. Overall, age and sex were not significant predictors of technology acceptance. However, the study indicates that organizational characteristics significantly influence technology acceptance. Practice size is a significant predictor of technology acceptance, with nearly 90% of large-group practices having access to tests electronically and more than 50% having access to EMRs routinely or occasionally (compared with 37% and 13%, respectively, for solo physicians). Physician salary status is the only other significant variable for technology acceptance in the study. Salaried physicians are more likely to use IT. These authors also reported costs, lack of standards, and lack of time as three major barriers to IT adoption. Surveys were returned by 1,837 physicians, and logistic regression was used to evaluate potential predictors of technology acceptance. However, barriers to IT adoption were analyzed only descriptively, and further analysis is indicated to draw any strong conclusions (Audet et al. 2004). Despite this methodological weakness, this study offers, by far, the largest sample size of any conducted regarding physician barriers to technology acceptance.

The third study citing organizational issues as barriers to technology acceptance is the qualitative study by Karsh and colleagues (2006) referenced earlier. Organizational

issues with confidentiality and policies regarding error reporting are identified as potential barriers to technology acceptance in addition to physician time costs (Karsh et al. 2006). Finally, a qualitative study performed by Lapinsky and colleagues (2006) suggests that technology-specific training influences physician technology acceptance. Because training is usually coordinated and financed by organizations implementing technology, this is considered an organizational issue. Although the study analyzed only 17 physicians, the researchers followed the participants during a 1-year implementation period for handheld computers (Lapinsky et al. 2006), allowing barriers to be measured over time. Despite the small sample size, this study provides significant insight into physician perceptions of barriers to technology acceptance.

Personal characteristics have also been identified as barriers to physician technology acceptance in four empirical studies, with computer experience or familiarity with technology emerging as a common theme. Dansky and colleagues (1999) found anxiety regarding computers to be a negative predictor of technology acceptance. Furthermore, they found that the value a physician places on a close patient relationship is a negative influence (Dansky et al. 1999). The Lapinsky et al. study (2006) provides additional support for familiarity with technology as a barrier to acceptance. Austin and colleagues performed semistructured interviews of 27 Australian general practitioners regarding utilization of electronic mental health resources. Lack of familiarity and knowledge of available resources were cited as barriers to technology acceptance (Austin et al. 2006). No statistical analysis was performed on the data, deeming the study of little importance beyond exploration; however, it does validate earlier findings from Dansky et al. (1999) and Lapinsky et al. (2006).

In a larger study, Gagnon and colleagues (2003) surveyed physicians regarding the acceptance of telemedicine in hospitals. Responses were received from 519 general practitioners and specialists in 32 hospitals in Quebec. Constructs based on the theory of interpersonal behavior were tested using SEM, and the model was found to explain 81% of the variance in technology acceptance. Although the model adequately fit the sample, only two constructs appear to influence technology acceptance significantly in this study: normative factors and self-identity. Social and personal norms appear to predict technology acceptance, while physician self-identity factors actually suppress technology acceptance. Based on a poor fit for the variable representative of barriers to technology, a major limitation of this study is that all barriers might not be adequately captured (Gagnon et al. 2003). Also, as the physicians were surveyed on acceptance of a technology in Canadian hospitals, cost cannot be considered as a potential barrier. The telemedicine technology in this study was paid for and provided by the Canadian government and not by individual physicians or their practices.

Finally, issues specific to the technology in question, or system-specific issues, have been identified as barriers to technology acceptance among physicians. A qualitative study was performed on practicing physicians who did or did not use handheld computers. McAlearney, Schweikhart, and Medow (2004) conducted eight

focus groups to determine physician satisfaction and perceptions about the use of the technology. Physicians using the handheld devices appear to be satisfied with the technology; however, they anticipate future generations of handheld computer devices will provide even more value to physicians. The physicians interviewed cite reliability and dependency as the main concerns with adopting such technology (McAlearney, Schweikhart, and Medow 2004). Because the studies were qualitative and exploratory in nature, the amount of technology acceptance explained by the variables identified was not available. Although this qualitative study was limited to eight focus groups of 54 physicians, the sample was representative in that it included both users and nonusers. Also, physicians from various practice settings and specialties were represented. Although this study provides preliminary evidence that system-specific characteristics are barriers to physician technology acceptance, additional research is necessary to validate this relationship.

The TAM in Physician Populations

Several studies testing the TAM have been conducted using a physician population. Despite potential differences in the barriers to technology acceptance perceived by physicians and the general population of technology users, recent empirical research suggests that the TAM is a good predictor of physician behavioral intent to accept technology (Chau and Hu 2001, 2002b; Chismar and Wiley-Patton 2002; Hu et al. 1999). Hu and colleagues (1999) initially tested the TAM among a sample of acute care physicians in a tertiary care hospital in Hong Kong to determine physicians' acceptance of telemedicine. Results provide support for the adequate fit of the model in a physician population. Additionally, the relationship between perceived usefulness and both attitude and behavioral intention was shown to be significant. However, no support was found for the relationship between perceived ease of use and either usefulness or attitude. The possibility that the perceived ease of use component of the TAM might not be applicable for individuals with above-average intelligence was raised in this study (Hu et al. 1999). Empirical research confirms a significant relationship between intelligence and both educational attainment and job complexity (Ganzach 1998). Physicians are arguably more educated than the general population, and certainly their jobs are complex. Using both education and job complexity as a proxy for intelligence, physicians could be deemed more intelligent than the average person, and this above-average intelligence might cancel out the influence that perceived ease of use has on technology acceptance.

Further testing on this sample indicates that the TPB, which uses attitudes, subjective norms, and perceived control to predict behavioral intention, also adequately explains physician technology acceptance (Hu and Chau 1999). An integrated TAM/TPB model, which essentially incorporates subjective norms and behavioral control with the TAM, was also tested using this sample (Chau and Hu 2002b), as was a decomposed model. The decomposed model uses the TPB as a basis, and then

decomposes attitude by using perceived usefulness and perceived ease of use as mediating variables (Chau and Hu 2001). Although these models all adequately predict physician technology acceptance, this research suggests that the TAM explains physicians' technology acceptance decisions more accurately than the TPB, the integrated TAM/TPB, or the decomposed model (Chau and Hu 2001, 2002b). In all empirical tests of the TAM in this population, an R^2 of approximately .40 was produced, indicating that although a considerable amount of physician behavioral intention is explained, some predictors of this intention remain unknown (Chu and Hu 2001, 2002a, 2002b; Hu et al. 1999).

Chismar and Wiley-Patton (2002) tested an extended TAM (TAM2) model on a sample of pediatricians in Hawaii to determine the variables contributing to the acceptance of Internet-based applications. The extended model added cognitive instrumental processes and social influence processes. The study did support TAM2 in the physician sample; however, the results did not indicate support for the perceived ease of use component of the model. Again, this raises the issue that more intelligent individuals might not be influenced by the ease of use portion of the model. The TAM2 model explained 59% of physician behavioral intention in this sample. Empirical research suggests that all of the variations on the TAM explain at least 40% of physician intention to use technology. Although the TAM2 explained more variance, it was analyzed using regression analysis (Chismar and Wiley-Patton 2002), while the Chau and Hu model was evaluated using SEM (Chau and Hu 2001, 2002a, 2002b; Hu et al. 1999). With SEM, measurement error is minimized through the use of multiple indicators of latent variables prior to testing model fit. This approach to model testing is probably more accurate than regression because construct measurement is more rigorous. Furthermore, as this is a more parsimonious model, this version of the TAM will be the model referenced in our later discussion.

Pare, Sicotte, and Jacques (2006) tested TAM among physicians with an added psychological ownership construct. Although the researchers did not test a direct relationship between this construct and technology acceptance, they did find evidence that psychological ownership influences perceived usefulness and perceived ease of use. Furthermore, support for the TAM constructs was offered. Study results suggest that perceived usefulness and the attitudinal construct directly influence technology acceptance, while perceived ease of use influences both perceived usefulness and the attitudinal construct (Pare, Sicotte, and Jacques 2006). The study sample included 91 physicians who are currently using a specific brand of CPOE, so it is inclusive only of those practices that have actually adopted the technology (Pare, Sicotte, and Jacques 2006). Therefore, some barriers to technology such as initial cost of implementation probably are not applicable to the model.

Despite the strong support offered for the TAM in the physician population derived from existent literature, it is important to consider the samples studied. In all but two previously cited articles (Chau and Hu 2001, 2002a, 2002b; Hu and Chau 1999; Hu et al. 1999), the same sample of hospital physicians (in Hong Kong) were

studied, drawing into question the generalizability of the conclusions. This study population consisted of physicians in public tertiary care hospitals in China. These physicians were employed by public hospitals, and they did not have to pay for the technology implemented. As cost and compensation structure might represent a barriers to technology acceptance, this bias might influence study results. One other study cited (Chismar and Wiley-Patton 2002) used a sample of 89 specialty physicians in Hawaii. Questions exist regarding the applicability of study results due to the physicians' specialization, location, and small sample size. Finally, Pare, Sicotte, and Jacques (2006) used a sample of 91 physicians who were currently using a particular brand of CPOE. Therefore, the sample consisted of strictly those physicians in practices that made the decision to use the technology, biasing results related to physician technology acceptance.

A more recent study of physician technology acceptance tested an integrated model incorporating the TAM, the TPB, and an innovation diffusion model on a sample of medical residents in the eastern United States. The model was supported, and again perceived usefulness was found to directly influence physician intention to accept the technology while perceived ease of use was not found to directly influence this intention. However, perceived ease of use was shown to influence perceived usefulness in this study (Yi et al. 2006). While the study population is more representative than those studied in the past (Chau and Hu 2001, 2002a, 2002b; Chismar and Wiley-Patton 2002), a sample of medical residents might represent a slightly younger physician sample than the population. The mean age of respondents in the study is 35.4 years (Yi et al. 2006). SEM was used to test the model, but data is limited by being cross-sectional. A longitudinal study with a more representative sample might have returned different results.

Summary

Based on extant research on barriers to physician technology acceptance, it can be concluded that time/practice-related issues, organizational issues, personal issues, and system-specific characteristics influence a physician's acceptance of a new technology. In a physician's eyes, speed is the most important attribute a CPOE or an EMR system can possess. For the implementation of systems such as CPOEs or EMRs to be successful, a physician's practice environment must have a collaborative organizational culture that emphasizes teamwork. Without such a culture, the process redesign necessary to make such a system workable and efficient is impossible. Clinically, physicians desire the flexibility of such a system. However, the ability to customize and organize the knowledge captured on a local level is critical for physician technology acceptance. Additionally, the level of comfort a physician has with a computer also factors into his or her acceptance of technology. Furthermore, the lack of evidence that available technologies increase productivity or quality of care provides no incentive for physician technology adoption.

Seven rigorous empirical studies confirm the appropriateness of the TAM in a physician population, but the significance of the perceived ease of use construct as a part of the model is not fully supported. In five of the studies (from two samples), perceived ease of use was not significantly related to technology acceptance or perceived usefulness. The construct significantly influences perceived usefulness in two studies and has a direct influence on technology acceptance in only one study. Researchers have proposed that the reason for this construct's lack of relevance in the physician population is related to the intelligence level of the subjects; however, no additional analysis on this proposition has been conducted.

Although a number of empirical studies claim to identify physician barriers to technology acceptance, the vast majority are exploratory in nature. Five of the studies cited are qualitative in nature, and while this is useful in the initial phases of research on a phenomenon, additional quantitative research is certainly indicated to draw concrete conclusions. Furthermore, most of the published studies evaluated in this review utilize convenience samples that are small in size and not necessarily representative of the larger physician population.

The studies testing the TAM in a health care setting appear to be the exception with regard to methodological rigor. Although the samples utilized in the physician-specific TAM studies are not absolutely representative of the physician population, the sample sizes and methodological tools used are far more rigorous than those used in the majority of studies evaluating physician technology acceptance. However, it needs to be noted that four of the TAM studies cited in the review on physician-specific technology acceptance use the exact same sample. Therefore, truly only four samples validate the usefulness of the TAM in a physician population. Finally, to increase the TAM's explanatory power for physicians, a tailored approach that involves the incorporation of physician-specific variables into the model is probably indicated.

Discussion

Although the IT literature is ripe with rigorous empirical studies validating the usefulness of the TAM in predicting technology acceptance in many different contexts, health care researchers have not done such a good job identifying barriers to technology acceptance among physicians. Only 18 empirical studies on physician-specific technology acceptance have been conducted during the past 10 years. Eleven of the studies are non-TAM related and, of those, the majority are either qualitative in nature or test small convenience samples of physicians. Seven studies of the TAM in a physician context suggest that the model consistently predicts a good portion of variation in physician intention to accept new technology.

The TAM constructs generally hold in a physician-specific context, but the perceived ease of use component of the model does not prove to be consistently related to either attitudes or perceived usefulness. In five out of seven empirical studies,

perceived ease of use does not influence either attitudes or the perceived usefulness construct (Chau and Hu 2001, 2002a, 2002b; Chismar and Wiley-Patton 2002; Hu et al. 1999). In one study, perceived ease of use does not influence behavioral intention to accept technology but does influence perceived usefulness (Yi et al. 2006). Finally, in the study by Pare, Sicotte, and Jacques (2006), perceived ease of use appears to influence both attitude and perceived usefulness, but the construct does not influence attitude to the same degree that perceived usefulness does.

Although the perceived ease of use construct does not appear to be a very strong predictor of physician intention to accept technology, it is important to mention that four of the five studies testing the model use the same sample (Chau and Hu 2001, 2002a, 2002b; Hu et al. 1999). Therefore, essentially two study populations find a complete lack of significance for this construct (Chau and Hu 2001, 2002a, 2002b; Chismar and Wiley-Patton 2002; Hu et al. 1999), one offers partial support (Yi et al. 2006), and one offers full support for its continued inclusion in the model (Pare, Sicotte, and Jacques 2006). In comparing the studies to garner the actual value of the perceived ease of use construct in a physician population, probably the most representative sample was used by Yi and colleagues (2006), who detected a significant relationship between perceived ease of use and perceived usefulness.

The suggestion that this variable's importance to the model fades as individual intelligence increases has been made (Hu et al. 1999) but not empirically validated. Furthermore, this claim is contingent on the assumption that the physician population is more intelligent than the general population. It is true that physicians are more educated than the average person, and intelligence has been empirically related to educational attainment (Ganzach 1998). Still, using education as a proxy for intelligence is probably not an appropriate measurement. Standardized test scores have been used to measure intelligence (Ganzach 1998) in the management literature, and simulations of complex scenarios have been used in the decision-making literature (Wittmann and Hattrup 2004). Either or both of these approaches might be adequate in assessing physician intelligence. However, based on existent research, evidence is probably not strong enough to justify the exclusion of the perceived ease of use construct from the model based on this argument. Regardless, in the interest of parsimony, this variable's importance should be monitored in future studies of technology acceptance among physicians, and it should potentially be removed from the TAM if the significance of its predictive capability is not supported.

Health care researchers have identified increased time, organizational issues, personal characteristics, and system-specific issues as barriers to physician technology acceptance. Additionally, the lack of evidence proving the efficiency and effectiveness of information technologies in health care probably also serves as a barrier, though no empirical support for this claim exists. Based on existent research on the acceptance of information systems, it is likely that the constructs of the TAM probably mediate the influence that some of these variables might have on technology acceptance to some degree. The TAM has proven its efficacy for predicting the

acceptance of numerous types of technologies over both voluntary and involuntary practice settings (Venkatesh and Davis 2000) and numerous cultures (Al-Gahtani 2001; McCoy, Everard, and Jones 2005; Rose and Straub 1998; Straub, Keil, and Brenner 1997), and the model is applicable for individuals at all levels of IT competency (Lai and Li 2005; Yu et al. 2005). However, recent research on the TAM indicates that external variables do have the ability to influence technology acceptance both indirectly through the model's constructs and directly, beyond the mediating power of the constructs (e.g., Burton-Jones and Hubona 2006). Although TAM constructs were initially thought to fully mediate the influence that external variables have on technology acceptance, researchers continue to include external influences in efforts to increase the explanatory power of the model. Numerous external variables have been considered in the literature, but barriers to technology acceptance have been included in only one study using the TAM framework (Mathieson, Peacock, and Chin 2001).

Physician technology acceptance is hindered by a set of strong barriers that technology users in other organizational contexts do not have to face, and numerous physician-specific barriers to technology have been cited in the literature (Ash et al. 2003; Dansky et al. 1999; F. Lee et al. 1996; Overhage et al. 2001). Although the TAM likely mediates the influence that personal characteristics, system-specific characteristics, and certain organizational issues have on technology acceptance, the cost of technology adoption has been largely ignored in the literature specific to this framework. The exclusion of cost as a predictor of technology acceptance probably stems from the fact that numerous studies are conducted in a work environment where new technologies are not paid for by individual users. The TAM studies conducted in a health care context look largely at settings where either the technology was (1) not individually financed by physicians or (2) already in place. If physicians are not paying for the cost of the technology, or if the decision to pay for the technology has already been made, cost is probably not a barrier to technology acceptance. However, in private practice settings, cost might explain much of the hesitancy that physicians have in implementing new technologies.

The cost of physician time and change in practice patterns have been identified as significant barriers to technology acceptance. Although additional time is certainly required for any user to learn technology, the nature of a physician's work environment makes this barrier even stronger. For one thing, physicians are typically reimbursed based on productivity in a private practice setting. Although some doctors are salaried, this is typically the exception and not the rule. When physicians slow down to learn new technology, it costs them patient visits, which translates into revenues. Second, the unique relationship between a physician and his or her patient is different from that found in other service industries. Many physicians value this interaction and are hesitant to give it up or take time away from the experience due to new information technologies. Although the TAM has proven its predictive abilities among individuals of all IT competencies, this relationship might prove to be different in a physician context.

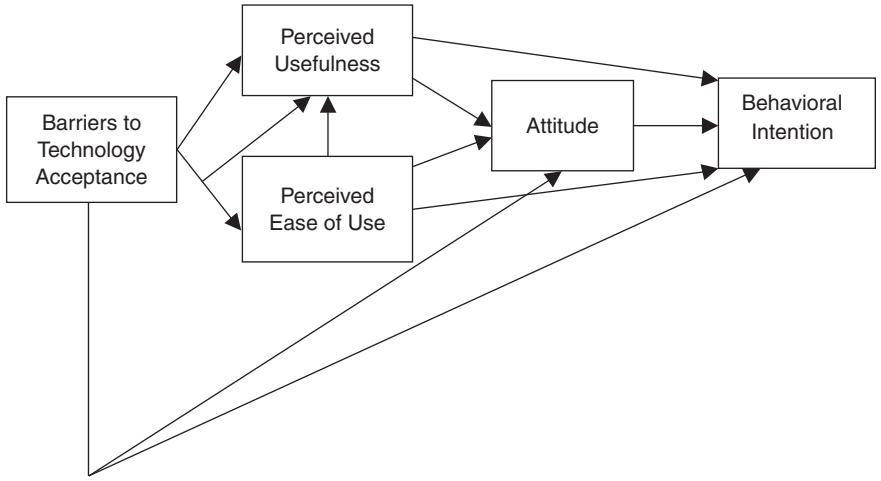
In an effort to increase the explanatory power of the TAM, a variable representing external barriers to technology acceptance needs to be added. Research indicates that time, organizational issues, system issues, and personal characteristics are significant barriers to physician technology acceptance. Testing in other contexts indicates that the TAM constructs probably mediate the influence that certain personal characteristics (i.e., level of IT competency and gender) and system-specific issues have on technology acceptance to some degree. However, barriers to technology acceptance that are unique to the physician population need to be included in the model. Both the financial and time costs of implementation should be considered as barriers in the model because both might be significant depending on the proposed new technology. Organizational issues such as the unique nature of physician reimbursement structures (salaried vs. nonsalaried) deserve consideration, as does the ownership of the health care organization in question. For example, the implementation of EMR is probably a greater cost burden to small physician practices than to larger multispecialty clinics. Finally, physician perceptions of the utility of new technology must be measured. Most empirical tests of the TAM and physician-specific technology acceptance assume that a new technology provides some value to the user. However, no compelling evidence exists to indicate that IT in a health care setting increases quality or decreases the cost of care delivery.

In figure 2, we present an enhanced version of the existing TAM that includes a new variable representing physician barriers to technology. We predict that the variable representing barriers to technology will indirectly influence technology acceptance through perceived usefulness, perceived ease of use, and the attitudinal construct. Furthermore, this variable will directly influence behavioral intention to accept technology. This model will increase the predictive capability of the TAM, furthering our understanding of physician acceptance of technology.

Implications for Future Research

For various reasons, physician technology acceptance is important to understand. The implementation and appropriate usage of telemedicine-type technologies have the potential to improve the quality of care that physicians provide and to influence patient satisfaction. However, the TAM serves to explain only a portion of technology acceptance behavior among this population. To better understand physician technology acceptance, a new scale needs to be developed to represent the physician barriers to adoption variable included in the modified model (figure 2). This scale can be derived from barriers to physician technology acceptance previously indicated in the literature (i.e., physician time, no evidence of benefit, etc.). After the scale development is complete, the new model should be tested in a sample of U.S. physician practices to determine its predictive and explanatory capabilities. After initial pilot testing of the new model, we suggest that it be tested on a sample of physicians

Figure 2
Enhanced Technology Acceptance Model



who are high utilizers of telemedicine technologies and compared to a sample of relatively average utilizers of technology. The proposed model can also be used to help us further understand the differences in the adoption of various forms of technology by different types of physician practices.

Although understanding of physician technology acceptance has been advanced through the utilization of the TAM, opportunities still exist for researchers. By incorporating external factors such as barriers to acceptance into the model, knowledge of this phenomenon can be enhanced. Recent advances in both clinical and administrative systems provide opportunities for physicians to improve communication, efficiency, and clinical quality. A better comprehension of the factors contributing to physician technology acceptance can promote the appropriate implementation of information systems in health care organizations.

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