Understanding Patients' Compliance Behavior in a Mobile Healthcare System: The Role of Trust and Planned Behavior

Completed Research Paper

Paul Benjamin Lowry
Department of Information Systems
City University of Hong Kong
88 Tat Chee Avenue
Kowloon, Hong Kong, P. R. China
pblowry@cityu.edu.hk

Dongsong Zhang
Department of Information Systems
University of Maryland, Baltimore County
1000 Hilltop Circle
Baltimore, MD 21250, USA
zhangd@umbc.edu

Dezhi Wu
Computer Science & Information Systems Department
Southern Utah University
351 West University Boulevard
Cedar City, UT 84720, USA
wu@suu.edu

Abstract

The ultimate goal of any prescribed medical therapy is to achieve desired outcomes for patients. However, patient non-compliance has long been a major problem detrimental to patients' health and thus is a concern of all healthcare providers. Patient trust in doctors and patient-doctor communication have been identified as critical factors influencing patient compliance. Nevertheless, little is known about the role of mobile technologies in patient compliance. The purpose of this paper is to predict and empirically demonstrate how mobile healthcare applications juxtaposed to patient trust can increase patients' compliance. We conducted a field survey with 125 patients in the United States. PLS techniques were employed to analyze our dataset. The results reveal that patient-doctor communication and the use of mobile system significantly impact patients' trust, which has a prominent effect on patient compliance attitude. We also find that behavioral intention, response efficacy, and self-efficacy positively influence patients' actual compliance behavior.

Keywords: healthcare, mobile healthcare system, patient compliance, trust, patient-doctor communication, patient planned behavior

Introduction

The most important goal of any prescribed medical therapy is to achieve desired outcomes for patients. However, many medical interventions and therapies are unsuccessful because patients do not comply with

the recommended treatment. It was estimated that the compliance rate of long-term medication therapies is between 40% and 50%, and that of short-term therapies is even higher at 70%~80% (DiMatteo 1995). Patients' compliance with medication therapies for hypertension was reported to vary between 50% and 70% (Sabaté 2003). People who are prescribed self-administered medications typically take less than half the prescribed dose (Haynes et al. 2008).

Therapeutic compliance has been a clinical concern for decades due to the widespread nature of non-compliance. From a perspective of healthcare providers, patient compliance is a major issue for two reasons. One is that non-compliance can have a major effect on treatment outcomes and direct clinical consequences. Poor treatment outcomes is directly associated with non-compliance (Sabaté 2003). Almost all patients who had poor compliance with drugs eventually dropped out of treatments completely, and therefore did not benefit at all from the treatment (Lim and Ngah 1991). Besides undesirable impact on clinical outcomes, non-compliance also causes increased financial burdens on societies. For example, therapeutic non-compliance has been found to be associated with excessive urgent care visits, hospitalizations, higher treatment costs, and indirect cost implications due to the loss of productivity (Osterberg and Blaschke 2005). Because of undetected or unreported therapeutic non-compliance, physicians may change the regimen, which may increase the cost or complexity of a treatment, thus further increasing the burden on patients. Therefore, from perspectives of achieving desirable clinical and economic outcomes, the factors that influence patients' non-compliance and the negative effect of non-compliance need to be examined and better understood in order to formulate effective strategies to address these problems.

Computer-aided patient education programs have been playing an important role in improving patient compliance. With the advances of today's mobile technologies, it is easy to disseminate patient education materials online and make them accessible regardless of patients' location. Recently, increasing research has started to expl0re whether mobile technologies can help improve patients' compliance behavior. A few recent studies reported a positive relationship between using mobile technologies and the increase of patients' compliance with medication (New England Healthcare Institute 2009; Qudah et al. 2010), with exercise advice (Newell and Mchiro 2012), and with HIV/AIDS treatment & prevention (Catalani et al. 2013). Research has shown that some of the biggest factors driving patient compliance include patients' trust in their doctors, and the quality of the relationships and communication among them (Piette et al. 2005). Meanwhile, research also indicates that technology can be used to increase patients' knowledge of medical therapies (Finkelstein and Wood 2009; Finkelstein and Wood 2011; Ładyzyński et al. 2006) and improve patient-doctor communication (Rowe and Calnan 2006). However, little has been done to examine how mobile technology can be further leveraged in patient education to increase patients' trust in doctors and increase patients' compliance. Therefore, the purpose of this paper is to explore this issue through predicting and empirically demonstrating how a mobile healthcare application can influence patient trust to increase their compliance with prescribed medical therapies.

The rest of the paper will be organized as follows. First, we introduce the previous work related to patient compliance and patient education, followed by the presentation of research model and hypotheses. Then, the research methodology and study results will be presented. Finally, the paper will be concluded with discussion on implications and limitations of this study and future research.

Background on Related Work

Patient compliance

Numerous studies using various methods have been conducted to evaluate the rate of patient compliance in different diseases and different patient populations, as well as to investigate the driving factors and impact of therapeutic non-compliance on clinical outcomes. The World Health Organization (WHO) identifies five interaction dimensions of patient medication adherence, which includes social/economic factors, healthcare system factors, medical condition-related factors, therapy-related factors, and patient behaviors. Mitchell and Selmes (2007) identify approximately twenty factors that influence patients' compliance, such as duration and complexity of regimen, concerns about side-effects, few perceived benefits, concerns about cost and dependency, misunderstanding instructions, poor doctor-patient

relationship, and poor explanation and communication. Jin et al. (2008) conducted a literature review and found that (1) patients' beliefs about the causes and meaning of illness and motivations to follow a therapy were strongly related to their compliance; (2) patients with a lower educational level might have more trust in physicians' advice; (3) patients with low health literacy were reported to be less compliant with their therapy; (4) patient's knowledge about their disease and treatment is not always adequate. Some patients lack of understanding of the role in a treatment (Ponnusankar et al. 2004); others lack knowledge about a disease and consequences of poor compliance (Alm-Roijer et al. 2004). Patients typically leave a clinic with a poor understanding of the rationale for a therapy (Weiden et al. 2004). As a result, patient education is very important for enhancing compliance. Compliance generally increases if patients are given clear and understandable information about their condition and progress in a sincere and responsive way. For example, counseling about medications has been proven to be useful in improving patient's compliance (Ponnusankar et al. 2004).

Patient education

In current patient-centered health care, the role of patients as an active partner, instead of just a passive object of diagnostic testing and medical treatment, has been widely accepted (Pellisé and Sell 2009). A number of surveys have shown that a significant proportion of patients would like to play an active role in decisions concerning their health (Légaré et al. 2010). One of the most critical problems existing in healthcare service delivery is patients' lack of valuable information and knowledge related to their disease diagnosis and treatment processes (Tait et al. 2009), which may result in poor compliance and drug adherence of patients. Some patient intervention programs may help improve this situation. For example, the American Health Association's 360 Web-based home blood monitoring program has led to greater blood pressure reductions, superior patient control, and higher patient satisfaction (Magid et al. 2013).

It is argued that educating patients about their disease status and general comprehension of medications would increase their active participation in a treatment (Rubin 2005). Some research has suggested an "inverted U shape" relationship between medical knowledge and patient compliance in adolescents, indicating that patients who have an appropriate level of knowledge about their disease and drug regimens are more likely to comply (Jin et al. 2008). However, there has also been research reporting that patients with detailed knowledge about a disease may not always be effective (Chan and Molassiotis 1999).

In summary, there has been extensive research on patient compliance in the literature. However, we have not found any studies on the impact of mobile health education systems on patient trust in doctors and on their compliance behavior. Achieving a better understanding of such impact can provide significant research and practical implications on how to leverage mobile technologies to improve patient compliance, which in turn improves healthcare outcomes.

Mobile technologies in improving patient compliance

Patient compliance can be potentially improved with new advances in ubiquitous computing and mobile communication. There has been increasing research on using mobile devices to improve patients' compliance. Some research uses mobile patient monitoring systems that include medical sensors. For example, Qudah et al. (2010) proposed a medication compliance management system to improve medication compliance and awareness for cardiac patients using mobile phones. The system is designed to collect and analyze medication compliance, side effects, and symptom responses, and transfers the collected data in real time to a web-based system for remote monitoring by caregivers and health professionals. Corventis has deployed a NUVANT Mobile Cardiac Telemetry system that includes an externally worn adherent sensing device called PiiX (Engel et al. 2011). Patient compliance in that context is a challenge for such patient-applied adherent devices. Corventis PiiX offers a unique opportunity for extracting patient application compliance information from incoming health data.

The second type of research is to use mobile health education systems or mobile SMS to deliver instructions to patients in order to improve compliance. For instance, Saidinejad and Zorc (2014) propose to incorporate images, animation, and web-based video content that is better suited for patients with low health literacy.

Such educational information can be delivered both synchronously and asynchronously to mobile devices of patients whenever it is needed. However, that system has not been implemented and evaluated yet. Mobile phone text messaging is also often used for promoting adherence to treatment (Nglazi et al. 2013). Newell and MChiro (2012) investigated the use of mobile SMS messages in increasing chiropractic patients' compliance through providing them with exercise advice. Results revealed that patients in the SMS group were six times more likely to complete exercises than those who did not receive advice through SMS. In addition, only patients in the SMS group reported significant increases in self-reported compliance. Overall, the positive effects of mobile technologies on patient compliance are promising.

Research Model and Hypotheses

In this section, we propose our theoretical model and hypotheses that can be used to explain how a mobile patient education system enhances communication, trust, and compliance of patients. Our model is presented in Figure 1. The theoretical foundation of our model is the well-known theory of planned behavior (TPB) (Ajzen 1991). The key focus of our use of TPB is to explain how a patient's trust in his/her doctor may influence his/her treatment compliance, along with other factors that are derived from TPB. We explain that one's general satisfaction and communication quality with his/her doctor helps form his/her trust of his/her doctor, while communication barriers with the doctor decrease trust. Moreover, we will explain how the use of a mobile healthcare application designed to increase patients' understanding of treatments also serves to increase trust and compliance. Finally, we include a large number of covariates in our model so that we could test what else might affect patient compliance. An unrelated marker variable was included in the survey questionnaire so that we could check whether a common-method bias exists in our data.

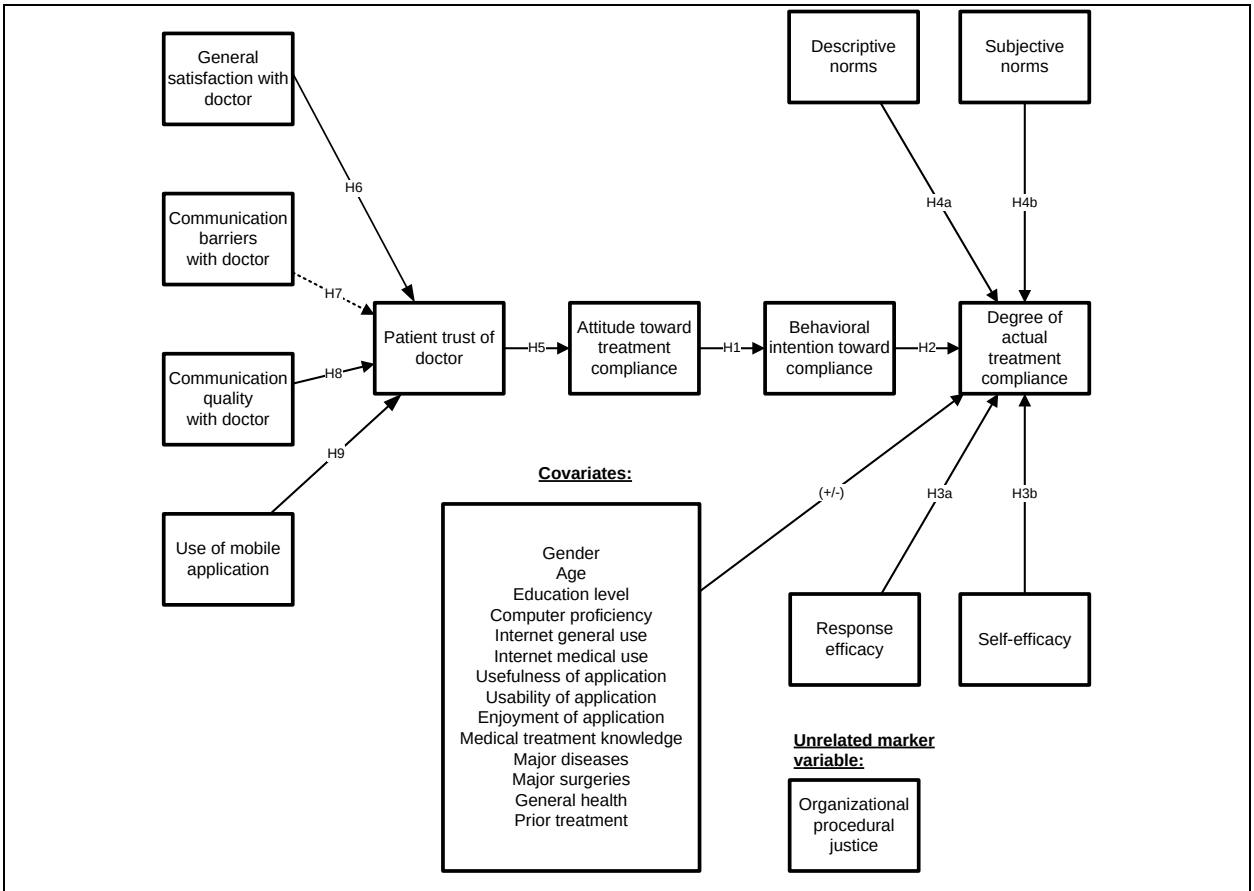

Figure 1. Proposed Research Model

Note: a dotted line indicates a negative relationship.

Predictions from the Theory of Planned Behavior

We use the TPB to account for the formation of attitudes from beliefs, norms, and self-efficacy, which can then be used to predict subsequent behaviours (Ajzen 1991). The TPB implicitly assumes that individuals seek to attain an objective and that they need to assess the extent to which the technology under consideration can help them do so (Liang et al. 2009). Fundamental to TPB is the idea that attitudes are the drivers of intentions, which are the drivers of actual behaviors. We leveraged and applied these concepts and predictions to the healthcare compliance context. In our model, 'attitudes toward treatment compliance' is the primary driver of behavioral intention toward treatment compliance, which then drives actual treatment compliance behaviors. If TPB holds in our context, then the following should hold:

H1. An increase in positive attitude toward treatment compliance is associated with an increase in behavioral intention toward treatment compliance.

H2. An increase in behavioral intention toward treatment compliance is associated with an increase in the degree of actual treatment compliance.

We also follow the TPB assumption that one's actual behaviors will be impacted by his/her efficacy. Self-efficacy is a long-established component of the TPB that we believe is highly significant for the medical treatment compliance context because it covers patients' basic self-assessment regarding their ability to follow medical advice effectively and regarding whether they believe a recommended treatment is efficacious. In TPB, efficacy is conceptualized as response efficacy and self-efficacy. Based on the literature on compliance (Bulgurcu et al. 2010; Herath and Rao 2009; Johnston and Warkentin 2010), we define *self-efficacy* in our context as a patient's judgment of his/her personal ability, competency, and knowledge in complying with a recommended medical treatment. Likewise, *response efficacy* is a patient's judgment of the likely effectiveness and positive outcomes associated with a recommended medical treatment. Assuming that these efficacy judgments play a role in patients' compliance with medical recommendations, the following hypothesis should hold:

H3. Increases in response efficacy (a) and in self-efficacy (b) toward a treatment are each associated with an increase in the degree of actual treatment compliance.

Finally, we follow the TPB assumption that social influence or normative beliefs will influence actual compliance behaviors. *Normative beliefs* represent a person's perceived social pressure to comply with a recommendation, as informed by a person's important social referents for the context (Bulgurcu et al. 2010). Normative beliefs are also known as social influence, which comprises subjective norms and descriptive norms (Herath and Rao 2009). We apply the same concepts to our research model. By following compliance literature (Herath and Rao 2009; Johnston and Warkentin 2010), *subjective norms* in our context represent the degree to which patients believe other key people (e.g., family, friends, co-workers) in patients' lives want them to comply with a treatment recommendation. *Descriptive norms* represent a patient's beliefs about what is commonly done by most patients or by general public in terms of compliance with a specific medical recommendation.

According to the TPB, norms affect individuals' intentions (Ajzen 1991; Leone et al. 1999). In a security context, Siponen (2000) found that norms work due to the desire to conform to a group to which one belongs; this was also confirmed by Mishra and Dhillon (2006). Psychology researchers have long proposed that conformity to groups is attributable to norms and the pressures that norms place on individuals within a group (Postmes and Spears 1998; Reicher and Levine 1994; Wiatrowski et al. 1981). Assuming these social norms also play a role in patients' decisions regarding medical recommendation compliance, the following hypothesis should hold:

H4. Increases in descriptive norms (a) and subjective norms (b) toward a treatment are each associated with an increase in the degree of actual treatment compliance.

The Crucial Role of Trust in Patient Compliance Attitude Formation

Trust has traditionally been considered a cornerstone of effective doctor–patient relationships (Rowe and Calnan 2006). The need for interpersonal trust relates to the vulnerability associated with being ill, the

information asymmetries arising from the nature of medical knowledge, and the uncertainty and element of risks regarding the competence and intentions of the practitioner on whom a patient is dependent (Rowe and Calnan 2006). Without trust, patients may not access services at all, let alone disclose all medically relevant information (Rowe and Calnan 2006). The days of 'doctor knows best' when patients blindly trusted in and deferred to medical expertise are fast becoming a distant memory in industrialized societies where the patient is dubbed 'king'. Patients expect to play an active part in decision-making regarding their treatment. Might lower levels of trust, or in fact distrust, be merited in light of medical errors, drug side effects, and the slow adoption of 'evidence-based' medical innovations and clinical guidelines? In this paper, we set out how and why trust relations in the healthcare context are changing, arguing that although trust may now be more conditional, it is still vitally important for both health care providers and institutions.

Trust and communication are two elements critical to optimizing patient compliance and adherence. Central to patient compliance is the relationship between patients and healthcare service providers. In particular, healthy relationship is based on patients' trust in physicians and empathy from physicians (Gonzalez et al. 2005). Accordingly, modifying patients' attitudes and beliefs is only possible when a high level of patient trust exists.

Numerous studies have shown that patient trust in physicians is more important than treatment satisfaction in predicting adherence to prescribed therapy and overall satisfaction with care (Piette et al. 2005). Trust in a physician correlates positively with patients' acceptance of new medications, intention to follow physician instructions, perceived effectiveness of care, and improvements of self-reported health status (also representing increased communication quality). Rubin (2005) introduced some situations that may influence a patient's trust in physicians. For example, there will be low levels of patients' trust in physicians when physicians answer few questions or when patients find it difficult to understand a physician's language or writing. More importantly, too little time spent with patients is also likely to diminish patient's motivation for maintaining a therapy (Lawson et al. 2005). Summarizing this section, we predict the following:

H5. An increase in patients' trust of their doctors is associated with an increase in their positive attitudes toward treatment compliance.

H6. An increase in patients' general satisfaction with their doctors is associated with an increase in their trust of their doctors.

H7. An increase in patients' communication barriers with their doctors is associated with a decrease in their trust of their doctors.

H8. An increase in patients' communication quality with their doctors is associated with an increase in their trust of their doctors.

Use of a Mobile Healthcare Application to Increase Patient Trust and Compliance

Our final hypothesis predicts that mobile healthcare applications designed for patient education can help increase patients' trust in their doctors and subsequent treatment compliance. Our contextual assumption for the design of this study was that patients would use a mobile healthcare education system to learn about the treatment that they are seeking in a just-in-time manner in their doctors' waiting room right before seeing a doctor about the treatment. The idea here is that patients can learn the key terms, procedures, issues, and benefits involved in a treatment, and thus to communicate with a doctor with more knowledge and confidence to discuss a treatment. Furthermore, such an educational artifact allows basic questions to be answered ahead of time and thus enables patients to use time with their doctors more effectively.

To further explain and justify this prediction, we use several lines of reasoning and evidence. First, one of the biggest problems in trust formation between patients and doctors is poor communication and misunderstandings between them (Rubin 2005). One of the reasons for this poor communication is that patients do not have similar training as doctors and often do not express a shared understanding of the terms and issues involved in a treatment. Seminal research shows that key reasons for patient dissatisfaction is doctors' use of jargons, not accounting for patients' concerns and expectations, and doctors not explaining diagnosis and treatments clearly (Korsch et al. 1968). We thus argue that a mobile

educational artifact can help eliminate these barriers and create more shared understanding and better communication during a visit. Such an experience will be more satisfying for patients as they will have more of their questions answered and talk to their doctors with more knowledge. Furthermore, a key issue in relationships between patients and doctors is too little time together, which undermines communication and trust (Lawson et al. 2005). Using a mobile patient education application before a time-constrained visit would allow such a visit to be more effectively utilized by both a patient and a doctor and strengthen their relationship.

Some researchers have explored the use of interactive patient education systems on mobile devices such as mobile phones (e.g., Finkelstein and Wood 2009; Finkelstein and Wood 2011; Ładyzyński et al. 2006). Preliminary results show that such devices do increase patients' knowledge about treatment. However, few researchers have explored patient trust and satisfaction issues. Although little related research has examined mobile healthcare technology use and increased patient trust in doctors, initial work suggests that this link is likely. Street Jr. et al. (2010) examined the effect of a tailored education intervention, grounded in social-cognitive and communication theories, to help patients more effectively discuss their pain-related questions, concerns, and preferences with physicians. The results indicated that patients using the tailored coaching intervention discussed their pain concerns more than patients in the control group did, and that ratings of physicians' information about patients' pain were higher because patients talked more about their pain concerns. We believe that the same benefits should be observed in the use of a personalized mobile patient education system.

Finally, we argue that doctors who provide such a mobile patient education application in their waiting rooms not only better prepare their patients for communication about the treatment, but also send a message of care and empathy and signal that they want to help patients prepare and engage in an intelligent discussion about their treatment. In addition, long waiting by patients in a waiting room is linked to patients' dissatisfaction and switching their care providers (Rubin et al. 1993). Use of a mobile education application could help cut down the monotony of waiting and potentially improve patient satisfaction. Finally, since the lack of understanding, poor communication, and medical jargon decrease patient satisfaction (Korsch et al. 1968), anything that can overcome these issues should help foster satisfaction and subsequent trust. Therefore, we believe that the use of mobile patient education applications should foster trust between patients and doctors.

By summarizing our arguments in this section, we predict the following:

H9. An increase in patients' use of a mobile patient education application designed to increase patients' knowledge about a particular medical treatment will increase patients' trust in their doctors.

Research Methodology

To test our research model, a field survey study was conducted with real patients in several states of the United States, who were able to use the ABC Company's mobile healthcare system designed to improve patient education and experiences at either their doctors' clinics or hospitals. This study was officially approved by the respective Institutional Review Board (IRB), and carefully followed the U.S. Health Insurance Portability and Accountability Act of Privacy, Security and Breach Notification Rules (HIPAA) to protect patients' rights. After getting all approvals, we were able to put up a flyer on the ABC Company's website to invite the interested patients who have used the mobile education system to participate in our field study. The incentive that we provided was a US$10 honorarium for each survey respondent who provided valid and complete responses to our survey.

Patient participation was voluntary. During the period of two and half months, 126 patient responses were received and we excluded one response from further data analysis due to the majority of questions unanswered. Therefore, there were 125 valid responses including 110 plastic surgery patients, 9 obstetrics patients, and 6 from other medical fields. All of the respondents were female. The average age was 39.6.

A Mobile Healthcare System

The mobile healthcare system on which we focused in this study was one of the commercial products owned by the ABC Company. ABC is a software company whose main products are healthcare systems that aim to address the communication and trust issues between patients and doctors and to improve patients' knowledge related to their medical procedures. The system has been sold and deployed in many clinics and hospitals in North America and South America. Patient users can access patient records and education materials via the system in doctors' clinics or anywhere else through the Internet with different mobile devices. The web portal interface is easy to navigate, and the contents are customized for patients according to their individual health situations.

Measures

For the study constructs and measures, we either adapted or modified existing validated scales from prior research. We tailored the questions to fit in the context of this study. Questions on general satisfaction with doctors were taken from the "overall satisfaction" dimension of the patient satisfaction questionnaire for a specific doctor designed by Ware Jr. et al. (1983). Questions for communication barriers and communication quality with doctors constructs were adapted from the scale developed by Steine et al. (2001). Questions about patient trust of a doctor were adopted from Hall et al. (2002)'s study. Use of application was customised to the medical context based on a self-reported intranet use measure (Horton et al. 2001). Subjective norms and descriptive norms constructs were modified based on the validated instruments originally developed by Herath and Rao (2009). Response efficacy and self-efficacy constructs were adapted from the scale developed by Workman et al. (2008). Attitude toward treatment compliance, intention toward treatment compliance, and degree of actual compliance constructs were constructed by modifying similar measures developed by Bulgurcu et al. (2010) and Hu et al. (2011).

Data Analysis Results

Because all of our constructs are reflective and our research model contains both the first-order and second-order constructs, Partial Least Squares (PLS) techniques were employed to examine our research model. PLS has been suggested for testing novel propositions with limited prior theoretical development (Gefen et al. 2011; Lowry and Gaskin 2014; Rai et al. 2006), which is the nature of this study. More specifically, we used SmartPLS software version 2.0 (Ringle et al. 2005) to examine our research model. We also used the marker-variable technique to test the common-method bias issue (Malhotra et al. 2006) with our survey data, and confirmed that common-method bias was not a major concern.

Measurement Model

We tested internal consistency reliabilities and convergent and discriminant validity of the measurement items. Both composite reliability (>0.70) and the average variance extracted (AVE>0.50) (Fornell and Larcker 1981) reached a satisfying level as suggested by Fornell and Larcker (1981). As such, the internal consistency reliabilities and convergent validity were confirmed.

Furthermore, in order to verify discriminant validity, we computed the square root of the AVE for all latent variables and compared them against their correlations with other constructs (Fornell and Larcker 1981). All the square roots of the AVEs are greater than their correlations with any other constructs, so discriminant validity is also confirmed (Barclay et al. 1995).

Because all factor measures load highly (>0.50) on their associated latent constructs (Wixom and Watson 2001), we were able to confirm both convergent and discriminant validity of this study. More specifically, all items are above 0.70 on their targeted constructs, which are much higher than the suggested threshold (>0.50), and these loadings are much higher than any other cross-loadings. Therefore, our results support convergent and discriminant validity, following the latest standards (Lowry and Gaskin 2014).

Structural Model

Using SmartPLS version 2.0, we assessed the structural model to examine the path coefficients and utilized the bootstrapping method with 500 re-samples to compute their statistical significance levels. Figure 2 provides an overview of the PLS results. General satisfaction with doctor positively affected patient trust of doctor (β = 0.245; $p < 0.001$; H6 supported); communication barriers with doctor negatively impacted patient trust of doctor (β = -0.322; $p < 0.001$; H7 supported), and communication quality with doctor significantly influenced patient trust of doctor (β = 0.276; $p < 0.01$; H8 supported). Use of application was found to significantly affect patient trust of doctor (β = 0.143; $p < 0.01$; H9 supported). Furthermore, patient trust of doctor had a very positive relationship with attitude toward treatment compliance (β =0.414, $p < 0.001$; H5 supported). Attitude toward treatment compliance was positively related to behavioural intention toward compliance (β = 0.661; $p < 0.001$; H1 supported), which also significantly influenced degree of actual treatment compliance (β = 0.306; $p < 0.05$; H2 supported). The data results also indicated that response efficacy (β = 0.352; $p < 0.01$; H3a supported), and self-efficacy (β = 0.263; $p < 0.05$; H3b supported) significantly influenced degree of actual treatment compliance. However, subjective norms and descriptive norms had no impact on patients' actual treatment compliance behaviour (H4a and H4b not supported). Overall, this research model explains 69.3% variance in patients' actual compliance behaviour (see Figure 2). A summary of our hypotheses testing results is presented in Table 1.

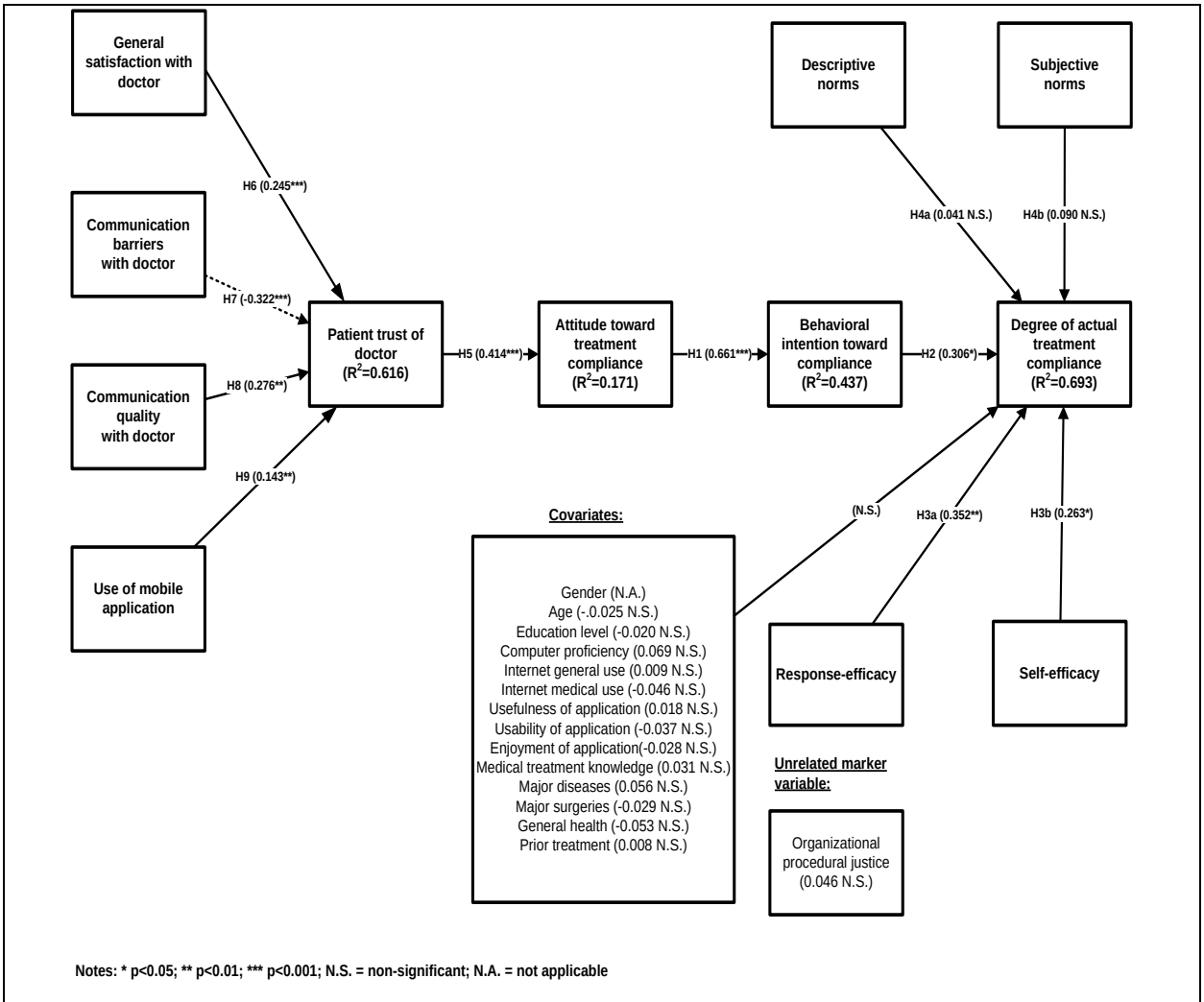

Figure 2. Results of Research Model Testing

Table 1. Summary of Hypotheses Testing Results			
Hypotheses	Path coefficient	Level	Hypothesis supported? (Yes/No)
H1. An increase in positive attitude toward treatment compliance is associated with an increase in behavioral intention toward treatment compliance.	0.661	$p<0.001$ (***)	Yes
H2. An increase in behavioral intention toward treatment compliance is associated with an increase in the degree of actual treatment compliance.	0.306	$p<0.05$ (*)	Yes
H3. An increase in response efficacy (a) and in self-efficacy (b) toward a treatment are each associated with an increase in the degree of actual treatment compliance.	H3a: 0.352 H3b: 0.263	H3a: $p<0.01$ (**) H3b: $p<0.05$ (*)	Yes Yes
H4. An increase in descriptive norms (a) and subjective norms (b) toward a treatment are each associated with an increase in the degree of actual treatment compliance.	H4a: 0.041 H4b: 0.090	H4a: Non-significant H4b: Non-significant	No No
H5. An increase in patients' trust of their doctors is associated with an increase in their positive attitudes toward treatment compliance.	0.414	$p<0.001$ (***)	Yes
H6. An increase in patients' general satisfaction with their doctors is associated with an increase in their trust of their doctors.	0.245	$p<0.001$ (***)	Yes
H7. An increase in patients' communication barriers with their doctors is associated with a decrease in their trust of their doctors.	-0.322	$p<0.001$ (***)	Yes
H8. An increase in patients' communication quality with their doctors is associated with an increase in their trust of their doctors.	0.276	$p<0.01$ (**)	Yes
H9. An increase in patients' use of a mobile patient education application designed to increase patients' knowledge about a particular medical treatment will increase patients' trust in their doctors.	0.143	$p<0.01$ (**)	Yes

Study Contributions and Implications

We leveraged TPB along with fundamental concepts of trust to propose a model that explains and predicts how a mobile patient education system can help foster trust of patients in doctors and eventually increase treatment compliance. In our focused context, we found strong evidence for our expanded TPB model. Attitudes toward treatment compliance were positively related to intentions toward treatment compliance, and these intentions were positively related to actual treatment compliance behaviors. As a key finding of our study, we demonstrated that patients' trust in their doctors indeed is a significant predictor of positive attitude formation. We also confirmed that satisfaction with doctor, communication quality, and use of a mobile education application all foster patients' trust in doctors. Communication barriers, on the other hand, decreases trust. The one key exception in our model was the insignificant impact of social norms (i.e., subjective and descriptive norms). This was particularly surprising in the context of plastic surgery visits, in which we expected social norms to play a stronger role.

We believe that our results are particularly important because of the importance of communication, trust, and system use factors to patient treatment compliance. None of these 14 identified control variables was significant.

Study Limitations and Future Research

Due to the nature of the field study, there are a few limitations of the present study: (1) This field study was restricted to the physicians who have adopted the mobile healthcare system for their practices and were willing to offer us the access to their patients. Although all valid survey respondents were female, they perfectly represent the population in the related medical practices (i.e., plastic surgery and obstetrics). (2) After going through many complicated legal and research coordination processes, we were only allowed to conduct the study with patients who have tried the mobile system, thus we were not able to reach the patients who were still using the traditional patient education systems as a control group.

Patient compliance behaviour has not been well studied across populations, diseases, and settings. This makes it difficult for health professionals and patients to know which strategies work and which do not (Ryan and Hill 2011). For future research, in order to make our findings more generalizable, we may seek new opportunities to approach other types of patients such as chronic diabetes and cardiovascular patients who have serious compliance problems with both females and males in a mobile healthcare setting. For example, given the huge burden of coronary artery disease and the effectiveness of medication therapy, understanding and quantifying known impacts of poor medication adherence by patients will be critical to patient compliance (Bitton et al. 2013). In addition, according to Fogg (2009)'s behavior model of persuasive design and more personally controlled help-seeking features suggested by Lau et al. (2013), it would be more valuable to conduct a longitudinal field study, through which we can observe patients' compliance behaviours during their different stages of treatments in comparison to a control group. Moreover, we may also explore how different types of mobile interface designs affect both patients' compliance behavior and doctors' decision-making processes. Conversely, because mobile healthcare systems represent a new technology innovation, many hospitals and physicians' offices have not adopted such a system to benefit their patients. However, how physicians can make more informed decisions to address patients' non-compliance issues with a mobile healthcare system more effectively warrants further investigation.

References

Ajzen, I. 1991. "The Theory of Planned Behavior," *Organizational Behavior and Human Decision Processes* (50:2), pp. 179-211.

Alm-Roijer, C., Stagmo, M., Udén, G., and Erhardt, L. 2004. "Better Knowledge Improves Adherence to Lifestyle Changes and Medication in Patients with Coronary Heart Disease," *European Journal of Cardiovascular Nursing* (3:4), pp. 321-330.

Barclay, D. W., Higgins, C. A., and Thompson, R. 1995. "The Partial Least Squares Approach to Causal Modeling: Personal Computer Adoption and Use as an Illustration," *Technology Studies* (2:2), pp. 285-324.

Bitton, A., Choudhry, N. K., Matlin, O. S., Swanton, K., and Shrank, W. H. 2013. "The Impact of Medication Adherence on Coronary Artery Disease Costs and Outcomes: A Systematic Review," *The American Journal of Medicine* (126:4), pp. 357. e357-357. e327.

Bulgurcu, B., Cavusoglu, H., and Benbasat, I. 2010. "Information Security Policy Compliance: An Empirical Study of Rationality-Based Beliefs and Information Security Awareness," *MIS Quarterly* (34:3), pp. 523-548.

Catalani, C., Philbrick, W., Fraser, H., Mechael, P., and Israelski, D. M. 2013. "Mhealth for Hiv Treatment & Prevention: A Systematic Review of the Literature," *The Open AIDS Journal* (7:2013), pp. 17-41.

Chan, and Molassiotis 1999. "The Relationship between Diabetes Knowledge and Compliance among Chinese with Non-Insulin Dependent Diabetes Mellitus in Hong Kong," *Journal of Advanced Nursing* (30:2), pp. 431-438.

DiMatteo, M. R. 1995. "Patient Adherence to Pharmacotherapy: The Importance of Effective Communication," *Formulary* (30), pp. 596–598, 601–592, 605.

Engel, J. M., Chakravarthy, N., Katra, R. P., Mazar, S., Libbus, I., and Chavan, A. 2011. "Estimation of Patient Compliance in Application of Adherent Mobile Cardiac Telemetry Device," Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEEpp. 1536-1539.

Finkelstein, J., and Wood, J. 2009. "Mobile Elearning Platform for Interactive Patient Education," International Conference on Mobile, Hybrid, and On-line Learning (ELML '09), February 1-7, pp. 23-27.

Finkelstein, J., and Wood, J. 2011. "Information Technology for Continuous Patient Health Education," in: *Proceedings of the 2011 conference on Information technology education*, ACM, West Point, New York, USA, pp. 245-250.

Fogg, B. J. 2009. "A Behavior Model for Persuasive Design," in: *Proceedings of the 4th International Conference on Persuasive Technology*, ACM, Claremont, CA, pp. 1-7.

Fornell, C., and Larcker, D. F. 1981. "Evaluating Structural Equation Models with Unobservable Variables and Measurement Error," *Journal of Marketing Research* (18:1981), pp. 39-50.

Gefen, D., Rigdon, E. E., and Straub, D. W. 2011. "An Update and Extension to SEM Guidelines for Administrative and Social Science Research," *MIS Quarterly* (35:2), pp. iii-xiv.

Gonzalez, J., Williams, J. W., Noël, P. H., and Lee, S. 2005. "Adherence to Mental Health Treatment in a Primary Care Clinic," *The Journal of the American Board of Family Practice* (18:2), pp. 87-96.

Hall, M. A., Zheng, B., Dugan, E., Camacho, F., Kidd, K. E., Mishra, A., and Balkrishnan, R. 2002. "Measuring Patients' Trust in Their Primary Care Providers," *Medical Care Research Review* (59:3), pp. 293-318.

Hamburg, B. A., and Inoff, G. E. 1982. "Relationships between Behavioral Factors and Diabetic Control in Children and Adolescents: A Camp Study," *Psychosomatic Medicine* (44), pp. 321-339.

Haynes, R. B., Ackloo, E., Sahota, N., McDonald, H. P., and Yao, X. 2008. "Interventions for Enhancing Medication Adherence," *Cochrane Database of Ssytematic Reviews* (2:2).

Herath, T., and Rao, H. 2009. "Protection Motivation and Deterrence: A Framework for Security Policy Compliance in Organisations," *European Journal of Information Systems* (18:2), p 106.

Horton, R. P., Buck, T., Waterson, P. E., and Clegg, C. W. 2001. "Explaining Intranet Use with the Technology Acceptance Model," *Journal of Information Technology* (16:4), pp. 237-249.

Hu, Q., Xu, Z., Dinev, T., and Ling, H. 2011. "Does Deterrence Work in Reducing Information Security Policy Abuse by Employees?," *Communications of the ACM* (54:6), pp. 54-60.

Jin, J., Sklar, G. E., Oh, V. M. S., and Li, S. C. 2008. "Factors Affecting Therapeutic Compliance; a Review from the Patient's Perspective," *Therapy clinical risk management* (4:1), pp. 269-286.

Johnston, A. C., and Warkentin, M. 2010. "Fear Appeals and Information Security Behaviors: An Empirical Study," *MIS Quarterly* (34:1), pp. 549-566.

Korsch, B. M., Gozzi, E. K., and Francis, V. 1968. "Gaps in Doctor-Patient Communication: I. Doctor-Patient Interaction and Patient Satisfaction," *Pediatrics* (42:5), pp. 855-871.

Ładyzyński, P., Wójcicki, J. M., Krzymień, J., Foltyński, P., Migalska-Musiał, K., Tracz, M., and Karnafel, W. 2006. "Mobile Telecare System for Intensive Insulin Treatment and Patient Education. First Applications for Newly Diagnosed Type 1 Diabetic Patients," *The International journal of artificial organs* (29:11), pp. 1074-1081.

Lau, A. Y., Proudfoot, J., Andrews, A., Liaw, S.-T., Crimmins, J., Arguel, A., and Coiera, E. 2013. "Which Bundles of Features in a Web-Based Personally Controlled Health Management System Are Associated with Consumer Help-Seeking Behaviors for Physical and Emotional Well-Being?," *Journal of medical Internet research* (15:5).

Lawson, V. L., Lyne, P. A., Harvey, J. N., and Bundy, C. E. 2005. "Understanding Why People with Type 1 Diabetes Do Not Attend for Specialist Advice: A Qualitative Analysis of the Views of People with Insulin-Dependent Diabetes Who Do Not Attend Diabetes Clinic," *Journal of Health Psychology* (10:3), pp. 409-423.

Légaré, F., Ratté, S., Stacey, D., Kryworuchko, J., Gravel, K., Graham, I. D., and Turcotte, S. 2010. "Interventions for Improving the Adoption of Shared Decision Making by Healthcare Professionals," *Cochrane Database of Systematic Reviews* (5:May).

Leone, L., Perugini, M., and Ercolani, A. P. 1999. "A Comparison of Three Models of Attitude-Behavior Relationships in the Studying Behavior Domain," *European Journal of Social Psychology* (29:2-3), pp. 161-189.

Liang, H., Xue, Y., Lim, V. K. G., and Teo, T. S. H. 2009. "Avoidance of Information Technology Threats: A Theoretical Perspective Prevalence," *MIS Quarterly* (33:1), pp. 71-90.

Lim, T. O., and Ngah, B. A. 1991. "The Mentakab Hypertension Study Project. Part Ii – Why Do Hypertensives Drop out of Treatment?," *Singapore Medical Journal* (32), pp. 249-251.

Lowry, P. B., and Gaskin, J. 2014. "Partial Least Squares (PLS) Structural Equation Modeling (SEM) for Building and Testing Behavioral Causal Theory: When to Choose It and How to Use It," *IEEE Transactions on Professional Communication* (57:2), pp. 123-146.

Magid, D., Olson, K., Billups, S., Wagner, N., Lyons, E., and Kroner, B. 2013. "A Phramacist-Led, American Health Association Heart360 Web-Enabled Home Blood [Ressure Monitoring Program," *Cardiovascular Quality Outcomes* (6:2013), pp. 157-163.

Malhotra, N., Kim, S., and Patil, A. 2006. "Common Method Variance in IS Research: A Comparison of Alternative Approaches and a Reanalysis of Past Research," *Management Science* (52:12), pp. 1865-1883.

Mishra, S., and Dhillon, G. 2006. "Information Systems Security Governance Research: A Behavioral Perspective," 1st Annual Symposium on Information Assurance, Academic Track of the 9th Annual 2006 NYS Cyber Security Conference, New York, NY, June 14-15, pp. 18-26.

Mitchell, A., and Selmes, T. 2007. "Why Don't Patients Take Their Medicine? Reasons and Solutions in Psychiatry," *Advances in Psychiatric Treatment* (13), pp. 336-346.

New England Healthcare Institute 2009. *Thinking Outside the Pillbox: A System-Wide Approach to Improving Patient Medication Adherence for Chronic Disease*: New England Health Care Institute.

Newell, D., and Mchiro, R. B. 2012. "Increasing Compliance toward Home Exercise in Chiropractic Patients Using Sms Texting: A Pilot Study," *Clinical Chiropractic* (15:3), pp. 107-111.

Nglazi, M. D., Bekker, L. G., Wood, R., Hussey, G. D., and Wiysonge, C. S. 2013. "Mobile Phone Text Messaging for Promoting Adherence to Anti-Tuberculosis Treatment: A Systematic Review Protocol. Systematic Reviews," *BMC Infectious Diseases* (2:6).

Osterberg, L., and Blaschke, T. A. 2005. "Adherence to Medication," *New England Journal of Medicine* (353), pp. 487-497.

Pellisé, F., and Sell, P. 2009. "Patient Information and Education with Modern Media: The Spine Society of Europe Patient Line," *European Spine Journal* (18:3), pp. 395-401.

Piette, J. D., Heisler, M., and Krein, S. 2005. "The Role of Patient-Physician Trust in Moderating Medication Nonadherence Due to Cost Pressures," *Archives of Internal Medicine* (165), pp. 1749-1755.

Ponnusankar, S., Surulivelrajan, M., Anandamoorthy, N., and Suresh, B. 2004. "Assessment of Impact of Medication Counseling on Patients' Medication Knowledge and Compliance in an Outpatient Clinic in South India," *Patient Education and Counseling* (54:1), pp. 55-60.

Postmes, T., and Spears, R. 1998. "Deindividuation and Antinormative Behavior: A Meta-Analysis," *Psychological Bulletin* (123:3), pp. 238-259.

Qudah, I., Leijdekkers, P., and Gay, V. 2010. "Using Mobile Phones to Improve Medication Compliance and Awareness for Cardiac Patients," 3rd International Conference on Pervasive Technologies Related to Assistive Environments, Samos, Greece, June 23-25.

Rai, A., Patnayakuni, R., and Seth, N. 2006. "Firm Performance Impacts of Digitally Enabled Supply Chain Integration Capabilities," *MIS Quarterly* (30:2), pp. 225-246.

Reicher, S., and Levine, M. 1994. "On the Consequences of Deindividuation Manipulations for the Strategic Communication of Self: Identifiability and the Presentation of Social Identity," *European Journal of Social Psychology* (24:4), pp. 511-524.

Ringle, C. M., Wende, S., and Will, S. 2005. "Smartpls 2.0 (M3) Beta," retrieved: September 17, 2010, from http://www.smartpls.de.

Rowe, R., and Calnan, M. 2006. "Trust Relations in Health Care—the New Agenda," *European Journal of Public Health* (16:1), pp. 4-6.

Rubin, H. R., Gandek, B., Rogers, W. H., Kosinski, M., McHorney, C. A., Ware, J. E., and Jr 1993. "Patients' Ratings of Outpatient Visits in Different Practice Settings: Results from the Medical Outcomes Study," *JAMA* (270:7), pp. 835-840.

Rubin, R. R. 2005. "Adherence to Pharmacologic Therapy in Patients with Type 2 Diabetes Mellitus," *American Journal of Medicine* (118), pp. 27s–34.

Ryan, R., and Hill, S. 2011. "Consumer-Oriented Interventions for Evidence-Based Prescribing and Medicines Use: An Overview of Systematic Reviews," *Journal of Evidence-Based Medicine* (4:4), pp. 260-260.

Sabaté, E. 2003. *Adherence to Long-Term Therapies: Evidence for Action*, Geneva: World Health Organization.

Saidinejad, M., and Zorc, J. 2014. "Mobile and Web-Based Education: Delivering Emergency Department Discharge and Aftercare Instructions," *Pediatric Emergency Care* (30:3), pp. 211-216.

Siponen, M. 2000. "A Conceptual Foundation for Organizational Information Security Awareness," *Information Management and Computer Security* (8:1), pp. 31-41.

Steine, S., Finset, A., and Laerum, E. 2001. "A New, Brief Questionnaire (Peq) Developed in Primary Health Care for Measuring Patients' Experience of Interaction, Emotion and Consultation Outcome," *Family Practice* (18:2001), pp. 410-418.

Street Jr., R. L., Slee, C., Kalauokalani, D. K., Dean, D. E., Tancredi, D. J., and Kravitz, R. L. 2010. "Improving Physician–Patient Communication About Cancer Pain with a Tailored Education-Coaching Intervention," *Patient Education and Counseling* (80:1), pp. 42-47.

Tait, A. R., Voepel-Lewis, T., Moscucci, M., Brennan-Martinez, C. M., and Levine, R. 2009. "Patient Comprehension of an Interactive, Computer-Based Information Program for Cardiac Catheterization: A Comparison with Standard Information," *Archives of Internal Medicine* (169:20), pp. 1907-1914.

Ware Jr., J. E., Snyder, M. K., Wright, W. R., and Davies, A. R. 1983. "Defining and Measuring Patient Satisfaction with Medical Care," *Evaluation and program planning* (6:3-4), pp. 247-263.

Weiden, P. J., Mackell, J. A., and McDonnell, D. D. 2004. "Obesity as a Risk Factor for Antipsychotic Noncompliance," *Schizophrenia Research* (66), pp. 51-57.

Wiatrowski, M. D., Griswold, D. B., and Roberts, M. K. 1981. "Social Control Theory and Delinquency," *American Sociological Review* (46:5), pp. 525-541.

Wixom, B. H., and Watson, H. J. 2001. "Empirical Investigation of the Factors Affecting Data Warehousing Success," *MIS Quarterly* (25:1), pp. 17-41.

Workman, M., Bommer, W. H., and Straub, D. W. 2008. "Security Lapses and the Omission of Information Security Measures: A Threat Control Model and Empirical Test," *Computers in Human Behavior* (24:6), pp. 2799-2816.