

Patient Adoption of Smart Cards

Full paper

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Abstract

This paper adapts the Unified Theory of Acceptance and Use Technology Model (UTAUT) to assess the factors impacting the adoption of smart cards in Medicaid Health Home context. We contribute to the theory by including three constructs specific to smart card and health devices: (i) concern for error, (ii) sickness orientation (iii) concern for data security. Utilizing a survey design we collected responses from 116 participants who are ethnic minorities, enrolled in a Medicaid Health Home program or from a high-risk population. We developed a conceptual model and an instrument to measure the patient's likelihood to use the smart card. The concern for error, social influence and sickness orientation significantly impact the likelihood to use the smart card. Our results show that patients are more concerned about prevention of errors as compared to security breaches.

Keywords

Smart cards, compliance, healthcare, care coordination, Medicaid Health Home.

Introduction

The pursuit of the trifecta - lower cost, higher quality and better patient outcomes - has determined the last few years of government and private sector policies in healthcare. Officials face tremendous hardship to lower the cost of providing healthcare for millions of Americans who gained eligibility under the Affordable Care Act (ACA) and many others previously insured. Slow economic growth and growing financial disparities resulted in many newly eligible patients gaining access to insurance through state funded programs such as Medicaid. The Center for Disease Control reports that a minimum of \$256 million is spent per state annually on 11 chronic illnesses of which, 29% - 56.7 % is funded by Medicare and Medicaid (Trogon et al. 2015). The Medicaid Health Homes (MHH) program developed under Affordable Care Act (ACA) of 2010, Section 2703, was implemented to combat cost and improve quality by coordinating all primary, acute, behavioral health, and long-term services for people with chronic conditions (Auxier et al. 2015). These goals may be achieved by leveraging health information technology (HIT) that can track and monitor large amounts of data in real-time, with or without human intervention.

One innovative HIT option is to implement a cloud-based smart card system. The card is a medium for providers to reduce test duplication, engage patients and increase their involvement in information sharing decisions. Patients typically share information with their physicians to facilitate correct diagnosis and treatment and to avoid adverse drug interactions (Appari and Johnson 2010). However, information privacy and security are barriers to the adoption of HIT. Conveniently, the smart card incorporates sophisticated security features requiring three-level authentication to gain access to encrypted protected health information (PHI).

Integration of smart cards with other HIT is possible due to the expansion of electronic medical records (EMR) and health information exchanges (HIE). Though the smart card is neither an EMR nor HIE, it offers a hybrid solution to access health information. It increases the quantity of shareable information by allowing access to individual provider records which are usually inaccessible through the HIE. Similar to other mobile health devices the smart card improves delivery processes by providing support and services that change traditional modes of information sharing and dissemination (Gagnon et al. 2016). For example, it allows participating doctor's convenient and immediate access to current testing, medication, and medical history. This access enables faster decision making and provides greater opportunities for care coordination. The benefits of smart cards extend to providing financial incentives for compliance with various preventative services and testing (Adams et al. 2014; Giles et al. 2015). It facilitates integration with pharmacies or supermarkets allowing medication monitoring and encouraging dietary compliance. The device offers a convenient method to motivate compliance and it is an effective population management tool.

Despite the numerous benefits to patients and providers, patient adoption and the use of smart cards have not been studied extensively. This research investigates the factors that motivate the adoption and use of smart cards intending to impact practice and to contribute to the existing body of literature on compliance and adherence. We developed and technically validated an instrument to predict the likelihood to adopt. We consider the patient's beliefs associated with social influence, sickness orientation, data security, patient-physician relationship, and error concern. If patients fail to participate the system performs inadequately. Our motivation is to inform both theory and practice, by finding the factors that can limit adoption and provide practical implications on how to address them.

Background and Hypothesis Development

Overview of Literature

Smart Cards are being used with greater frequency to assist healthcare providers to deliver comprehensive care and involve patients in their healthcare decisions (Alliance 2012; Toraldo and Mangia 2013). This research extends the body of literature in healthcare, information security and privacy by studying patient compliance when physicians merely endorse the use of smart cards. The intellectual contribution comes from modifying the Unified Theory of Acceptance and use of Technology Model (UTAUT), thus far it has not been considered the context of healthcare smart card adoption. Prior assessment of the likelihood to use information technology is grounded in the technology acceptance model (TAM) (Davis 1989). UTAUT further developed the factors and likelihoods related to technology use. Likelihood to use is a measure of the strength of one's probability to adopt a device (Ajzen 1991). The present study aims to enhance UTAUT by adding variables specific to smart card implementation for high-risk Medicaid patients. By doing so, we integrate the compliance theory to UTAUT in the healthcare framework.

Compliance refers to a particular kind of response to a particular kind of communication (Cialdini and Goldstein 2004). The theory of compliance is studied in healthcare, information security policies (ISP) and environmental studies (Safa et al. 2016; Vroom and von Solms 2004). In the latter contexts, behaviors are mandated by the company or governmental policy. Individuals may deviate from the expected. Likewise, patients also have the ability to depart from the mandates of their physician. In ISP research, responses are from employees and are based on the perception that deviation may lead to some form of sanction (Herath and Rao 2009). Conversely, unwillingness of the patient to adopt the card will result in no sanctions or immediate losses. Patients face a stronger coercive force from their physicians to comply with medication and treatment plans; whereas, using the card is not mandatory even though it is endorsed by the healthcare provider.

Numerous gaps exist in current research as it pertains to the likelihood to adopt smart cards. Studies typically review product security, architecture, and design but do not focus on the likelihood to use the device. Patient-physician relationship, concern for data security and errors are salient constructs insufficiently explored in the extant literature. Sickness orientation simulates the performance expectancy variable in the UTAUT model. Social influence is modeled in adaptations of UTAUT; however, limited studies have examined those influences on smart card adoption when a MHH acts as the facilitator. Our context-specific research identifies relevant predictors and mechanisms vital in providing a rich understanding of an important phenomenon and extending theory (Venkatesh et al. 2012). We investigate

the following question: what factors influence a patient's likelihood to adopt a smart card endorsed by their physician?

Social Influence

Individuals are influenced by the people around them; they are programmed to react in socially acceptable ways. Prior to even perceiving the card use as intrinsically rewarding or associating its use with a desired relationship, a patient may simply choose to comply (Kelman 1958). Such compliance may be spurred by the patients' perception that people important to them think they should perform a behavior (Ajzen 1991; Davis 1989; Han et al. 2015). In the healthcare context, patients may perceive pressure from; other patients, caregivers, nurses, doctors and/or insurance companies. The perceived pressure from others to perform certain behaviors is described as social influence (Venkatesh et al. 2003). The TAM model assessed mandatory and voluntary influences within the organization and UTAUT reviewed influences such as family and friends. This study expands the scope of social influences by evaluating the impact of the insurance company, other patients, and doctors on a patient's adoption of the smart card.

H1: Social influence will positively affect patient's likelihood to use smart cards.

Sickness orientation

The sickness orientation variable assesses the patient's perception of their condition. When patients perceive that they are susceptible to illness, they tend to take more preventive actions (Sheeran and Abraham 1996). People of the opinion that they are likely to get sick would be more inclined to seek coping mechanisms (Park et al. 2015). The adoption of smart cards is a coping behavior as it ensures information is available when needed. According to the health belief model a patient's acceptance of a recommended intervention such as the smart card, is dependent on that individual's perceived threat of the disease (Janz and Becker 1984). By using a smart card as a coping mechanism a patient may experience better health outcomes, this is similar to an employees gain from using a system at work (Venkatesh et al. 2003). We therefore hypothesize that an increased sickness orientation is likely to impact a patient's desire to adopt smart cards.

H2: Sickness orientation will impact the adoption of smart cards.

Data Security Concern

The data security construct assesses the physical safety of the data contained or accessed using the smart card. Data security means data is securely stored and transferred. Last year numerous security breaches occurred in insurance company databases. An average of thirty-one million records were breached at Anthem, Excellus BlueCross and a UCLA Healthcare system (Hautala 2015). Unauthorized access to protected information may increase an individual's concern about the security of electronic records. Data security is important since the smart card may be lost or stolen, information intercepted during cloud-based access or breached by end users (Messerges et al. 2002; Vasel 2015). Security concerns emanating from the banking industry such as fraud and identity theft may also affect patient's perception (Udo 2001; Vasel 2015). Patients who have a greater concern about the potential for unauthorized access and exploitation of their health information may feel dissuaded from adopting the smart card in order to mitigate the risk of exposing their health data.

H3: Concern for data security will decrease the patient's likelihood to adopt the smart card.

Patient-Physician Relationship

A patient-physician relationship is the combination of emotional intensity, time, intimacy and reciprocal exchanges that characterize the physician-patient rapport. The concept of patient-physician relationship in this study extends the strength of ties theory (Granovetter 1973). In the primary-care setting, such a relationship is typically long-term where patients rely on the expertise of their physician for care recommendations. The stability of patient-physician relationship could significantly impact the likelihood of using a smart card (Cooper-Patrick et al. 1999). In the marketing literature when assessing whether people were more likely to consume a product, a highly credible source is more valuable than a less

reliable one (Ohanian 1991). By leveraging the patient-physician relationship, the doctor may be viewed as a highly credible source.

H4: Patient-physician relationship positively impacts the likelihood to use a smart card.

Concern for Errors

Privacy and security are important factors that influence a patient's decision to release information to healthcare providers (Agaku et al. 2014). Individuals are willing to disclose personal information in exchange for some benefit and assess whether the subsequent use of information is fair (Culnan and Armstrong 1999). Privacy breaches can erode the trust in HIT (2015). A patient's reluctance to provide information or reduced trust in HIT could impact the efficiency of a smart card system or result in its failure. Data privacy means only authorized users view and use data (Li et al. 2010). We nuanced the study to address errors in personal information. The smart card may prevent errors when prescribing medication or diagnosing the patient. Patients desire the disclosure of all harmful errors and seek information about the prevention and reduction reoccurrences (Gallagher et al. 2003). Protection against deliberate and accidental errors in PHI could result in the increase adoption of the smart card. Similarly, the perception of insufficient safeguards from errors may lessen the likelihood to use a card.

H5: Concern for errors impacts patient likelihood to use smart cards.

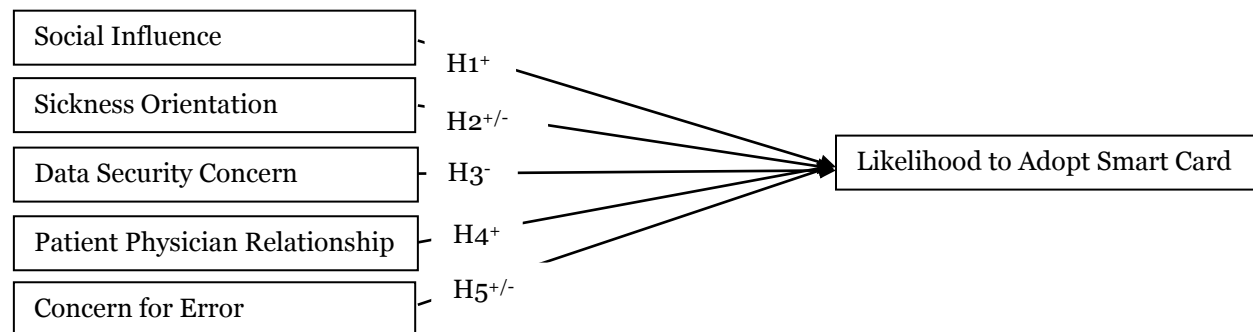


Figure 1: Research Model for Patient Adoption of Cloud-based Smart Card

Method

Data

An urban population including patients from a MHH in the United States serve as study participants. Participants are from a subset of high-risk Medicaid patients. Each patient agreed to complete a survey during a routine visit to their primary care physician. The survey was anonymized to protect privacy, maintain confidentiality and reduce acquiescence. Ninety-three of 116 responses were valid. Mean Age 49.4 +/- 13.2 (S dev). Sixty-eight percent of participants were female. Ten percent of respondents are White (non-Hispanic), 30% were Hispanics, 52% were African-American, and 8% were other races. Seventeen percent had less than high school education, 37% high school, 24% some college, 19% college and 3% graduate studies.

Measures

The instrument was developed after literature review and interviews with subject matter experts including information systems professionals, physicians, and patients. We consulted professors who typically design survey instruments to ensure questions are phrased appropriately to elicit proper responses for the factors being measured. To validate revised constructs, a short questionnaire was distributed with the items and construct definitions. Items that did not match exactly with the construct definition were either refined or removed from the final instrument. Next we created the measurement model. The model depicts the likelihood to use smart cards in healthcare with several reflective indicators. Data security concern and patient-physician relationship are constructs refined for this study, each has five and four reflective items.

The item for likelihood to adopt was formulated based on Venkatesh et al. 2012 using a binary item. Sickness orientation has three reflective items based on patient health status (Ware and Sherbourne 1992). Concern for error, uses two items adapted from (Smith et al. 1996). Scale scores were computed as the average of individual items. Finally, items on social influence are from Han et al. 2015 and calculated by multiplying the aggregation of motivation to comply with reference *i* by the normative belief concerning referent *i*. Independent variables are measured on a seven-point Likert scale. The scales are anchored strongly agree, agree, somewhat agree, strongly disagree, disagree and somewhat disagree. Likelihood was dichotomous (yes and no).

Results, Analysis and Implications

SAS 9.4 was used to analyze the research model. Using principal component analysis we selected only factors with Eigen values greater than 1.0 and conducted a visual assessment using a scree plot. Exploratory factor analysis determined that twenty-four items fit into five conceptually distinct factors. To test the effect of common bias, we performed Harman's single-factor test and marker-variable analysis (Lindell and Whitney 2001; Podsakoff et al. 2003). A single factor did not emerge. The smallest correlation between the predictor variable and the marker variable was selected $r = 0.01959$. The correlation between the marker variable and other predictor variables are low; this is evidence of discriminant validity. The significance of the correlation among the independent did not change after controlling for the marker variable using formulas developed by Lindell and Whitney (2001).

Results of the measurement model for reflective measures indicate that satisfactory reliability and validity were achieved (Cronbach's Alpha, $\alpha > .70$), see Table 1. Discriminant validity is adequate: (Table 2); each item loads higher on its factor than on other factors. One item measuring the sickness orientation and two items measuring patient-physician have loadings of less than .70, these items were retained to capture the crux of each construct. Comrey and Lee (1992) suggest that loading 0.55 are good and 0.45 are fair. The highest correlation between independent variables is 0.32, well below the conventional threshold value of 0.6 (Peng and So 2002). Multicollinearity is not a concern in this analysis since correlation values were within the thresholds.

	Cronbach's Alpha	Social Influence	Sickness Orientation	Data Security	Patient Physician Relationship	Concern for Error
Social Influence	0.91	1				
Sickness Orientation	0.75	0.32592	1			
Data Security	0.93	0.31622	0.12838	1		
Patient Physician Relationship	0.77	-0.04548	-0.03958	-0.15797	1	
Concern for Error	0.82	-0.06463	-0.01454	0.26939	0.0321	1

Table 1. Correlation and Reliability

	Data Security	Social Influence	Patient Physician Relationship	Sickness Orientation	Concern for Errors
CFDS4	0.96128	0.08749	-0.02949	0.02754	0.04338
CFDS3	0.9371	0.1377	-0.00161	-0.05227	0.06753
CFDS5	0.90718	0.10433	-0.00953	0.02277	0.14771
CFDS1	0.77791	0.08905	-0.11577	0.14838	0.10782
CFDS2	0.71613	0.27141	-0.04229	0.16456	0.13136
SOIDC	0.07134	0.88291	0.16954	-0.01314	0.10079

SOINS	0.04617	0.85973	0.07208	0.04158	0.05261
SOIFA	0.19048	0.80298	-0.01614	0.29594	-0.09833
SOIFR	0.30504	0.72599	-0.12672	0.37833	-0.1341
SOIPT	0.2953	0.71293	-0.11864	0.38456	-0.1373
PPR4	-0.14178	0.00072	0.80845	0.02058	-0.0845
PPR3	-0.13365	-0.13767	0.78871	-0.06178	-0.07649
PPR2	0.10436	0.06269	0.61571	-0.01633	0.06241
PPR1	-0.02286	0.09857	0.55482	0.0981	0.12974
SOK1	0.06434	0.12391	-0.08477	0.71856	-0.0278
SOK2	0.02069	0.15027	0.00446	0.639	-0.01789
SOK3	0.0436	0.08229	0.11323	0.42816	0.07351
CFPE2	0.12765	-0.08248	0.05997	0.01809	0.78812
CFPE1	0.1817	0.02346	-0.00271	0.0147	0.76388

Table 2. Factor Loadings

Power was validated using the likelihood ratio test based on a non-central chi-square distribution and compared to an asymptotic approximation of power. The analysis indicated a nominal power of 80 - 90% for a sample of 83 – 92 participants (Self and Mauritsen 1988; Self et al. 1992). Binary logistic regression is used to test the model (Hosmer et al. 2013). Every patient was asked to indicate his or her likelihood to use the smart card given the opportunity. In the analysis, likelihood to use smart card was coded as 1, and likelihood not to use was coded 0. If the odds ratio is greater than 1, then we might conclude that a one-unit increase in the predictor variable is associated with an increase in the likelihood of using the smart card.

The significant chi-square test for the difference between the -2LL ratios for the intercept and covariates model (-2 Log L = 76.636) and the base model that includes only the intercept (-2 Log L = 128.053) demonstrated a better fit for the data than did the base model. The value of $c = 0.89$, it ranges from 0.5 to 1, a 1 corresponds to the model perfectly discriminating the response. A model with a c statistic higher than 0.8 is strongly discriminating the subjects to the corresponding group of outcome (in this case the likelihood to use or not use the smart card) (Hosmer and Lemeshow 2000). Thus, our model is strong in discriminating the subjects. Figure 2 illustrates the model path coefficients (β). Four of the five hypothesized relationships were significant.

The parameter estimate and odds ratio results indicate that social influence positively impacted the likelihood to use the smart card given the other variables are held constant $\beta = 0.035^{***}$ Odds Ratio (OR) = 1.036. This finding supports hypothesis 1. The impact of social influence is statistically significant, though the economic value of the effect is not large. Thus, we further investigated the impact of each influential group. We found that among the five groups, the insurance company is most influential. This finding is counterintuitive and interesting. Further investigation is needed to give scientific insights on the reasons. Part of the explanation could be that a patient's decision to go to specific healthcare providers or take specific medical tests is constrained by insurance coverage. Therefore, the insurance company has a noteworthy impact on patients' medical-related decisions. This surprising finding suggests insurance companies more influential compared to physicians and family members.

The odds ratio indicates that sickness orientation negatively affected the likelihood to use the smart card *ceteris paribus* $\beta = -0.4417^*$ OR = 0.643. This finding supports hypothesis 2 suggesting that sickness may be associated with more sensitive information thus reducing the likelihood to use. Results may also indicate that sickness perhaps triggers other associated factors such as the probability of the privacy breaches associated with more frequent use. The parameter estimate for data security concern demonstrated that it negatively affects the likelihood to use the smart card $\beta = -0.4066^*$ OR = 0.666 which supports hypothesis 3. Higher concern for security breaches decreases the likelihood to use smart

cards. Given that smart cards are protected by the latest security encryption technology, healthcare providers need to increase their efforts to address patient's security concern by highlighting policies and processes in place that help protect information. This finding provides practical insights on the type of education that should accompany the launch of new technologies in the healthcare context in particular technologies that are associated with security issues.

We found no evidence in support of hypothesis 4. This means that the strength of the relationship between the physician and the patient has no significant impact on the likelihood of adopting the smart card. This finding, although not significant, is quite important. This finding along with the social influence of physicians on the likelihood to adopt was not significant could mean that patients do not give value to physicians' opinions on non-medical issues and security/technology related concepts. Essentially, patients want to hear it from the experts. This finding provides practical implication that healthcare providers when addressing security issues, they should use security experts to address patients concerns rather than medical professionals.

Results indicate that concern for error positively affects the likelihood to use the smart card $\beta = 0.9313^{***}$ OR =2.538 providing supports for hypothesis 5. As mentioned earlier, one of the main advantages of using smart cards is the reduction of errors. This finding suggests that patients believe this feature beneficial enough to increase their likelihood of adopting the smart cards. Another practical implication suggesting that providers should emphasize this advantage to patients in order increase adoption and patient engagement. More importantly, among all factors concern for error has the highest magnitude and thus the highest impact on the likelihood to adopt. Gender and health home status are control variables. There were no significant differences in likelihood to use the smart card between males and females.

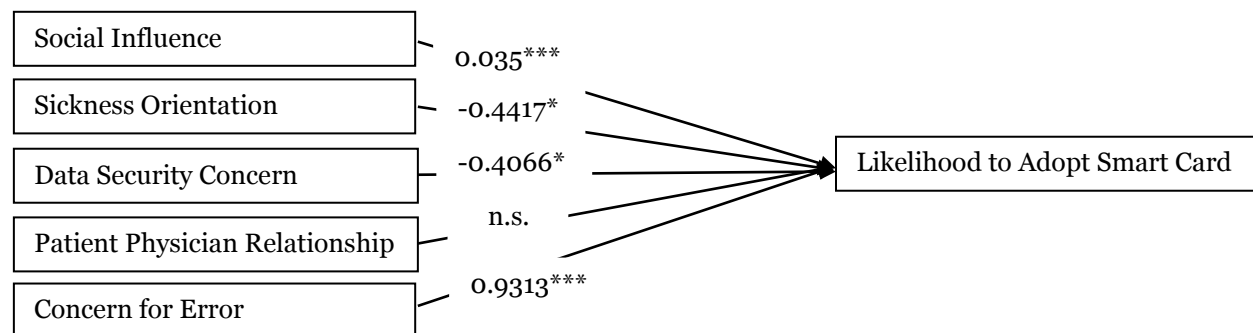


Figure 2. Model Results: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Discussion, Conclusion and Limitations

The smart card offers a convenient method of providing access to patient data, promoting preventative care compliance and assessing population risk factors. This study investigated the factors influencing a patient's likelihood to adopt a smart card endorsed by their physicians. The results show that four of the five hypothesized relationships were significant. Concern for error has the highest impact on a patient's likelihood to use smart cards. This impact is positive which means if this benefit is made salient to patients, then the success of the system is higher. Medicaid Health Home administrators should work on two main factors: educating patients on the security measures used to ensure data is protected and on the benefits of using smart cards specifically its ability to reduce errors. Health Home Administrators can also work jointly with the insurance companies to improve the likelihood of adoption; their influence appears to increase patient engagement.

The findings indicate our research model is relevant when there are higher incidences of errors in medical care. Promoting the smart card as a medium to reduce error for example in the emergency room or urgent care may increase the likelihood of adoption. Interestingly, security and sickness orientation have a weaker impact on likelihood to use the smart card in this particular context. Considering security concern, health providers should to address patients concern and clarify/educate them on the privacy and security rules that will safeguard their PHI. Patients not enrolled in the health home were less likely to use the smart card, an unusual finding that requires exploration. Medicaid recipients have access to a payment

and identification card; upgrading these to the smart card could magnify the benefits beyond MHH members. The smart card may be a useful tool to achieve the healthcare trifecta – higher quality, reduced cost, and enhanced patient outcome.

This study is one of the first to evaluate smart card adoption using the UTAUT. We acknowledge that the study has limitations, each will be addressed with future research. One limitation is the self-selection of respondents. Another limitation is the relatively small sample size which limits the generalizability of our results. This study does not assess use behavior. Only five variables impacting smart card adoption are used and each UTAUT construct is expressed using its healthcare counterpart. Future studies will evaluate risk, benefits and additional aspects of the UTAUT model and privacy concerns.

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