This is the author's version of a work that was submitted/accepted for publication in the following source:


This file was downloaded from: http://eprints.qut.edu.au/61256/

© Copyright 2013 IEEE Communications Society

Notice: Changes introduced as a result of publishing processes such as copy-editing and formatting may not be reflected in this document. For a definitive version of this work, please refer to the published source:
The Role of Perceived Usefulness and Attitude on Electronic Health Record Acceptance

An empirical investigation using response surface analysis

Randike Gajanayake and Tony Sahama

a Science and Engineering Faculty
Queensland University of Technology (QUT)
Brisbane, Australia
g.gajanayake@qut.edu.au, t.sahama@qut.edu.au

Renato Iannella a
Semantic Identity
Brisbane, Australia
ri@semanticidentity.com

Abstract—Information and communications technologies are a significant component of the healthcare domain and electronic health records play a major role within it. As a result, it is important that they are accepted en masse by healthcare professionals. How healthcare professionals perceive the usefulness of electronic health records and their attitudes towards them have been shown to have significant effects on their overall acceptance. This paper investigates the role of perceived usefulness and attitude on the intention to use electronic health records by future healthcare professionals using polynomial regression with response surface analysis. Results show that the relationship is more complex than predicted in prior research. The paper concludes that the predicting properties of the above determinants must be further investigated to clearly understand their role in predicting the intention to use electronic health records and in designing systems that are better adopted by healthcare professionals of the future.

Keywords—electronic health records; technology acceptance; future healthcare professionals; attitudes; response surface analysis

I. INTRODUCTION

The use of information and communications technology (ICT) in healthcare has become a significant aspect of the global healthcare agenda. The interaction with electronic health records (EHR) is bound to become a considerable part of a healthcare professional’s (HCP) daily activities and access to EHRs will be a critical requirement as more of the administrative and clinical processes are handled through EHR systems [1]. If adopted en masse by HCP and patients alike, EHRs and related technologies promise enviable benefits to healthcare delivery [2, 3]. However, dissatisfaction amongst HCPs remain a barrier for realising these benefits and there is a need for studies that thoroughly identify the factors contributing to technology acceptance in the healthcare domain [3].

Past studies on EHR adoption in care settings have shown that adoption of EHRs is not as high as expected [1, 2, 4-6]. Several reasons are said to be contributing factors for the low adoption and these have been clustered into eight categories by Boonstra and Broekhuis [7]: financial, technical, time, psychological, social, legal, organisational, and change process. According to Boonstra and Broekhuis, physicians have concerns regarding the use of EHRs that are based on their personal issues, knowledge, and perception. The perception of what an EHR system can deliver and the HCPs’ attitudes towards it can significantly contribute to the acceptance of the system [8]. In past studies this relationship has been considered to be a linear relationship and conclusions have been drawn accordingly about their significance in system adoption. With the development and availability of new technologies, however, they may be more complex than what is currently known. As regards to the intention to use EHR systems by future HCPs’, this paper investigates the role played by perceived usefulness and attitudes towards EHRs as predictors. As a measure of each predictor and the dependent, the results of a quantitative survey conducted involving medical, nursing and health students from three education institutions in Queensland, Australia are utilised.

In what follows, first the background details are given for technology acceptance research and its role in the healthcare domain. Then details pertaining to the theoretical foundations that underpin the hypotheses of the study are presented. Details of the method employed in the study are given followed by the results and data analysis. The paper concludes with a discussion and conclusion, which summarises the findings and makes recommendations for future work.

II. BACKGROUND

The use of ICT in the healthcare domain is gaining increasing importance with the advancement of information systems and eHealth technologies. In Australia for example, with the launch of the Personally Controlled Electronic Health Record (PCEHR), future HCPs are destined to interact with EHRs for healthcare information and patient interaction. Therefore, it is important to understand how they...
perceive EHRs and how those perceptions contribute to the overall intention to adopt EHRs.

A. Technology Acceptance Research

Technology acceptance studies have been conducted in a vast range of domains. Early theories such as the technology acceptance model (TAM) have been widely used and several variations have also been introduced. TAM was developed by Davis et al. [9, 10] who argued that the key to increasing use of ICT was to first increase their acceptance. They showed that this can be assessed by asking about their future intentions to use ICT. The foundations for TAM laid within the theory of reasoned action (TRA), a theory based in socio-psychological and behavioral theory. Following preliminary studies, several variables were established as measurements of ICT use behavior. Behavioral intention (BI) or acceptance and Attitude (ATT) were chosen as the principal determinants of ICT use. BI is influenced by one’s attitude towards using ICT. Attitude, in turn, has two more determinants: perceived ease of use (PEOU) and perceived usefulness (PU). Furthermore, PU has an independent effect on BI and PEOU has an effect of PU and BI [10]. These relationships have been further confirmed in studies which followed [11].

B. Technology Acceptance in Healthcare

Although TAM and related models have been applied in the study of ICT use in the healthcare domain since far back as the 1990’s [12], its application is not as prominent as other fields [13]. The study samples of the application of TAM in the healthcare domain include physicians, nurses, pharmacists, physiotherapists and medical technicians. Interestingly, support was not found for some of the key relationships in TAM and related models within the healthcare domain [12, 14]. It is recommended that the theories be augmented with additions and modifications to suit the healthcare domain [12]. For detailed reviews of technology acceptance research in healthcare refer to [12, 15].

III. THEORETICAL FOUNDATIONS

Considering what has been reported in prior research studies and the importance of the aforementioned relationships, the following hypotheses are made and tested in this study.

H1a. Perceived usefulness is positively related to behavioural intention, such that future HCPs with positive (negative) perceptions of usefulness on EHRs will have high (low) intention to use EHRs in the future.

H1b. EHR Attitude is positively related to behavioural intention, such that future HCPs with positive (negative) attitudes on EHRs will have high (low) intention to use EHRs in the future.

IV. METHOD

The method of data collection was an online questionnaire. The survey was administered via email and was left open for approximately four weeks with a reminder sent after two weeks. An online survey instrument and administration via email were seen as appropriate methods given that all participants had access to an Internet facility, owned email accounts and were considered to use email on a regular basis.

A. Survey Instrument

The survey instrument consisted of basic demographic details followed by a description of an EHR system that the respondents may use in their future professional activities. Table I shows the questionnaire items used to measure each of the constructs that are of focus in the paper. A 5-point Likert scale was used to measure the perceptions with 1 being “Strongly Disagree” and 5 being “Strongly Agree”. All measurement items were reflective of the specific construct.

A. Perceived Usefulness and EHR Attitude

Perceived usefulness is defined as ‘the prospective user’s subjective probability that using a specific application system will increase his or her job performance within an organizational context’ [10]. As reported in a recent review of the application of TAM in healthcare, perceived usefulness has been shown to be a significant factor in the intention to use ICT in all of the studies that were reviewed [12]. The report also reported that Attitude, which is defined as ‘an individual’s overall affective reaction to using ICT’ [16], showed a significant relationship with the intention to use ICT in 5 out of 6 studies considered in the review. Attitude is said to tap into an individual’s interest in and feelings of enjoyment and pleasure with ICT use [16].

Considering what has been reported in prior research studies and the importance of the aforementioned relationships, the following hypotheses are made and tested in this study.

H1a. Perceived usefulness is positively related to behavioural intention, such that future HCPs with positive (negative) perceptions of usefulness on EHRs will have high (low) intention to use EHRs in the future.

H1b. EHR Attitude is positively related to behavioural intention, such that future HCPs with positive (negative) attitudes on EHRs will have high (low) intention to use EHRs in the future.

H2. EHR Attitude mediates the impact of perceived usefulness on behavioural intention.

IV. METHOD

The method of data collection was an online questionnaire. The survey was administered via email and was left open for approximately four weeks with a reminder sent after two weeks. An online survey instrument and administration via email were seen as appropriate methods given that all participants had access to an Internet facility, owned email accounts and were considered to use email on a regular basis.

A. Survey Instrument

The survey instrument consisted of basic demographic details followed by a description of an EHR system that the respondents may use in their future professional activities. Table I shows the questionnaire items used to measure each of the constructs that are of focus in the paper. A 5-point Likert scale was used to measure the perceptions with 1 being “Strongly Disagree” and 5 being “Strongly Agree”. All measurement items were reflective of the specific construct.
TABLE I. CONSTRUCT MEASUREMENT ITEMS

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
<th>a,b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Usefulness (PU)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PU1: I believe that this EHR system would be useful in my professional activities.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PU2: I believe that this EHR system would help improve my patient care delivery.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PU3: I think that this EHR system would improve my job performance.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PU4: I feel that this EHR system can make health information sharing easier and more effective.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EHR Attitude (ATT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATT1: I believe that paper records can be better utilised to keep health information more secure than in EHRs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATT2: Using this EHR system is a good idea.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATT3: I think EHRs are easy to work with than paper records.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATT4: I think I would enjoy working with this EHR system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATT5: I think that EHR systems are expensive to implement and maintain. The expense could be better utilised to improve other healthcare facilities.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral Intention (BI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BI1: I would use this EHR system in my professional activities for a few months.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BI2: I would use this EHR system throughout my professional career.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Measured in a 5 – point Likert scale. 1 = Strongly Disagree to 5 = Strongly Agree
b Primarily drawn from [16] and have been altered to fit the context and cohort. New measures were also introduced to fit the context

B. Participants

The participants of the survey were medical, nursing and health students from three academic institutions from Queensland, Australia. This cohort was chosen to represent the future HCP population because current HCPs’ perceptions towards EHRs may be influenced by constraints such as institutional facilitating conditions, influence from governing bodies and other environmental conditions. Their perceptions on usefulness and attitudes may not reflect what may be present when EHRs are implemented and become operational thus not reflecting initial intention to adopt EHR systems. The attitudes of a student cohort, on the other hand, are not motivated by such factors. However, it is recommended that the validity of this argument be established using data collected from current healthcare professionals in the presence of the moderating factors mentioned above.

V. RESULTS AND ANALYSIS

A. Results

A total of 334 valid responses were received from both undergraduate and postgraduate students and are used in the analysis. The demographics of the respondents are shown in Table II. The age of the respondents ranged from 17 years to 60 with a mean age of 27.8 (SD = 10.1) years.

B. Analysis

First the measurement model was analysed to test its validity and reliability using partial least square (PLS) analysis of structural equation modeling (SEM). The hypothesis testing was twofold: polynomial regression analysis was used to test the hypotheses H1a and H1b whilst PLS was used to test H2.

TABLE II. DEMOGRAPHICS OF THE RESPONDENTS

<table>
<thead>
<tr>
<th>Study Level</th>
<th>Medicine</th>
<th>Nursing</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (N=104)</td>
<td>F (N=230)</td>
<td>M (N=29)</td>
</tr>
<tr>
<td>Undergraduate</td>
<td>10 17</td>
<td>7 56</td>
<td>25 123</td>
</tr>
<tr>
<td>Postgraduate</td>
<td>3 7</td>
<td>4 23</td>
<td>15 44</td>
</tr>
</tbody>
</table>

TABLE III. ITEM LOADINGS, INTERNAL COMPOSITE RELIABILITIES AND AVERAGE VARIANCE EXTRACTED

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item</th>
<th>Item Loadings</th>
<th>AVE</th>
<th>Composite Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Usefulness</td>
<td>PU1</td>
<td>0.8506</td>
<td>0.642</td>
<td>0.8768</td>
</tr>
<tr>
<td></td>
<td>PU2</td>
<td>0.8550</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PU3</td>
<td>0.8845</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PU4</td>
<td>0.6828</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitude</td>
<td>ATT1</td>
<td>0.7067</td>
<td>0.5653</td>
<td>0.8659</td>
</tr>
<tr>
<td></td>
<td>ATT2</td>
<td>0.6531</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATT3</td>
<td>0.8452</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATT4</td>
<td>0.8414</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATT5</td>
<td>0.6951</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioural Intention</td>
<td>BI1</td>
<td>0.6671</td>
<td>0.6504</td>
<td>0.7838</td>
</tr>
<tr>
<td></td>
<td>BI2</td>
<td>0.9251</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Assessment of the Measurement Model

The construct reliability and construct validity were measured as an assessment of the measurement model. The statistical tools used were SPSS 19 [17] and smartPLS 2.0 [18].

In PLS, construct reliability is determined by the individual item reliability, internal composite reliability and the average variance extracted (AVE) [19]. Individual item reliabilities were tested by producing individual item loadings for each construct. All measurement items showed acceptable item loadings (greater than 0.3 [20]) as shown in Table III. The internal composite reliability and AVE of each construct were of acceptable levels being higher than the thresholds of 0.707 and 0.5 respectively. The measurements for construct validity used were discriminant validity and convergent validity.

In PLS, correlations of the constructs and cross loading of constructs are used to determine the discriminant validity and convergent validity. As seen in Table IV, the square roots of AVE (shown in bold) for each construct were greater than the correlation of constructs for each construct, indicating acceptable discriminant and convergent validity. Cross loadings of the constructs were also calculated to determine how well individual indicators load on the latent variable compared to other variables. As seen in Table V, the cross loading of each of the measurement items (shown in bold) are greater than the loading with other items indicating that the measures used in the study are more reflective of the constructs they were supposed to measure than the other constructs.

TABLE IV. CORRELATION OF CONSTRUCTS AND SQUARE ROOT OF AVE

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item</th>
<th>Item Loadings</th>
<th>AVE</th>
<th>Composite Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>PU</td>
<td>ATT</td>
<td>0.8012</td>
<td>0.7055</td>
<td>0.7518</td>
</tr>
<tr>
<td></td>
<td>BI</td>
<td>0.6661</td>
<td>0.6091</td>
<td>0.8065</td>
</tr>
</tbody>
</table>
2) Hypotheses testing

a) PU and ATT as Predictors of BI

Hypotheses H1a and H1b are tested here using response surface analysis. To test the hypotheses, polynomial regression with response surface analysis [21] was employed. The polynomial equation used is as follows.

$$BI = \beta_0 + \beta_1PU + \beta_2ATT + \beta_3PU^2 + \beta_4(\text{PU} \cdot \text{ATT}) + \beta_5ATT^2 + \varepsilon$$  

(1)

The response surface methodology provides the means to examine [22]: 1) how the degree of agreement/discrepancy between two predictor variables relate to an outcome variable and 2) how the direction of discrepancy between two predictor variables relate to an outcome variable. Table VI summarises the results of our polynomial regression analysis. Since the $R^2$ value (variance of BI explained by (1)) is significantly different from zero, the results of the regression analysis are evaluated using four surface test values [21, 22]: $\alpha_1, \alpha_2, \alpha_3, \alpha_4$, where the slope of the line of perfect agreement (PU = ATT, shown as a straight line on the base of Fig. 1) as related to BI is given by $\alpha_1 = \beta_1 + \beta_2$, the curvature along the same line as related to BI is given by $\alpha_2 = \beta_2 + \beta_3 + \beta_4$, the slope of the line of incongruence (PU = -ATT, shown as a dotted line on the base of Fig. 1) as related to BI, indicating the direction of the discrepancy, is given by $\alpha_3 = \beta_1 - \beta_2$, and the curvature of the line of incongruence indicating the discrepancy between PU, ATT and BI is given by $\alpha_4 = \beta_3 - \beta_4 + \beta_5$.

b) Mediation by ATT

H2 was tested using PLS-SEM. To test the mediating effects of Attitude, the effect of PU on BI was tested with and without ATT. Table VII shows the resulting path coefficients and t-values with their standard errors.

Sobel’s mediation analysis [23] was employed to eliminate the limitation of not testing the significance of the indirect paths. Sobel’s test revealed that the relationship between perceived usefulness and behavioral intention is mediated by attitude (Sobel test statistic = 3.753 (> 1.96), $p < 0.0005$). The direct effect of PU on BI decreased from 0.665 to 0.491 ($p < 0.005$) without and with ATT respectively, indicating a partial mediation.
VI. DISCUSSION AND CONCLUSION

This paper investigated the role of perceived usefulness and attitudes towards EHRs as predictors of the intention to adopt EHR systems by future HCPs. It hypothesised that perceived usefulness and attitude were positively related to the intention to adopt and that attitude mediated the effect of perceived usefulness on intention to adopt. After establishing that the measurement model used was reliable and valid, all hypothesised relationships were shown to be significant within the study boundaries. It was identified that the relationship between attitude and perceived usefulness on intention to adopt is curvilinear and attitude partially mediates the relationship between perceived usefulness and intention to adopt.

Although these relationships have previously being shown to be significant within the healthcare domain, the results of this study make a significant contribution to the available literature in that by taking a student cohort, who can be considered more technology aware or digital natives, it was shown that some relationships are in fact more complex than previously known. This leads to a recommendation for further studies using students prior and post exposure to EHR systems and to compare the results to data obtained from current healthcare professionals to further understand the relationships.

There are also grounds to recommend that in the development of EHR systems it is imperative to understand how users perceive system capabilities their benefits towards systems being useful in their job performance and how the users’ attitudes may be influenced by them. User studies may be conducted to investigate how their perceptions evolve with continued use of systems such that appropriate pre-emptive measures can be taken to alter these changes such that system acceptance and use are kept at optimal levels.

REFERENCES


