The adoption of mobile healthcare by hospital's professionals: An integrative perspective

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The adoption rate of mobile healthcare is relatively low in the hospital. In practice, a study of how healthcare professionals adopt mobile services to support their work is imperative. An integration of TAM and TPB, concerning both technological and organizational aspects, is important for understanding the adoption of mobile healthcare. However, mobile healthcare is a wireless device which is often used in a voluntary motive. Service provisions for pervasive and timely usage and individual psychological states are critical in determining its use. Accordingly, perceived service availability (PSA) and personal innovativeness in IT (PHIT) may be the important drivers to be included in TAM and TPB. This study thus proposed such a research framework from a broader and integrative perspective. The empirical examination showed high predictive power for adoption intention and the influential role of these important variables.

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1. Introduction

For the last decade, wireless technologies have been growing pervasively in various applications in the business sector, such as mobile commerce, supply chain management, customer relationship management, vendor managed inventory and so on. However, it is only quite recently that a surge of mainstream popularity has motivated researchers to acknowledge the healthcare value of wireless technologies. Hospitals are the places closely related to people’s health and medical professionals are responsible for the patients’ health and life. Medical professionals are always very concerned about the risk or uncertainty when using new technologies to assist in medical treatments. Therefore, medical professionals usually tend to adopt new technologies later until they have become more mature and safety in their use. However, wireless technologies can be widely applied in many ways to help medical professionals complete their work safely and efficiently, for example, electronic patient records and real-time monitoring systems of heart rate variability. This creates a great need and importance for mobile healthcare in the healthcare sector. However, a recent survey by the Department of Health in Taiwan in 2008 indicated that the adoption rate of mobile healthcare for medical professionals is only 16.3% among all hospitals. Moreover, there are only 62 hospitals (13.7%) in Taiwan using mobile phones to perform wireless healthcare.

More specifically, during the last several years, a gradual shift in the focus of mobile healthcare has taken place in hospitals. More and more medical professionals are considering using some types of mobile devices to support their work due to limitations of time and space [8,27,56,58]. For instance, medical doctors can get patient records or the latest medical reports by using Multimedia Messaging Service (MMS) on a mobile phone. Some hospitals have adopted Radio Frequency Identification (RFID) to help medical doctors and nurses identify a large number of patients in emergency room [41,55]. Accordingly, a study of how medical professionals adopt mobile devices is desperately needed to effectively promote the pervasion of such devices in hospitals. In particular, the advent of 3G mobile phones has provided a wide range of application services for performing mobile healthcare in an easy and convenient manner.

The technology acceptance model (TAM) [14,15], the theory of planned behavior (TPB) [4] and their extensions have been widely applied in examining the acceptance in various IS contexts [13,23,44,51,67]. TAM focuses more on technological aspect and its strengths are its parsimony and high explanatory power. However, it lacks consideration of the effects of individual and organizational factors in the adoption process. TPB is used to explain the behavior of technology adoption by taking into consideration of the individual role and organizational system in this process. Moreover, while mobile devices with wireless features are portable for personal use and provide instant supports for various medical activities anytime and anywhere, the quality of system services, such as real-time service availability, is a major concern for medical professionals. This is because the use of mobile healthcare is closely related to the
patients’ health and life and medical professionals need to make sure that system services are able to provide pervasive and timely access before they use these devices. Many studies have indicated the same concern about perceived service availability (PSA) when trying to understand the adoption of mobile devices [15,25,27,62].

In addition, while mobile healthcare is an emerging technology for personal use which is often used voluntarily, the psychological states of medical personnel play a critical role in determining system use. Many researchers have considered such a psychological antecedent for identifying individual differences in the adoption of new technology, namely personal innovativeness [19,22,50,54]. It refers to an individual’s psychological state of willingness to take a risk by trying out an innovation. As personal innovativeness is applied in examining IT acceptance, it is defined as personal innovativeness in IT (PIIT) [1,68].

In summary of the above discussion, while the adoption process of mobile healthcare involves both technological and organizational aspects on the level of individual, in this study, we first integrated TAM and TPB in a complementary manner. Many studies have proposed a unified model primarily based on TAM and TPB for various IS settings [62,65]. In particular, a similar study worked on exploring PDA acceptance by healthcare professionals with higher explanatory power [68]. Moreover, while considering the importance of PSA and PIIT in the adoption of mobile healthcare in particular, an enhancement of the unified view with the two important antecedents may positively increase the explanatory power of a proposed model. However, little research has discussed the personal use of mobile healthcare in a broader view in the hospital context. Therefore, the objective of this study aims at proposing an integrated model by including four components to explore the adoption of mobile healthcare.

In addition, many researchers have generally argued that the acceptance of an emerging IT in hospitals may be affected by some hospital characteristics other than IT-related attributes, such as hospital size/type and user/provider type [28,33,48,52]. Hospital type was defined to include three major types, medical center, regional hospital, and local hospital, based on a combination of some hospital attributes, such as quality of medical service, annual revenue, and number of employees, in Taiwan. Provider type was classified as two major types of professional users in the mobile healthcare context, physicians and nurses. Therefore, we specified hospital type and provider type as two control variables in this study. Furthermore, empirical examination is conducted to examine the practical validity of the proposed model.

2. Literature review and hypotheses development

Based on the above discussion, Fig. 1 provides a pictorial depiction of this research framework. The following section discusses the theoretical bases and development of relevant hypotheses.

2.1. Mobile healthcare

With an increasingly mobile society and the worldwide deployment of wireless networks, the wireless infrastructure can provide support for many current and emerging healthcare applications. This can fulfill the vision of ubiquitous healthcare or healthcare to anyone, anytime, and anywhere. A recent study has pointed out that the wireless requirements for supporting healthcare services are in a comprehensive coverage with readiness, including reliable access and transmission of medical information, location management, and support for patient mobility [58]. A comprehensive wireless architecture for location management in a healthcare environment can be designed by utilizing one or more location tracking technologies, including GPS, cellular networks, wireless LANs, and RFID [55,57]. Specifically, various remote devices have been applied in wireless healthcare. Examples include the implementation of infrared and radio-based locator badges [49], long-term health monitoring by wearable devices [29], wireless telemetry systems for EEG epilepsy monitoring [37], wireless sensors for blood oxygen saturation monitoring [6,43], real-time monitoring of patients in the home environment [32,39], short range blue tooth-based systems for digitized ECG [31], and several systems for remote heart monitoring using cellular-type wireless networks [46]. Furthermore, Sherman et al. [47] conducted a case study to understand the usage of mobile incentive care units (MICU) in medical emergency services.

A recent report has shown the importance of health monitoring systems in reducing the number of readmissions for patients suffering from many chronic health problems [16]. Health monitoring systems can also help in keeping track of patients with one or more cognitive disabilities, such as stray prevention system for the elderly with dementia [36]. Many cost-effectiveness analyses for mobile healthcare services have been reported for the potential usage [21,64]. Lehoux et al. [34] conducted an interview of a small group of physicians to point out some problems in using mobile devices for clinics. An economic analysis of health insurance was performed by Gravelle and Sicilian [24] and they indicated that if wireless networks could provide the help to a treatment process of patients in hospitals, the outcome of healthcare would be effectively increased. Moreover,
the use of wireless technologies can reduce the long-term cost of healthcare and result in an increased productivity of healthcare providers. To support the long-term healthcare needs of patients, comprehensive wireless patient monitoring solutions must be developed for the homes, nursing homes, and hospitals [27,42,56]. In summary, these objectives can be well achieved by the features of wireless technologies: improved coverage and scalability of wireless networks, dependable and reliable operations, implementable and reusable wireless technologies, and expandable and modifiable wireless technologies [57]. We argue that emerging mobile devices in the hospitals are important tools for improving the quality of healthcare in the near future. Therefore, exploring the use of mobile devices is a major issue for medical personnel, nursing staff, and patients in hospitals.

2.2. TAM and TPB

Both TAM and TPB were originally based on the efforts of the theory of reasoned action (TRA) [18]. TRA is a well-established model that has been broadly used to predict and explain human behavior in various domains. According to TRA, a person’s behavior toward a certain action is determined by his or her behavioral intention (BI) to perform the behavior and in turn, BI is jointly determined by the person’s attitude (ATT) and subjective norm (SN) concerning the behavior in question. Behavioral intention is a measure of the strength of one’s willingness to try and exert while performing certain behavior. Attitude refers to the degree of a person’s favorable or unfavorable evaluation or appraisal of the behavior in question. Subjective norm refers to the perceived social pressure to perform or not to perform the behavior. A person’s attitude toward a behavior is determined by his or her salient beliefs (sbj) about the consequences of performing the behavior multiplied by the evaluation (ei) of these consequences, that is, \( A = \Sigma sbj \times ei \). An individual’s subjective norm (SN) is determined by a multiplicative function of his or her normative beliefs (nbj), for example, perceived expectations of specific referent individuals or groups, and his or her motivation to comply (mc) with these expectations, that is, \( SN = \Sigma nbj \times mc \).

Based on the effort of TRA, TAM is designed for modeling user acceptance of information technology [15]. This model hypothesizes these relationships, actual use of a certain technology directly influenced by a person’s behavioral intention to use and in turn, behavioral intention to use determined by perceived usefulness (PU) and attitude toward the technology. Furthermore, perceived usefulness and attitude are affected by perceived ease of use (PEOU). Perceived usefulness refers to the prospective user’s subjective assessment of the probability that using a specific application system will increase his or her job performance within an organizational context. Perceived ease of use refers to the degree to which the prospective user expects the target system to be free of effort in use. TRA has theorized that behavioral intention to use is determined by attitude toward the behavior and subjective norm. However, TAM is only concerned with the effect of attitude and neglects the influence of subjective norm on behavioral intention to use. This is due to the uncertainty about theoretical and psychometric status when TAM was developing [15]. The appeal of this model is that it is both specific and parsimonious. These determinants are easy to understand and can be manipulated through system design and implementation. They should be able to generalize across various settings [9,51]. Building on TRA, TPB differs from TRA by adding a third component, perceived behavioral control (PBC). Accordingly, behavioral intention to use is jointly determined by a person’s attitude, subjective norm, and perceived behavioral control toward the behavior. PBC refers to a person’s perception of ease or difficulty in performing the behavior of interest. It is concerned with the beliefs about presence of control factors that may facilitate or inhibit performance of the behavior [3]. Thus, control beliefs about resources and opportunities are the underlying determinants of PBC and it can be depicted as control beliefs (cbj) weighted by perceived power of the control factor (\( \rho_j \)) in question, that is, \( PBC = \Sigma cbj \times \rho_j \). In sum, TPB proposes to eliminate the limitation of TRA in dealing with the behaviors over which people have incomplete volitional control [4]. Many studies have indicated the need for considering control-based beliefs to understand personal behavior related to the adoption of mobile healthcare [10,68]. Control-based beliefs can fall into individual categories, such as perceived self-efficacy in using mobile technology, and organizational categories, such as perceived technology support and training and perceived management support.

The following section discusses the development of relevant hypotheses. While the acceptance of mobile healthcare generally involves both technological and behavioral aspects for personal use, TAM is not complete in its coverage of both aspects, including perceived usefulness, perceived ease of use, and attitude. Many studies have therefore proposed the concept of integrating TPB in a complementary manner, including subjective norm and perceived behavioral control, in many business applications [38,44,62,65]. More specifically, some researchers have also applied the integration concept to explore the use of telemedicine technologies by healthcare professionals, for example, WAP-based telemedicine systems [10,26]. Additionally, other studies have shown that the integration of TAM and TPB should lead to higher power to explain technology acceptance in both business and healthcare applications [62,68]. Therefore, we simply integrated TAM with two belief structures, subjective norm and perceived behavioral control, and ignored their decomposed attributes in this study.

Based on the above discussion, there are three direct antecedents, attitude, perceived behavioral control, and subjective norm, for determining behavioral intention to use. We argue that there are three potential linkages between these three antecedents and behavioral intention to use in the usage context of mobile healthcare. Three hypotheses are thus proposed.

H1. Attitude has a positive effect on behavioral intention to use mobile healthcare.

H2. Perceived behavioral control has a positive effect on behavioral intention to use mobile healthcare.

H3. Subjective norm has a positive effect on behavioral intention to use mobile healthcare.

Moreover, according to the TAM structure, as discussed previously, perceived usefulness has a direct impact on behavioral intention to use, perceived usefulness and perceived ease of use are two antecedents of attitude, and perceived ease of use has a direct effect on perceived usefulness. We argue that these potential linkages exist in the usage context of mobile healthcare. Four hypotheses are thus proposed.

H4. Perceived usefulness has a positive effect on behavioral intention to use mobile healthcare.

H5. Perceived usefulness has a positive effect on attitude toward using mobile healthcare.

H6. Perceived ease of use has a positive effect on attitude toward using mobile healthcare.

H7. Perceived ease of use has a positive effect on perceived usefulness for mobile healthcare.

2.3. Personal innovativeness and IT adoption

Personal innovativeness represents the degree to which an individual is willing to take a risk by trying out an innovation [19,40]. People with this trait tend to launch a new idea in a system by importing the innovation from outside of the system’s boundaries.
According to innovation diffusion theory (IDT), people react differently due to differences in personal innovativeness, which is a predisposed tendency toward adopting an innovation [45]. Personal innovativeness can be classified into five types: innovators, early adopters, early majority, late majority, and laggards. The application of personal innovativeness in information technology has been referred to as personal innovativeness in IT [1,2]. PIIT has been widely used to examine the adoption of various IS settings [3,22,50,53,54,68]. PIIT is conceptualized as a trait, which is a relatively stable descriptor of an individual and invariant across situations. As also noted by Webster and Martocchio [65], traits are generally not influenced by environmental or internal variables. When individuals have great power to decide to either use an innovation or not in an organization, we can base PIIT on analyzing their psychological states to further understand human behavior intention to use the innovation.

The following section presents the development of relevant hypotheses. Many studies have examined the relationship between PIIT and attitude in many IS settings. One study investigated the personal acceptance of Internet-based public grid computing software with a PC-based device among voluntary participators and argued a linkage between PIIT and attitude toward using this device [50]. Another study analyzed individual’s Internet anxiety, an attitude toward the Internet use, when individual may experience perceived unreliability, risk, and vulnerability from using the Internet. Thus, the authors suggested a relationship between PIIT and Internet anxiety [53].

Additional study discussed the potential relationship between software developers’ innovativeness and their attitude toward an innovation in terms of the redesign of software development process in their organization [22]. Other studies have identified the indirect effect of PIIT on attitudes toward using various information technologies [54,63,68]. Accordingly, while healthcare professionals usually work in an independent decision-making manner for patients’ treatment and the early use of mobile healthcare is considered in a voluntary mode, PIIT is argued to be an important determinant of attitude toward using mobile healthcare. The following hypothesis is thus proposed.

**H8.** Personal innovativeness in IT has a positive effect on attitude toward using mobile healthcare.

According to IDT, individuals with high innovativeness are more likely to try out new things and have greater ability to control uncertainty and risk [45]. Many studies have discussed the direct and indirect effects of PIIT on perceived behavioral control on adoption behavior of various information technologies [3,68]. In the study by Yi et al. [68], in terms of the acceptance of PDA by medical professionals, the PIIT was posited as a direct antecedent of perceived behavioral control toward the behavior of adopting PDA. Another study proposed PIIT as a determinant of computer self-efficacy with respect to the use of Window or Lotus software [3]. Moreover, the decomposed TPB identifies computer self-efficacy as a determinant of perceived behavioral control toward the behavior of using a new technology [51]. Therefore, PIIT has the indirect impact on perceived behavioral control toward the behavior. Accordingly, we argue that there is a potential linkage between PIIT and perceived behavioral control toward the behavior of using mobile healthcare. The following hypothesis is thus proposed.

**H9.** Personal innovativeness in IT has a positive effect on perceived behavior control with respect to using mobile healthcare.

Individuals with more innovativeness in IT are more technically competent than others in using new technology. They tend to be earlier adopters of new technology while compared to later adopters. They consider the complexity of using new technology less troublesome than others [30]. Perceived ease of use is considered as the major technical feature in initiating the use of new technology for new users [14]. Much research has discussed the direct relationship between PIIT and perceived ease of use in various IS settings [35,63,68]. A prior study indicated that PIIT is a significant antecedent of perceived ease of use in terms of knowledge of workers in their use of IT [35]. Extending these findings, Yi et al. [68] theorized the direct effect of PIIT on perceived ease of use while testing the acceptance of PDA by healthcare professionals. Another study indicated that higher PIIT leads to higher perceived ease of use for financial service software [63]. In addition, Agarwal et al. [3] proposed an indirect relationship between PIIT and perceived ease of use with a moderating role of computer self-efficiency for using Window or Lotus software. Based on the above arguments, we assume that there is a linkage between PIIT and perceived ease of use for mobile healthcare. The following hypothesis is thus proposed.

**H10.** Personal innovativeness in IT has a positive effect on perceived ease of use for mobile healthcare.

### 2.4. Perceived service availability and IT adoption

Wireless technologies can provide high availability of medical resources for healthcare professionals anytime and anywhere and therefore, enable employees to significantly improve the quality of patient care and their working practice. The final challenge for using mobile healthcare is to achieve the dream of ubiquitous healthcare. However, the use of mobile healthcare is closely related to the patients’ health and life. Healthcare professionals are usually hesitant to adopt a new system service, such as mobile healthcare, when it is still in the early development stage of its regular use. Among the concerns regarding mobile service, there is a specific perception that relates to the unique features of wireless devices and their particular usage context for patient safety. Perceived service availability refers to the degree to which an innovation is perceived as being able to support pervasive and timely usage. It is considered as an important determinant for use in mobile healthcare.

The following section discusses the development of relevant hypotheses. Many studies have generally highlighted the importance of service provisions in determining the personal use of a new mobile service [17,25,27]. More specifically, one study indicated that PSA is expected to have a direct effect on perceived usefulness for a mobile data service and in turn, behavioral intention to use [25]. Accordingly, we posit a potential linkage between PSA and perceived usefulness for mobile healthcare. The following hypothesis is thus proposed.

**H11.** Perceived service availability has a positive effect on perceived usefulness for mobile healthcare.

The same study, as discussed above, also argued that PSA has a direct influence on perceived ease of use for a mobile data service [25]. Another study proposed that facilitating conditions are determinants of perceived ease of use for a new technology [59]. Facilitating conditions are defined as the provision factors in the user environment to support the use of a new technology [62]. Thus, facilitating conditions can be considered as certain forms of PSA based on the above definition, such as the readiness of a wireless service. In conclusion, PSA has an influence on perceived ease of use in the mobile healthcare context. Based on the above discussion, we argue that there is a potential linkage between PSA and perceived ease of use for mobile healthcare. The following hypothesis is thus proposed.

**H12.** Perceived service availability has a positive effect on perceived ease of use for mobile healthcare.

### 3. Research design

#### 3.1. Instrumentation

A survey was conducted to collect data. The instrument was designed with a two-part questionnaire. The first part uses a nominal...
scale and the second part uses 7-point Likert scales, as shown in the Appendix A.

3.1.1. Basic information

This part of the questionnaire collects basic information about organizational characteristics including hospital type and bed size as well as respondent characteristics including position, gender, work experience, education level, and age.

3.1.2. TAM constructs

The measuring items for TAM constructs, including perceived usefulness, perceived ease of use, attitude, and behavioral intention to use, were adapted from the measurement developed by Venkatesh and Davis [60,61]. They contain 4 items, 4 items, 4 items, and 3 items respectively.

3.1.3. TPB constructs

The measuring items for TPB constructs, including perceived behavior control and subjective norm, were adapted from the measurements developed by Taylor and Todd [51] and Bhattacharjee [7]. They contain 3 items and 3 items, respectively.

3.1.4. PIIT and PSA

The measuring items for personal innovativeness in IT are based on the recommendations of Agarwal and Prasad [1] and Yi et al. [68], including 3 items. The measuring items for perceived service availability were adapted from the measurements developed by Venkatesh [59] and Hong and Tam [25], including 4 items.

3.1.5. Control variable

Hospital type is indicated as three types, medical center, regional hospital, and local hospital and provider/user type is clustered as two types, physicians and nurses, as discussed previously.

3.2. Sample design

This survey was conducted to examine the acceptance of mobile healthcare by healthcare professionals in hospitals. Mobile healthcare is still in an early stage of use and is considered to be a new technology by medical professionals. It was assumed that larger hospitals would be more likely to have early experience. Three types of hospitals are qualified for this study, including medical centers, regional hospitals, and district hospitals, as classified by the Taiwan Joint Commission on Hospital Accreditation. 450 hospitals of these three types were accredited by the above-mentioned organization in 2007. We randomly selected 80 hospitals for the study sample from the population of 450 hospitals. Furthermore, physicians and nurses in the hospitals were the major respondents since they are the major users of mobile healthcare. Afterward, we first sent an invitation letter to one designated person in each selected hospital and asked them to help distribute questionnaires to their colleagues, including physicians and nurses. After that, 10 questionnaires were sent to each hospital through the designated person. The designated person for each hospital was also responsible for the collection of the questionnaires. In order to improve survey return, a follow-up procedure was carried out with a phone call made to the designated person from each hospital after 3 weeks.

3.3. Demographics

A pretest was conducted for the scale. The scale was carefully examined for translation, wording, structure, and content by selected practitioners (i.e., physicians and nurses) and scholars in this area. Initial reliability and content validity of the scale should be acceptable. After the questionnaire was finalized, 800 questionnaires were sent out to the potential respondents in terms of 10 potential respondents for each hospital and 80 sample hospitals. A total of 140 valid questionnaires were received. The response rate was 17.5%. The seemingly low response rate raised possible concerns about non-response bias. To check non-response bias, the responding sample was divided into two subsamples, that is, early and late subsamples, including 95 and 45 respondents, respectively. The two groups were compared using various demographic characteristics, including hospital type, bed size, position, gender, and age, for their correlation with t-test. None of them (t value = 0.76, 0.68, 1.24, 0.98 and 1.01) showed significant differences at the 0.05 level. Their results indicated that there was no systematic non-response bias for the responding sample. Table 1 summarizes the demographics of the respondents.

3.4. Measurement model

PLS is a structural equation modeling (SEM) technique that employs a nonparametric and component-based approach for estimation purposes. PLS allows latent variables to be modeled as either formative or reflective constructs, and places minimal demands on sample size and residual distributions [11–13]. Theoretically, the sample size for executing PLS requires 10 times the number of indicators associated with the most complex construct or the largest number of antecedent constructs linking to an endogenous construct. When there are 8 variables and each comprises 3–4 measuring items, the sample size (140 respondents) may not be large enough for a goodness of mode-fit with AMOS technique. This study uses PLS to analyze the measurement model. PLS is the best analytical tool available to fit the requirement of small sample size.

Construct validity is defined to comprise convergent and discriminant validities. First, convergent validity for a construct is assessed by three criteria: (1) all item loadings (λ̂) in a construct should be larger than 0.70 for each hospital and 80 sample hospitals. A total of 140 valid questionnaires were received. The response rate was 17.5%. The seemingly low response rate raised possible concerns about non-response bias. To check non-response bias, the responding sample was divided into two subsamples, that is, early and late subsamples, including 95 and 45 respondents, respectively. The two groups were compared using various demographic characteristics, including hospital type, bed size, position, gender, and age, for their correlation with t-test. None of them (t value = 0.76, 0.68, 1.24, 0.98 and 1.01) showed significant differences at the 0.05 level. Their results indicated that there was no systematic non-response bias for the responding sample. Table 1 summarizes the demographics of the respondents.

### Table 1

<table>
<thead>
<tr>
<th>Demographics of the respondents.</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of hospital</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical center</td>
<td>15</td>
<td>18.7</td>
</tr>
<tr>
<td>Regional hospital</td>
<td>45</td>
<td>56.2</td>
</tr>
<tr>
<td>Local hospital</td>
<td>20</td>
<td>25.1</td>
</tr>
<tr>
<td><strong>Bed size</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;500</td>
<td>18</td>
<td>22.5</td>
</tr>
<tr>
<td>500–1000</td>
<td>45</td>
<td>56.2</td>
</tr>
<tr>
<td>1000–1500</td>
<td>10</td>
<td>12.5</td>
</tr>
<tr>
<td>&gt;1500</td>
<td>3</td>
<td>8.8</td>
</tr>
<tr>
<td><strong>Position</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physician</td>
<td>50</td>
<td>35.7</td>
</tr>
<tr>
<td>Nurse</td>
<td>90</td>
<td>64.3</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>88</td>
<td>62.9</td>
</tr>
<tr>
<td>Male</td>
<td>52</td>
<td>37.1</td>
</tr>
<tr>
<td><strong>Work experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5 years</td>
<td>30</td>
<td>21.4</td>
</tr>
<tr>
<td>5–15 years</td>
<td>62</td>
<td>44.3</td>
</tr>
<tr>
<td>15–25 years</td>
<td>36</td>
<td>25.7</td>
</tr>
<tr>
<td>&gt;25 years</td>
<td>12</td>
<td>8.6</td>
</tr>
<tr>
<td><strong>Education level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school</td>
<td>21</td>
<td>15.0</td>
</tr>
<tr>
<td>College</td>
<td>48</td>
<td>34.3</td>
</tr>
<tr>
<td>Graduate</td>
<td>21</td>
<td>15.0</td>
</tr>
<tr>
<td>M.D.</td>
<td>50</td>
<td>35.7</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;30 years</td>
<td>25</td>
<td>17.8</td>
</tr>
<tr>
<td>31–40 years</td>
<td>54</td>
<td>38.6</td>
</tr>
<tr>
<td>41–50 years</td>
<td>43</td>
<td>30.7</td>
</tr>
<tr>
<td>&gt;50 years</td>
<td>18</td>
<td>12.9</td>
</tr>
</tbody>
</table>
and statistically significant, (2) composite reliability for a construct should exceed 0.80 and can be interpreted like a Cronbach’s α coefficient, and (3) average variance extracted (AVE) for a construct should be larger than 0.50 [20]. Next, discriminant validity is assessed using the criterion that the square root of AVE for a construct should be larger than its correlations with other constructs [13,20]. Table 2 shows the indices of reliability and convergent validities for the scale. Item loadings range from 0.84 to 0.96 and are all significant at the 0.01 level. Composite reliabilities range from 0.85 to 0.93, and AVE range from 0.82 to 0.90. These indices together indicate a high degree of convergent validity. Cronbach’s α coefficients range from 0.87 to 0.93, which suggests a high level of reliability. The correlation matrix between constructs shows that the square root of AVE for a construct is above its correlations with other constructs, as indicated in Table 3. The results suggest a high degree of discriminant validity.

### Table 2
Reliability and convergent validity.

<table>
<thead>
<tr>
<th>Construct</th>
<th>No. of items</th>
<th>Mean</th>
<th>S.D.</th>
<th>Item loading</th>
<th>Composite reliability</th>
<th>AVE</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived usefulness</td>
<td>4</td>
<td>4.89</td>
<td>1.15</td>
<td>0.92 - 0.96</td>
<td>0.93</td>
<td>0.90</td>
<td>0.93</td>
</tr>
<tr>
<td>Perceived ease of use</td>
<td>4</td>
<td>4.88</td>
<td>1.13</td>
<td>0.90 - 0.94</td>
<td>0.91</td>
<td>0.86</td>
<td>0.92</td>
</tr>
<tr>
<td>Subjective norm</td>
<td>3</td>
<td>5.27</td>
<td>1.26</td>
<td>0.85 - 0.92</td>
<td>0.88</td>
<td>0.85</td>
<td>0.88</td>
</tr>
<tr>
<td>Perceived behavioral control</td>
<td>3</td>
<td>4.78</td>
<td>1.23</td>
<td>0.84 - 0.89</td>
<td>0.85</td>
<td>0.82</td>
<td>0.87</td>
</tr>
<tr>
<td>Attitude</td>
<td>3</td>
<td>5.31</td>
<td>1.11</td>
<td>0.86 - 0.88</td>
<td>0.87</td>
<td>0.83</td>
<td>0.89</td>
</tr>
<tr>
<td>Behavioral intention</td>
<td>3</td>
<td>4.77</td>
<td>1.22</td>
<td>0.88 - 0.90</td>
<td>0.85</td>
<td>0.85</td>
<td>0.90</td>
</tr>
<tr>
<td>Personal innovativeness in IT</td>
<td>4</td>
<td>5.08</td>
<td>1.12</td>
<td>0.89 - 0.90</td>
<td>0.85</td>
<td>0.85</td>
<td>0.90</td>
</tr>
<tr>
<td>Personal service availability</td>
<td>3</td>
<td>4.52</td>
<td>1.26</td>
<td>0.84 - 0.91</td>
<td>0.88</td>
<td>0.83</td>
<td>0.90</td>
</tr>
</tbody>
</table>

### Table 3
Discriminant validity.

<table>
<thead>
<tr>
<th>Construct</th>
<th>PU</th>
<th>PEOU</th>
<th>SN</th>
<th>PBC</th>
<th>ATT</th>
<th>PIIT</th>
<th>PSA</th>
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</thead>
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<td>0.80</td>
<td>0.06</td>
<td>0.83</td>
<td>0.15</td>
<td>0.11</td>
<td>0.75</td>
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<tr>
<td>Subjective norm</td>
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<td>0.13</td>
<td>0.13</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral intention</td>
<td>0.30</td>
<td>0.28</td>
<td>0.15</td>
<td>0.16</td>
<td>0.15</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Personal innovativeness in IT</td>
<td>0.14</td>
<td>0.16</td>
<td>0.09</td>
<td>0.21</td>
<td>0.13</td>
<td>0.13</td>
<td>0.82</td>
</tr>
<tr>
<td>Personal service availability</td>
<td>0.15</td>
<td>0.29</td>
<td>0.25</td>
<td>0.07</td>
<td>0.31</td>
<td>0.22</td>
<td>0.20</td>
</tr>
</tbody>
</table>

**Diagonal value:** square root of AVE and non-diagonal value: correlation

5. Findings and discussions

This current model indicates high explanatory power for behavioral intention to use mobile healthcare with $R^2 = 0.63$. Similar TAM or TPB-based studies in the context of telemedicine technologies have reported in lower levels of predictive power, Yi et al. [68] with $R^2 = 0.57$, Chau and Hu [10] with $R^2 = 0.43$, and Hu et al. [26] with $R^2 = 0.44$. This may be because the four antecedents of behavioral intention to use, that is, perceived usefulness, attitude, perceived behavioral control, and subjective norm, are all significant in their influence. This also well confirms the importance of an integration of TAM and TPB with two particular factors, PIIT and PSA, in effectively determining the acceptance of mobile services in the healthcare context.

Among these antecedents, perceived usefulness, in particular, plays the same significant role as the three major components of TPB, attitude, perceived behavioral control, and subjective norm. Research on the issue of integrating TAM and TPB has shown mixed results in its impact on behavioral intention to use [68]. Moreover, perceived usefulness has much greater influence on attitude toward using mobile healthcare than perceived ease of use. ($β = 0.60$ vs. 0.16). In brief, for the two findings, perceived usefulness is particularly important in encouraging the use of mobile healthcare. The reason behind this may be due to the unique relevance of using mobile healthcare in the patients’ health and life. As a

<table>
<thead>
<tr>
<th>Construct</th>
<th>No. of items</th>
<th>Mean</th>
<th>S.D.</th>
<th>Item loading</th>
<th>Composite reliability</th>
<th>AVE</th>
<th>Cronbach’s α</th>
</tr>
</thead>
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<td>Perceived usefulness</td>
<td>4</td>
<td>4.89</td>
<td>1.15</td>
<td>0.92 - 0.96</td>
<td>0.93</td>
<td>0.90</td>
<td>0.93</td>
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<tr>
<td>Perceived ease of use</td>
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<td>4.88</td>
<td>1.13</td>
<td>0.90 - 0.94</td>
<td>0.91</td>
<td>0.86</td>
<td>0.92</td>
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<tr>
<td>Subjective norm</td>
<td>3</td>
<td>5.27</td>
<td>1.26</td>
<td>0.85 - 0.92</td>
<td>0.88</td>
<td>0.85</td>
<td>0.88</td>
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<tr>
<td>Perceived behavioral control</td>
<td>3</td>
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<td>0.90</td>
</tr>
</tbody>
</table>
result, healthcare professionals should cautiously evaluate its real usefulness in helping patient cares before it is actually used. Perceived ease of use indicates no significant effect on attitude toward using mobile healthcare. This may be because the designs of user interfaces for mobile services are in well-defined forms and are able to communicate with medical professionals in a user-friendly manner. From a broader perspective, a lack of variation in users’ evaluations of user interfaces may be a part of a well-defined form since the designs of user interfaces have reached a level of maturity.

Next, this study importantly indicates that PIIT is not significant in determining attitude, but is significant in influencing perceived behavioral control. The findings are particularly novel for the adoption of mobile healthcare while attitude is usually reported as the major produced effect in the literature. The findings also explain the above indication of the similar role played by perceived behavioral control in affecting behavioral intention to use. More specifically, the reasons to explain this are two-fold. First, while mobile healthcare has been widely advocated and recognized by healthcare professionals in hospitals in order to improve healthcare quality recently, the major problem for determining the use of mobile healthcare is not the favorable or unfavorable psychological states of healthcare professionals but externally physical forces or control factors that encourage their usage, such as the necessity of using innovations to treat patients in certain environments. Second, perceived behavioral control is concerned with beliefs about the presence of control factors that may facilitate or inhibit performance of the behavior [5], such as computer self-efficacy and locus of control. Furthermore, potential users with higher PIIT tend to have favorable psychological states and are thus willing to take risks by trying out innovations [50,68]. Therefore, healthcare professionals with higher PIIT enforce their interests or psychological states in favor of the use of mobile healthcare and as a result, they perceive better control or ease in performing the adoption behavior.

Moreover, PSA, as an important determinant of using new technology, reveals significant effect on perceived usefulness and no significant effect on perceived ease of use. The findings are particularly critical for the use of mobile healthcare since most professionals still think that mobile healthcare is a type of emerging technology which is difficult to use. This may have an indication for healthcare professionals should cautiously evaluate its real usefulness in helping patient cares before it is actually used. Perceived ease of use indicates no significant effect on attitude toward using mobile healthcare. This may be because the designs of user interfaces for mobile services are in well-defined forms and are able to communicate with medical professionals in a user-friendly manner. From a broader perspective, a lack of variation in users’ evaluations of user interfaces may be a part of a well-defined form since the designs of user interfaces have reached a level of maturity.

Finally, a few words about the control variables are in order. The three hospital types, medical center, regional hospital, and local hospital, are significantly different in influencing behavioral intention. This indicates that larger hospitals (medical centers) are in a position to have high behavioral intention to use mobile healthcare among medical personnel. The reasons behind this may be explained as below. Larger hospitals have more responsibility to guarantee quality of patient care in terms of improving customer care and administrative processes. Moreover, they possess the resources and skills necessary to assimilate the innovation among medical personnel efficiently and effectively. As a result, users of mobile healthcare are more likely to adopt healthcare mobile in the situation of both internal and external pressures. Next, the two provider types, physicians and nurses, indicate no significant difference in impacting behavioral intention. In other words, physicians and nurses have no difference in behavioral intention to use mobile healthcare across hospital sizes. Two major reasons are discussed as below. First, the use of mobile healthcare, while offering ubiquitous healthcare or healthcare to anyone, anytime, and anywhere, has increasingly become an important working concept for all healthcare professionals. Second, the features of mobile healthcare have grown into more maturity recently for providing usefulness and usability (ease of use) for all healthcare professionals.

6. Conclusions and suggestions

In general, this study first integrated TAM and TPB to explain the adoption behavior in general IS settings. In particular, while considering the context of mobile healthcare for healthcare professionals, PIIT and PSA have been well indicated as important antecedents of individual adoption. This study integrated the two perspectives to propose a research model for exploring the adoption of mobile healthcare in a complementary manner. First, this model has reported high explanatory power for the adoption of mobile healthcare compared to previous studies. Next, there are several new findings regarding the roles of TAM and TPB as well as PIIT and PSA. The components of TAM and TPB are all important in the adoption of mobile healthcare. PIIT is particularly important to the perceived behavioral control toward using mobile healthcare as the control or facilitating factor. PSA is crucial to the perceived usefulness in the
particular healthcare environment. These findings have important implications for both practitioners and researchers.

For the practitioners, healthcare professionals are very conservative about trying new technologies since their work directly relates to patients’ safety. They often adopt new technology with high confidence only when skill level or knowledge seems stable and mature. These particular properties regularly impede the diffusion of mobile healthcare. As a result, this study has shown that recognizing some improvements of technological, organizational, and individual characteristics is critical in increasing the behavioral intention to use mobile healthcare by medical professionals. First, PSA is the initial driving force determining behavioral intention to use through two layers of mediators in terms of TAM beliefs, that is, perceived usefulness and attitude. This description basically relates to a particular technological issue in the adoption of mobile services. This means that to effectively encourage medical professionals to use mobile healthcare, the service provided should be well prepared in the hospitals to enable pervasive and timely usage without any difficulty.

Next, a TAM belief (perceived usefulness) and PIIT are shown to be the underlying antecedents in determining behavioral intention to use through the mediators of attitude and perceived behavioral control, respectively. This means that both technological (perceived usefulness) and individual issues (PIIT) are important for overcoming the impediment of using mobile healthcare. For the technological aspect, the design of a mobile healthcare needs to first carefully examine the functional requirements of users and then, this system is able to provide useful information for helping in the decision making of medical professionals. For the individual aspect, the hospitals may provide incentives for encouraging medical professionals to carry out their regular tasks in an innovative manner. This would improve the willingness of individuals to take risks by trying out innovations. Finally, the TPB components, attitude, perceived behavioral control, and subjective norm, involve relevant organizational and individual issues for indicating their impact on the adoption of mobile services. The hospitals, as a type of an organization’s form, should be able to provide some training programs for increasing the skill levels of employees and nurturing their confidence in facing new technologies as well as to be able to carefully plan and design certain interactive/coordinative programs for employees in terms of their formal and informal communication needs in their work in order to establish the mechanism of mutual trust and influence for their co-workers.

For the researchers, prior research on IT acceptance in general and mobile services in particular has been focused on the general components of TAM or TPB. This research considered the roles of system services and personal traits in the innovation acceptance. This is because mobile healthcare with wireless features is an emerging technology for medical professionals in terms of high uncertainty in system services, great change of their work styles, and real belief of its usefulness. These considerations are particularly important for the context of mobile healthcare. We approached this from a broader perspective in terms of considering various perspectives, including the attributes of organizations, individuals, technology, system services, and psychological states. The empirical findings have been confirmed to have higher predictive power compared to previous studies. This will provide a new way of thinking for theoretically defining the antecedents of behavioral intention to use in the context of mobile healthcare.

Furthermore, subsequent research can be based on this foundation. First, while the sample respondents of physician and nurses in this study have been identified as new users of innovations, behavioral intention to use may change in terms of user levels of experience. Additional research can be conducted to examine differences of behavioral intentions as users become more aware of mobile healthcare. Next, this study primarily develops a theoretical framework and further empirically validates it with survey data. Future research can be redesigned with case studies to longitudinally observe the usefulness of this research framework in practice. In addition, while mobile healthcare in this study is still in its early use, our focus is on exploring the purpose of its use and types of tools from a more general perspective. After moving to a more mature stage, the support of specific clinic tasks from some types of mobile devices may need to be importantly identified for understanding the specific decisions of users’ behaviors. Future research can be extended based on the specific features for deeply exploring intention to use mobile healthcare.

Finally, although this research has produced some interesting results, a number of limitations may be inherent in it. Many studies have reported that gender difference plays a moderating role in the relationship between attitude, perceived behavioral control, or subjective norm and behavioral intention to use. This study showed that approximately 62.9% and 37.1% of the respondents were female and male, respectively. The result may not appropriately reflect the population distribution of gender and cause a bias against the current findings. However, no systematic non-response bias was reported among the sample respondents in regard to gender. Accordingly, the bias was minimized in an acceptably low degree. Second, the response rate for this survey was lower than desirable, despite the various efforts to improve it. One of the reasons for this may be due to the inexperience of the respondents in using mobile healthcare and they were reluctant to answer the questionnaire. However, the sample respondents reported no systematic non-response bias and were well representative of the study sample. Finally, since medical doctors from larger hospitals are always quite busy, some questionnaires may have been completed by subordinates and therefore, the data may have some biases.

Appendix A. Questionnaire

Part I

Basic information
Type of hospital: Medical center □ Regional hospital □ Local hospital
Position: Physician □ Nurse
Gender: Female □ Male
Work experience: □ <5 years □ 5–15 years □ 15–25 years □ 25 years
Education level: □ High school □ College □ Graduate □ M.D.
Age: □ <30 years □ 30–40 years □ 40–50 years □ >50 years

Part II

Perceived usefulness
PU1 Using mobile devices for wireless healthcare would improve my work performance.
PU2 Using mobile devices for wireless healthcare would improve my work productivity.
PU3 Using mobile devices for wireless healthcare would enhance my work effectiveness.
PU4 I find mobile devices for wireless healthcare to be useful in my job.

Perceived ease of use
PEOU1 My interaction with mobile devices for wireless healthcare is clear and understandable.
PEOU2 My interaction with mobile devices for wireless healthcare does not require a lot of mental effort.
PEOU3 It is easy to get mobile devices for wireless healthcare to do what I want it to do.
PEOU4 It is easy to use mobile devices for wireless healthcare.
Perceived service availability

PBC1 I would be able to use mobile devices for wireless healthcare well for my job.
PBC2 Using mobile devices for wireless healthcare are entirely within my control.
PBC3 I had the resources, knowledge and ability to use mobile devices for wireless healthcare.

Subjective norm

SN1 People who are important to me would prefer that I use mobile devices for wireless healthcare.
SN2 People who influence me would think that I should use mobile devices for wireless healthcare.
SN3 People whose opinions are valued to me would prefer that I should use mobile devices for wireless healthcare.

Behavioral intention

BI1 Assuming I have access to mobile devices for wireless healthcare, I intend to use it.
BI2 Given that I have access to mobile devices for wireless healthcare, I predict that I would use it.
BI3 If I have access to mobile devices for wireless healthcare, I want to use it as much as possible.

Personal innovativeness in IT

PIIT1 If I heard about a new information technology, I would look for ways to experiment with it.
PIIT2 Among my peers, I am usually the first to try out new information technologies.
PIIT3 In general, I am not hesitant to try out new information technologies.
PIIT4 I like to experiment with new information technologies.

References

[23] D. Gefen, M. Keil, The impact of developer responsiveness on perceptions of usefulness and ease of use: an extension of the technology acceptance model, ACM.