

# **Examining a model of mobile healthcare technology acceptance by the elderly**

(Preferred Journal: *European Journal of Information Systems*)

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# **Examining a model of mobile healthcare technology acceptance by the elderly**

## **Extended abstract**

“Graying of the globe” is increasing exponentially worldwide due to the rising number of seniors and retirees in developed countries; accompany with this phenomenon is the expanding healthcare costs for long-term care and hospitalization. Given current trend, people aged over 60 in Taiwan was nearly 4 million in 2012, and will reach 6.5 million by 2025, approximately one quarter of total population. In response to the aging of Taiwan’s population and the accompanying enormous Medicare expenses, the Home-Department of Health in Taiwan has planned to carry out the “Telecare Service Development Project” from 2010 to 2014. The tele-healthcare centers will provide 24-hour continuous healthcare consulting and health management services, and assist with patient referrals. By the end of June 2011, the network has already provided over 745 thousand times services but only for less than 4 thousand people.

Previous medical literature suggested that the ultimate success of telemedicine depends not only on the technology itself but also on including user technology acceptance. These health applications become particularly relevant through the issue of access. Although the functions of wireless healthcare devices are to monitor elderly people’s biometric measurements and transmit emergency signals as a means of precaution, elderly people tend not to be accustomed to modern technology. Therefore, the ultimate success of these mobile healthcare systems relies on the acceptance of elderly people.

This study addressed two main questions: “What factors impact the elders’ acceptance of mobile wireless healthcare technology?” and “Does the technology acceptance model (TAM) adequately generalize to mobile wireless healthcare technology among the elderly?” By answering these questions, the study contributes to the knowledge gap regarding the mobile wireless healthcare technology by integrating the TAM, and other factors including individual differences referring to health cognition, technology characteristics, and social influences.

Past IS studies related to mobile healthcare have been conducted by healthcare

professionals such as physicians. Instead, the current study investigates the use intention of mobile healthcare-related devices from the perspectives of elderly people, as only a few other studies have done.

Therefore, we aim to propose an extended TAM model to examine the elderly users' perceptions of mobile healthcare technology. We employed the survey methodology to investigate elderly people (over 60 years old) for the research purpose. Some trained instructors recruited volunteers among elderly people in several spots in northern Taiwan, including health centers, parks, and nursing homes. It took about four month for the investigation. A total of 338 effective questionnaires were collected and used for subsequent analysis. Structural equation modeling was used to analyze the data. Valid and reliable scales for each construct in the model were developed. Implications and policy suggestions are also discussed.

The present study strengthens our conclusions with a sound theoretical base and fills the gap in the knowledge regarding the elderly people's adoption of mobile healthcare technology. The empirical findings support the inclusion of perceived ubiquity, personal health knowledge and perceived need for mobile healthcare technological devices in the TAM. The mobile healthcare technology acceptance model (MHTAM) therefore presents an explication of how different determinants influence older people's adoption of mobile healthcare devices, thus providing researchers and practitioners with an in-depth understanding of the introduction of new technology devices for mobile healthcare.

We believe that conducting research on the behavioral aspects of mobile healthcare can provide important empirical results and theoretical ideas in the IS field, and thus benefit the further development of IS theory.

**Keywords:** Mobile healthcare technology acceptance model (MHTAM), Telehealth, Ubiquity, Health knowledge, Health need

# **Examining a model of mobile healthcare technology acceptance by the elderly**

## **Introduction**

The worldwide population of the elderly (over 60 years old) is on the rise. The number was 865 million in 2010 and is expected to reach nearly 1.4 billion by 2025 [1]. Given current trend, it is estimated that people aged over 60 in Taiwan was nearly 4 million in 2012, and will reach 6.5 million by 2025 (Council for Economic Planning and Development, 2013). Furthermore, Taiwan's population is aging faster than that of western countries, with an elderly population of 9.95%, higher than the global average of 7%. Accompanying this phenomena of the "graying of the globe" are the exponentially increasing healthcare costs for long-term care and hospitalization due to the rising number of seniors and retirees in developed countries. Improper management of chronic illnesses and unnecessary long-term hospitalization lead to the enormous expenses of Medicare. Therefore, it is essential for elderly people to take precautions against possible chronic and acute illnesses.

Population aging and its associated health care issues are crucial in Taiwan as well. In response to the aging of Taiwan's population and the accompanying enormous Medicare expenses, the Home-Department of Health (DOH) planned to carry out the "Telecare Service Development Project" from 2010 to 2014. As of the end of June 2011, the network has provided 745,061 services for 3,717 people [3].

The health-related Internet applications (collectively called e-health) deliver a range of content, connectivity, and clinical care. The use of wireless technologies for patients in homes, nursing homes, and hospitals is proposed to reduce the long-term cost of healthcare and to result in increased productivity of healthcare providers [4]. This IT-based technology is an effective way of supporting patient care from a distance. The healthcare applications range from healthcare maintenance and checkups, short-term monitoring (or home healthcare monitoring), long-term monitoring (nursing home), personalized healthcare monitoring, incidence detection, and emergency intervention [4]. These health applications become particularly relevant through the issue of access, which determines who will be able to get a healthcare intervention. Wireless networks can serve patients who are able to move around in terms of monitoring [5,6], creating a great need and important role for mobile healthcare in the healthcare sector. The main problem in monitoring patients at home is whether they are capable of using the equipment. However, with the increasing use of wireless technology and widespread deployment of wireless networks, the wireless infrastructure can provide support for many current and emerging healthcare applications, allowing patients to be monitored anytime in any place by sending an alerting message to the nearest healthcare professional.

The wireless healthcare applications vary from pervasive health monitoring, intelligent emergency management systems, pervasive healthcare data access, to ubiquitous mobile telemedicine [4]. Comprehensive wireless architecture in a healthcare environment is designed by using location tracking technologies, including GPS, cellular networks, wireless LANs, and RFID [7]. These

health-monitoring devices can be wearable or handheld depending on the level of ease of use, including from healthcare wrist watch, GSM bluetooth watch phones, healthcare GPS watch phones, and so on. The main advantages of the above products are that they remotely monitor patients' biometric measurements and transmit both routine vital signs and alerting signals when vital signs exceed a certain "individualized" threshold. For example, the research interest, intelligent RFID healthcare watches or mobile healthcare watches (MHW) provide functions such as emergency call, user location tracking, biometric measurements via Bluetooth, possible slip detection, and speed dial for family members when detecting abnormal temperature or blood pressure.

There is considerable potential for wireless healthcare systems to provide an effective means to assist elderly care. Such healthcare systems do not require extensive hardware or infrastructure, but are mostly designed as handheld or wearable devices which can be used in an easy and convenient manner. However, elderly people tend not to be accustomed to modern technology. Perednia and Allen [8] suggest that the ultimate success of telemedicine depends not only on the technology itself but also on managerial challenges, including user technology acceptance. We believe that conducting research on the behavioral aspects of mobile healthcare can provide important empirical results and theoretical ideas in the IS field, and thus benefit the further development of IS theory.

Various acceptance models such as the theory of reasoned action (TRA) and the

technology acceptance model (TAM) have provided an insight into the major universal factors that are likely to affect a user's perceptions of a technology. Although some studies in the past few years have strongly concluded that TAM is not suitable for use in healthcare settings because it does not consider a substantial number of factors influencing the adoption of technology in healthcare, it is still one of the leading theoretical models with strong empirical support for the acceptance of various forms of technology by end-users. Additionally, other studies have shown that the integration of TAM and TPB (the theory of planned behavior) or TRA should lead to higher power to explain technology acceptance in both business and healthcare applications [9,10].

This study empirically addressed two main questions: "What factors impact users' acceptance of mobile wireless healthcare technology?" and "Does TAM together with TRA generalize to mobile wireless healthcare technology?" By answering these questions, the study contributes to the knowledge gap regarding the mobile wireless healthcare technology by integrating the theory of reasoned action (TRA), the technology acceptance model (TAM), and other factors including individual differences related to health cognition, technology characteristics, and social influences as previous studies have suggested [11,12]. Past studies related to mobile healthcare have been conducted by healthcare professionals such as physicians [13,14]. However, this study investigates the use intention of mobile healthcare-related devices from the perspective of elderly people, as only a few other studies have done [15,16]. Therefore, we aim to propose an extended TAM model to examine the elderly users' perceptions of mobile healthcare technology. Valid and reliable scales for each construct in the

model were developed. Implications and policy suggestions are also discussed.

## **Theoretical background and hypotheses development**

In this section, we review the key IS literature on technological adoption/acceptance and propose the Mobile Healthcare Technology Acceptance Model (MHTAM). MHTAM is theoretically grounded in TRA and TAM. Our proposed model therefore includes technological factors (key factors from TAM, and perceived ubiquity), individual factors (i.e., personal health knowledge and need for health care), social factor (subjective norms), as well as attitude and behavioral intention. The following describes our research model in detail.

### ***The technological contexts in healthcare***

Several models have been proposed to study and understand user acceptance behavior and influential factors, including the Theory of Reasoned Action (TRA) [17], the Theory of Planned Behavior (TPB) [18], and the Technology Acceptance Model (TAM) [19]. These theories appear to be well-structured and are adequate to interpret users' intentions to use an information system [16]. Among them, TAM is the dominant model for investigating user technology acceptance with its strengths of parsimony and high explanatory power [19]. Based on TRA, TAM focuses on two main beliefs about IT: perceived ease of use (PEOU) and perceived usefulness (PU). These two factors directly affect an individual's attitudes (AT) towards and behavioral intention (BI) regarding



using a system. BI is a person's subjective probability of engaging in a certain behavior. AT refers to the feelings of favorable or unfavorable evaluation of performing a behavior. PEOU is defined as the degree to which a person believes that using a particular system would enhance his or her job performance, while PU refers to the degree to which using the technology will be free of effort.

The acceptance of new technologies has long been an area of study in the MIS literature, even in the telemedicine and mobile healthcare contexts [14]. Some researchers have also successfully adopted the integration concept of TAM to explore the adoption of mobile healthcare by healthcare professionals [13,14]. In the review article of Holden and Karsh [20] which proposed that TAM is well adapted to the healthcare context even though some modifications is suggested, such as including additional variables. In this study, BI is a measure of an elderly person's willingness to adopt the mobile healthcare watch (MHW). AT refers to an elderly person's positive or negative evaluative affect regarding using the MHW.

In attitudinal research, the relationship between AT and BI is significant and has been supported in the literature regarding the adoption of technology [21]. In the study of mobile healthcare, a healthcare professional's attitude is found to have a positive impact on his/her adoption intention regarding wireless healthcare devices [14]. According to TAM, we suggest that an elderly user's perception of ease of use and usefulness will affect his/her attitude toward using MHW. In addition, PU is hypothesized to be influenced by PEOU, because the

easier a technology is to use, the more useful it will be. Ultimately, the elderly user's intention to use MHW can be explained by the attitude towards using it. Thus, following the earlier TAM research, we hypothesize:

Hypothesis 1: An elderly person's attitude towards MHW positively affects his/her behavioral intention towards MHW usage.

Hypothesis 2: An elderly person's perceived ease of use towards MHW positively affects his/her perceived usefulness towards HWP usage.

Hypothesis 3: An elderly person's perceived ease of use towards MHW positively affects his/her attitude towards MHW usage.

Hypothesis 4: An elderly person's perceived usefulness towards MHW positively affects his/her attitude towards MHW usage.

Beyond the technology acceptance model, past research has suggested that the acceptance of mobile healthcare generally involves technological and behavioral aspects for personal use; therefore TAM alone is not sufficient to explain a user's behavioral intentions [22]. It has been suggested that characteristics of the technology context be integrated into the TAM model [11]. In the information technology literature, perceived ubiquity is a relatively new concept and is becoming more popular in research relating to wireless technology. Ubiquity represents a definitive form of spatial, temporal, and contextual mobility [23].

The wireless infrastructure can support current and emerging healthcare devices. In our context, perceived ubiquity refers to an elderly person's

perception of the extent to which MHW provides personalized connections between the individual and other people or healthcare networks anytime and anywhere [24]. Indeed, the wireless features of mobile healthcare devices offer elderly adults extraordinary levels of flexibility and convenience to engage in multiple outdoor activities so that they can contact others anytime and anywhere. This benefit of ubiquity affects the elderly's overall evaluation of the healthcare device [25]. Thus, we hypothesized the following:

Hypothesis 5: An elderly person's perceive ubiquity towards MHW positively affects his/her attitude towards MHW usage.

### ***The individual contexts in healthcare (health knowledge, health needs)***

In addition to the technology factor, individual differences and social influences also have a positive influence on users' attitudes and intention to use mobile wireless Internet [12], among which personal difference in knowledge has caught researchers' interest. It is assumed that as consumers' knowledge increases, they are more likely to engage in behavior which is consistent with their beliefs or knowledge [26]. For example, if patients are inclined to seek information related with their health, in this case, they will gradually acquire adequate knowledge about their health condition; then, the likelihood for them to accept delivered e-health is great [27]. Accordingly, we anticipate that elderly persons' healthcare knowledge could provide significant predictions of their attitudes toward the adoption of e-health devices.

Furthermore, patients who are more concerned and care about their physical condition, especially with certain health conditions such as chronic diseases (e.g., diabetes or severe injuries) are more likely to confer with their health care providers [28]. In an e-health environment, people can easily access medical information via mobile devices rather than via a medical library or asking from a physician personally [27]. Therefore, it is anticipated that patients who are highly involved in their own health care and have a high information-seeking preference will have stronger tendencies to accept e-health technology as a means of receiving additional healthcare. Accordingly, we inferred that elderly persons with high concern and needs for their own health knowledge and healthcare would have more positive attitudes toward MHW.

Hypothesis 7: An elderly person's health knowledge positively affects his/her attitude towards MHW usage.

Hypothesis 8: An elderly person's need for healthcare positively affects his/her attitude towards MHW usage.

### ***The sociological contexts in healthcare (subjective norm)***

In the current study, we include one more factor from sociological perspective, namely subjective norm, which refers to the perceived social pressure that one's reference group desires one to perform or not perform a certain behavior [18]. Any person or group serving as a reference group could exert a key influence on the person's beliefs, attitudes, and event decisions, especially in the adoption of technology devices. We define it as an elderly adult's perceived social pressure

desiring him or her to adopt mobile healthcare devices (i.e., the MHW). Subjective norm is not in the original TAM, but Davis et al. [19] did acknowledge the need to investigate the impact of social influences on usage behavior. Later on, Venkatesh and Davis [22] readopted it into the extended model of TAM (namely TAM2) after the confirmation of a longitudinal test regarding four IS systems.

Subjective norm is influential to the adoption of information technology because before a technology is developed, users usually have very little knowledge of it. Therefore, they must rely on others' opinions regarding its usage [29], especially for novel technology such as the use of wireless Internet via mobile technology [12]. For elderly adults, family members (e.g., spouse and children) usually serve as their reference group. It is confirmed from the study of mobile phone usage that family members do exert their influence on the elderly through the provision of advice and support [30]. Besides family members, healthcare professionals such as physicians also play an important role in patients' acceptance of technology [14]. Accordingly, we hypothesized the following:

Hypothesis 6: An elderly person's subjective norm towards MHW positively affects his/her behavioral intention towards MHW usage.

## **Methodology**

### ***Participants and procedure***

To explore the underlying factors of the Mobile Healthcare Technology

Acceptance Model (MHTAM), 390 respondents above 60 years old were recruited by several trained instructors in northern Taiwan. Although most developed countries have accepted the chronological age of 65 years as a definition of “elderly” or older person, but there is no United Nations standard numerical criterion. According to the world health organization, in addition, it that any age after 60 is acceptable to refers to the older population [31]. For this study, we use 60 years of age and older as the general definition of an older person. Some trained instructors visited several health spots in the early morning to recruit older people, including health centers, nursing homes, and parks in northern Taiwan. It took about four month for the investigation.

First, the instructors explained that the research purpose was for academic use and that anonymity was assured. After acquiring their consent, the instructors then briefly presented the functions of the mobile healthcare watch (MHW). Then questionnaires were distributed with or without the instructors’ help. As a result, 338 questionnaires with complete answers were available for analysis, reaching an effective response rate of 86.7%. Males and females made up 48% and 52% of the sample, respectively. Most of the investigated subjects lived with their families (65.7%), 21.9% of them lived in long-term care centers located in northern Taiwan, and the rest of them lived alone. Note that the respondent’s families and the volunteers in the long-term care facilities provided the necessary assistance to complete this survey. More detailed information about the respondents is listed in Table 1.

Table 1 here

## ***Measurement***

Measurement items in this paper were developed from previous studies and carefully restated to reflect the characteristics of the MHW. One advantage of using the TAM is that it has a well-validated measurement inventory. In this study, intention was chosen over actual usage to measure technology acceptance. It is reasonable that actual use of MHW in Taiwan was not widespread at the time of this study. Nevertheless, sufficient empirical research supports that behavioral intention can explain or predict actual behavior well, and can be an adequate proxy of actual behavior [32]. All measures use 7-point Likert scales with anchors ranging from “strongly disagree” to “strongly agree”. A backward translation technique (with items translated from the original English scale into Chinese, and then back into English) was used to solve any discrepancies between the two versions.

Consistent with past research in technology acceptance, items on perceived ease of use (PEOU) and perceived usefulness (PU) were drawn from Davis et al. [19] and Wilson and Lankton [27]. In addition, items on perceived ubiquity were modified from Kim and Garrison [33]. Subjective norm, attitude and behavioral intention toward using mobile healthcare technology originated from Fishbein and Ajzen [17] and Ajzen [18]. Items on health knowledge and healthcare needs were modified from Wilson and Lankton [27] and Jiang and Leung [34].

## ***Measurement assessment***

Items developed from previous studies do not automatically guarantee

satisfactory validity and reliability. Pretests were required to examine the validity of the survey instrument, and to ensure that the content validity and reliability was at an acceptable level. Subjects for the pretest were drawn from another collection of samples which was similar to our target sample. Cronbach's alpha values ranged from 0.82 (for perceived need) to 0.96 (for subjective norm). Due to a low item-to-total value (less than 0.7), one item from health knowledge was removed from the initial version. The above process assured the content validity of the questionnaire. The refined instrument was then used to measure the respective constructs of the research model (listed in Appendix).

## **Empirical results**

### ***Measurement model***

To assess the reliability and validity of the measures, a recommended two-step structural equation modeling (SEM) approach was facilitated [35]. First, the measurement model was evaluated by using confirmatory factor analysis (CFA) accompanied with LISREL 8.54. The results showed a satisfactory fit to the data with  $\chi^2_{(247)} = 666.51$  ( $p < 0.001$ ) and other goodness of fit indices: NNFI = 0.98; CFI = 0.98; IFI = 0.98; GFI = 0.86; AGFI = 0.082; RMR = 0.051; RMSEA = 0.071; NFI = 0.97.

The reliability was assessed by the Cronbach's alpha coefficients of more than 0.7 [36]. The Cronbach's alpha coefficients, ranging from 0.83 to 0.96, show a satisfactory requirement of reliability for research instruments. In addition,



composite reliability (CR) was also used to check the internal consistency. As shown in Table 2, all composite reliabilities of constructs (ranging from 0.83 to 0.96) have a value higher than the threshold value 0.7.

To validate our measurement model, three types of validity were assessed: content validity, convergent validity, and discriminant validity. Content validity is established by ensuring the consistency between the measurement items and the existing literature. Convergent validity is assessed by how closely related the two measures are with the same construct. It is statistically achieved under two criteria recommended by Fornell and Larcker [37]. First, all item factor loadings should be significant and should exceed 0.7. Second, composite (CR) and average variance extracted (AVE) for each construct must exceed the recommended threshold of 0.8 and 0.5, respectively. AVE is used to measure the percentage of total variance observed in the items accounted for by each construct [37]. As shown in Table 2, standardized CFA loadings for all constructs were significant at the 0.001 level (the lowest  $t$  value is 14.22) and exceeded 0.7. Also, our CRs (ranging from 0.82 to 0.96) and AVEs (ranging from 0.60 to 0.86) all exceed 0.5. Hence, all the conditions for convergent validity were met.

Table 2 here

Discriminant validity is evaluated by using the simultaneous pair-wise comparisons of  $\chi^2$  constrained and unconstrained CFA models [38]. Discriminant validity is obtained if the chi-square difference (with 1  $df$ ) was significant, showing that the two constructs are viewed as distinct (but

correlated) factors. The critical value of the chi-square test based on the Bonferroni method under overall 0.01 levels is  $\chi^2_{(1, 0.01/28)} = 12.74$ . As shown in Table 3, the lowest chi-square difference statistic is 45.07 (the unconstrained chi-square value is 711.58), exceeding the critical value 12.74. Furthermore, discriminant validity is also achieved if the square root of AVE for each construct exceeds all correlations between that and other constructs [37]. From the data shown in Table 4, the square roots of AVE were all greater than the off-diagonal elements in the corresponding rows and columns. Therefore, it can be concluded that the instrument had proper convergent and discriminant validity. Table 4 shows the means, standard deviation, and intercorrelations for all variables, with the square root of the AVE on the diagonal values.

Table 3 here

Table 4 here

### ***Structural model***

With an adequate measurement model, structural equation modeling was then conducted to examine the hypothetical relationships among the abovementioned constructs. Note that the goodness-of-fit of our proposed model is acceptable as well ( $\chi^2_{(257)} = 689.01$ ; NFI = 0.97; NNFI = 0.98; CFI = 0.98; IFI = 0.98; GFI = 0.86; AGFI = 0.82; RMR = 0.052; RMSEA = 0.071).

The hypothetical paths between the independent and dependent variables were all supported except for one, the path from PU to AT (hypothesis 4). Hypotheses

1 to 5 were proposed to identify the technological factors which influence elderly people's healthcare technology acceptance. The results indicated that: AT has a significant effect on elderly people's adoption intention ( $\beta = 0.26, p < 0.001$ ); the two paths of PEOU to PU ( $\beta = 0.93, p < 0.001$ ) and PEOU to AT ( $\beta = 0.59, p < 0.001$ ) were statistically significant; the significant linkage between perceived PB and AT ( $\beta = 0.38, p < 0.001$ ) was also confirmed. However, PU failed to impact AT significantly. Referring to the individual factors, HK has shown its importance in explaining elderly people's attitudes ( $\beta = 0.11, p < 0.05$ ). HN also had a significant effect on AT, but in the opposite direction ( $\beta = -0.12, p < 0.05$ ). Result of Mobile Technology Acceptance Model (MHTAM) was shown in Fig. 1.

Fig. 1 here

Other than the results of the proposed model, the current study also compared the TAM model with our proposed model. As shown in Table 5, the TAM model also showed a satisfactory fit to the sample data and all paths were significant at the 0.01 level except for the path from PU to AT. However, the variance explained of AT is 83% in TAM and 90% in our proposed model. The present study also found that the proposed model accounted for 67% of the variance explained in behavioral intention (40% in the TAM model). Therefore, we concluded that our proposed model is more adequate than TAM in terms of explaining elderly people's adoption intention of mobile health technology.

Table 5 here

## **Discussions**

This study presents important contributions and implications to both researchers and practitioners. Given the above findings, our proposed model was supported by high variance explained and most of our paths are significant. The results show that over 80% of the variance in attitudes is explained by its three antecedents, and over 67% of the variance in adoption intention was explained by attitudes and subjective norms, thus providing important insights into healthcare technology adoption. For academicians, this study may be the first that empirically extends TAM by incorporating one technological variable and two personal variables: perceived ubiquity, perceived health knowledge and perceived need for healthcare. Our findings may contribute to a comprehensive understanding of the acceptance of healthcare technology.

Previous research using the TAM has stressed the importance of perceived ease of use and perceived usefulness as key determinants of attitudes towards technology acceptance. Our result failed to recognize the effect of perceived usefulness on attitudes, but did confirm the important determinant of perceived ease of use on attitudes. This result is consistent with a previous study which found that perceived usefulness is not relevant for technology-based self-service products [39]. A possible explanation is that most elderly people are usually not familiar with new technology; even though they know that some multi-functional healthcare devices can be helpful in monitoring their physical conditions, their major concern may be whether they can easily operate the equipment by themselves without the help of others. This possible explanation

also emphasizes the importance of perceived ease of use. In addition, we found another strong influence of perceived ubiquity on attitude. This indicates that elderly people's major concern is to connect with others anytime and anywhere when some critical condition arises. These results suggest that ease of use and ubiquity are more relevant and influential factors for elderly people to build favorable attitudes towards the MHW.

Two individual factors, namely personal health knowledge and perceived need for healthcare, also display a significant influence on elderly people's attitudes towards healthcare technology. Contrary to our expectations, personal need for healthcare had a negative impact on attitudes towards the MHW. This suggests that the more elderly people are concerned about their own health condition and feel the need to consult physicians or healthcare professionals, the more negative their attitudes towards healthcare technology devices are. One possible explanation is that the medical expense of consulting physicians in hospital is comparatively cheap and convenient in Taiwan. Therefore, elderly people would rather consult with clinic personnel than rely on healthcare equipment to give them the proper information about their health condition. Another reason may be the inclination for interaction with a service employee in the self-service technology, especially for elderly people [39], because physicians or clinic professionals can interpret the physiological data, explain or eliminate any doubts derived from it, or even appease their uneasy emotions about their health conditions.

Finally, subjective norm was a stronger predictor of adoption intention than

attitude. This result suggests that a favorable attitude toward healthcare technology can enhance the elderly people's intention to use such equipment; however, the elderly people's reference group, such as clinical personnel, family, and their friends, exerts a stronger decisive influence on them. Therefore, elderly people's interaction with their reference group appears to be an essential factor in encouraging their use of healthcare technological equipment.

### **Practical Implications**

There are a number of important practical implications of this study. With the help of the extended TAM, a company could look at different perspectives on how to stress the important features of products. For instance, the proposed model shows that ease of use and perceived ubiquity are important traits influencing elderly people's adoption of mobile healthcare products. Therefore, the design of healthcare technology equipment should be clear at a glance. This means that most elderly people can operate this device to monitor and transmit their health data by themselves. Adequate demonstration or training would foster their self-efficacy in operating this system. Furthermore, ubiquitous functions, such as one-touch call to their emergency contact or GPS positioning, can provide them with a sense of security to enhance their favorable attitudes towards such technology.

Furthermore, this study suggests the importance of relative health knowledge and the necessity for concern for one's health condition. To improve elderly people's attitudes toward the adoption of mobile healthcare technology it is

necessary to deliver them with current relevant medical information and to enhance their involvement in their physical condition. Practitioners can educate elderly people in relevant health knowledge and information to enhance their involvement in improving their physical condition. In addition, healthcare providers should provide interpersonal counseling services through the mobile health devices. Thus, providing prompt visual or audio medical support would improve customers' assessment of this mobile healthcare system.

Finally, the results provide evidence to support the strong influence of subjective norm on these elderly people's adoption of mobile healthcare technology. Therefore, health industry marketers need to interact not only with elderly people but also with the relevant people around them, such as family or clinic personnel, in order to promote the mobile healthcare technology successfully.

### **Limitations and Conclusions**

Several limitations of this study should be addressed. First, it did not measure the change in user reactions over time. All measures were taken at a single point in time. A longitudinal study tracing individuals' pre- and post-implementation behavior may yield deeper understanding of behavioral patterns over time. Second, the study's results were obtained within the context of one healthcare technology system and need further validation across other different technologies. Finally, the research model is valid in Taiwan, and probably can be generalized in countries with Chinese culture, like China, but not in western

countries. Thus, the generalizability of this finding is limited.

Even with the above limitations, our results yield several conclusions. The most important is the proposal of an extended TAM model that sheds new light on the study of mobile healthcare technology for elderly people. This study contributes to existing user acceptance research in important ways. We have demonstrated that simply using the TAM is insufficient to explain intention. Compared to the extended TAM, the TAM was found to explain less variance in intention by up to 27%. Furthermore, the extended TAM enriches research in the IS field by reemphasizing the important role of ease of use from the original TAM, combining it with another key technological construct, namely perceived ubiquity.

The present study strengthens our conclusions with a sound theoretical base and fills the gap in the adoption of mobile healthcare technology. The empirical findings are supportive of the inclusion of perceived ubiquity, personal health knowledge and perceived need for healthcare into the TAM. The model presents an explication on how different determinants influence elderly persons' adoption of mobile healthcare devices such as RFID healthcare watches or GPS wristwatches, thus providing researchers and practitioners with an in-depth understanding of the introduction of new technology devices for mobile healthcare.



## Appendix— Measure of Constructs

Construct	Source
<b>Perceived ease of use (PEOU)</b>	
PEOU1. I find the MHW to be clear and understandable.	Davis et al. [19]
PEOU2. I find that the MHW does not require a lot of mental effort.	
PEOU3. I find the MHW to be easy to use.	
<b>Perceived usefulness (PU)</b>	
PU1. Using the MHW will improve my performance in managing my personal life.	Davis et al. [19]
PU2. Using the MHW will increase my productivity in managing my personal life.	
PU3. Using the MHW will enhance my effectiveness in managing my personal life.	
PU4. I find the MHW to be useful in managing my personal life.	
<b>Perceive ubiquity (PB)</b>	
PB1. MHW providing communication and network accessibility “anytime-and-anywhere” is crucial.	Kim and Garrison [33]
PB2. The MHW provides me with anytime-and-anywhere communication and connectivity.	
PB3. I will use the MHW very often for health purposes.	
<b>Health Knowledge (HK)</b>	
HK1. I am very knowledgeable regarding care for my health problems.*	Wilson and Lankton [26], Jiang and Leung, [32]
HK2. I understand my health problems and how to care for them.	
HK3. I am aware of the information about my health problems.	
HK4. I have paid attention to the reports about my health problems.	
<b>Health Care Need (HN)</b>	
HN1. I have visited my physician face-to-face during the past six months.	Wilson and Lankton [26]
HN2. I have seen many different physicians at my health care provider during the past six months.	
HN3. I have a chronic disease (such as diabetes or asthma) that requires special medical attention.	

**Attitude (AT)**

AT1. I think that using the MHW is a good idea.

Fishbein and

AT2. I think that using the MHW is beneficial to me.

Ajzen [17];

AT3. I have a positive perception of using the MHW.

Ajzen [1]

**Subjective norm (SN)**

SN1. My family would think I should use the MHW.

Fishbein and

SN2. My physicians would think I should use the MHW.

Ajzen [17];

SN3. My peers would think (suggest, encourage) I should use the MHW.

Ajzen [1]

**Behavioral intention (BI)**

BI1. I intend to use the MHW in the future.

Venkatesh et al.

BI2. I will always try to use the MHW in my daily life.

[9]

BI3. I plan to use the MHW frequently.

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\* The item was dropped due to the low item-to-total correlation to better improve this model's goodness-of-fit.

\* MHW stands for Mobile Healthcare Watch

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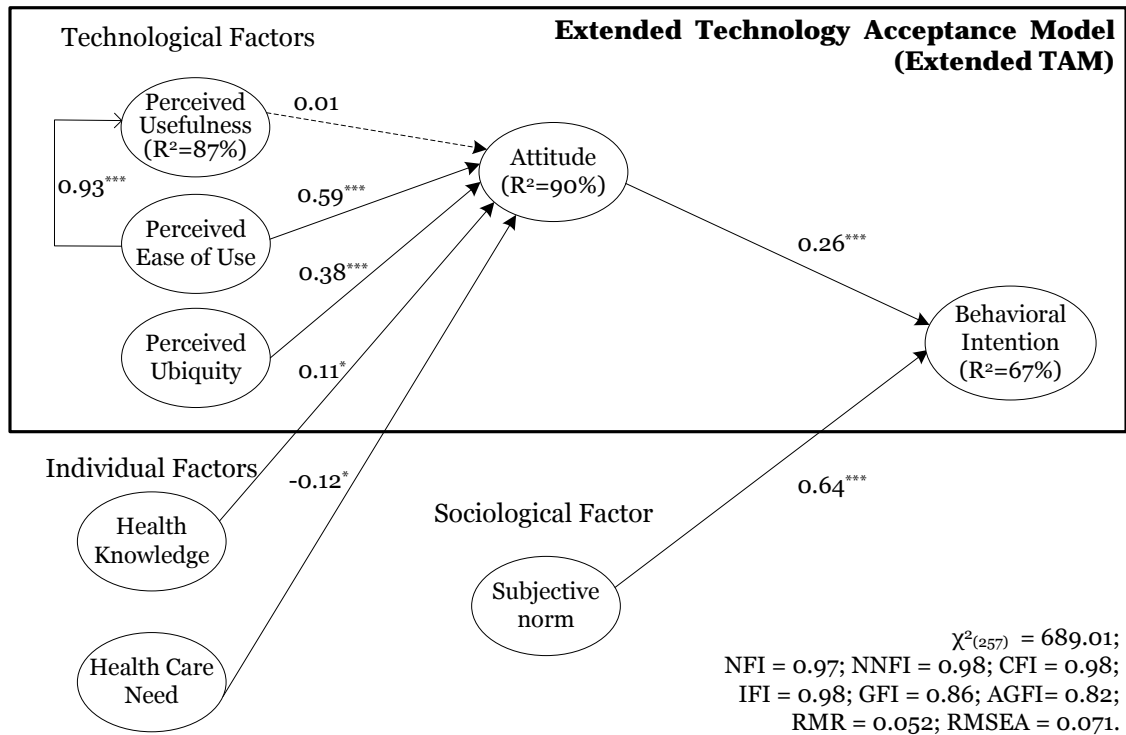


Fig. 1 – Results of MHTAM.

Note: Solid lines represent a significant path; in contrast, dotted lines stand for a non-significant path.

Significance level: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

Table 1— Characteristics of the sample (N = 338)

Characteristics	Number	Percentage
<i>Gender</i>		
Male	162	47.9
Female	175	51.8
<i>Age</i>		
60~65	155	45.9
65~70	101	29.9
70~75	56	16.6
75~80	5	1.5
Over 80	21	6.2
<i>Residence</i>		
Home with families	222	65.7
Live alone	41	12.1
Nursing home	74	21.9
others	1	0.3

Note: missing data were not counted



Table 2— Reliability and validity test

Construct	Items	Standardized loading	Cronbach's $\alpha$	CR	AVE
Perceived ease of use	PEOU1	0.88 (t = 20.09)	0.88	0.88	0.70
	PEOU2	0.88 (t = 20.38)			
	PEOU3	0.75 (t = 15.96)			
Perceived usefulness	PU1	0.93 (t = 22.48)	0.96	0.96	0.86
	PU2	0.94 (t = 23.04)			
	PU3	0.93 (t = 22.66)			
	PU4	0.90 (t = 21.45)			
Perceived ubiquity	PB1	0.78 (t = 16.30)	0.83	0.83	0.62
	PB2	0.83 (t = 17.82)			
	PB3	0.76 (t = 15.66)			
Health knowledge	HK1	0.81 (t = 17.07)	0.85	0.85	0.66
	HK2	0.83 (t = 17.40)			
	HK3	0.79 (t = 16.28)			
Health need	HN1	0.81 (t = 16.64)	0.83	0.83	0.63
	HN2	0.84 (t = 17.19)			
	HN3	0.72 (t = 14.22)			
Attitude	AT1	0.88 (t = 19.95)	0.88	0.88	0.71
	AT2	0.85 (t = 19.02)			
	AT3	0.80 (t = 17.31)			
Subjective norm	SN1	0.79 (t = 16.55)	0.85	0.82	0.60
	SN2	0.82 (t = 17.29)			
	SN3	0.71 (t = 17.20)			
Behavioral intention	BI1	0.81 (t = 17.10)	0.83	0.83	0.62
	BI2	0.81 (t = 17.04)			
	BI3	0.74 (t = 15.07)			

Note: CR = composite reliability. AVE = Average variance extracted.

$\chi^2_{(247)} = 666.51$ ; NNFI = 0.98; CFI = 0.98; IFI = 0.98; GFI = 0.86; AGFI = 0.082;  
RMR = 0.051; RMSEA = 0.071; NFI = 0.97.

Table 3 – Chi-square difference tests for examining discriminant validity

Constrained	PEOU	PU	PB	HK	HN	AT	SN	BI
$\chi^2_{(248)}$								
PEOU	—	—	—	—	—	—	—	—
PU	711.93	—	—	—	—	—	—	—
PB	803.66	842.75	—	—	—	—	—	—
HK	935.76	957.30	865.90	—	—	—	—	—
HN	939.32	960.84	921.67	948.70	—	—	—	—
AT	721.17	817.74	711.58	881.43	946.21	—	—	—
SN	931.76	960.80	833.19	1042.50	916.43	921.26	—	—
BI	882.50	917.06	867.94	1034.56	942.70	897.51	744.54	—

Note: N=338; unconstrained  $\chi^2_{(247)} = 666.51$ .

Table 4— Means, standard deviations, and correlations

	Means	S.D.	PEOU	PU	PB	HK	HN	AT	SN	BI
PEOU	5.01	1.27	0.84							
PU	4.92	1.55	0.85	0.93						
PB	5.18	1.18	0.66	0.66	0.79					
HK	5.29	1.09	0.54	0.52	0.54	0.81				
HN	4.98	1.30	0.38	0.32	0.43	0.34	0.79			
AT	5.22	1.17	0.79	0.78	0.74	0.59	0.33	0.84		
SN	5.06	1.14	0.51	0.47	0.57	0.35	0.42	0.51	0.77	
BI	5.07	1.12	0.54	0.52	0.52	0.30	0.36	0.54	0.66	0.79

Note: N=338; \*  $p < 0.01$ . Diagonal elements are the square root of AVE.

Table 5— Overall fits of models

Fix index	Recommended value	TAM*	MHTAM** (Proposed model)
Chi-square/ <i>d.f.</i>	$\leq 3.0$	3.37	2.68
GFI	$\geq 0.90$	0.91	0.86
AGFI	$\geq 0.80$	0.81	0.82
NNFI	$\geq 0.90$	0.98	0.98
CFI	$\geq 0.90$	0.99	0.98
SRMSR	$\leq 0.10$	0.033	0.052
R <sup>2</sup> for AT		0.83	0.90
R <sup>2</sup> for BI		0.40	0.67

\* Technology Acceptance Model.

\*\* Mobile Healthcare Technology Acceptance Model.