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Factors Influencing Use of Smartphone Applications for Healthcare Self-Management: An Extended Technology Acceptance Model

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<Abstract>
Objectives: The self-management of chronic diseases is currently receiving much attention. This study applied an extended technology acceptance model (ETAM) to analyze the factors influencing acceptance of a healthcare smartphone application. **Methods:** Three hundred people living in Seoul and Gyeonggi who used smartphones were quota sampled. A telephone survey was conducted using a structured questionnaire based on ETAM. A path analysis was carried out using the AMOS 17.0 program, and the model was verified. **Results:** The analysis revealed significant factors of perceived usefulness (.374, $p < .001$), enjoyment (.210, $p < .001$), subjective norms (.168, $p < .001$), perceived costs (.146, $p < .001$), and innovativeness (.138, $p < .001$). Cost directly influenced intention to use health applications; self-efficacy and perceived ease of use indirectly affected intention through innovation and perceived usefulness. **Conclusions:** This study helped to identify the main factors that influence usage intention of smartphone applications. These findings could contribute to promoting the self-management of chronic disease through future health applications using smartphones.

Key words: Mobile Applications, Chronic Diseases, Information Seeking Behavior, Intention, Health Service,Technology Acceptance Model

Ⅰ. Introduction

There has been a global shift from the prevalence of acute infectious disease to the rising incidence of chronic diseases. Therefore, self-management of chronic diseases, such as hypertension and diabetes, is receiving increased interest. An aging population, the improvement of living standards, and the Western lifestyle, have led to a greater occurrence of chronic diseases, which are the greatest contributors to mortality and healthcare expenses around the world (Lee, Lee, Hwang & Kam, 2012).

According to the World Health Statistics 2012, non-communicable diseases have increased around the world (World Health Organization [WHO], 2012); in 2008, global mortality due to non-infectious disease was estimated at 63%. In addition, population growth and the extension of life expectancy have led to an increase in the elderly population. According to this report, mortality for non-communicable disease was expected to increase gradually; one third of adults have hypertension, which is a cause of stroke and heart disease, and one in 10 adults suffers from diabetes (WHO 2012). This increase in chronic diseases causes a variety of problems, such as degraded quality of life for individuals and increased medical costs. In addition, lack of professional medical staff and problems of accessibility to medical institutions are accompanying social problems.

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Many studies have reported that health behaviors, such as exercise and diet control, have an important influence on the onset and management of chronic disease (Kim & Lee, 2011; Lee, Yim, Im, Oh & Han, 2013). It is important that approaches that aim to improve health behaviors focus on prevention rather than treatment in the management of chronic diseases. In other words, an individual needs proper self-management and lifestyle changes to be able to manage chronic disease. For this reason, it is necessary to develop specific methods of informing and guiding people in this type of self-management.

Therefore, self-management of chronic disease through steady health behavior has become a very important issue for health promotion. In addition, there is increasing information and interest in personal health management. Advancement of the mobile network and breakthrough of the terminal are also contributing to the provision of healthcare information due to full-fledged smartphone popularization and Internet commercialization (Heo & Yu, 2013). For example, there are services that record individual physical activities, help weight management by calculating calories of food eaten, help people quit smoking, or manage blood pressure and blood sugar.

A smartphone does not have time and space restraints; people can easily use information from smartphone applications in their daily lives, extending their function beyond that of mere communication tools. Depending on the nature of the application, the advantage of a more immediate point of care can facilitate healthcare self-management (Lee, Kim, Kim, Min, Jung & Park, 2010). Smartphone applications are a recent and effective means for more easily managing chronic disease (Wang, Park, & Choi, 2011); however, even though they can provide useful information, health applications are not used more frequently, or for longer, than other applications (Wang et al. 2011).

According to a 2011 study by the National Internet Development Agency of Korea, the most popular categories of applications are games (17%), followed by books (15%) and entertainment (11%); health applications comprise only 3%. To facilitate greater dissemination of health applications, it is necessary to examine the use intention of current smartphone users, and to identify the factors that affect acceptance and use of health applications. This may help to enhance actual utilization, and the duration of use, of health applications for the self-management of chronic disease.

Ⅱ. Methods

1. Study design

This study employed a descriptive, survey approach. The aim was to identify the factors affecting both usage intention and actual use of health applications.

2. Data collection

We sampled participants who used smartphones, and explained the study objectives and procedures to them; we then distributed the survey to those who agreed to participate. In consideration of ethical aspects, we informed them that they could withdraw their personal data at any time during and after the study, and that the collected data would be anonymous. We set a target of 300 people for the quota sampling, with reference to the research on smartphone use by Embrain in 2011.

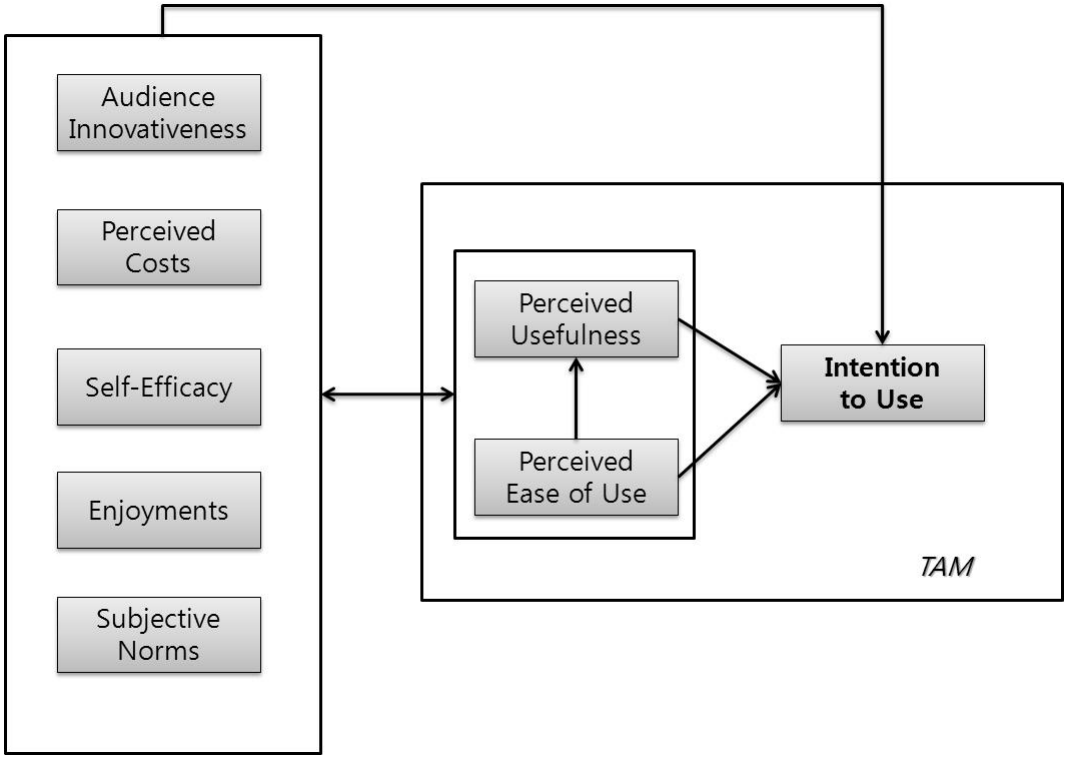
The participants were 300 persons over the age of 19 extracted by considering the ratio of sex, age groups, and regions among the residents living in Seoul and Gyeonggi Province. Adults aged 19–59 years in the metropolitan area who used smartphones were surveyed via the Internet for 4 days (March 8–11, 2011).

3. Study model

One explanatory model for the adoption of new devices or programs is the Technology Acceptance Model (TAM) proposed by Davis (1986). This model explains how the perceived usefulness of and intention to use a given technology are important factors in the adoption of new

technologies.

The extended TAM (ETAM) includes factors of social influence, such as enjoyment, image, and voluntariness, which can affect technology acceptance, to supplement the limitation that the TAM measures behavior related to some technology (Davis 1986; Venkatesh and Davis 2000). In considering these facts, we must examine both exposure to objective information and individuals' internal beliefs, attitudes, and intentions with regard to U-Health smartphone application use. The ETAM can explain the behavioral factors that drive the acceptance of innovative technologies (e.g., IT) while also accounting for individuals' internal beliefs In this study, the ETAM is used to theoretically and empirically verify the factors governing the acceptance of healthcare applications by smartphone users, and to analyze the structural relationships between factors related to the intention to use these applications.



[Figure 1] Framework of the study

4. Instruments

Survey questions were adapted to Korean and modified for the purpose of this study. The ETAM questions developed by Venkatesh and Davis (2000) were combined with questions about the use of health applications.

To ensure consistency of responses, the 30 questionnaire items were measured on a 7-point Likert scale, ranging from 1 (*does not agree at all*) to 7 (*agrees very strongly*). In other words, higher scores indicated a higher degree of agreement <Table 1>.

The reliability of this instrument was measured using Cronbach's alpha coefficient. Cronbach's alpha coefficients were Audience Innovativeness .857, Self-efficacy .905, Intention to use .816, Perceived Usefulness .908, Perceived ease of use .894, Subjective norm .909, Perceived costs .759, and Enjoyments .938.

<Table 1> Questionnaires

Variable	Definitions	Questionnaires	Reference
Health application	These are applications that offer the user healthcare methods by providing information on medical and health issues, exercise, and diet. Such applications can be downloaded through their own market as paid or free versions.	Currently uses health applications? (open question) *It was subdivided into "general health information," "diet," "exercise," "disease care," "nutrition management," and "others." Multiple responses were allowed [Figure 2].*	
Intention to use	Participants were asked to rate their intention to use health applications in the future, and the degree to which they intended to purchase them	I am going to look for health applications **(BI 1).** I am willing to use health applications **(BI 2).** I am willing to buy health applications **(BI 3).**	Venkatesh and Davis (2000)
Perceived usefulness	Perceived usefulness means the degree of belief that one's life or performance could be improved by the use of a particular application.	If I use health applications, my healthcare ability will improve **(PU 1).** If I use health applications, my health will improve **(PU 2).** Health applications will be useful for my health care **(PU 3).**	Venkatesh and Davis (2000)
Perceived ease of use	Perceived ease of use refers to the degree of individual adoption, assessed as ease of use of a specific application.	It will be easy to use health applications **(PEOU 1).** It will be easy to learn how to use health applications **(PEOU 2).** I can skillfully use health applications **(PEOU 3).** I can skillfully use health applications **(PEOU 4).**	Segars & Grover (1993), Venkatesh & Davis (2000)
Audience Innovativeness	Innovativeness is the degree of first acceptance of a new technology among other social group.	If a new product comes out, I replace my old one faster than others **(AI 1).** I try to obtain up-to-date information about new mobile applications **(AI 2).** I try to increase my daily-life efficiency by using mobile applications **(AI 3).** I do not hesitate when trying a new mobile application **(AI 4).** I like using new mobile applications **(AI 5).**	Kim (2009)
Subjective norms	This refers to the attitudes that people significant to the user hold about his or her use of health applications.	People who are important to me think that I should use health applications **(SN 1).** People who influence me think that I should use health applications **(SN 2).**	Venkatesh and Davis (2000)
Self-efficacy	Self-efficacy was defined as individuals' faith in their abilities to use applications.	I am confident in my use of my current applications **(SE 1).** I have the ability to use applications related to every part of my daily life **(SE 2).** I can skillfully use the functions of applications that are related to every part of my daily life **(SE 3).**	Compeau, Higgins and Huff (1999)
Enjoyment	Enjoyment was defined as the degree of perceived fun of using health applications.	Those measuring interest (**P1**), fun (**P2**), excitement (**P3**), and pleasure (**P4**).	Davis, Bagozzi, and Warshaw (1992)
Perceived costs	Perceived costs were defined as the total perceived monetary and psychological costs associated with accepting the innovation.	If needed, I would agree to pay to purchase a health application **(PC 1**). I would use a health application even when it took a long time **(PC 2**).	Kim (2009)

5. Analysis

Following analysis of descriptive statistics, the following three main analyses were performed: First, to test internal consistency reliability, Cronbach's alpha values for the questionnaire results for each latent factor were assessed. Second, the adequacy of the overall model was measured using confirmatory factor analysis (CFA). Third, a model of intention to use health applications was constructed through structural equation modeling.

To evaluate the internal consistency of the data, Cronbach's alpha coefficient for each factor was calculated; these values indicated good internal consistency reliability (i.e., all values were above .75). CFA was conducted to extract common factors; its input data were the averages of each component of each dimension.

CFA indicated that the standardized loading values of the measured factors were above .5; thus, the model was acceptable. In addition, the average variance extracted (AVE) and composite reliability (CR) values were above 0.6 and 0.7, respectively; these values indicate the validity of the potential factors. Thus, reliability and convergent validity were verified. Finally, the test for discriminant validity utilized the cross-loading method. The square root of the AVE for each construct is compared with the correlations between it and other constructs; discriminant validity is demonstrated if the square root is higher than the correlations. In addition, in order to verify the set model, path analysis was carried out using structural equation modeling (SEM) with AMOS 17.0. Model fit was evaluated by using the fit indices CFI, RMSEA, and AGFI, and Bentler's model of the minimal research model. With regard to the evaluation results, an AGFI of >.8, a CFI of >.9, and an RMSEA of <.8 were considered to indicate a suitable model (Bae, Cheon, Kim and Kang, 2013). To verify the statistical significance, the path coefficient and Critical Ratio (CR) were identified. The survey responses from 300 participants were analyzed using PASW 17.0 and AMOS 17.0.

Ⅲ. Results

1. Characteristics of the sample

The following sociodemographic characteristics of the 300 participants were analyzed: gender, residence area, age, educational level, income level, and use of healthcare applications and applications in general <Table 2>. The dependent variable was intention to use healthcare applications, and the reliability of the final structural model was considered in light of the results. Analyses of variance were performed to examine sociodemographic differences in use intention, with no differences found.

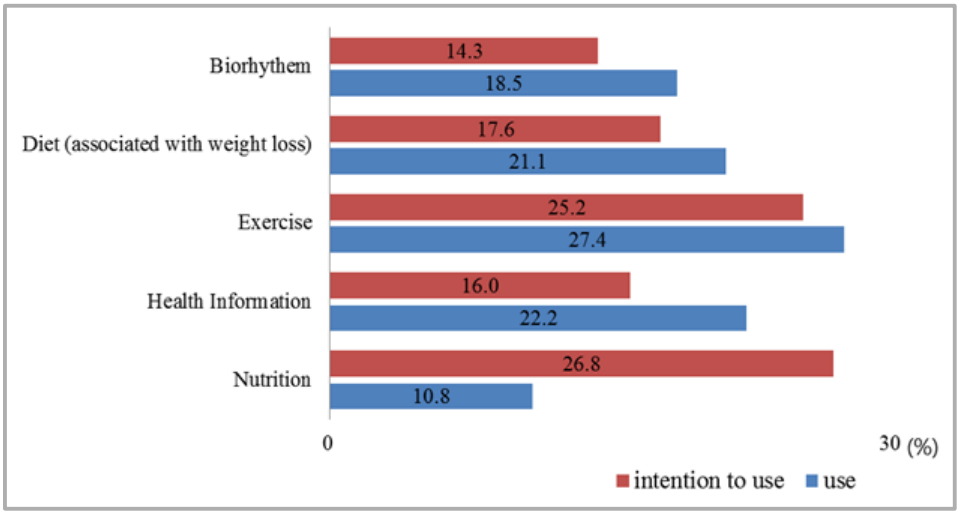
<Table 2> Characteristics of the respondents.

Demographic characteristics		N	%
Total		300	100.0
Gender	Male	150	50.0
	Female	150	50.0
Residential area	Seoul	192	64.0
	Gyeonggi Province	108	36.0
Age (years)	20-29	105	35.0
	30-39	75	25.0
	40-49	60	20.0
	50-59	60	20.0
Use of a mobile application	Yes	293	97.7
	No	7	2.3

Demographic characteristics		N	%
Use of a mobile health application	Yes	216	72.0
	No	84	28.0
Education	High school or under	43	14.3
	College	39	13.0
	University or beyond	218	72.7
Annual income	Greater than or equal to $30,000	40	13.4
	Greater than or equal to $30,000 and less $50,000	97	32.3
	Greater than or equal to $50,000 and less $70,000	81	27.0
	Greater than or equal to $70,000	82	27.3
Occupation	Office worker	123	41.0
	Specialized job/administrative position	50	16.7
	Technical post/sales work/service	27	9.0
	Private business	25	8.3
	Housewife	36	12.0
	Other	39	13.0
Marriage	Single	137	45.7
	Married	154	51.3
	Other	9	3.0

2. Use of Healthcare applications

The types of health applications in current use are shown in [Figure 2]. The application showing how to exercise was the most frequently used, followed by those on health information and diet 27.4%, 22.2%, and 21.1%. The health applications preferred for future use are shown in [Figure 3]. With respect to future use intent, the diet-related application was the most preferred, followed by the application on how to exercise 26.8% and 25.2%.



[Figure 2] Usages of healthcare applications and intention to use

3. Results of Reliability and Confirmatory Factor Analysis

<Table 2> provides evidence of reliability and convergent validity, and <Table 3> shows that discriminant validity appears satisfactory at the construct level for all constructs. Further, the goodness of fit was confirmed by measures of incremental and absolute fit (Song, 2005). Therefore, the results of the CFA were deemed acceptable; Table 3 shows those results.

<Table 3> Result of convergent validity and reliability test

Constructs	Mean	SD	Communality	Cronbach's alpha	C.R.	AVE
Audience Innovativeness						
AI 1	4.38	1.20	.437			
AI 2	5.17	1.12	.645			
AI 3	5.60	.94	.688	.857	.933	.740
AI 4	5.16	1.16	.706			
AI 5	5.35	1.07	.763			
Self-Efficacy						
SE 1	5.12	1.06	.799			
SE 2	4.96	1.12	.838	.905	.927	.810
SE 3	5.07	1.13	.886			
Intention to Use						
BI 1	4.79	1.08	.817			
BI 2	5.29	1.00	.750	.816	.847	.649
BI 3	4.29	1.33	.668			
Perceived Usefulness						
PU 1	4.97	.99	.842			
PU 2	4.80	1.01	.857	.908	.928	.810
PU 3	4.91	1.04	.835			
Perceived Ease of Use						
PEOU 1	4.98	1.00	.766			
PEOU 2	5.20	.96	.840	.894	.927	.761
PEOU 3	5.16	1.06	.785			
PEOU 4	4.86	1.12	.667			
Subjective Norms						
SN 1	4.29	1.26	.917	.909	.887	.796
SN 2	4.28	1.20	.917			
Perceived Costs						
PC 1	4.15	1.33	.807	.759	.775	.633
PC 2	3.90	1.20	.807			
Enjoyments						
P 1	4.85	1.05	.789			
P 2	4.79	1.07	.868	.938	.952	.831
P 3	4.46	1.09	.836			
P 4	4.54	1.05	.877			

Note: C.R.= construct reliability; AVE= average variance extracted.

4. Path Analysis with Structural Equation Modeling

The absolute, parsimonious, and incremental fit measures were applied to judge the goodness of fit of the study model (Midgley & Dowling, 1978). In contrast to the parsimonious fit measures, the absolute and incremental fit measures reflected good fit; thus, this model was deemed suitable. The results are summarized in <Table 4>.

<Table 4> Assessment of ETAM fit.

Fit index	Result of index	Reference (recommended level)
AGFI	.826	> .8
CFI	.947	> .9
RMSEA	.076	< .08

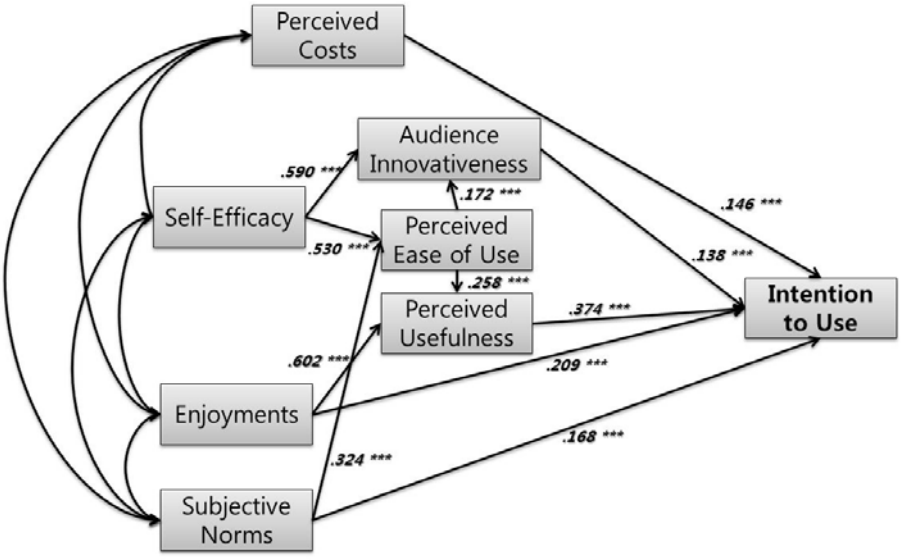
<Table 5> Correlations among ETAM constructs

Correlation factors			Estimate
Perceived Costs	<-->	Self-Efficacy	.143*
Perceived Costs	<-->	Enjoyments	.502***
Perceived Costs	<-->	Subjective Norms	.436***
Self-Efficacy	<-->	Enjoyments	.263***
Self-Efficacy	<-->	Subjective Norms	.165**
Enjoyments	<-->	Subjective Norms	.515***

Note: * p-value < .05, ** p-value < .01 , *** p-value < .001

The model presented in this study is shown in Figure 4. According to the structural equation modeling analysis, the factor that had the strongest direct effect on intention to use was perceived usefulness (.374, p-value<.001), followed by enjoyment (.210, p-value<.001), subjective norms (.168, p-value<.001), perceived costs (.146, p-value<.001), and innovativeness (.138, p-value<.001). That is, the more strongly participants believe that using health applications can improve healthcare capacity, the more pleasure they feel when using them, the greater the subjective norm, the more willing they are to pay the costs, and the more innovative they are in using new products, all of which indicate a greater intention to use health applications.

Perceived ease of use was found to affect intention to use not directly, but indirectly through perceived usefulness. Self-efficacy and perceived ease of use did not directly affect intention to use, but indirectly affected that outcome variable through innovation and perceived usefulness.



Note: * p-value < .05, ** p-value < .01 , *** p-value < .001 ; A solid line represents pathways with statistically significant effect

[Figure 3] Path analysis of the effects of the constructs of ETAM.

Ⅳ. Discussion

The purpose of this study was to use the TAM to identify the factors associated with intention to use healthcare applications via smartphones, and to understand the relationships among these factors. These factors were then validated empirically and theoretically.

The factor with the greatest direct impact on intention to use health applications in this Korean sample was perceived usefulness. Enjoyment affected recognition of usefulness and directly affected intention to use; thus, it was identified as an important variable. Subjective norms, perceived costs, and innovativeness also directly affected intention to use.

However, perceived ease of use did not directly affect intention to use. In previous studies, perceived ease of use (among other factors used in information technology) has been discussed in terms of conflicts (Lee, Whang, Kang & Lee. 2006). However, this study selected and examined participants who already used smartphones and who presumably did not experience difficulties engaging with this technology. Therefore, it is likely that perceived ease did not have a large effect on usage intention for health applications.

In this study, perceived ease of use was connected (indirectly) with action intention through perceived usefulness (Ajzen & Fishbein, 1980). Information on how to use Korean smartphone applications can be found easily on the Internet. Despite the current mature phase of development of the Internet, perceived ease of use was not taken into account, compared to usefulness. Further, the fact that perceived ease of use affected usefulness indicated that although use of healthcare applications was not easy, use intention would be high because of the belief in the usefulness of the applications. In relation to the present aim to determine factors influencing intention to use healthcare applications, it seems that the usefulness of health information (i.e., its quality) was a primary consideration for users.

Enjoyment was identified as directly or indirectly affecting intention to use health applications. In studying the acceptance of information technology, personal interest (an inducible factor) should be considered, in addition to the factors of the traditional TAM model.

As found in previous studies, when the use of applications

(i.e., software used on smartphones) could be selected voluntarily for personal enjoyment, users with strong motivation positively affect the number of searches for health information (Na, 2002; Song, 2005). Therefore, in addition to the factors identified by the traditional TAM model, personal feelings might influence the acceptance of new technology, and might be part of the needs identified by the ETAM (Lee et al., 2006).

Subjective norms affected intention to use health applications, perhaps because of social influence: Koreans use new phones to be recognized in social comparisons with others, as reported in previous studies from other countries (Lee et al., 2006; Na, 2002). Subjective norms were found to directly influence behavior in the initial research on the TRA and the theory of planned behavior (TPB). That is, peripheral acquaintances (via sufficient motivation) positively influence behavioral intention (Venkatesh & Davis, 2000). Further, the present study showed that individuals were influenced by social networks to form and maintain good images in the social groups to which they belonged. Thus, in modern society (in which social networks are considered highly important), subjective norms could be an important factor in the search for health information (Song, 2005).

Numerous studies have highlighted the importance of innovativeness in new media and technology adoption. Many previous studies have suggested that innovativeness, which is associated with acceptance of new ideas or objects (Kim 2009), is a result of personality, which changes throughout life. Midgley & Dowling (1978) revealed that innovativeness is an important social and psychological factor that affects acceptance of technology. Further, Wang et al. (2011) discovered that people who embrace technology with ease and speed have better acceptance of health applications. Given the definition of individual innovativeness as the voluntary degree to which individuals try to adopt new media and technology in terms of healthcare applications, persons with high innovativeness may be more likely to adopt, develop, and increase health information than individuals with low innovativeness. In this study, high self-efficacy had a significant, positive impact on innovativeness. Self-efficacy could be increased through education on how to use health applications or a pilot test, in order to ultimately increase intention to use.

Upon the adoption of a product or technology, the technical audience's expectations for the future determine their current behavior; these factors are also shaped by past experiences. The selection factors may vary depending on the circumstances surrounding the individuals. However, individuals are most likely to be sensitive to the past price (i.e., the cost; Kim 2009). Ahtola (1984) suggested that technology users perceive cost in terms of the cost of giving up or sacrificing combined with the nonmonetary costs of technology adoption. Zeithaml (1988) explained that technical audiences perceive the total costs to include psychological costs, as well as those of time, navigation, and money. These findings reflect the present results, which indicate that perceived cost significantly influenced acceptance of healthcare applications.

The findings of this TAM-based study investigating factors influencing intention to adopt health smartphone applications are significant in two respects. First, this study suggested some basic data to utilize the services of professional counseling, programs provision and monitoring system necessary for improving all kinds of life habits like exercise, nutrition and non-smoking through some application programs. At considering the smart phone's strengths free from the time-space limits, it means that a smart phone can contribute in improving an individual's health by making a chronic disease patient be able to research the health information and directly checkup his/her health conditions (blood pressure, blood sugar, height, weight, etc) from the aspect of 'self-management', and recognize any changes in his/her health condition. The factors found to directly impact intention to use health applications were usefulness, enjoyment, subjective norms, costs, and innovativeness. These results suggest that forms of gaming or interactive applications should be developed to increase interest. In addition, the study findings can shed light on the perceived usefulness of

applications, perhaps helping towards their effective distribution. Thus, it is necessary to raise subjective norms. All things taken together, it is considered that several professionals like public health professionals, the chronic disease managers as well as technology developers should jointly participate in the process developing the contents. Additionally, it should be considered some ways to increase the self-efficacy for continually keeping the health management as an important factor from the chronic disease patient's self-management. And, it should also be considered a monitoring system to provide accurate information and manage the health well. Second, a model was suggested through SEM and relevant relationships between influencing factors and intention to use smartphone applications were found. One reason that information technology and U-Health is important in the field of healthcare is that the delivery of health information via smartphones allows many people the advantage of convenient access to information. Therefore, it is expected that health information acquisition will increase in the future, and the provision of such services is also predicted to increase. Thus, it is essential to study the factors that affect users. In addition, individuals' voluntary adoption of health information services could be connected with health promotion, and play a role in healthcare management through the process of health information acquisition. Therefore, this study could shed light on effective means of providing healthcare information, assisting individual healthcare management by providing support in the establishment and usage of applications for health and chronic disease management.

This study had some limitations. First, the sample was limited to residents of the metropolitan area, and the distribution of respondents did not accurately reflect the nation's total population distribution. Second, like many studies based on the TAM, it was difficult to measure the external factors of the adoption process accurately and objectively, because self-reported measurements might not have reflected actual adoption. Third, to identify usage of healthcare applications, we did not consider the levels of use of other applications or applications overall. The reliability of this research model could be increased by refining the survey questions to address some of these omissions. Finally, the model's goodness of fit was in the acceptable range for some criteria, but certain fit indices did not quite reach the recommended levels. Thus, it is necessary to develop the research model to increase its explanatory power.

The results of this study indicate that further research is necessary to expand the study model by adding new external factors that could affect the adoption of information technology by analyzing more audience characteristics and tendencies. In addition, this study focused on the acceptance factors for applications offering information, which can only be used for simple health information checking; research is needed on applications that offer health maintenance, which can be used for continuous management of chronic disease and obesity.

Ⅴ. Conclusions

This study investigated factors related to the intention to adopt a health smartphone application based on the TAM. A quota sample of adult smartphone users in Seoul and Gyeonggi identified factors affecting usage intention of health applications based on the theory of ETAM.

The study results showed that the more participants think health applications are useful for individual healthcare, the more pleasure they feel when using these applications, the more they are aware of people around them when using health applications, the more willing they are to pay the costs, and the more innovative their use of new applications is.

It was found that self-efficacy had a positive impact on innovativeness, and that enjoyment when using applications had an indirect impact on usage intention of health applications, because it gives a positive impact that health applications may be useful for health management. While most studies until now have focused on the development of quantitative health applications, future studies should focus on the development of qualitative health applications that meet

the individual needs of users. Through identifying the main factors affecting usage intention of health applications, we expect that this study could help promote the health management of chronic disease.

The results of this study allow us to make several suggestions regarding the use of smartphone health applications for the self-management of chronic disease. First, user interest should be considered when producing health applications. Second, health applications should be promoted by distributing them to early adopters who are interested in health. Finally, programs that use health applications to address chronic disease health management in the community, such as obesity, diet, smoking cessation, and exercise need to be developed. Moreover, in order to set a health application program for the people's health management, it needs to develop some chronic disease self-management programs increasing a person's confidence in the self-management ability and a monitoring system supervising whether the accurate information is provided and utilized well.

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