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An Empirical Study on the Adoption Intention of IoT-based Medical Information Services: Focusing on the Moderating Effect of User Usability

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Abstract

Background/Objectives: Based on the anticipation that IoT-based smart healthcare systems will lead to improvement of the quality and efficiency of healthcare services, an empirical analysis was conducted, with the aim of proposing the necessary strategic measures to enhance the adoption intention among potential users.

Methods/Statistical analysis: A survey was carried out from February to March 2019 using the convenient sampling method, targeting the members of a user group interested in the advancement of smart healthcare. A total of 327 questionnaire forms were returned, of which 321 forms, excluding the 6 forms that were deemed unsuitable, were used in analyses of descriptive statistics, Pearson correlation coefficient analysis and multiple regression analysis, using SPSS 22.0.

Findings: First, a multiple regression analysis was carried out in order to examine the effects of the Selective Attributes of an IoT-based smart healthcare system on the intention to accept the system. The results showed a positive (+) correlation between the motivation for use and service suitability among the Selective Attributes and the adoption intention, while the correlation between the adoption intention and user innovativeness was not statistically significant. Second, the user usefulness was found to have a moderating effect between the adoption intention and the Selective Attributes such as user innovation, motivation for use, and service suitability. The analysis results showed that the interaction effect of usefulness was statistically significant, meaning that as the user usefulness increased, the adoption intention also increased.

Improvements/Applications: This study analyzed the causality of Selective Attributes in the introduction of IoT-based smart healthcare system and analyzed the interaction effect of user usability.

***Keywords*:** Smart healthcare system, Selective Attributes, user innovativeness, motivation for use, service suitability, adoption intension, user usefulness.

1. Introduction

With the recent advances in information and communications technology (ICT), we are entering into a "super-connected society," where Internet communication involves devices and things, rather than a human-to-human communication, as though they are alive. The convergence of the Internet of Things (IoT) technology and the healthcare sector, in particular, is expected to lead to new innovations in the healthcare industry. The technology to measure, analyze and use information in real time based on IoT will result in the creation of new economic added values, and this is why IoT is drawing attention from various industries.

Globally, population aging and chronic diseases are increasing the burden of medical expenses. The medical information system applying IoT technology is expected to help the socially vulnerable by improving medical service and reducing medical expenses. Therefore, medical institutions are interested in securing patient management and reducing medical expenses through IoT-based smart healthcare.. In addition, with the occurrence of population aging and an increase in chronic diseases and healthcare costs, smart healthcare services, which can provide healthcare and health management services, without any constraints in terms of healthcare service environment, time or location, have emerged as a new trend. IoT-based smart health systems are also expected to improve the quality and efficiency of healthcare services from the aspect of preventive management, with the use of smart healthcare and health management services via mobile devices.

This study was conducted examine the trends in smart healthcare, in addition to empirically analyzing the effects of Selective Attributes, which reveal the characteristics of individual users, and usefulness to users on the

user intention to accept a smart healthcare system, which is a new information system environment, and the moderating effect of usefulness of smart healthcare to users on the interrelation between the Selective Attributes and the adoption intention, based on a survey with smart healthcare service users. The aim was to use the analysis results to propose the necessary strategic measures to enhance the user intention to accept smart healthcare services.

2. Materials and Methods

2.1. *Definition of variables*

2.1.1. Concept of Smart Healthcare

Smart healthcare has been undergoing dramatic changes in terms of function and scope of use among others, along with the technical advances, and thus it is difficult to give a standardize definition of this term. "Smart healthcare system" has been defined as a hybrid device that combines the functions of a personal wellness device (PWD) and a digital healthcare device by some, and has also been explained as a medical device comprised of software and IoT communication functions to meet user needs[1].

In addition it has been asserted that it is a tool that enables the implementation of functions of wearable devices in a mobile environment, a key tool that will play a pivotal role in the mobile convergence era of the future, and a tool allowing the application of diverse information technologies and functions at the optimum locations[2]. The functions of smart healthcare services, which have been differentiated from ubiquitous healthcare (U-health) services, must have the following attributes: first, it should be possible to use multiple application programs simultaneously; second, it should be possible to send and receive information such as data and video and audio files even when on the move; and third, it should enable interaction between users and devices to make it convenient for the users to use the program they need.

In preceding studies, it has been explained that a smart healthcare system must include the following characteristics: location service, personal identification, ubiquity and mobility. Location service is the function for locating the user, and personal identification allows the user to be distinguished based on his or her unique identification numbers. Ubiquity refers to a characteristic that allows individual users to be able to communicate with and obtain information form the system anytime, anywhere by carrying their own devices, while mobility means that the tools and information resources that were only available to desktop PCs can be used on mobile devices in real time, and this requires that the user device be connected to the Internet at all times[3].

IoT-based smart healthcare systems are fourth-generation wearable healthcare service devices, with reinforced characteristics of the conventional mobile devices. They can be connected to the Internet anywhere, anytime for the user to use the smart healthcare services, and allows URL input. Also, the tasks that could only executed at fixed locations can now be done on the move, using mobile and portable devices, with the installation of an app program[4], and compared to U-health systems, which were a simple means of communication based on mobility[5], smart healthcare systems are a scaled-up multimedia system, in which anyone can easily use due to the characteristics of mobility and openness with the use of WiFi. It is a new type of system that provides diverse forms of communication and services such as through the use of apps.

2.1.2. Selective Attributes

Selective Attributes are determinants affecting adoption intentions and represent the level of consumer perception of the attributes of goods or services. In order to analyze the effects of the Selective Attributes on adoption intention, the sub-factors of the Selective Attributes were classified into user innovativeness, motivation for use, service suitability and user usefulness, based on the previous studies.

First, user innovativeness means how fast the user in question accepts new things, and this has an important influence on adopting new products. Thus, as a personal characteristic of the user, innovativeness becomes a component of the behavioral attributes of the user, and affects the spread of information including even oral transmission. Users with high innovativeness have relatively high propensity to quickly accept new products, technologies and services, and thus innovativeness acts as an important variable.

Based on an analysis, user innovativeness, which is a personal attribute of the user, is a major factor in the process of accepting an IoT-based smart health system, and the impact of innovativeness of potential users on the process of accepting a smart healthcare system was verified in this study. In this study, "user innovativeness" was defined as the "degree to which a user tries to accept a certain technology faster than the general users." In order to measure user innovativeness, the questionnaires used in previous studies[6] were restructured and used as a measuring tool.

Second, the effects of motivation for use on the intention to accept a smart healthcare system were verified, based on a study that examined the motivation for using mobile services and the relationship between the attitude toward the use of mobile services and the intention of using mobile services[7], an empirical study of the factors that impact the user attitude in the high-tech market that found the direct impact of the motivation for use among consumers on the intention of use, and a study suggesting that the motivation for use must be heightened in order to increase the

intention of use among users[8]. In this study, “motivation for use” was defined as the “user’s objective of using a service to satisfy his or her expectations and needs.” In order to measure the motivation for use, a questionnaire used in a previous study[9] was restructured and used as a measuring tool.

Third, service suitability has been defined as the degree to which a service meets the user’s desires and background. Based on the studies that viewed suitability as the degree to which the item examined was consistent with the values and desires of the user[10], it was deemed that service suitability represents the degree to which an individual accepts and is satisfied with a service when introducing a certain type of innovative technology into a service. Accordingly, it was inferred that service suitability would have a positive impact on the service results.

In this study, “service suitability” is defined as "the degree to which the user meets the desire for innovation and the expectation desire by using a specific technology when performing the service". The questionnaires used in previous studies[10, 11] were restructured in order to be used a tool for measuring service suitability.

2.1.3. User Usefulness

In the case of information systems and technologies, user usefulness refers to the extent to which it is believed that such systems and technologies can be used in an easy and convenient manner, while attitude means the personal preferential tendencies in response to the use of an information system or technology, and adoption intention means the intent to accept or the plan to use an information system or technology within a certain period of time if the use of such system or technology is permitted.

In order for a certain type of product to continue to survive, the new product model must be able to provide consumers with value in terms of functions and performance that was not presented by the existing product models. This has been confirmed to promote faster adoption in the market and also increase usefulness[12], There have been studies on theories and approaches that could explain the adoption and propagation of the new media since the advent of the Internet, and based on a previous study presenting the uses and gratification theory that has traditionally be used in relation to the media[13] the effects of usefulness of a smart healthcare system to users on the adoption intention and its interaction effect were attempted to be verified in this study.

In this study, “user usefulness,” which is perceiving the degree to which a certain technology has contributed to fast decision making, improvement of living standards and environment, and attainment of personal goals among others, was defined as the “subjective attitude that is apparent when using a new technology, and the degree to which the introduction of an innovative technology or smart healthcare service is perceived as useful.” In order to measure user usefulness, questionnaire items were restructured based on a previous study[14] to be used as a tool for measuring user usefulness.

2.1.4. Adoption Intention

In reference to a previous study on the determinants of adoption intention, the relationships of the Selective Attributes, which are the variables that affect adoption intention, were set up. The attributes were set as the variables that have an impact on the adoption intention of users, and it was deemed that they affected adoption intention with the perceived ease of use and usefulness playing a mediating role[15]. They were classified into the media attributes and content attributes in relation to bilateral broadcasting services to identify the relevance with the adoption intention, and the relationship of the ease of use and usefulness of new IT services with the adoption intention was identified in an attempt to verify their impact on the intention to accept a smart healthcare system. In this study, “adoption intention” was defined as the “plan or intent to accept a new technology, and how long the technology in question is used continually.” In order to measure the adoption intention, the questionnaire used in a previous study[16] was restructured to be used as a measuring tool.

2.2. *Methods*

2.2.1. Research Model

In this study, a research model was set up as shown in [Figure 1] in order to analyze the effects of user innovativeness, motivation for use, and service suitability, which are the attributes perceived by users, and the moderating effect of user usefulness on the interrelation between the Selective Attributes and the adoption intention for the purpose of promoting the use of healthcare system incorporate new technology.

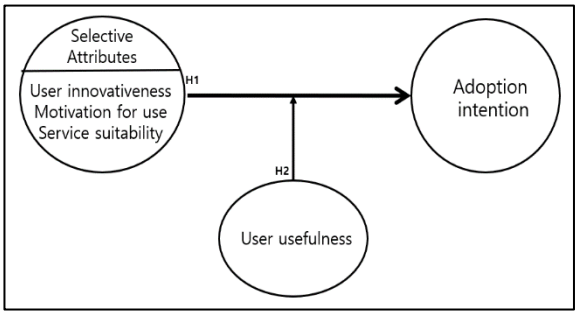

Figure 1. Research Model

2.2.2. Hypothesis

In order to analyze the influential relationship between the Selective Attributes and adoption intention, the following hypotheses were set forth, based on the purpose of this study and the previous studies:

Hypothesis 1: Selective Attributes have a positive (+) impact on adoption intention;

Hypothesis 1-1: User innovative among the Selective Attributes has a positive (+) impact on adoption intention;

Hypothesis 1-2: Motivation for use among the Selective Attributes has a positive (+) impact on adoption intention;

Hypothesis 1-3: Service suitability among the Selective Attributes has a positive (+) impact on adoption intention;

Hypothesis 2: User usefulness has a mediating effect between the Selective Attributes and adoption intention;

Hypothesis 2-1: User usefulness has a mediating effect between user innovative among the Selective Attributes and adoption intention;

Hypothesis 2-2: User usefulness has a mediating effect between motivation for use among the Selective Attributes and adoption intention;

Hypothesis 2-3: User usefulness has a mediating effect between service suitability among the Selective Attributes and adoption intention.

2.2.3. Data Analysis

In this study, a survey was carried out over the course of two months from February until March in 2019, using the convenient sampling method, targeting the members of a user group, who were interested in the advancement of smart healthcare. A total of 327 questionnaire forms were returned, of which 327 forms, excluding the 6 forms that were deemed unsuitable, were used in the actual analysis. A statistics program, SPSS 18.0 for Windows was used to analyze the data.

As for the analysis methods, a frequency analysis was performed to determine the demographic characteristics, and a reliability analysis and a factor analysis were carried out to review the statistical reliability and validity of the questionnaire administered. Also, a correlation analysis for identification of the correlation between the variables and a hierarchical regression analysis for testing the hypothesis were carried out.

3. Results and Discussion

3.1. Feasibility and reliability analysis

In the case of the factor analysis performed to verify validity, the exploratory factor analysis method was used to analyze the principal components, while varimax rotation was used as the factor rotation method and variables with communalities of less than 0.4 were excluded from the factor analysis. As for the reliability analysis, the coefficient of reliability of the variables grouped together through the factor analysis was calculated, and the factors with a reliability coefficient of less than 0.6 were excluded from the analysis.

The questionnaire on the Selective Attributes was comprised of 16 question items. When the factors were analyzed after excluding the component variables with low factor loading or variables that load on factors with different constructs, it was found that there were three factors with an Eigen value of 1 or over, and the user usefulness and adoption intention were extracted as single factors, as shown in Table 1.

Table 1: Factor Analysis results

Item	Factor analysis			Communalities
	User innovativeness	Motivation for use	Service suitability	
Selective Attributes 07	0.865	0.219	0.302	0.888
Selective Attributes 03	0.852	0.268	0.238	0.854
Selective Attributes 05	0.797	0.377	0.201	0.817
Selective Attributes 09	0.774	0.437	0.155	0.814
Selective Attributes 02	0.736	0.458	0.199	0.791
Selective Attributes 06	0.662	0.296	0.534	0.811
Selective Attributes 14	0.318	0.885	0.168	0.912
Selective Attributes 04	0.370	0.837	0.139	0.857
Selective Attributes 11	0.241	0.804	0.338	0.819
Selective Attributes 08	0.529	0.699	0.184	0.803
Selective Attributes 16	0.067	0.175	0.848	0.755
Selective Attributes 01	0.255	0.110	0.761	0.656
Selective Attributes 13	0.389	0.252	0.723	0.738
Eigen value	8.129	1.359	1.028	
Cronbach's α	0.951	0.931	0.778	

3.2. *Correlation Analysis*

The correlations between the certain measurement factors were analyzed by Pearson product-moment correlation coefficient (PPMCC). The results showed that there was a positive correlation between all of the factors, with statistical significance, as shown in Table 2, and it is deemed that there was no issue of multicollinearity as the correlation value between all the factors was less than 0.8.

Table 2: Correlation analysis

	Adoption intention	User innovativeness	Motivation for use	Service suitability	User usefulness
Adoption intention	1.000	0.474***	0.482***	0.488***	0.111**
User innovativeness		1.000	0.743***	0.614***	0.166***
Motivation for use			1.000	0.517***	.051
Service suitability				1.000	.023
User usefulness					1.000

주) *: p<0.10, **: p<0.05, ***: p<0.01

3.3. Hypothesis 1 Verification

Mode 1 in Table 3 shows the results of a multiple regression analysis conducted to examine the effects of the Selective Attributes of IoT-based smart healthcare systems on the intention to accept such system. Prior to the regression analysis, the values of tolerance and variance inflation factor were examined in order to check for multicollinearity among the variables. The results showed that the tolerance of each of the variables was larger than 0.1, and the VIF did not exceed 10, indicating that there were no issues of multicollinearity.

The explanatory power of Model 1 was found to be 31.5%, and in relation to the results on the effects, motivation for use (β=.206, p<.001), service suitability (β=.316, p<.001) among the Selective Attributes were found to have a statistically significant impact on the intention to accept the smart healthcare system, whereas the effect of user innovativeness (β=.081, p<.05) was not statistically significant. The t values of the motivation for use and service suitability were 3.574 and 4.916, respectively, which indicated that these Selective Attributes of IoT-based smart healthcare systems were positively (+) correlated with adoption intention. On the other hand, it was found that the correlation between user innovativeness and adoption intention was not statistically significant. This means that the higher the motivation for use and service suitability in relation to IoT-based smart healthcare systems, the higher the

adoption intention is, while the correlation between user innovativeness and adoption intention is not statistically significant. Thus, "Hypothesis 1: Selective Attributes have a positive (+) impact on adoption intention" was partially supported by the results.

Table 3: Results of regression analysis

		Mode1	Mode2	Mode3	VIF
Independent variables	User innovativeness (A)	.109	.164**	.249***	3.108
	Motivation for use (B)	.250***	.231***	.165***	2.516
	Service suitability (C)	.292***	.265***	.265***	1.681
Moderating variable	User usefulness (C1)		.145***	.205***	1.174
Interaction effect	A x C1			.200***	3.912
	B x C1			.176***	3.519
	C x C1			.161***	2.027
R^2		0.315	0.334	0.376	
F (p-value)		48.504*** (0.000)	39.660*** (0.000)	26.896*** (0.000)	

주) *: p<0.10, **: p<0.05, ***: p<0.01

3.4. Hypothesis 2 Verification

Mode 3 in Table 3 shows the results of a hierarchical regression analysis performed to examine the interaction between the Selective Attributes of IoT-based smart healthcare systems on the intention to accept the system and the adoption intention.

The overall explanatory power of the model was found to be 37.6%, and in relation to the results on the moderating effect, user usefulness was found to have a moderating effect between the Selective Attributes and adoption intention, with a statistical significance. The results also showed that the usefulness of IoT-based smart healthcare systems to the users had a positive (+) effect on between the relationship of the Selective Attributes, which were user innovativeness, motivation for use, and service suitability with the adoption intention. Because the analysis results showed that the moderating effect of user usefulness between the Selective Attributes of IoT-based healthcare systems and the adoption intention was statistically significant, indicating that an increase in user usefulness would increase the adoption intention. These results supported Hypothesis 2.

3.5. *Results of Testing the Hypotheses*

The results of testing the hypotheses in relation to the effects of the Selective Attributes of IoT-based smart healthcare systems on the adoption intention, as shown in Table 4.

Table 4: Results of testing the hypotheses

No.	Hypothesis	Result
Hypothesis 1	Selective Attributes have a positive (+) impact on adoption intention.	Partially supported
Hypothesis 1-1	User innovative among the Selective Attributes has a positive (+) impact on adoption intention.	Rejected
Hypothesis 1-2	Motivation for use among the Selective Attributes has a positive (+) impact on adoption intention.	Supported
Hypothesis 1-3	Service suitability among the Selective Attributes has a positive (+) impact on adoption intention.	Supported
Hypothesis 2	User usefulness has a mediating effect between the Selective Attributes and adoption intention.	Supported

Hypothesis 2-1	User usefulness has a mediating effect between user innovativeness among the Selective Attributes and adoption intention.	Supported
Hypothesis 2-2	User usefulness has a mediating effect between motivation for use among the Selective Attributes and adoption intention.	Supported
Hypothesis 2-3	User usefulness has a mediating effect between service suitability among the Selective Attributes and adoption intention.	Supported

4. Conclusion

The effects of user innovativeness, motivation for use and service suitability, which are the Selective Attributes of IoT-based smart healthcare systems, on the adoption intention as well as the interaction effect of user usefulness were statistically verified based on the users who were using such systems, through which the factors that impact the adoption intention were analyzed, and the results were as follows:

First, of the Selective Attributes of smart healthcare services, motivation for use and service suitability were found to have a positive impact on adoption intention, whereas a statistically significant relationship was not found between user innovativeness and adoption intention.

Second, based on the results showing that the influence of service suitability was higher statistically, it is deemed that in order to propagate smart healthcare services, there is a need to implement support measures in relation to service suitability when providing smart healthcare services to users.

Third, the usefulness of smart healthcare services to users had a significant interaction effect on adoption intention, and more significant interaction effect was exerted on user innovativeness.

The significance of this study is that it explored the factors that affect the intention to accept smart healthcare services, using a new research model incorporated with a moderating variable, and that it presents an academic implication that user usefulness is an important factor in promoting the use of smart healthcare systems was proposed.

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