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Examining the Intention to Use Infant Health Monitoring Devices in South Korea

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Examining the Intention to Use Infant Health Monitoring Devices in South Korea

Mideum Choi¹, Seongcheol Kim²

1. Introduction

The era of ‘Internet of Things’ (IoT), in which all objects and the internet are connected and information is shared without human involvement, has arrived. According to <IoT Tech Road Map> published by SRI Consulting Business Intelligence in 2013, representative areas of IoT which will lead the market in 2017, include indoor positioning system applied to smart home and healthcare sector (SRI Consulting Business Intelligence, 2013). Gartner (2013) argued that global IoT market will produce economic value of 1.9 trillion dollar by 2020, and healthcare provider industry (15%) and manufacturing (15%) will account for the largest portion of the global IoT market. Healthcare industry is specifically expected to generate 285 billion dollar in added value, respectively (Gartner, 2013; KISDI, 2014). A number of specialists are considering healthcare industry as one of the areas where IoT technology will be most actively applied, and it is expected to form 'Mass Market; mass production and consumption' for consumers in the near future (Lee, 2014; BI Intelligence, 2013).

With UN's estimation that world population over 100 years old in 2050 will be 10 times of 2010 and varied social and economic problems of aging populations rising above the surface (David, Axel, Patrick, & Atsushi, 2011), health has been set as a critical social agenda. In this sense, medical and healthcare sector are becoming more attractive in the process of IoT commercialization. Medical paradigm has now changed from post-treatment to proactive managing, and medical marketing has expanded from patients to those who are interested in health and wellness (Lee, 2014). So, currently what level is IoT healthcare technology, services and products? The most common healthcare products are wearable devices, such as smart-watches, smart-band, wrist-band, wearable bio-monitors which continuously measure and transmit biometric information while people are wearing it. In the United States more than one out of ten people who are over the age of 18, are known to have the activity tracker (e.g., Jawbone

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UP, Fitbit Blaze, Nike+ FuelBand, Misfit Wearables, etc.) (Ledger & McCaffrey, 2014).

The strength of the IoT health device increases when personal health information is passed on to healthcare professionals. For example, ITU (2005) explains that IoT has enabled telemedicine as it applies to the health sector and this characteristic is particularly helpful for handicapped or elderly with movement disabilities. IoT based health related devices for the infant who have difficulty controlling their own body and hard to express their condition are also receiving great interest. The ‘Sproutling Baby Monitor’, ‘Owlet’, ‘TempTraq’, ‘Mimo’, and other infant health monitoring devices can provide information such as body temperature, heart rate, oxygen concentration, respiration rate and sleep status of baby in real time so that parents are able to mind the condition of their baby anytime, anywhere. Specifically, ‘Owlet smart sock’ gives real-time alerting of rollover in sleep to prevent a sudden death caused by difficulty in breathing while a baby sleeps prostrate. By transmitting biometric information of infants, who cannot express themselves, it helps parents to promptly respond to any emergency (Lee, 2014). ‘TempTraq’ and ‘Mimo’ automatically notify parents when their baby’s temperature change is sensed, because baby often has high fever without any environmental changes and, if serious, lead to febrile seizure, brain damage, and other severe sequelae. Most of the products are available in wearable form such as band, sticker, and socks, and the information collected through the device attached to the babies is transmitted to the parent's smart device including smartphones. It refers that three objects, parents, baby and the device, are concurrently connected. Devices are not only a child safety guard but also a helping hand for parents who are struggling to care for their children.

However, despite these strengths, the current rate of infant health device usage is low. Failure to secure a sufficient number of users means that the size of the industry is difficult to expand, which means that industrial development is not hopeful. For autonomous development of the IoT healthcare industry, it is necessary to make efforts to supplement IoT based healthcare device and service function based on prediction and analysis of IoT consumer behavior. In this sense, this study aims to provide theoretical and practical implications that can help development of the healthcare industry by analyzing the effect of user’s perception on IoT based health devices usage. This study, specifically, tried to modify the CMIS (Comprehensive Model of Information Seeking) which has been used mainly as a theoretical framework to explain people’s media use behavior and health-related behavior (Hartoonian et al., 2014; Johnson & Meischke, 1993; Kelly et al., 2007; Paek et al., 2017).

2. Comprehensive Model of Information Seeking (CMIS)

As the comprehensive model of information seeking (CMIS) is built upon existing

theoretical foundation such as the uses and gratification theory (U&G), the health belief model (HBM), and the model of media exposure and appraisal (MEA), it is widely used in the fields of media and health communication.

Examining the background in which CMIS was established, first, the U&G approach (Katz, Blumler, & Gurevitch, 1973; Rubin & Perse, 1987) provided the concept of the active audience to CMIS. Since the active audience here means the viewpoint that people actively use media to fulfill their needs (Katz, Blumler, & Gurevitch, 1973). In the context as U&G, McQuail, Blumler, and Brown (1972) mentioned that people's media use is a goal-oriented behavior. The CMIS focuses on the instrumental media orientation and assumes that people perform certain behaviors (e.g., reading magazines, watching TV, etc.) to get useful information.

Second, CMIS includes the viewpoint of HBM (Becker & Rosenstock, 1984; Rosenstock, 1974; Yarbrough & Braden, 2001) that beliefs and values about health affect the individual's disease-preventing behavior. HBM explains that the following beliefs affect people when they do a series of actions to avoid disease; *Perceived susceptibility*: I am susceptible to the disease, *Perceived severity*: If I contract the disease, it is a very serious thing in my life, both medically (e.g., death, disability, and pain, Janz & Becker, 1984, p.2) and socially (e.g., effects of the conditions on work, family life, and social relations, Janz & Becker, 1984, p.2), *Perceived benefit*: If I perform a certain action, it will reduce susceptibility to the illness or the severity of the time when I suffer from the disease, *Perceived barrier*: Taking the action will not be that chargeable, dangerous (e.g., side effects, iatrogenic outcomes, Janz & Becker, 1984, p.2), and unpleasant (e.g., painful, difficult, upsetting, Janz & Becker, 1984, p.2).

Previous studies have explained health-related behaviors such as people's preventive-health behaviors, sick-role behaviors, clinic utilization behaviors based on these four antecedents (Janz & Becker, 1984). The CMIS borrowed HBM's psychological antecedents mentioned above. The perceived susceptibility and perceived severity refers to "the degree of perceived health threat an individual feels" (Johnson & Meischke, 1993, p.347), and make people to find out health information. The perceived benefits and perceived barrier refers to "the personal anticipation of the efficacy on various medical procedures associated with individuals' health problem" (Johnson & Meischke, 1993, p.347). CMIS also contains the demographics and the individuals' experience with disease as personal factors, because many previous studies have been explaining health behavior have verified the influence of personal factors (Cummings, Becker, & Maile, 1980; Pack, Choi, & Hove, 2017), it considers that the actual experiences and conditions of an individual are also important.

Finally, the MEA emphasizes that specific factors related to the media affect to people's media channel selection, and it gave CMIS a viewpoint that user's perception of media properties is major antecedent variable explaining that people selected media to acquire information (Johnson & Oliveira, 1988). Following the MEA model, Johnson

& Meischke (1993) named media related variable ‘Information Carrier Factors (ICF)’ and explained the relation of it to information seeking behavior. Also, they divided ICF into two levels: ‘Information Carrier Characteristics (ICC)’ (e.g., editorial tone and communication potential) meaning of evaluation for media itself; and ‘utility’ meaning of evaluation for information in media, and they established influencing relationship among the variables included in each level. Specifically they elucidated that the ICC influence utility and the action (Johnson & Meischke, 1993).

The ICC was described in a variety antecedents such as editorial tone, communication potential, quality, understandability, accuracy, credibility and so on. Johnson & Meischke (1993) adopted two concepts, editorial tone and communication potential, defined editorial tone as the level of individual confidence in media (perceived message credibility) and communication potential as how well media deliver and visually express information (style and comprehensive of presented information), while Hartoonian and his colleagues (2014) measured the ICC with perceived quality and understandability. As stated earlier, the ICC is measured in a variety of variables however numerous researchers are focusing on credibility of media (Lapinski et al., 2006; Paek et al., 2016; Rains, 2007; Robinson et al., 2006). Next, The utility was defined in most studies as to how useful the information is (DeLorme et al., 2011; Johnson et al., 1995; Lapinski et al., 2006), and the action was defined as “the purposive acquisition of information from selected information carriers” (Johnson & Meischke, 1993, p. 345).

To put it simply, the CMIS includes three main schemas: health related factors, information carrier factors, and information seeking actions. Firstly, the CMIS antecedents – demographics, direct experience and health belief factors - explain why people become information seekers. Secondly, the information carrier factors - information carrier characteristics and utility - mean people’s evaluation of medium and information. Lastly, the information seeking action means the nature of the usage itself.

This study intends to explain health information seeking behavior via infant health monitoring devices based on CMIS. We endeavor to analyze how the demographics, direct experience, health belief factors, user’s perception of device properties (ICC) and user’s perception on usability (utility) are related to intention to use infant health monitoring device. To fit CMIS to the current study’s context, we considered babies’ gender, age and experience of disease as personal factors and propose the following research hypotheses.

H1: The infant’s age, gender and experience of disease will give effect to utility.

The CMIS assumes that four health belief factors of HBM influence user's perceived usefulness. Specifically, it means that the usefulness of the device is more highly evaluated the more a person perceives that he or she is likely to get sick, the

more a person perceives that it is a serious event that he or she gets sick, the more a person perceives that devices could prevent and treat diseases, and the more a person perceives that the device will not cause any side effects. Therefore, this study assumed that the four variables of HBM will affect utility.

H2: The perceived susceptibility, severity, benefits and barriers will give effect to the utility.

In addition, while the original CMIS only assumes that the health belief factors affect the utility, this study accepted the logic of HBM, the foundation of CMIS, and assumed that the health belief factors have a direct effect on the behavior intention. In the case of a model in which various theories are converged, the influence relationship between some variables is omitted for the parsimony of the model (Whetten, 1989). The CMIS also omits the influence of health belief factors on action in the process of convergence of HBM, U&G, and MEA theories. This study established the following hypothesis to more closely examine the influence relations between health related factors, information carrier characteristics and information seeking action. We assume that the health belief factors have a significant impact on not only usefulness but also intention to use.

H3: The perceived susceptibility, severity, benefits and barriers will give effect to the intention to use the infant health monitoring device.

According to the original conception of CMIS, the information carrier characteristics such as perceptions of the credibility and quality has an indirect effect through information usefulness as well as a direct effect to health information seeking behavior. This study intends to suggest modified model of CMIS revising ICC factors based on the fact that prior studies were not concerned enough about the properties of each media. However, no study has yet been conducted on how users perceive the characteristics of the IoT infant health monitoring device. We first determined that the characteristics of the infant health monitoring device should be clearly summarized before analyzing the user perception of the characteristics of the infant health monitoring device. This study focused on the fact that the infant health monitoring devices were mostly based on wearable computing technology and examined the characteristics of wearable computing in the next section. We then aim to analyze how potential users perceive these characteristics using EFA analysis. This study established the following research hypotheses according to the assumptions of CMIS.

H4: The ICC factors will give effect to the utility.

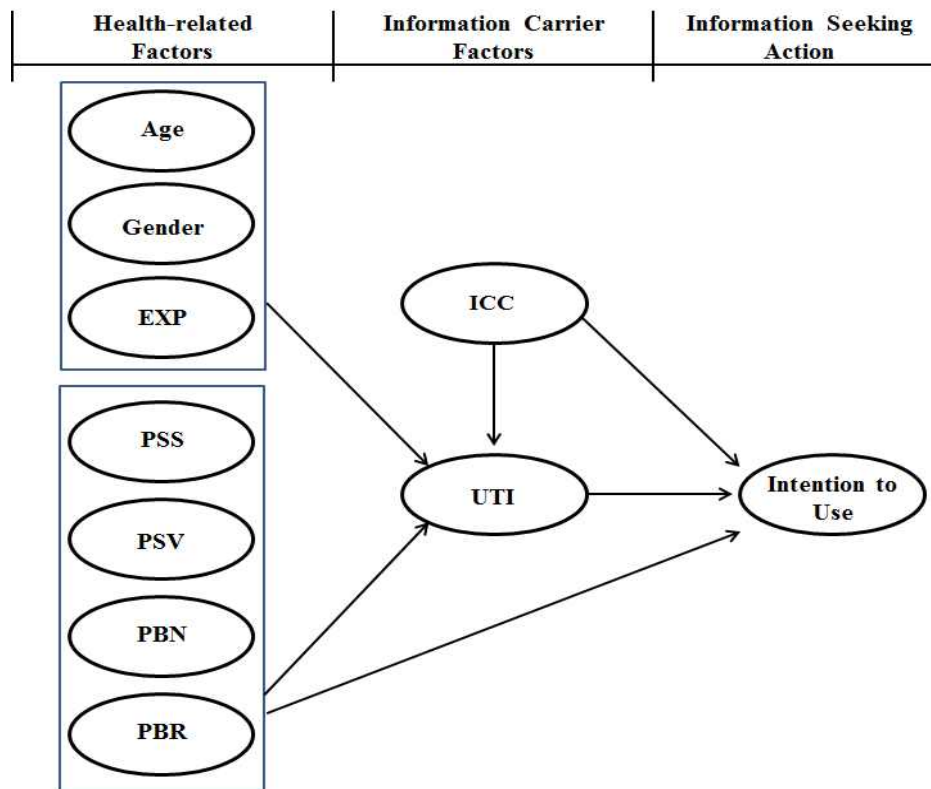
H5: The ICC factors will give effect to the intention to use the infant health monitoring

device.

Lastly, unlike ICC which directly or indirectly affects actions, the utility served as a direct determinant of actions as in the following example: Johnson et al. (1995) found a direct relationship between perceived usefulness of information and the number of different messages and people (their action variable).

H6: The utility factor will give positive effect to the intention to use the infant health monitoring device.

Figure1 presents the modified model of CMIS that this study proposes.



Note: EXP=Experience; PSS=perceived susceptibility; PSV=perceived severity; PBN=perceived benefits; PBR=perceived barriers; ICC=information carrier characteristic; UTI=utility.

Figure1. Proposed research mode

3. Health device with wearable computing

More personalized form of healthcare systems are established with the IoT technology, which leads people to self-managing and self-monitoring of their own health (Schreier, 2014). For example, the smart-band users check hours of nighttime

sleep and its quality right after they wake up and the exercise patterns such as distance and speed after jogging in the morning. Donald Jones with the Scripps Translational Science Institute states, “My favorite wearables today are those that measure blood pressure and that can be used to impute stress” (Metcalf et al., 2016). Furthermore, the physically disabled and elderly with mobility difficulties can take the medical examinations at home, and the people with chronic illnesses such as diabetes or heart diseases can lessen the number of visits to the hospitals.

As the essential part of the remote patient monitoring development, the IoT technology help the hospitals to collect and analyze the detailed biometric data of patients, and provide the personalized remote care (Evans, 2011), or it can save lives by notifying emergency situation in real time to the patients (Rajput & Gour, 2016). According to the MobiHealthNews (2014. 5. 29), about 20% of the doctors in the States were contacting to average 22 patients a month using the remote patient monitoring in practice. Now the IoT technology is realizing 4P (Personalized, Preventive, Predictive, Participatory), which was expected to be realized by meeting of healthcare and ICT technology (Schreier, 2014).

The core of such IoT healthcare services can be described as wearable computing or wearable technology. ITU (2004) explained the feature of the latest communication environment such as ubiquitous network “can be connected at any time / any place / any object”, and the wearable devices would be the best way for realizing those feature. Connecting every object specifically means ‘between PC, human to human, human to thing, thing to thing’ (ITU, 2004; Murakami, 2005), and the ‘human to human’ connection includes when information is passed each other without human intervention as well the conscious communication. For instance, the infant health monitoring devices introduced in wearable form, such as wrist/ankle/finger/arm bands, socks and small devices for clothes, grasp accurate information of a baby like posture, body temperature, breathing, voice, and whether he or she is sleeping or not, and concurrently send them to their parents’ smartphones and notify parents with audible alert on smartphones when something is not normal. The necessary information is delivered to the parent without conscious decision and moreover, the bio-information is transmitted automatically even if the baby is not holding it in their hands.

With the dawning of the IoT age, position of the wearable devices is getting more enlarged. Allied Business Intelligence Research predicted that 48,500 million wearing devices would be available around the world by 2018 (Kim & Cho, 2016), in particular, the wearable healthcare market is expected to reach 41,300 million dollar in 2020 (Jeong et al., 2014). The wearable computing, of implementing the wearable device, may be defined as “the system that is always with the user, is comfortable and easy to keep and use, and is as unobtrusive as clothing” (Henriques, 2003), and its application areas are divided into the following five categories: Healthcare and medical, fitness and wellness, infotainment, military, and industrial (Jhajharia et al., 2014).

Though wearable computing is being used in various fields, the same principal features and properties are applied: ①fit/comfort/wearing sensation: its weight and wearing sensation are hardly sensed as daily clothing or accessories, ②consistency/sustainability/real-time/mobile/persistent/constancy: whenever and wherever it is constantly sensing and operating, and provides user interface, ③quality/robustness/accuracy: it provides solidity externally, and accurate and credible information internally, ④usability/convenient: it has special feature and is easy to use and offers user the maximum, ⑤proactive alarm function/enhancement/unrestrictive/enable hands-free, eyes free and brain free: it can alert to draw user's attention when necessary, therefore user can multitask without being disturbed in daily life (Chen et al., 2017; Han et al., 2005; Henriques, 2003; Jhajharia et al., 2014; Ledger & McCaffrey, 2014).

When these properties of wearable computing apply to IoT healthcare device, wherever and whenever the credible health information should be provided and there must be no inconvenience by wearing it. It must be easy to use and needs proactive function by alarming when necessary to set user free from continuous attention. This study aims to use such characteristics of wearable computing devices as items to measure ICC variables. This is to construct the ICC variable with a more appropriate item than the reliability variable used repeatedly in previous studies.

4. Methods

1) Data collection

To collect research data, an online survey was conducted with the help of a professional research firm. Survey items were collected for a week in May, 2017. 419 complete respondents collected. 160 (38.2%) of the respondents were male and 259 (61.8%) were female. 45 (10.7%) of the respondents were 25-29, 329 (78.5%) were 30-39 and 45 (10.7%) were 40-49 ($M=34.5$, $SD=3.86$). Most respondents have a bachelor's degree (60.4%) and high school degree (19.3%).

2) Measures

For antecedent variables, demographic characteristics (infant's age and gender) and direct experience (baby's experience of disease) were measured. Next, health belief factors consist of PSS, PSV, PBN and PBR were measured with the items that were drawn from the study of HBM (Adams, Hall, & Fulghum, 2014; Noroozi, Jomand, & Tahmasebi, 2011). First, PSS was measured with four items on 5-point scale (1=not at all ~ 5=very much): "My baby has the potential to suddenly have a fever or lose body

heat even when it was maintaining adequate temperature”; “My baby may have irregular breathing compared to adults”; “My baby has difficulty flipping the body, and there is a possibility of difficulty breathing when sleeping”; “My baby, unlike an adult, may get a high fever or hypothermia without any environmental changes”. Second, PSV was measured with five items: “Aftereffects (e.g. flu, brain damage, febrile seizure) from a high fever or hypothermia could be serious for my baby”; “Having a difficulty in breathing while sleep could be serious for my baby”; “It is a serious matter that my baby's temperature goes beyond normal range”; “I would be afraid if my baby had high fever or hypothermia”; “I would be afraid if my baby had irregular breathing.”. Third, PBN was measured with five items: “Using the infant health monitoring devices will prevent my baby from diseases (e.g. flu, brain damage, febrile seizure) caused by a high fever/hypothermia”; “By using an infant health monitoring device, I will be able to take action before my baby experiences severe difficulty in breathing.”; “By using an infant health monitoring device, I will be able to quickly detect the health problem of my baby”; “If I use the health device, I will be able to take precautions before my baby has a high fever or hypothermia”; “Using the health device will prevent early the health problems that can occur due to my baby's sleeping posture”. Fourth, perceived barriers was measured with three items: “I am afraid that using the infant health monitoring device cause any side effect to my baby”; “I am afraid that using the infant health monitoring device might be dangerous to my baby”; “I am worried that using the health device will have a detrimental effect on my baby” .

To configure the ICC factor, we measured the characteristics of the device with wearable computing technology. The measurement items were constructed based on the characteristics of wearable computing mentioned in previous studies (Chen et al., 2017; Han et al., 2005; Henriques, 2003; Jhajharia et al., 2014; Johnson & Meischke, 1993; Johnson et al., 1995; Ledger & McCaffrey, 2014). Specifically, ICC factor was measured using the following 15 items: “I think the infant health monitoring device would be accurate”; “The infant health monitoring device would provide reliable information”; “I would trust the information from the device”; “The infant health monitoring device would be convenient”; “The infant health monitoring device would provide information clearly”; “The infant health monitoring device would present various information for easy understanding”; “The infant health monitoring device would not that heavy to being attached”; “The infant health monitoring device would be light enough to wear”; “The infant health monitoring device would be comfortable enough to wear”; “The infant health monitoring device would operate continuously”; “The infant health monitoring device would available whenever I want to use”; “The infant health monitoring device would be keep sensing without stopping”; “The infant health monitoring device intelligently provides information through an alarm function”; “The infant health monitoring device informs the necessary information in a timely manner”; “Without paying attention continuously, I can get information from the infant

health monitoring device when I need it”.

The utility variable was measured with five items: “The infant health monitoring device would help to raise my baby healthy”; “The infant health monitoring devices would be valuable”; “The infant health monitoring devices would be helpful on parenting”; “The health device would help me monitor my baby's health”; “By using the health device, it would be easier to manage my baby's health” (Johnson et al., 1995; Venkatesh, Morris, Davis, & Davis, 2003; Venkatesh, Thong, & Xu, 2012). Intention to use the infant health monitoring devices was constructed with four question items that were drawn from existing literature (Agag & El-Masry, 2016): “I am willing to use the infant health monitoring device”; “I have the intention to purchase the infant health monitoring device”; “I will look for more information about the infant health monitoring device”; “I am likely to purchase a health device”. Responses were rated on a 5-point Likert scale.

Variables measured with multiple items were examined with the following: exploratory factor analysis (EFA) for preliminary factor structure; Cronbach’s alpha reliability for internal consistency; and confirmatory factor analysis (CFA) for checking discriminant validity, convergent validity and measurement model fit.

5. Results

1) Model specification

(1) Results of the Exploratory Factor Analysis of ICC

We conducted exploratory factor analysis (EFA) using the SPSS 16.0 program on the 15 items to analyze how people perceive the characteristics of infant health monitoring device. We chose the factor analysis results extracted in the VariMax orthogonal solution method to obtain a factor structure that kept the information characteristics as intact as possible. The criteria to be recognized as an independent factor structure include an Eigen value of 1.0 or higher, primary factor loading of .60 or higher, secondary factor loading of .40 or lower. By applying those criteria, we identified three characteristics of infant health monitoring device people perceived. 15 items that explained 69.13% of the entire variance in use motivation.

Table1. Factor analysis for ICC

Questions	Factor loadings		
	1	2	3
Factor 1: Quality			

I think the infant health monitoring device would be accurate	.822		
The infant health monitoring device would provide reliable information	.843		
I would trust the information from the device	.822		
The infant health monitoring device would be convenient	.623		
The infant health monitoring device would provide information clearly	.789		
The infant health monitoring device would present various information for easy understanding	.622		
Factor 2: Fit			
The infant health monitoring device would not that heavy to being attached		.747	
The infant health monitoring device would be light enough to wear		.688	
The infant health monitoring device would be comfortable enough to wear		.849	
Factor 3: Consistency			
The infant health monitoring device would operate continuously			.747
The infant health monitoring device would available whenever I want to use			.832
The infant health monitoring device would be keep sensing without stopping			.826
The infant health monitoring device intelligently provides information through an alarm function			.785
The infant health monitoring device informs the necessary information in a timely manner			.819
Without paying attention continuously, I can get information from the infant health monitoring device when I need it			.792
Eigen Value	3.95	2.09	4.33
Common Variance%	26.34	13.92	28.87
Cronbach's alpha	.895	.753	.919

(2) Results of the confirmatory factor analysis

After conducting EFA, we checked our measurement model by performing confirmatory factor analysis (CFA) using the AMOS 18 program with the maximum-likelihood estimates method. Multifarious goodness-of-fit indices such as RMSEA; TLI; CFI and SRMR were examined. It is ordinarily considered that a value of 0.9 or more on the CFI and TLI represents a good fit (Shin, 2013), and a value of 0.8 or more on the NFI and the AGFI represents a good (Šumak & Šorgo, 2016); a model counts as acceptable if SRMR is less than .08 (Hu & Bentler, 1999) or is less than .10

(Kline, 1998; Šumak & Šorgo, 2016). RMSEA value of 0.8 or less represents a good fit (Shin, 2013) and the values between .08 and .10 are considered to be a mediocre fit (Browne & Cudeck, 1993).

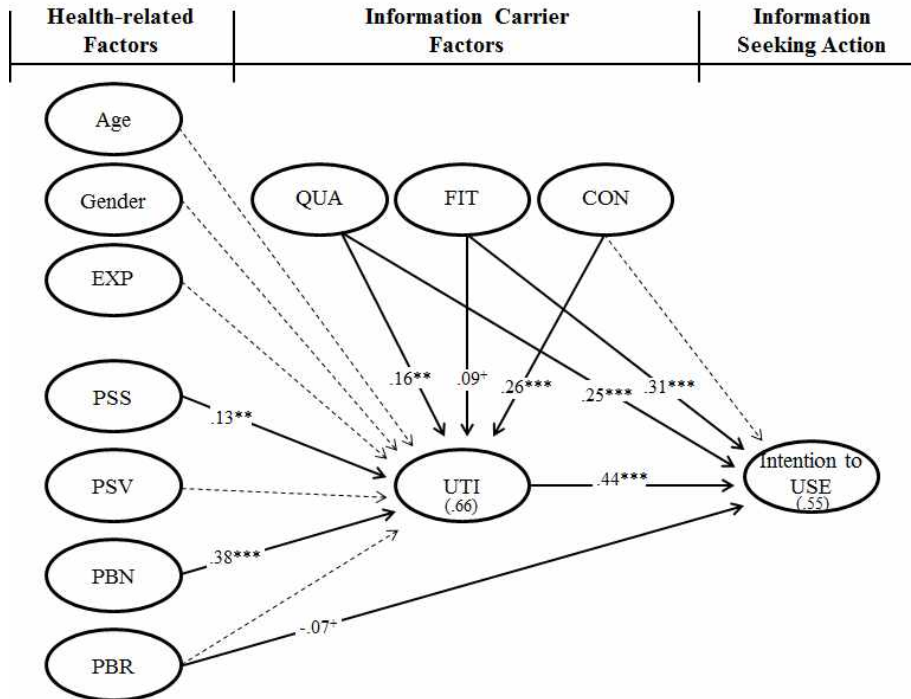
A CFA model was reasonably well fitted with the nine latent constructs and 41 observed indicators by adding demographics and the direct experience variable which was measured with a single item each and therefore not included in the CFA model: Chi-square (743)=1624.50, $p < .001$, Q (CMIN/DF)=2.18, RMSEA=.053 (90% Confidence Interval [CI]=.050, .057), CFI=.93, TLI=.92, SRMR=.05, NFI=.88, AGFI=.81. After the measurement model fit was verified, convergent and discriminant validity of the latent variables were examined. Results showed that all items significantly ($p < .001$) loaded to the intended factors, indicating good convergent validity. If the CR value is 0.7 or higher and the AVE value is 0.5 or higher, convergent validity is said to have been met. (Anderson & Gerbing, 1988; Shin, 2013). In addition, an appropriate level of discriminant validity is secured when the AVE value for each latent variable is larger than the coefficient of correlation squared (r^2) of the every two latent variables (Fornell & David, 1981). The result shows that discriminant validity was confirmed as appropriate level (See Table2).

Table2. Correlations between latent variables

CR	latent variable	AVE	Square of correlations								
			PSS	PSV	PBN	PBR	QUA	FIT	CON	UTI	INT
.902	PSS	.701	1								
.960	PSV	.707	0.203	1							
.950	PBN	.697	0.110	0.179	1						
.942	PBR	.728	0.007	0.029	0.001	1					
.952	QUA	.675	0.023	0.029	0.325	0.009	1				
.836	FIT	.627	0.004	0.003	0.126	0.005	0.389	1			
.962	CON	.697	0.069	0.118	0.366	0.000	0.339	0.220	1		
.950	UTI	.692	0.131	0.127	0.524	0.001	0.382	0.223	0.452	1	
.941	INT	.711	0.027	0.018	0.272	0.013	0.397	0.352	0.258	0.402	1

(3) Results of the structural equation model analysis

After EFA and CFA, we checked our measurement model by performing SEM (Structural Equation Model) using the AMOS 18 program. The proposed model was reasonably well fitted: Chi-square (842)=1717.348, $p < .001$, Q (CMIN/DF)=2.04, RMSEA=.050 (90% Confidence Interval [CI]=.046, .053), SRMR=.048, CFI=.93, TLI=.92, NFI=.871, AGFI=.81. Figure2 shows statistical significance for the final model.



Note: All the coefficients are completely standardized. We only draw significant paths between the HBM and the intention to use to simplify the figure; dotted lines indicate non-significant paths. EXP=Experience; PSS=perceived susceptibility; PSV=perceived severity; PBN=perceived benefits; PBR=perceived barriers; QUA=quality; FIT=fit; CON=consistency; UTI=utility. + $p < .1$, ** $p < .01$, *** $p < .001$.

Figure2. Result of the SEM analysis

First, among the antecedents, the PSS (completely standardized coefficient=.13, $p < .01$) and PBN (completely standardized coefficient=.38, $p < .001$) were positively related to utility. People who more consider their baby could be sick and more think the benefits of using the device are more likely to think that using the health device is useful. The baby's age, gender and experience of disease were not significantly related to utility.

Second, all ICC factors positively gives effect to utility (completely standardized coefficient (quality)=.16, $p < .01$; (fit)=.09, $p < .1$; (consistency)=.26, $p < .001$). That is, the people who more think that the health device provides accurate information, who more perceive the device is comfortable, who more think the device is constantly providing information are more likely to think that infant health monitoring devices is useful.

Next, we looked at which variables influence intention to use infant health devices. In ICC, only quality (completely standardized coefficient=.25, $p < .01$) and fit (completely standardized coefficient=.31, $p < .001$) affected intention to use, and consistency did not have influence. This means that the person who more strongly believes that the baby's health information provided by the device is accurate and reliable, and the person who more strongly thinks that the device is light and

comfortable enough to be attached to their baby's body, has a high intention to use the device.

In addition, only the perceived barrier in HBM had a negative effect on intention to use infant health device (completely standardized coefficient=-.07, $p < .1$). The intention to use was lowered with higher perception that health devices may cause side effects or use of devices will actually harm the baby. Finally, the utility of the infant health device had a significant effect on the intention to use the device (completely standardized coefficient=.44, $p < .001$). It signifies that the intention to use increases the more a person perceives that the device is useful.

6. Discussion and conclusion

The aim of this study is to explain the behavior of those who use infant health monitoring device, based on the CMIS. The reasons why this research sought to explain the behavior of using the infant health monitoring device through the CMIS are as follows. First, it is because the U&G, which is one of the three theories that formulate the CMIS, emphasizes the concept of an active audience. As the infant health monitoring device is a product inserted with IoT technology, habitual or portable use, which is possible with TV or cellphones, is impossible with infant health monitoring device. Moreover, by explaining people's goal oriented behavior, the U&G also explains why infant health monitoring device is used to gain information about health. HBM, which is the second theory that develops the CMIS model, emphasizes that self-awareness about one's health causes the usage behavior of media that provides health information. Therefore, HBM theory can explain the behavior of parents using the infant health monitoring device in order to check their baby's health conditions and to gain health information. The MEA, the last theory to formulate the CMIS model emphasizes that the characteristics of media is the deciding factor in usage of that particular device. Prior research that supposedly applied the CMIS model has shown that media reliability is a deciding factor in usage of that particular media. By focusing on the point that infant health monitoring device is an innovative product that provides personal health information, this research used the CMIS model, which is used frequently in the area of media and health communication, as theoretical evidence.

Based on the results of this study using the CMIS, the following discussions are possible. First, CMIS classifies demographics, personal disease history, and HBM variables into health related factors, and argues that health related factors affect media usefulness. For example, According to Pack et al. (2017), those who are old, female tend to evaluate TV health programs more useful. It can be explained in the similar context of other studies that the older one is, the more dependent one is to TV (Korea Press Foundation, 2015), and that women are more concerned about health management (Kim & Lee, 2014). Next, personal disease history is measurement of whether one has

experience of having had diseases. But, when the objects of research are only those who have had cancers, they are measured with self-reported health status (Hartoonian et al., 2014). According to Hartoonian et al. (2014) the more one think that one is not healthy, the more one seeks health information.

This study, based on hypotheses of CMIS and previous researches applying CMIS, set up a hypothesis that age of infant, gender, and experience of having a sickness will have effect on perception on usefulness of media. But, it was found that all antecedents variables did not have effects on perception of usefulness of such media information. The finding that demographic antecedents were not significant may imply that HBM variables (i.e., PSS, PSV, PBN, PBR) play a more critical role in people's perception of health information carriers. In this research, PSS and PBN were found to be significant antecedents to people's evaluation of health devices' usefulness. It means that those parents who think that their baby (24 months old or younger) can suffer rapid change of body temperature and fever, and irregular breath compared with cases of adults tend more to perceive infant health monitoring device as useful. And, those parent who think that infant health monitoring device can help them to take measures in advance before health of their baby gets bad, or discover abnormality of their baby's health in initial stage and treat the disease more easily tend to evaluate the usefulness of the device highly. On the other hand, to perceive it as serious if babies' body temperature goes beyond normal range or their breath becomes irregular (PSV), or to perceive it as dangerous to babies to use such device (PBR) does not have meaningful effect on media usefulness. It seems that, as this research investigated PSV with body temperature changes and breath irregularity of infant, instead of examining perception of users on specific diseases, it did not discover any effect of PSV.

Meanwhile, such results can be discussed, by applying them to message frame. There have been huge accumulation of researches on health message in the aspect of communication. In particular, researches on public health campaign message actively use both gain-frame and loss-frame (Banks, et al., 1995; Jones, Sinclair, & Courneya, 2003; Rothman, Bartels, Wlaschin, & Salovey, 2006). In the process of forming and delivering health related messages, depending on whether message is constructed focusing on possibility of gain (gain-frame), or on possibility of loss (loss-frame), receivers can have different perception, behavior, and will. For example, it was found that, regarding to prevention behaviors, gain-frame has more persuasive power, but that, regarding to detection behaviors, loss-frame has more persuasive power. This study found out that, while PBN, which means benefits gained from using health device, has positive effect on usefulness, PBR, which means side effect or danger caused by use of device, does not have any effect on usefulness. Based on such findings, this study suggests to use gain-frame to increase use of infant health monitoring device.

Second, CMIS classifies ICF into ICC and ICU, and argues that ICC has effect on ICU and on intention to use infant health monitoring device. Most of previous

researches measure ICC as editorial tone (people's perception of credibility), or communication potential (issues of style and comprehensiveness). According to Pack et al. (2017) which measured ICC as media trust, while the more people trust media, the more highly they evaluate usefulness of media, media trust does not directly influence their intention to use health media. That is, media trust does not lead directly to willingness to use, but, passing through perception of usefulness of media, affects indirectly willingness to use it. In order to encourage people to use health media, we should not stop at efforts to boost media trust, but think over how media trust can contribute to boosting media usefulness. Hartoonian et al. (2014), who measured ICC as quality of information and easiness of information interpretation provided by media, found out that ICC has significant effect on usefulness. That is, the more people perceive that information quality is good and it is easy to interpret information, the more highly they tend to evaluate media usefulness.

Aware that all the IoT infant health monitoring devices in the market or which are expected to enter market have used wearable computing technology, this study measured ICC (information carrier characteristic) as characteristics of wearable computing products. EFA, and CFA analyses found three kinds of media characteristics — 'quality', 'fit', and 'consistency'. Next, SEM analysis revealed that all the three ICC variables have significant effects on usefulness. That is, the more parent think that infant health monitoring device will help them to be able to understand correct information easily, and the more parents thank that the device will be light-weighted and comfortable for their baby to attach on their bodies, and the more they think that the health device will provide them with information about their baby whenever they want it the more highly they evaluate usefulness of the device.

Third, this study tried to figure out which variables have direct effects on willingness to use infant health monitoring device. Analysis of direct causes determining use of health device showed that usefulness has positive effect on willingness to use infant health monitoring device. The more people think that infant health monitoring device is useful, the more they are willing to use it. And, it was found that 'quality' and 'fit' in ICC have significant effects on willingness to use it. People who perceive that device quality is good and its wearable feeling is good tend to be willing to use it. But, 'consistency' does not have direct effect on willingness to use it. It means that the perception of parents that the health device will continuously provide them with information about baby's health and that it will smartly provide them with information about baby's health on time with alarm does not lead directly to willingness to use it. However, as mentioned before, 'consistency' has significant effect on usefulness. The findings of this research that the characteristics of the device that it provides information continuously, and on time with alarm don't have effects on people's evaluation of the device as useful, but then, perception of usefulness has effect

on willingness to use. This result means that usefulness of health device is the core variable to predict behavior of using the device. In the future, it seems necessary to try continuously to find out what are media characteristics to boost media usefulness.

This study added the hypothesis of which HBM variables would influence behavior intention according to the hypothesis of HBM theory and analyzed the direct relation between these variables. The result showed that perceived barriers had a negative effect on behavior intention. This means that a parent who thinks that using a health device can have side effects to their baby or that it can be dangerous to attach the device to baby has low intention to use the device. It is assumed that the perception that electromagnetic wave generated in the apparatus may be harmful to the human body had influence. However, this influential relationship was omitted in existing CMIS; therefore, we fitted the original CMIS that doesn't link the path toward behavior intention from HBM variables. Based on such results, it is possible to present a theoretical suggestion in that it is necessary to add the path. The result shows that the original model fit was slightly poorer than that of our proposed model (Chi-square(846)=1724.94, $p < .001$, $Q (CMIN/DF)=2.04$; SRMR=.049, NFI=.870). Based on this fit difference check, it is possible to suggest that the HBM needs to add a path to the information seeking action variable.

On the other hand, it was found that PSS, PSV, and PBR, which are three variables that constitute HBM, did not have a significant effect on behavior intention. Based on previous studies where PSS and PBN had significant effect on utility, it can be determined that concerns and perception about health only affects utility, and that it is not a direct factor in deciding the health device usage. To promote the use of health devices, rather than emphasizing the gain of using the device (gain frame) or loss of not using the device (loss frame), a strategy that emphasizes the usefulness of the device and the characteristics of the device would be more appropriate.

This study explained the behavior to use IoT health device which provides parents with infants 24 months old or younger with health information on their infants, based on theoretical backgrounds of CMIS. In particular, this study can contribute to related researches in the sense that it pays attention to up-to-date IoT health device which links three objects called parents, offspring, and device, and that it tried to do research on application of CMIS to the area which has not been fully dealt with up to now. In addition, this study made efforts to revise existing variables, which have been used repeatedly without any critical consciousness, matching the research environment. Specifically, first, this study included all the four important variables of HBM to HRF. Second, it tested how users perceive characteristics of infant health monitoring device (ICC) through EFA and CFA. Then, it included the results to the research model. This study is meaningful in the sense that, while it utilized CMIS and observed the core hypotheses of CMIS, it tried to measure and analyze it more elaborately.

But, though CMIS is a theoretical model explaining the behavior to seek health

information, this study set up willingness to use, rather than real usage, as endogenous variable. It is due to the reality that there are still not many people who use infant health monitoring device, and that it is not easy to collect survey respondents. Nevertheless, it is necessary to make efforts to consider real behavior of users to seek health information through media, when we apply the CMIS. Future studies also may need to include more psychological antecedents in addition to PSS, PSV, PBN and PBR.

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