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Innovative Healthcare Wearable Device Usage and Service Enhancement

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ABSTRACT

Purpose: The purpose of this study is to analyze the range of use of healthcare wearable devices in the changing healthcare environment based on digital transformations and to suggest strategic ways to be proactively established for well-being, disease treatment and prevention, and improving operational efficiency.

Design/methodology/approach: This study presents to analyze real-world cases of current wearable devices use by people for healthy daily life.

Findings: As the results of the study based on previous studies and cases, the following five items can be proposed to enhance the service of the spread of healthcare-based wearable devices. The accuracy of the data, the safety of data being built in real-time, the institutional security to reduce risk, the establishment of the platform, the product design reflecting customer needs, and the adequacy of product prices should be considered.

Research limitations/implications: This study suggests implications of applications of wearable and smart devices in healthcare through cases for service enhancement and a widespread of wearable devices in healthcare.

Keywords: Healthcare device, Wearable device, Healthcare wearable devices, Case study

1. Introduction

The revolution of digital devices has made various changes in the healthcare industry as well as the manufacturing industry (Lee and Lee, 2019). Digital devices of the Internet of things (IoT) linked to personalization services from customers' smartphones have released in the market. The convergence of IoT and smart devices enables the creation of service values through the collection of information using various sensing technologies or controls by smart

devices at the remote. Users will be provided information collected by IoT sensors and utilize the information in their life. The use of artificial intelligence (AI) for disease diagnosis or healthcare wearable devices for service efficiency enhancement has been reported recently (Yoon and Lee, 2019). Results of the applications of AI receive attention from doctors, researchers, or technicians who try to improve healthcare management or diagnosis.

A wearable device refers to a terminal or an electronic device that conducts special computing activities on a user wearing the device (Chi et al., 2018; Kim, 2013). IDC (Internet data center, 2019) estimated that the world wearable market would grow by 15.3% by the end of 2019, 198.5 million devices

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would be shipped in 2019, but 279 million in 2023. Chinese market size for wearable devices was 26.4 billion yuan in 2017 and sales have grown 29.64% to 50.3 million in 2017 from 37.8 million in 2016. By 2021 sales will be increased to 100 million (IDC, 2019).

Wearable devices are classified into three types: portable, attachable, and implantable based on wrist-wear, eye-wear, foot-wear, neck-wear, and body-wear (Issue Report, 2013). Smartwatch and the smart band are dominated in the current market, and Apple and Samsung are leading companies for smartwatches, while Fitbit and Xaiomi for smart bands. Market share for wearable devices is driven by Apple (27.4%), Xaiomi (12.6%), Huawei (9.6%), Fitbit (9.4%), and Samsung (6.8%) by the end of 2018 (IDC, 2019). Utilization of wearable devices has sharply increased in the areas of fitness, well-being, healthcare, infotainment, entertainment, defense, enterprise, and industrial as well as everyday life, thanks to the exchange of data between smart devices, portability, and convenience (Park, 2018). Especially wearable devices are small, lightweight enough to wear or attach to cloth to enable activities without noticing it (Chi et al., 2018). Some wearable devices are developed to prevent and diagnose diseases in healthcare by collecting real-time information about biorhythm or body changes and providing that information to users. Smart eyeglasses, smartwatches, smart shoes, smart rings, smart bracelets, smart buttons are examples of such wearable devices. Despite such benefits from the devices, a relatively small number of people use them (MEDpac, 2017).

This study is to investigate current using areas of wearable devices such as healthcare treatment and diagnosis of diseases, administration, and issues from the devices, and people's requirements on them. Since wearable devices in healthcare can be used to collect data on a user's health including heart rate, calories burned, blood pressure, physical strain, etc. other than other general wearable devices, the collected data can be used to forecast changes in health or stress, monitor how sick the user is, and assess health risk by medical staffs. These functions will enhance service quality in the healthcare industry. The purpose of the study is to provide a strategic way to improve

operational efficiency and efficiency of treatment or prevention of diseases through the usage analysis of a wearable device in the healthcare industry.

II. Evolution of Wearable Devices

The wearable devices market is getting bigger enough to attract a lot of technology companies like Apple, Google, Samsung, and Fitbit to research and develop their products. The size of medical device global market reached roughly 209 billion dollars in 2006 (Acmitte Market Intelligence, 2014), it was estimated to be between 220 and 250 billion dollars in 2013 (Vinny, 2013), current, and it is valued at 425.5 billion dollars and will be forecasted as 612.7 billion dollars in 2025 (More, 2019).

Initially, wearable devices were heavy and bulky, but the power of innovation made them light and incredibly smart. Medical wearable devices vary, can be wristbands, watches, glasses, shoes, or clothing, and the list continues to be updated.

A. Wearable Device Development Stage

A wearable device has been evolving; In the 1960s and 1970s, a camera or calculator was attached to a watch or shoe. In the 1980s, a device was developed to be worn on a wrist or foot and to provide the information through the device thanks to the advanced information communication technology. Most wearable devices were developed for the military at that time. Helmet-camera equipped with wireless communication technology, for example, was used in the military for a location trace system. In the 1990s with ubiquitous computing emerged, a wearable device was spread to the various industries with the advanced design of the device that is smaller attachable to a human body (Kim, 2013; Korea Creative Content Agency, 2012). In the 2000s, a wearable device has been spread with an advanced technology that enables a

device to be attached to a textile or a monitoring and biological technology (Korea Creative Content Agency, 2012). In the 2010s a wearable device has come into everyday life with the spread of smart devices (e.g., smartphones, tablets, etc.) (Chi et al., 2018; Park, 2018). These days a wearable device featuring connectivity with IoT and 5G smartphone has been introduced in various areas. Today's wearable devices like a smart band, smart shoes, smartwatch, and smart glasses, become a fashionable accessory which sends information to a smartphone that controls and monitors the devices. Also, wearable devices are not only improving product designs for sports, fitness, and remote patient monitoring, but also improving product performance by AI.

Thus, it is essential to understand user requirements to design and develop an integrated approach for wellness services in healthcare wearable devices. In this context, it is crucial to analyze real-world cases of current wearable devices use by people for healthy daily life and hospitals for patient care, prevention, and management of operations.

B. Medical Devices

Henschke and Redberg (2018) presented that “the FDA defines a medical device as “an instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, or other similar or related article, including all parts, or accessory which is: recognized in the official National Formulary, or the United States Pharmacopoeia, or any supplement to them; intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease, in man or other animals; or intended to affect the structure or any function of the body of man or other animals, and which does not achieve its primary intended purposes through chemical action within or on the body of man or other animals and which is not dependent upon being metabolized for the achievement of any of its primary intended purposes.”

A definition of “medical device is difficult to establish because there are numerous regulatory

bodies worldwide overseeing the marketing of medical devices. Although these bodies often collaborate and discuss the definition in general, there are subtle differences in wording that prevent a global harmonization of the definition of a medical device. Thus the appropriate definition of a medical device depends on the region. Often a portion of the definition of a medical device is intended to differentiate between medical devices and drugs, as the regulatory requirements of the two are different” (Wikipedia, https://en.wikipedia.org/wiki/Medical_device).

In many ways, medical devices have revolutionized the care we receive (Marakhimov and Joo, 2017), but some of the regulatory and marketing practices for these products are exacerbating the rise in medical spending and patient safety (Henschke and Redberg, 2018).

III. Real-World Examples of Wearable Device

A. Cases in Sports, Fitness and Wellness

With information technology advance, a wearable device becomes smaller and lighter and increasingly popular for a person to keep track of sleeping, fitness, wellness patterns, for example. (Chi et al., 2018; Lee et al., 2016; Lee and Lee, 2018). Fitbit launched Fitbit Charge 3 in 2018, which checks and monitors human activities, such as heart rate measurement, pace counting, and calorie check through embedded sensors and wireless communication chips.

IOFIT by Salted Venture produces a shoe that balances a user when he/she walks or runs by sending a real-time signal, which enables to provide coaching solutions to him/her through IoT function embedded into a shoe. The shoe has a pressure and accelerator sensor of the bottom of the shoe, which measures a user's balance, movement of the center of gravity movement, and supporting power of each leg and sends the information to a connected smart device in real-time. An application is developed that enables

a golf swing and posture coaching based on the information coming from the shoe. Another shoemaker, Prospects, developed a smart shoe that shows a user's walking patterns like several walks per minute, angles of walking, etc., helping him/her to correct its user walking patterns. Le Chal, a startup in India, developed a smart shoe for the blinds by embedding GPS into a shoe. TLI, a fabless semiconductor company, has accumulated a big data about healthcare and sport that come from sensors attached to insoles of a smart shoe they made. They utilize big data for healthcare and medical analysis (Ahn, 2018). Another smart shoe made by LG was introduced to provide statistics about the health status of a user through walking speed, heart rate, walking distance, etc. (Kim, 2018).

Beddit is a sleep monitor that measures, manages, and improves sleep with accurate and automatic tracking such as sleep time, bedtime, and time to fall asleep, etc. (www.beddit.com). FITGaurd introduces a head injury awareness mouth guard, which aims to solve the problem of athletes returning to play when there is a high probability of head injury. This device significantly increases the likelihood of early detection and the overall safety of athletes around the globe (www.fitguard.me). Digitsole is a smart insole that integrates electronics into footwear to offer consumers more functions to bring significant comfort and well-being (www.digitsole.com). Table 1 shows a list of various wearable devices in sports, fitness, and wellness areas (www.movehealthandfitness.com.au).

Not all wearable devices have made a success in the market. ZEO found by Brown University students developed a smart alarm clock with a sleep monitor that measures sleep time and patterns to improve sleep but bankrupted by late 2012 (Choi, 2015). Today we have lots of data measured and recorded in real-time, continuously, and automatically and shared with people through SNS. Wearable devices technology advance is unprecedented. Through factor analysis of the success and failure of wearable devices, a better wearable device can be designed and developed, which leads our lives better.

B. Wearable Devices for Diagnosis and Treatment in Healthcare

As a doctor performs a medical service independently, even if he can get help from artificial intelligence (AI), cost reduction for quality improvement of medical services is not easy to make (Miyashita and Brady, 2019). According to World Health Organization, about 60 percent of human activities for personal well-being and life quality are related to a lifestyle such as receiving a prescription, exercising, and reducing stresses (Robinson et al., 2019).

AI can provide an alarm to a patient every day based on its user vitality changes. Manipal Hospital which introduced Watson for oncology, is one of the top cancer cares in Bangalore, India, announced that Watson's diagnosis on the breast, colorectal, rectal, and lung cancer from 1000 patients was not the same as two cancer specialists' ones. For rectal cancer, Watson's diagnosis was 85% the same as doctors' diagnosis but 17.8% for colorectal cancer (Somashexhar et al., 2016).

Healthcare and medical data have been collected in real-time through a wearable device in everyday life, which is only available in hospitals. Activity tracker, for example, tracks various medical data, such as calory consumption, amount of activity, body temperature, heart rate, oxygen saturation, electrocardiogram, respiratory rate, blood pressure, blood sugar, brain wave, etc. (Choi, 2015). The data a user or a patient has measured in real-time daily through a wearable device can be shared with a doctor who uses the data to diagnose, monitor, and treat the patient. Patients' generated health data will contribute to implementing preventive, precision, and predictive medicine (Lee, 2017).

Apple watches four tracks pulse signals of a heart when a user touches the stem of a watch by flowing the electric current to a heart. After 30 seconds collection of heartbeat is analyzed and saved in the Apple app. This data can be used by a doctor to determine the symptom of atrial fibrillation (IT World, 2018). Atsens in 2017 introduced the smallest wearable device for measuring electrocardiogram first in the

Table 1. Wearable Devices in Sports, Fitness and Wellness

Product type	Product Name	Company	Function
Smart Clothing	Nadi X Yoga Pants	Wearable X	Adjust user's yoga pose by creating small vibrations on the body part with the wrong pose
	Under Armour's Athlete Recovery	Under Armour	Absorb heat from the human body and reflects it onto the wearer's skin as Far Infrared light to encourage better muscle recovery and enhance relaxation.
	Sensoria Fitness Socks	Sensoria Fitness	Detect precise data on how your foot lands while walking or running
	Neviano Swimsuits	Spinali-design	Send alerts when UV levels are high and more sunscreen should be applied.
	Athos Core	Athos	Collect and evaluate electrical activity produced by muscles to show how hard they are working to help correctly exercising and avoiding injury.
	Hexoskin Smart Shirt	Hexoskin	Tracking activities (steps, cadence, calories), sleep, breathing rate, heart rate variability
	Levi's Commuter x Jacquard	Levi's and Google	Screen phone calls, control music volume, and even get you directions by tapping or brushing the sleeve.
	Tommy Jeans Xplore	Tommy	Tracking for collects product usage, location, and time
	Sensoria Fitness Socks		Detect precise data on how your foot lands while walking or running.
	Adidas miCoach	Adidas	Determine athletic performance like speed, acceleration, power, distance, and heart.
Smart Watches	Samsung Galaxy Fit	Samsung	Alert if heart rate gets too high above a pre-defined level or low
	Samsung Galaxy Watch Active 2	Samsung	A heart rate and ECG sensor and health app with stress and sleep monitoring.
	Motoactv	Motorola	Fitness Tracker, heart rate monitor, pedometer, GPS
	Apple Watch 5	Apple	Check heart rhythm with the ECG app
	Fitbit Versa2	Fitbit	Sleep and fitness tracker
	Fitbit Ionic	Fitbit	Heart Rate
	Fossil Sport Watches	Fossil	Heart rate, NFC, GPS, and Bluetooth.
	Ticwatch Pro LTE	Mobvoi	Receive the treatment, with cellular support through Verizon
Wristband	Flex	FitBit	Tracks steps, calories burned, sleep hours and quality, active minutes, distance traveled - tracks goals online and on mobile devices.
	Fitness Bracelet	Jawbone	Tracks movement and sleep, gives feedback in these areas.
	Fitness Band	Amiigo	Fitness bracelet for iPhone and Android - measures and tracks specific exercises, reps, sets, heart rate, and calories burned.
Smart Glasses	Google Glasses	Google	Wearable technology in head-mounted, eye-glass format with computer capabilities. It is used as a basis for health-related applications, especially targeting physician support and remote diagnostics.
	Vue	Vigo Technologies Inc	Keep track of steps walked, calories burned, and distance traveled, remind users to move if they were sitting for a while.
Smart Shoes	Original LI-NING Intelligent Running Sneakers	LI-NING	Check running routes, calories burnt and speed data
	IOFIT Smart Shoes	Salted Venture	Analyze and correct the golf swing of its user
	FootLogger	3L Labs	Help with patient rehabilitation, spot early symptoms of arthritis and dementia
	E-vone	E-vone	Detecting "abnormal" movements
	Altra Torin IQ Road Running Shoe	Altra Running	Rack of your running style, impact rate, foot landing zone, cadence, and pace

world and ATP-C100, a patchable device, was approved as a second class of medical device by the Korean Ministry of Food and Drug Safety. The device collects heartbeats through its sensors and sends the data to a personal computer or a mobile device by a week or so. The data are shared with doctors, who can set up a treatment plan. Quell is a wearable pain relief device for the chronic pain community, which integrates neurostimulation and digital medicine to address chronic pain, personalizes to meet a user’s needs, and adjusts therapy to changes during sleep and even to compensate for changes in the weather (Na et al., 2013).

In 2018, the global medical device market was valued about \$ 423.8 billion, growing at an annual average growth rate (CAGR) of 5.28% since 2014, and the pace is expected to grow as 5.33% (about \$ 521.64 billion) by 2022 (Research and Markets, 2019). Research and Markets (2019) suggested the following the reasons of the rapid growth: “the elderly population, strong economic growth, and the increasing use of medical facilities in emerging countries, the adoption of high technology in the manufacture of medical devices, and the increase in medical spending worldwide.”

Table 2 shows a summary of wearable devices

Table 2. Medical Devices

Medical device	Product Type	Function
Diagnostic Device	Vital Sign Monitoring Devices	In the case of an emergency
	Heart Rate Monitors	monitor heart rate and monitor activity
	Activity Monitors	Check patients' reaction to the treatment method
	Electrocardiographs	Check oxygen in the blood,
	Pulse Oximeters	Measuring the volume of air inspired and expired by the lungs
	Spirometers	Monitor blood pressure
	Blood Pressure Monitors	
	Sleep Monitoring Devices	Sleep tracking
	Sleep trackers	Record movements to estimate sleep parameters
	Wrist Actigraphs	Record brain waves, the oxygen level in the blood, heart rate and breathing, eye and leg movements
Therapeutic Devices	Polysomnographs	
	Electrocardiographs Fetal and Obstetric Devices	Monitor internal fetal heart rate
	Neuromonitoring Devices	Record electrical activity of the brain
	Electroencephalographs	Evaluate and record the electrical activity produced by skeletal muscles.
	Pain Management Devices (TENS, EMS)	improve the life quality of severely paralyzed or suffering patients from profound losses to various sense organs
	Neurostimulation	
	Insulin/Glucose Monitoring Devices	Insulin pumps and sensors give a prediction of the patient’s blood glucose levels then help doctors to ensure optimal clinical care and decision-making for their diabetic patients.
	Insulin Pumps	
	Rehabilitation Devices	Check recovery status of the patient by
	Accelerometers	Measures
Therapeutic Devices	Sensing Devices	Check body temperature
	Ultrasound Platform	A real-time imaging modality for bedside diagnostics
	Respiratory Therapy Devices	Support breathing
	Ventilators	Use a stream of compressed air to support the airway for sleep apnea patients during sleep
	Positive Airway Pressure(PAP)	
	Portable Oxygen Concentrators	Provide oxygen therapy to patients that need higher oxygen concentrations than the levels of ambient air.
	Wearable Defibrillators	Detect a life-threatening rapid heart rhythm and automatically deliver a treatment shock to save a patient’s life
	Drug Delivery Devices	Specialized tools for the delivery of a drug or therapeutic
	Hearing Aids	Improve hearing by making sound audible

used by medical institutions for diagnosis and treatment. Future wearable devices will be smarter with AI technology in the healthcare industry and be predicted to provide the diagnosis of the early symptoms of a specialty area like cancer as well as blood pressure, blood sugar, and heartbeat. The point is the movement of data generation subjects from doctors to users/patients. Wearable devices will contribute to the reduction of a government healthcare revenue to be paid for the treatment of chronic diseases, especially older people such as prevention or treatment of dementia, and also improve the productivity of older people and the quality of their life. Since data generated by wearable devices are usually transferred to the Internet, security issues on a patient's data shall be the first issue to address.

IV. Service Enhancement for the Diffusion of a Wearable Device

Aria, the AI speaker, has become a part of life and been used in a variety of areas: First, English learning contents, "Yoons SpeakerBook," reads an English book and teaches English by interacting/communicating with a learner. Aria recommends cooking recipes, including cooking materials for a request by searching online. Second, Aria provides voice call services by looking up names and their phone numbers in contacts of the smartphone connected to Aria. Lastly, Aria recommends a piece of financial information to a user, for example, finding credit cards with the lowest interest rates, exclusive discount benefits (mileage, meal purchase, etc.), or informs of a credit card's bill amount of this month.

Therefore, AI-based technologies, including wearable devices will be an essential and strategic operation factor for businesses to survive for the future (Lee, 2018; Lee et al., 2019), meeting a consumer's needs for customized service and a rapid response from the service using a smartphone. Considering potential issues (e.g., security, privacy, breakdown, explosion,

etc.), which can be occurred by the use of wearable devices, preemptive policies, or educated human resources to need to be addressed to handle the issues in advance. We propose five approaches for service enhancement and a widespread of wearable devices in healthcare based on literature reviews and cases.

A. Accuracy of Data

A user's trust in the accuracy of data from a wearable device can facilitate a wide spread of the device, and especially the device is designed to measure the user's health or disease. Fitbit and Apple Watch were reported to mismeasure heart rate while user exercises (Thomson et al., 2019). Consumer International and the Internet Association (2019) stated: "63 percent of people found connected devices to be reliable, with 75 percent saying they don't trust the way their data is shared by these devices" based on a survey of people in the United States, Canada, Japan, Australia, France, and the United Kingdom. Therefore, a customer's trust in the data generated by a wearable device plays a critical role in spreading the device.

B. Security and Risk of Data

Data from a wearable device are a user's sensitive and critical personal information on his/her health and disease, which should be kept secure from a hacker. For example, the most common threats to data privacy and security include data theft, data loss, and IT incident hacking because data includes patient personal health records and clinical data. According to IBM's Cyber Security Intelligence Index (2015), the healthcare industry will be attacked the most by cybercriminals. Nonetheless, a safety standard on data management (e.g., collection, storage of data, etc.) for a wearable device has not been established yet. In other words, there is no institutional device or law to protect personal privacy. Therefore, a safety standard on data management and an

institutional device needs to be established to protect a real-time measured and stored health-related data.

C. Construction of Platform

A smart device or a wearable device is required to connect to a smartphone or a computer through an application (or app) developed by the manufacturer of a device. However, an app is not compatible with another app, which hinders the integration of data generated from different devices. Amazon created a platform that facilitates a customer to use Amazon's new products or services in, for example, a smart dash shelf or supermarket, in which a customer can use a smart device. Data integration from different devices in one platform can help the spread of the devices. A vast amount of data integrated into a platform can be utilized for big data analysis for users' health or disease by a government or healthcare industry to prevent or forecast people's health-related issues or budget.

D. Price of a Smart Device

The price of a smart device or a wearable device is not likely to be attractive for every person to buy. The cost of Google Glass is about \$200, and Apple Watch Series 5 or Samsung Watch is sold at around \$400. Since a wearable device or a smart device is considered as a product for specific usage, unlike a smartphone or a computer, its price cut along with a construction of a platform, can be a significant factor for the spread of a smart device.

E. Design of a Smart Device

A wearable device like Google Glass, Apple Watch, or Samsung Watch was designed similar to a traditional watch or glass people have used, but a variety of its designs is minimal when considering a classic watch or glass as a fashionable item on which people

have their preference. For example, Samsung Galaxy Buds and Apple Airpod look very similar to their prices and performances, but their sales volumes are significantly different. The design of Airpod is likely to contribute to the sales volume increase. Therefore, a focused consumer design of a device will attract a consumer, which leads to the spread of the device.

V. Discussion and Conclusions

As technologies and services of a wearable device advance. Consumers will increasingly own the device. According to the Journal of Medical Association (JAMA), about 50 billion wearable devices, and the smart device will be held by customers by 2020, which means that a customer will keep about 6.6 wearable devices. A vast amount of data has been generated by wearable devices and has a potential value creation, but the policy supporting data usage and management have not been in place. For example, a wearable device, which measures a heart rate, has not been approved as a medical device by a Korean government for personal information protection. Therefore the following needs to be considered.

First, ethical, legal review on related technology needs to be reviewed and evaluated throughout for the social use of health-related data. A wearable device records not only a user's health-related data, but it also transfers the data through an app and provides a recommendation or feedback. A platform, which integrates and manages the data transferred from wearable devices, have been created and provided services to customers. Also, a wearable device is required to generate accurate health-related data, implement security countermeasures, and integrate data efficiently.

Second, an infrastructure needs to be constructed that supports the integration of data from different apps, advances, and development of technologies related to wearable devices, secure data management, and convergence with the medical industry. About

40 percent of wearable device users currently use their devices, pairing with smartphones. However, a wearable device will be an independent device in the future without connecting to a smartphone. A smartphone will be a supportive device to a wearable device. A personal device, which can identify human emotions or feelings using artificial intelligence (AI) technology will be developed by 2022, and a wearable device measuring human sense and recording way of life-based on the analysis of human feeling data will be launched by 2021. Cloud service providers like Google, Microsoft, or IBM have provided data sharing services using AI technology.

Third, as people are increasingly considering that a wearable device has a positive effect on their health awareness, a manufacturer of devices need to emphasize more on the positive impact of the use of devices and focus on the design of device from users' perspectives.

Traditionally businesses have manufactured and sold products, focusing on factors on a value chain, not the long-term relationship with customers, and the creation of value-add services or products. A decline in the sales volume of smart devices like smartphones or tablets has been a trend but the emergence of new technologies like the Internet of Things (IoT), wearable devices, a platform, or open hardware lead the change of ICT paradigm. Recently, the fourth industrial revolution with the smart factory has been highlighted and servitization with digitization needs to be emphasized to secure a competitive advantage in the market and to develop the manufacturing industry. From the servitization perspective, we propose the follows:

First, businesses need to actively find a way to foster the willingness to use a smart device by reflecting consumers' opinions into a device at the initial stage of development. Today businesses introduce a predictive maintenance service for quality enhancement. For example, a smart refrigerator manufacturer sends a notification or recommendation to the customers who do not use its "optimal" features, which provide the best condition a refrigerator can do based on AI technology embedded. This kind of predictive main-

tenance service will enhance a customer's satisfaction and loyalty, and help a new customer creation.

Second, businesses need to identify a customer's need for products and services for the sustainable creation of value-added and enhance a business model and wearable devices from the servitization perspective. Also, businesses provide all the software and hardware features to customers and strive to improve customer relationships.

The healthcare industry needs to contemplate its position in the fourth industrial revolution, whether it would be a first mover or a fast follower. Since the quality of healthcare service in Korea is high, collaborative works of medical staff and enterprises with funds can develop a new wearable or smart device or new technology for the device, which will position the healthcare industry at a fast follower or first mover.

This study examined the applications of wearable and smart devices in healthcare through cases and suggested five approaches for service enhancement and a widespread of wearable devices in healthcare. Future research can investigate each of the five strategies we suggested. This kind of research in healthcare has been scarce as wearable technology for healthcare or wellness presumably is new. As new technologies, which can be applied to a wearable device have been developed, for example, AI, to analyze and predict a human health based on data measured by a wearable device, research on the impacts of wearable devices will be more conducted to contribute to information and communication technology (ICT) and healthcare literature.

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