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# The Development Model of a non-rechargeable wrist-type smart-band for the vulnerable group

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***Abstract***

*We live in a digital age. Smartphones are used by everyone from children to the elderly. And many smart devices are pouring out and changing our daily life a lot. However, even in the development of this digital age, there are some marginalized groups. There are also those who are reluctant to expose their information in the digital age. They have difficulty making reservations on their smartphones, using payment systems, logging into the site using various authentication and verification procedures, and entering and leaving buildings. We still carry most IDs, seals, certificates, etc. in physical form. Those who use smartphones are enjoying the convenience of the times. However, among the underprivileged, the desire to pass everything with only one device is growing. In this study, the most suitable smart band model was proposed by collecting the Delphi survey and the opinions of the general public. Future research is required to improve practical usability and utility by developing cheaper and more convenient models.*

***Keywords:*** *Digital age, Wearable Device, Biometrics, DID, NFC.*

## 1. Introduction

The digitalization of our daily lives and unmanned services is expected to accelerate due to expectations for the Fourth Industrial Revolution and the rapid development of ICT technology. According to the results of the 2017 ICT Development Index (IDI) released by the International Telecommunications Union (ITU), Korea ranks second among 176 countries in the world (ITU, 2017), and the level of informatization in our society is very high.[1] According to the 2020 Digital Information Gap Survey Report[2] , the level of digital informatization of the four major information vulnerable groups (disabled, low-income, farmers and fishermen, and the elderly) was 72.7%, up 2.8% from 69.9% in 2019. Each level refers to the level of digital informatization of the four major classes compared to the general public when the level of digital informatization of the general public is 100. Looking at the results of each sector, the level of digital information access is 93.7%, 74.8% using digital information, and 60.3% of digital information capacity and

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the level increase is in the order of utilization (6.0%p↑) and approach (2.0%p↑). It can be seen that the level of use and competency of digital informatization by the underprivileged is relatively low. Although it is a world where high-tech digital devices are pouring in, they are not using half of the functions given. And there are many inconveniences due to the lack of necessary functions. Not only the elder but also the vulnerable are experiencing it together.[3] Therefore, it is judged that the distribution of customized digital devices for the elder and the vulnerable will contribute to improving the efficiency and rationality of society.[4]

## 2. Wearable device

### 2.1. Definition of the wearable device.

It refers to all electronic devices that can perform computing by attaching them to the body and includes applications that can perform some computing functions. It refers to an electronic device that is small and light enough to be worn on the body or clothing so that the user can freely use it while moving or active, and can communicate with the user closest to the body. [5]

### 2.2. Type of wearable device

Wearable devices can be divided into four types and have their functions according to their shape and purpose. It can be classified into accessory types such as portable types of products and accessories, clothing integration types, body attachment types that can be attached to the body, and biometric transplantation types that can be transplanted or taken directly into the body.[6]

**Table 1. Type of Wearable devices**

| Type | Accessory | Smart clothing | Body attachment | Biometric transplants |
|---|---|---|---|---|
| Description | Accessories such as watches , glasses, necklaces, etc. | Form integrated into f abric or clothing. | A form that can be att ached to the body. | A form that can be transp lanted into a living body. |
| Products | Smart glasses. Smartwatch. | Fabric sensor, Smartware. | Skin patch sensors and devices. | Implantable sensors and devices. |

### 2.3. Utility of wearable devices

ICT technology is used in various areas, wearable devices are used for fitness, healthcare, medical care, infotainment, and industrial and military purposes. As interest in wearable devices increases rapidly and income levels rise, more and more users enjoy leisure life, wearable products are being released that can increase the effectiveness of exercise by identifying their needs. Figure 1 shows the wearable technology and device development process. [7]

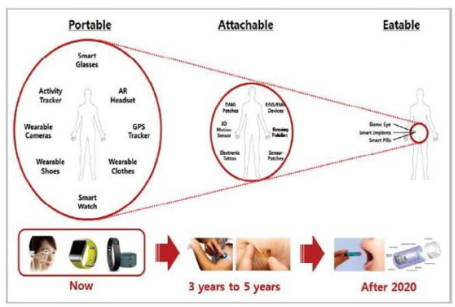


**Figure1. The development process of wearable technology and devices (source: wearable device industry white paper 2014)**

### 2.4. Trends in developing wearable devices.

Wearable devices are developing from one function to products of various functions, and are developing from multifunctional products to products of specialized functions, and in terms of future operation, dependence on smartphones is expected to decrease and connectivity with other devices and communication networks will be improved. Wearable devices are developing in various forms, and most of the products were initially worn on the wrist, but recently, the development of earwear and smart clothing worn on the ears is also active. It is developing by focusing on functions specialized in each wearing method, such as collecting information related to body and exercise or providing real-time language interpretation (earwear).

## 3. Related technology

### 3.1. Biometrics.

Biometrics is the measurement and statistical analysis of people's unique physical and behavioral characteristics. The technology is mainly used for identification and access control or for identifying individuals who are under surveillance.[8]

#### 3.1.1. Fingerprint recognition.

Fingerprint recognition is a technology that authenticates yourself with a fingerprint using the characteristics of a fingerprint and compares the registered data with the input fingerprint to determine whether it matches.

#### 3.1.2. Iris recognition.

Iris recognition is a biometric technology using the iris, one of the human biological organs. The iris varies from person to person, and even if it is the same person, the iris of the left eye and the right eye may differ. In addition, it is unlikely that it will be stolen because the nerves will break and change into a different shape when the eyeball is extracted.[9]

#### 3.1.3. Vein recognition.

Vein recognition technology uses the characteristic that infrared rays projected from LED lights pass through muscles or bone tissues, while red blood cells absorb infrared rays in blood vessels and fail to pass, resulting in dark blood vessels being photographed by cameras. The photographed finger veins extract and pattern features to determine whether they match the existing input finger veins and inquire about their identity.

### 3.2. DID.

Participants of DID service are divided into owner, issuer, and verifier as shown in Figure 2. Decentralized Identifier (DID) or distributed ID is a technology that, unlike conventional identification methods, is not controlled by the central system and allows individuals to have full control of their information. DID, which is set in the background of blockchain technology, has been established and designed under the leadership of the Decentralized Identity Foundation (DIF), and the Decentralized Identifiers Standards are being established through W3C. [10]

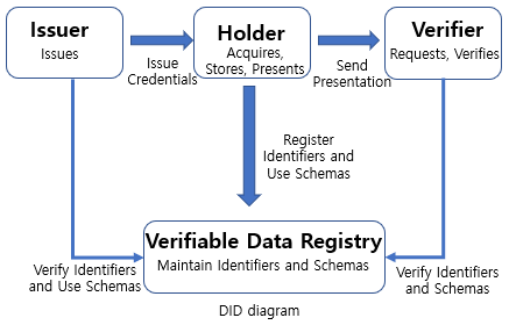


**Figure 2. Concept diagram of DID-based identity authentication**

### 3.3. NFC.

Near-field communication (NFC) is a set of communication protocols for communication between two electronic devices over a distance of 10 cm (1⅟2 in) or less. NFC offers a low-speed connection with a simple setup that can be used to bootstrap more-capable wireless connections.[11]

## 4. Development model proposal

**Table 2. Classification of Smart band**

| No | Property | Contents | Y/N |
|---|---|---|---|
| 1 | Information | SMS, Alarm, SNS etc | Y/N |
| 2 | GPS, Call | GPS, Compass, Phone call | Y/N |
| 3 | Life tracker | Weather, Gallery, Calendar | Y/N |
| 4 | Fitness tracker | Pedometer | Y/N |
| 5 | Healthcare tracker | Heart rate, Blood pressure, Oxygen saturation | Y/N |
| 6 | Smart home control(IOT) | Light, TV, A/C on/off | Y/N |
| 7 | D-wallet | ID, Passport, Certificate | Y/N |
| 8 | Payment | Credit, Debit, | Y/N |
| 9 | Digital Key | Car, House, Office | Y/N |
| 10 | Medical Info | Blood type, Allergy, Genetic disease | Y/N |
| 11 | Biometrics | Fingerprint | Y/N |
| 12 | Charge | Self-genration, Manual power supply | Y/N |
| 11 | Price(₩10,000) | Sale price | 3~100 |

### 4.1. Model A Proposal: High Function Smartwatch Type.

The model proposed by Plan A has almost the same level of function and shape as the high-end smartwatch type. Representative products are Samsung's Galaxy Watch and Apple Watch. It is a model that includes all functions up to ministry 1 to 12 among the attributes of smart bands. The price can be expected to be higher than the current famous Samsung smartwatch or Apple watch.

### 4.2. Model B Proposal: Wrist-type smart band for Healthcare-Centered.

As a representative smart band, there is Fitbit, a famous American smart band product. The difference from smartwatches is that they are mainly equipped with functions centered on healthcare trackers and are relatively inexpensive. And the exterior is also simpler in band form. It can be easily transmitted because it manages the user's health by wearing a band on the wrist. In particular, band products can be used independently of smartphones.

### 4.3. Model C Proposal: Wrist-type smart band for self-charging.

#### 4.3.1. Overview

It is self-charging. The band is equipped with a digital electronic wallet, digital key, and fingerprint recognition type credit card function. You can verify your identity, enter cars and buildings, and pay.[12]

#### 4.3.2. Draft Schematic

The draft schematic of the development model is shown in Figure 3. It is noteworthy that there is no need to charge separately because its own generator is installed inside.

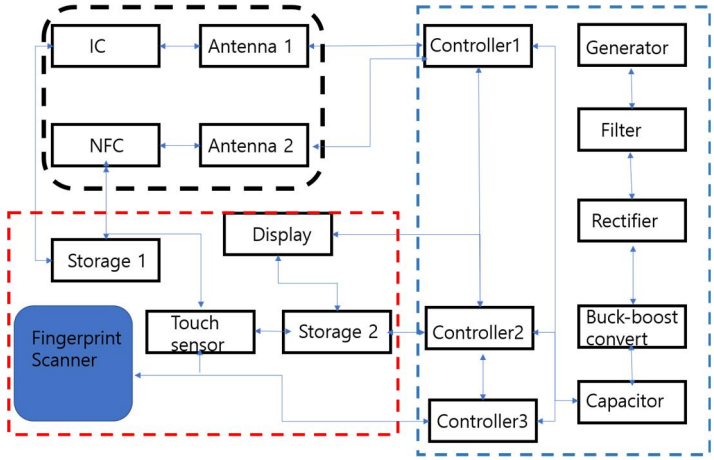


**Figure 3. Draft Schematic of Model C.**

#### 4.3.3. Prototype design

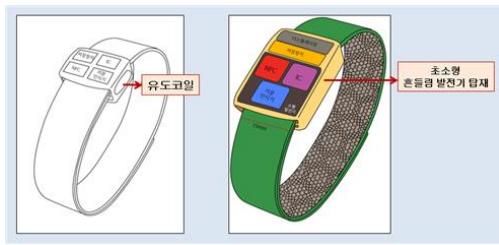


**Figure 4. Prototype design of Model C.**

Figure 4 shows the expected image that can be implemented based on the draft schematic.

#### 4.3.4. Features

##### 4.3.4.1. D-wallet

In this study, digital wallets are called D-wallets. D-Wallet refers to a digital wallet mounted on a smart band. D-Wallet includes ID card, driver's license, certificate, etc. Fingerprint recognition can be used when personal identification and electronic signature are required. [13]

As COVID-19 spreads, it can be used as a substitute for QR codes or call authentications when entering and exiting restaurants and department stores. The information loaded in the D-Wallet is recorded in the blockchain,

so it is not easy to forge or falsify. And the highest level of security technology is applied as it is mandatory to go through personal authentication. Users will be able to prove themselves and their credentials safely without fear of theft, loss, or damage.[14]

#### 4.3.4.2. Digital key

Digital keys are still being used as cards or mobile phones. Physical keys may be inaccessible to vulnerable groups, and risks such as theft or loss exist. In particular, it can be used very conveniently in automobiles, offices, houses, and warehouses, especially for those whose hands and feet are disabled.

As mentioned above, a wallet containing ID cards or credit cards is referred to as a D-wallet, and there is no need for a physical wallet, so it is free from the hassle of carrying it or the risk of loss.

Even the digital key is included in the band's function, making it convenient to use the band even in situations where it is difficult to carry the car key, risk of loss, and use of both hands.

## 5. Model verification.

### 5.1. Delphi survey.

The Delphi method is a method of increasing reliability through the process of searching for expert opinions to find matters necessary for decision-making through opinion surveys, inducing judgment from various people, and comprehensive judgment. In this study, in order to develop a non-charging wearable device model for the vulnerable, the panel was composed of 139 people to collect opinions from experts such as academia, industry, and professional users.[15]

- Survey period: September to December 2021.
- Survey method: Online survey and phone call
- Subject to the survey: Academic experts, Product developers, Marketer, Professional User, Ordinary person (226 people)

### 5.2. Panel composition and response.

**Table 3. Delphi survey target number**

| Division | The first round (Expert) | Secondary round (Expert) | The 3rd round (Expert, Ordinary person) |
|---|---|---|---|
| Academic expert (Master's Award on IT Convergence) | 3 | 22 | 22 |
| Product developer (IT product development field) | 3 | 14 | 14 |
| Marketer, professional user (IT product seller, early adopter) | 4 | 41 | 29 |
| Ordinary person (Not an expert, but a general user) | | | 74 |
| Total | 10 | 77 | 139 |

### 5.2.1. The results of the panel survey.

**Table 4. Demographic analysis of the 3rd survey**

| | Content | Frequency(N:139) |
|---|---|---|
| Group | Academia. | 22(15.8%) |
| | Product developer | 14(10.1%) |
| | Professional users such as marketers. | 10(7.2%) |
| | Ordinary person | 73(52.5%) |
| | Etc | 20(14.4%) |
| Gender | Man | 91(65.5%) |
| | Woman | 48(34.5%) |
| Age group | 20s | 15.(10.8%) |
| | 30s | 16(11.5%) |
| | 40s | 52(37.4%) |
| | 50s | 37(26.6%) |
| | more than 60s | 19(13.7%) |
| an academic career | high school graduation | 9(6.5%) |
| | University graduation (in school) | 78(56.1%) |
| | Master's and Doctoral Completion and Graduation | 50(36.6%) |
| | Etc | 2(1.4%) |
| Career | ~ within 5 years | 39(28.1%) |
| | ~within 10 years | 18(12.9%) |
| | ~within 20 years | 30(21.6%) |
| | over 20 years | 52(37.4%) |

The demographic analysis of the tertiary survey personnel is shown in Table 4. The proportion of 46 experts (33%.1%) and 93 (66.9%) for general users were surveyed. In terms of gender, 91 males (65.5%) and 48 females (34.5%), followed by 40s (37.4%) and 50s (26.6%). In terms of educational background, 78 graduates (56.1%) and 50 students (36.6%) above Master's. In terms of experience, 30 people (21.6%) were found between 10 and 20 years, and 52 (37.4%) were found to have more than 20 years.

### 5.2.2. Delphi course.

In this study, a questionnaire configured through the Delphi analysis method was used as a survey tool to

present a wearable device model for the vulnerable. The Delphi technique can be defined as a series of procedures that collectively judge and organize the opinions of experts.

### 5.3. First Delphi.

The first questionnaire was composed of an open questionnaire so that the study subjects could freely describe their opinions. In the first survey, unstructured surveys are mainly used because divergent perceptions can be considered through open surveys as a stage of collecting opinions from expert groups [16]

#### 5.3.1. Delphi 2nd survey.

In the Delphi 2nd survey, the opinions collected in the 1st survey were categorized for each factor after discussion by an expert group. The 2nd Delphi questionnaire is shown in Table 5. In consultation with several experts, a restructured closed questionnaire was created.

**Table 5. 2nd Delphi Survey Category**

| Survey item. | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| 1. Design and form, etc. | | | | | |
| 2. Financial sector | | | | | |
| 3. Security field | | | | | |
| 4. Public Administration and Welfare | | | | | |
| 5. Medical field | | | | | |
| 6. etc | | | | | |

#### 5.3.2. Delphi 3rd questionnaire.

The Delphi 3rd questionnaire was produced to investigate the level perceived by the general public through an expert meeting based on the categorization of the contents of the survey by the first and second expert groups. The 3rd Delphi questionnaire was unique in that 13 questions were surveyed, and experts and the general public were compared.

### 5.4. Research results.

#### 5.4.1. Results of the first survey

Table 6 shows the results of collecting expert opinions in the first survey. It was divided into a total of six categories, and each category can be further divided into four characteristics. Its core functions are digital wallets and digital keys, and functions such as payment and emergency medical information derived through two functions are mainly collected.

**Table 6. Analysis of the results of the first Delphi**

| Opinion category | Details. |
|---|---|
| 1. Design, shape, etc. (Wristband type) | Wearing type, proper weight, non-liquid crystal type |
| 2. The financial sector (digital wallet) | User authentication, security authentication, credit, transportation, check card, remittance |
| 3. Security field (digital key, digital wallet) | Physical space access, system access authentication, and identity authentication |
| 4. Administrative and welfare (digital wallet) | Mobile ID card, identity verification method |
| 5. Medical field. | Emergency medical information, emergency contact information |
| 6. etc | NFC, non-charging, memory, self-reliance |

### 5.4.2 Results of the 2nd survey

In the second survey, a total of 6 categories from form and design to the medical field were divided in detail, and 18 sub-questions were created for sub-elements to investigate the validity of experts. Analyzing the survey items, the overall average was 4 and the standard deviation was 0.6. In the wearable category, the average deviation was 3.97 and the standard deviation was 0.7, and the wrist-wearing average was 4.26. In the financial sector, the average was 3.75, the standard deviation was 0.9, and the average of remittance items was low. The security field showed an average of 3.94 and a standard deviation of 0.96. In the administrative field, the average was 4.0, the standard deviation was 0.96, and the items for certification were high. The emergency medical field showed an average of 4.54 standard deviation of 0.68, higher than other categories. The average of communication and charging fields was 4, and the standard deviation was 0.7.

Content Validity Ratio (CVR) is a value that shows consensus opinions on the importance of each item, and the frequency of panels responding to 'Strongly Agree' (5 points) and 'Agree' (4 points) on a 5-point scale was calculated as follows. [17]

$$CVR = \frac{Ne - \left(\frac{N}{2}\right)}{\frac{N}{2}}$$

(Ne: 'Strongly Agree' (5 points), 'Agree' (4 points) Number of panels answered, N: Total number of panels)

The CVR range of the survey items was -0.19 to 0.84, and the remittance items were -0.19, the financial sector (user authentication) 0.06, and the identity verification 0.27 were somewhat less valid than the standard. Remittance items need to be deleted from the function, and user authentication and identity verification are necessary items for payment and issuance of various certificates. Table 7 shows the average, standard deviation, variance, and content validity of the Delphi secondary survey.

**Table 7. Statistics of the 2nd survey results.**

| | N | M | SD | VA | CVR |
|---|---|---|---|---|---|
| 1-1. Wrist wear type | 77 | 4.26 | 0.834 | 0.695 | 0.61 |
| 1-2. Weight: 25 to 30g | 77 | 4.08 | 0.855 | 0.731 | 0.71 |

| | | | | | |
|---|---|---|---|---|---|
| 1-3. Non-liquid crystal type | 77 | 3.56 | 1.230 | 1.513 | 0.09 |
| Wearable type | 77 | 3.97 | 0.700 | 0.490 | |
| 2-1. Credit, check, transportation card. | 77 | 4.26 | 0.909 | 0.826 | 0.66 |
| 2-2. Remittance, transfer. | 77 | 3.19 | 1.308 | 1.712 | -0.19 |
| 2-3. Financial field (user authentication) | 77 | 3.64 | 1.347 | 1.813 | 0.06 |
| 2-4. The financial sector (self-certification: fingerprint authentication) | 77 | 3.90 | 1.242 | 1.542 | 0.30 |
| Financial field | 77 | 3.75 | 0.909 | 0.826 | |
| 3-1. Physical space access control (in and out of the building) | 77 | 3.96 | 1.094 | 1.196 | 0.35 |
| 3-2. System access authentication. | 77 | 3.96 | 1.069 | 1.143 | 0.32 |
| 3-3. Identification: Community center, etc. | 77 | 3.91 | 1.149 | 1.321 | 0.27 |
| Security field. | 77 | 3.94 | 0.965 | 0.931 | |
| 4-1. Certificate: Certificate of disability registration, etc. | 77 | 4.18 | 1.010 | 1.019 | 0.53 |
| 4-2. Mobile ID card. | 77 | 4.00 | 1.112 | 1.237 | 0.43 |
| Administrative field. | 77 | 4.09 | 0.965 | 0.472 | |
| 5-1. Emergency medical information. | 77 | 4.44 | 0.752 | 0.566 | 0.74 |
| 5-2. Emergency contact number. | 77 | 4.64 | 0.742 | 0.550 | 0.84 |
| Emergency medical field. | 77 | 4.54 | 0.687 | 0.472 | |
| 6-1. Short range wireless communication: NFC | 77 | 4.01 | 1.070 | 1.145 | 0.40 |
| 6-2. Non-rechargeable: Self-power generation | 77 | 4.08 | 1.073 | 1.152 | 0.45 |
| 6-3. Internal and external memory. | 77 | 3.95 | 1.075 | 1.155 | 0.38 |
| 6-4. Standalone. | 77 | 3.96 | 0.880 | 0.775 | 0.30 |
| Network, Charging | 77 | 4.00 | 0.781 | 0.610 | |
| Total | 77 | 4.00 | 0.60 | 0.36 | |

### 5.4.3. Results of the 3rd survey

The main purpose of the third survey was to break away from the survey centered on the expert panel of Delphi techniques and data analysis, mainly comparing the difference in perception between the expert panel and the general public panel, and the results showed significant results. Most of the errors in opinions on the main items of expert panels and general public panels were within the 5% range, as shown in Table 8. As for the power type, it was found that the expert panel had a 10% higher opinion that non-charging was needed than the general public. As a separate item from the second survey, when asked about purchasing, the function of the general public panel appeared as a priority to consider purchasing. Expert panels tend to prioritize functions. The function for mobile ID cards is part of the digital wallet, and it was found that the general public panel feels more necessary than the expert panel.

**Table 8. Comparison of perceptions of expert panel and general public panel**

| Division | Category | A group of experts | A group of ordinary people | Difference |
|---|---|---|---|---|
| Wearable type | Wrist shape | 78.30% | 81.70% | 3.40% |
| Type of power | Non-rechargeable | 56.50% | 46.20% | -10.30% |
| | Rechargeable | 41.40% | 45.38% | 3.98% |
| Purchase number one | Function | 56.50% | 65.60% | 9.10% |
| | Price | 23.90% | 22.60% | -1.30% |
| Security function | Fingerprint authentication | 65.20% | 69.90% | 4.70% |
| | Password | 17.40% | 21.50% | 4.10% |
| Certificate function | necessary | 54.30% | 53.80% | -0.50% |
| Digital key | necessary | 45.70% | 49.50% | 3.80% |
| Mobile ID card | necessary | 37% | 55.90% | 18.90% |
| Credit card, etc | necessary | 71.70% | 66.70% | -5.00% |
| Emergency medical information | necessary | 73.90% | 74.20% | 0.30% |
| Emergency contact number. | necessary | 67.40% | 68.70% | 1.30% |
| Purchase price range | 50000 to 10000 won. | 37.00% | 36.60% | -0.40% |
| | ~200 thousand won | 28.30% | 37.60% | 9.30% |

## 6. Conclusion

The Fourth Industrial Revolution is contributing greatly to digitizing our lives. In order for the vulnerable to fully enjoy the benefits of change in the digital environment, a new approach of ideas is needed from the existing idea. If the digital environment of the elderly and the disabled is improved in the digital environment based on the general public, the overall standard of life is expected to be very high.

The core device of the digital environment is a smartphone. However, there are many obstacles for the vulnerable to conveniently and efficiently use smartphones. A device capable of overcoming obstacles is a wearable device. Although there are many types of wearable devices, it has been confirmed that the smartwatch type in the form of an accessory is the most common. The next generation of wearable devices expects smart clothing, skin transplantation, and body insertion. Many studies are being actively conducted, so we expect to be able to use them someday. One of the most important technologies in using digital devices is the security field. One of them will be a means of security using biometric recognition. In addition, it is expected that means such as DID technology and NFC will be widely used.

In this study, three models for wrist-type smart bands among wearable devices were presented. Model A includes basic information functions to biometric authentication in models similar to existing high-end smartwatches. Model B is a mid-priced model for the existing healthcare-oriented band-type models are existing healthcare-oriented models. Model C is a non-rechargeable model that, unlike existing models, includes functions such as digital wallets, digital keys, payment payments, and fingerprint authentication, excluding functions such as healthcare. In particular, the non-charging type can eliminate the inconvenience and hassle of charging.

Although this study focused on device development, it emphasizes that a lot of social consensus and policy support are needed for the vulnerable to effectively use these devices.

## References


[1] International Telecommunications Union (ITU), 2017 ICT Development Index [Source] Korean policy briefing (www.Korea.kr)

[2] 2020 Digital Information Gap Survey https://www.iitp.kr/kr/1/knowledge/statisticsView.it?masterCode=publication&searClassCode=K_STAT_01&identifier=02-008-210311-000002

[3] Hak-Sil Kim, Jun Seop Kim, "Digital Literacy of Elderly People and Social Activities.", The Journal of KJPAE, Vol.30, No.2, pp. 153-180. 2020. DOI: 10.23036/kapae.2020.30.2.006

[4] Weol Seok Kang, Myung Suk Kim, Jea-Ug Ko "Effects of the Smartphone Information Use and Performance on Life Satisfaction among the Elderly.", Journal of the Korean Gerontological Society, Vol.33, No.1, pp. 199-214. 2013. DOI:https://doi.org/10.5762/KAIS.2018.19.11.264

[5] 'What is wearable device' EST security https://www.estsecurity.com/public/security-info/column/view/1114

[6] Chang Gyu Lee, "A Study on the Proposal of Smart System Model for the Elderly and the Disabled, 2013.

[7] Jae Joong Im, Ming Kui Li, Chan Song Hwang, "Wrist Wearable Device for the Measurement and Analysis of Physiological Signals", The Journal of The Institute of Internet, Broadcasting and Communication Vol.12 No.6, pp.65~73 Dec 2012. http://dx.doi.org/10.7236/JIWIT.2012.12.6.65

[8] Definition of Biometrics https://www.techtarget.com/searchsecurity/definition/biometrics

[9] Yong-Gyu Jung, Jeong-Seok Kang, "Hospital Security System using Biometric Technology " , The Journal of The Institute of Internet, Broadcasting and Communication Vol.11 No.2, pp.219~224 Feb 2011.

[10] Definition of DID in Wikipedia. https://en.wikipedia.org/wiki/Decentralized_identifier#DIDs

[11] Definition of NFC in Wikipedia https://en.wikipedia.org/wiki/Near-field_communication

[12] Ryu Dae Hyun, Seung-Jung Shin, Byoung-Wha Kim, "Implementation of Fingerprint Identification System in Wireless Environments.", The Institute of Electronics and Information Engineers (IE), Vol.42, No.1, pp. 53-60. Mar 2005. UCI: G704-F00451.2005.42.1.003

[13] Choon-Sung Nam, Min-Kyung Jeon, Dong-Ryeol Shin, "The secured mobile wallet system using by integrated ID.", JICS, Vol.16, No.1, pp. 9-20. 2015. DOI: 10.7472/jksii.2015.16.1.09

[14] Seung-Jung Shin, "Development of Life Management System for Elderly and People with Disabilities.", The Journal of The Institute of Internet, Broadcasting and Communication (JIBC), Vol.14, No.1, pp. 275-279. Feb 2014. DOI: http://dx.doi.org/10.7236/JIIBC.2014.14.1.275

[15] Jong-Bae Ahn, "A Study on Construction of On & Off Marketplace for global distribution of broadcasting contents", The Journal of The Institute of Internet, Broadcasting and Communication Vol. 15, No. 1, pp.85-93, Feb 2015. http://dx.doi.org/10.7236/JIIBC.2015.15.1.85

[16] Jihyeon Jeon, & Yoonmi Choi, "Three-round Delphi Study on Content Development for Business English Test" English teaching, Vol.57, No. 2, pp.451-479. UCI : G704-000189.2002.57.2.002

[17] Wonkyung Noh, Nayoung Cho and Hye-won Lee, "A Study on Tutoring Evaluation Program with Delphi Survey" Institute for Humanities and Social Sciences 14, no.2 (2013): 313-348.doi: 10.15818/ihss.2013.14.2.313