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Factors Underlying the Digital Divide for Disabled People: Focus on a Korean Case Study

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***Abstract*—**This study identifies factors underlying the digital divide that is faced by the disabled. The results of its analysis showed that the digital divide in PC use is affected by age, number of years of education, employment status, and household income of more than KRW 3 million. The digital divide in smart device use is affected by sex, age, number of years of education, time when disability struck, and household income of more than KRW 3 million. Based on these results, this study proposes methods for bridging the digital divide faced by the disabled.

***Keywords*—**Digital divide, digital divide for the disabled, information accessibility for pcs and smart devices.

I. Introduction

KOREA'S transformation into an information-oriented society has been unmatched in speed and paralleled by very few countries. Korea has quickly become a society in which information drives economic and social change. In such an information-oriented society, the use of information and communication technologies (ICTs) is highly important, as it allows people to obtain the skills that they require in their daily lives and economic activities, and to enjoy their social and cultural lives. However, there are individual differences in how people utilize ICTs to approach the information that they require, and how they obtain that information to use for their purposes. More specifically, the disabled are relatively less able to use ICTs to gain the information that they require than the non-disabled, which leads to the problem known as the digital divide. In the case of smartphones and other similar devices, such difficulties can be particularly immense. When disabled individuals lack the ability to utilize smart devices, it results in an inequality of information that may lead to unequal opportunities and difficulties forming social networks. This can potentially limit the lives of the disabled.

With the above in mind, this study has observed factors that affect the digital divide for the disabled. It identifies which factors impact the approachability of PCs and smart devices, and considers these factors from a policy perspective.

II. Theoretical Discussion

A. Definition of the Digital Divide

OECD defines the digital divide as "the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities" [1]. Moreover, NTIA in the United States defines the digital divide as the divide between people who are able to approach new technologies and those who are unable to do so [2]. Therefore, the digital divide separates people, who have access to ICTs and those who do not, as well as users and non-users of information. Recently, terms such as "digital opportunity" and "digital inclusion" have also come into use, as the United States and Europe expand their definitions of the digital divide.

B. Existing Research on the Digital Divide

Monlar has identified the types of digital divide by focusing on the mechanism that causes the digital divide to move through the phases of early adaptation, take-off, and saturation [3]. First, the stage of early adaptation is defined by differences in access, between people who are able to access ICTs and those who are unable to. This stage, in which the access divide first appears, is caused by factors such as income, living arrangements, education, and age. Second is the take-off stage, when information services become more accessible and widely-used, due to the supply and spread of information communication devices, the build-out of information communications networks, and the spread of PCs and the Internet. In this stage, the access divide, which has been present since the early adaptation stage, is partially resolved through efforts to boost information accessibility. However, a division called the usage divide then emerges, caused by the simple usage differences between information users and non-users. The third is the saturation stage, which does not signal differences in the approachability or usage of information services, but is a stage in which a divide exists between users with regard to what information is acquired for which purposes, how much information is acquired, and how the information is utilized to drive results, in terms of impact. Unlike in the early adaption and take-off stages, a divide does not exist between users and non-users of information, but within the group of users, and is thought to arise from differences in individual levels of recognition and accommodation.

Selwyn has broken down the digital divide through a multi-layered relational approach, beginning with access to information and moving through information use, engagement with information devices or content, resulting outcomes, and consequences [4]. He argues that the digital divide occurs and intensifies through various forms, ranging from access to consequences, in a staged or complex fashion. Meanwhile, Haywood (1998) has criticized the concept of the trickle-down

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effect, which views ICTs as being used by a few people in the early stages of their distribution, but over time spreading to the entire society. Haywood points out that inequality in access to information tends to persist, and can even intensify the separation between rich and poor that is caused by the digital divide [5]. Moreover, Mun-Jo Kim and Jong-Kil Kim assert that the digital divide occurs because of decisions concerning whether or not to accommodate information, the extent to which to do so, and the value gained by utilizing information [6].

C. The Digital Divide of the Disabled

Since 1983, the United Nations has pressed to guarantee information access to the disabled in many countries. As a result, from the policy and engineering perspectives, attention has turned to problems that ensue when users with physical or mental disabilities use information-communication products and services. Within this context, Korea has consistently researched policies for improving and maintaining information access for the disabled, through government agencies [7], [8].

A number of studies have focused on the digital divide facing the disabled. Ju-Eun Jo has compared and analyzed the reasons behind different levels of information access among the disabled and the non-disabled in Korea and the United States [9]. Jo's study concludes that the disabled in both Korea and the United States have very low information access levels compared to the non-disabled, and that socioeconomic factors have heavily influenced this divide. Katz and Aspden have focused on low levels of economic power as the primary reason for the digital divide experienced by the disabled [10]. To approach information, special equipment such as additional hardware, software, and other supporting devices are required, beyond the purchase of a PC, and the ability to make regular payments for internet access is also required. Moreover, valuable information tends to be commercialized, and therefore additional expenditures are required, in addition to the purchase of a PC. Therefore, as the disabled have fewer opportunities for economic activity and thus tend to have lower income levels than the non-disabled; further limitations are created with regard to information access. Moss asserts that the digital divide occur based on differences between individual abilities to utilize information [11]. As the majority of information found on the Internet is presented in English, as are the methodologies for utilizing a PC or the Internet, a certain level of foreign language skill is required. Since the education levels of the disabled are often low and digital education is institutionalized, this could also be a limiting factor for disabled individuals who are limited in their physical movement abilities.

The digital divide faced by the disabled is caused by differences in the individual characteristics and backgrounds of users, including features such as sex [12], [13], social status or job title, level of education received, age, geographic/ environmental condition [14], [15], and type of disability.

Seung-Ho Baek has determined that statistically meaningful influences on information inequality exist, as measured by divides in digital access and information utilization, according to sex, age, region of residence, income, and job factors [16]. Moreover, Jun-Woo Lee and Yun-Shin Kim have analyzed the impact of jobs and income levels, as socioeconomic characteristics, for those with hearing disabilities, and how they affect levels of information access. They have found that the higher a person's income level is, the higher their level of information access [17].

Physical and mental disabilities are some of the main factors that limit the access to and usability of information by the disabled. In order to utilize a keyboard and mouse, users must be able to see and move their hands nimbly, and users require sight in order to understand the outputs on a screen. Alternative input and output devices and methods have been developed for approaching information with devices other than a keyboard or a mouse, and for receiving information with skills other than sight (voice recognition and output, Braille printers). However, many of these alternatives have been made for the non-disabled, and therefore inherently limit access by disabled individuals who have difficulty using their hands and eyesight [18].

III. Methodology

A. Subjects

This study utilizes data from the "Current State Investigation of the Digital Divide of the Disabled – 2013" by the National Information Society Agency (NISA). The purpose of this investigation is to provide underlying information for determining policy direction and evaluating how to resolve the digital divide affecting the disabled, by determining the levels of information orientation among the disabled and the current state of the digital divide. This target of this investigation was registered disabled persons across the 17 provinces and diverse metropolitan areas of Korea, aged between 7 and 69, and the study employs an effective sample size of 2,700. It analyzes 1,862 respondents with regard to the information accessibility of PCs and 981 respondents concerning the information accessibility of smart devices.

B. Dependent Variable

The dependent variable of this study was defined through questions that measured levels of information accessibility, with 14 questions relating to PCs and 14 questions relating to smart devices. The questions are structured similarly to the following example: "To what extent are you able to carry out, without help, the following activities with your computer (desktop and laptop) and smart device (smartphone and tablet)?" Each question could be answered on a 4-point Likert scale, with 1 indicating "no activity" and 4 indicating "engage in the said activity often." The reliability of the questions relating to PCs, based on the use of Cronbach's Alpha, were 0.937. The smartphone questions had a Cronbach's Alpha of 0.941, indicating similarly high reliability.

C. Independent Variables

1) Socio-Demographic Factors

The sociodemographic factors in this study include sex, age, and number of years of education. Sex was coded first, with males having a value of 0 and females having a value of 1. Secondly, the respondents' ages were coded and changed to natural log values through normality tests. Thirdly, numbers of years of education were changed to root values, through normality tests of the number of years of the education variable, which is a continuous variable derived from the final education institution variable.

2) Disability Factors

The disability factors considered in this study include the type of disability and the period in which the disability occurred. Firstly, external bodily disability was coded as 0, while sensory disability, mental disability, and internal bodily disability were coded as 1. Secondly, for the period of disability occurrence, if the disability occurred before or at birth, this was coded as 0, while if it occurred after birth, it was coded as 1.

3) Economic Factors

The economic factors addressed in this study include employment status and household income. First, unemployment was coded as 0, while employment was coded as 1. Secondly, household income was split into four dummy variables: "below KRW 1 million," "from KRW 1 million to 2 million," "from KRW 2 million to 3 million," and "more than KRW 3 million." If the dummy variables did not apply, that was coded as 0, while if they did apply, it was coded as 1.

4) Control Variables

The control variables include the disabled person's status in the household and region of residence. If the respondent was not the head of the household that was coded as 0 while if he or she was the head of the household, it was coded as 1. Secondly, rural areas were coded as 0 and urban areas were coded as 1.

D. Data Analysis

To identify the influential factors affecting information accessibility for the disabled in using PCs and smart devices (i.e., the occurrence of the digital divide), a multiple regression analysis was performed. First, to test the normality of the dependent and independent variables, some variables were modified, with skewness and kurtosis considered. Secondly, in order to determine the presence of multicollinearity between independent variables, the variance inflation factor (VIF) was checked, and it was determined that it was not problematic. Secondly, an analysis of the relationships between independent variables showed that the high interrelatedness of independent variables was not of concern. Moreover, the presence of heteroscedasticity was checked for, and there were no instances in which heteroscedasticity were present.

IV. RESULTS

A. Results for Descriptive Statistics

The results regarding the descriptive statistics of this study are as follows (see Table I).

TABLE I
DESCRIPTIVE STATISTICS

		PC (N=1,862)	Smart device (N=981)
Sex	Male	1,281(68.8%)	731(74.5%)
	Female	581(31.2%)	250(25.5%)
Age	Average (Standard error)	49.0%(12.108)	46.2(11.327)
Number of years educated	Average (Standard error)	10.6(2.875)	11.7(2.385)
Disability type	Crippled	1,303(70%)	743(75.7%)
	Brain disorder	179(9.6%)	53(5.4%)
	Visual disability	201(10.8%)	98(10.0%)
	Auditory disability	157(8.4%)	78(8.0%)
	Lingual disability	22(1.2%)	9(0.9%)
Period of disability occurrence	At or before birth	458(24.6%)	203(20.7%)
	After birth	1,404(75.4%)	778(79.3%)
Employment status	Unemployed	847(45.5%)	398(39.6%)
	Employed	1,015(54.5%)	593(60.4%)
Household income	Below KRW 1M	467(25.1%)	176(17.9%)
	KRW 1M-2M	774(41.6%)	387(39.4%)
	KRW 2M-3M	416(22.3%)	265(27.0%)
	Over KRW 3M	205(11.0%)	153(15.6%)
Status in household	Not head of household	753(40.4%)	390(39.8%)
	Head of household	1,109(59.6%)	591(60.2%)
Region of residence	Rural	275(14.8%)	134(13.7%)
	Urban	1,587(85.2%)	847(86.3%

Firstly, with regard to the sociodemographic aspect, there were more males in both the PC and smart device groups. The average age was higher for the PC group (M=49.0, SD=12.108) than for the smart device group (M=46.21, SD=11.327). Moreover, the number of years of education was also higher for the smart device group than the PC group.

Secondly, with regard to disability factors perspective, the dominant type of disability for both of the PC and smart device groups was physical (PC group 70%, smart device group 75.7%), while language disability was the least common (PC group 1.2%, smart device group 0.9%).

Thirdly, concerning economic factors, more respondents were employed in both groups (PC group 54.5%, smart device group 60.4%) than unemployed (PC group 45.5%, smart device group 39.6%). Household incomes were primarily between KRW 1 million and 2 million for both the PC and smart device group (PC group 41.6%, smart device group 39.4%) and the least common household income level was over KRW 3 million (PC group 11.0%, smart devices group 15.6%).

Fourthly, in terms of the controlled variable, the most common household status of respondents was head of household (PC group 59.6%, smart device group 60.2%). The region of residence was primarily urban for both the PC and smart device groups (PC group 85.2%, smart device group 86.3%).

B. Results of Analysis of the Digital Divide for PC Users

A multiple regression analysis was performed in order to analyze the factors that influence the digital divide regarding disabled users of PCs (see Table II).

TABLE II
RESULTS OF THE DIGITAL DIVIDE OF PCS

		B	t
Sociodemographic factor	Sex	-0.032	-1.169
	Age	-0.197	-8.254***
	Numbers of years educated	0.247	10.075***
Disability factor	Disability type	0.008	0.367
	Period of disability occurrence	-0.079	-0.822
Economic factor	Employment status	0.064	2.742***
	Household income below KRW 1M	-0.001	-0.011
	Household income KRW 1M to 2M	0.052	0.718
	Household income KRW 2M to 3M	0.096	1.539
	Household income over KRW 3M	0.177	3.611***
Control variable	Status in household	0.044	1.576
	Region of residence	-0.003	-0.148
	N=1,862		
	R^2=0.447		
	F=38.437***		

* ρ<0.1, **ρ<0.05, ***ρ<0.01

The factors that were most statistically significant, in terms of influencing the digital divide, were sociodemographic and economic. Among the sociodemographic factors, age had a negative (-) impact at a significance level of 1%, while number of years of education had a positive impact (+) at a significance level of 1%. Moreover, among the economic factors, employment status had a positive (+) impact at a significance level of 1%, while a household income level of over KRW 3 million had a positive (+) impact at a significance level of 1%. However, the disability factor was found not to impact information accessibility for PCs.

Regarding the sociodemographic factor, it was determined that as the age of the disabled decreases, the information accessibility of PCs increases (β = -0.197, ρ< 0.001). This is consistent with the results of preceding research [19], [16], [20]. Moreover, as the number of years of education increases, the information accessibility of PCs also increases (β = 0.247, ρ< 0.001). In other words, it is likely for information inequality to occur according to education history among the disabled. However, it was found that sex does not impact the Information accessibility of PCs for the disabled.

Secondly, some existing research [9] has posited that disability type may influence the information accessibility of PCs. However, this was not found to be the case in this study. This could be explained in terms of Korea's national level of information orientation, as PCs are commonplace in the average household and ultra-high-speed internet connections can be easily accessed in the majority of households.

Thirdly, concerning economic factors, the information accessibility of PCs (β = 0.064, ρ< 0.001) was found to increase for disabled persons who were employed. Among the disabled, participation in the labor market is beneficial for improving information access, and as the majority of work involves using PCs, it could also decrease the digital divide. Moreover, it was found that the information accessibility of PCs (β = 0.177, ρ< 0.001) increases when household income is more than KRW 3 million. This shows that a certain level of household income is required to decrease the digital divide. This is because, in order to access information, a PC, additional software, and supporting devices must be purchased [10], [21].

C. Results of Analysis of the Digital Divide for Smart Device Users

In order to determine the influencing factors for the digital divide among disabled users of smart devices, a multiple regression analysis was performed (see Table III).

TABLE III
RESULTS OF THE DIGITAL DIVIDE OF SMART DEVICES

		B	t
Sociodemographic factor	Sex	-0.078	-2.173**
	Age	-0.174	-5.435***
	Numbers of years educated	0.212	6.462***
Disability factor	Disability type	-0.042	-1.484
	Period of disability occurrence	0.084	2.740***
Economic factor	Employment status	0.033	0.993
	Household income below KRW 1M	0.075	1.257
	Household income KRW 1M to 2M	0.103	1.309
	Household income KRW 2M to 3M	0.121	1.638
	Household income over KRW 3M	0.269	4.243***
Control variable	Status in household	-0.002	-0.063
	Region of residence	0.176	6.144***
	N=981		
	R^2=0.477		
	F=23.790***		

* ρ<0.1, **ρ<0.05, ***ρ<0.01

The results showed that statistically significant factors influencing the digital divide for the disabled included sociodemographic, disability, and economic factors. More specifically, among the sociodemographic factors, sex has a negative (-) impact, with a significance level of 5%, age has a negative (-) impact, with a significance level of 1%, and number of years of education has a positive (+) impact, with a significance level of 1%. Moreover, among the economic factors, a household income level of more than KRW 3 million has a positive (+) impact, with a significance level of 1%.With regard to our results, firstly, all of the sociodemographic factors influenced information accessibility for smart device users. For females, accessibility was lower (β = -0.078, ρ < 0.05). As can be seen from the descriptive statistics shown in Table I, 74.5% of men accessed information via smart device. As with the information accessibility of PCs, a decrease in age increased the information accessibility of smart devices (β = -0.174, ρ < 0.001). Moreover, number of years of education was in line with the results for information accessibility for PCs, and increased with the information accessibility of smart devices (β = 0.212, ρ < 0.001).

Secondly, concerning the disability factor, when disability occurred after birth, the information accessibility of smart devices increased (β = 0.084, ρ < 0.001).

Unlike persons disabled at birth, those that became disabled after birth can utilize their previous experience of using smart

devices like smartphones, which can influence the information accessibility of smart devices.

Thirdly, as with the effect of economic factors on information accessibility for PCs, household incomes of over KRW 3 million were found to increase the information accessibility of smart devices ($\beta = 0.269$, $\rho < 0.001$).

Fourth, among the control variables, residence in an urban area led to the increased information accessibility of smart devices ($\beta = 0.176$, $\rho < 0.001$).

V. Conclusion

In an attempt to analyze the factors influencing the digital divide affecting the disabled, this study has utilized the NIA's "Current State Investigation for the Digital Divide of the Disabled – 2013," and performed multiple regression analyses targeting 1,862 respondents with regard to the information accessibility of PCs, and 981 respondents concerning the information accessibility of smart devices.

The factors that influence the information accessibility of PCs, or the digital divide for PCs, are the sociodemographic factors of age and number of years of education, and the economic factors of employment status and having more than KRW 3 million in household income. As to the factors influencing the digital divide for smart devices, the sociodemographic factors include sex, age, and number of years of education, while disability factors include the period of disability occurrence and economic factors include having a household income of over KRW 3 million. Therefore, the common factors that influence the digital divide for both PCs and smart devices are the sociodemographic factors of age and the number of years of education, and the economic factor of having a household income over KRW 3 million. Based on these results, the following suggestions can be made for reducing the digital divide affecting the disabled.

Firstly, this study determined that the lower a person's age, the less he or she is affected by the digital divide for both PCs and smart devices. This means that the older disabled people are, the lower the information accessibility of PCs and smart devices are to them. Therefore, a method for expanding ICT education for middle-aged and older disabled persons must be considered.

Secondly, this study makes it clear that the more years of education people have, the less they are affected by the digital divide for PCs and smart devices. Therefore, in order to narrow the digital divide, diverse ways must be found to enable less-educated disabled persons to access information.

Thirdly, when a person's household income is more than KRW 3 million, the effects of the digital divide for PCs and smart devices are decreased. In order to reduce the digital divide for disabled persons with low incomes, the accessibility of information should be increased, by using regional community resources from sources such as public institutions, NGOs supporting the disabled and disabled welfare centers [17]. Active policies are required, such as those that construct environments in which low-income disabled persons can utilize the Internet, as well as those that reimburse expenses resulting from improving internet literacy.

This study carries significant meaning, as it analyzes the factors that influence the digital divide for both PCs and smart devices. However, it faces a limitation in that it does not identify influencing factors affecting specific disability types. Therefore, a new analytical method is needed for future studies, which can identify these factors.

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