

SOCIAL DAMAGE COST ESTIMATION MODEL FOR MOBILE DIGITAL DIVIDE

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ABSTRACT

The previous studies on the digital divide mainly consisted of comparative studies among groups according to education, age, occupation, and region. However, the digital divide is expected to vary depending on the individual situation. Therefore, this study suggests a model that calculates social damage cost of mobile divide at individual level based on individual cognitive value. According to this model, we conduct empirical verification by social damage types. For the empirical analysis of this study, 800 questionnaire data were collected. Based on the collected data, the cost of social damage caused by the individual mobile digital divide per person was estimated to be about 120,000 KRW, and the social cost of about 5.6 trillion KRW was calculated as a result of applying it to the population of South Korea. In the detailed analysis, males felt more harm than females, and people in their 40s or older felt more vulnerable than those in their 30s or less. Also, non-metropolitan area residents felt more damage than metropolitan area residents. In addition, the results of social damage analysis showed that the mobile digital divide was more significant in social participation activities, family issues and interpersonal relationships, and medical services. The results of this study are expected to contribute to the study of mobile digital divide and to the development of meaningful policies.

Keywords: *Mobile Digital Divide; Digital Divide; Mobile Divide; Social Damage Cost; Cost Estimation*

1. INTRODUCTION

The development of information and communication technologies (ICT) and the emergence of smartphones provide an environment where people can exchange information anytime, anywhere. As a result, both the amount and quality of information exchanged by people have improved significantly. According to a survey by Ministry of Science, ICT and Future Planning of Korea, the penetration rate of smartphones in Korea is 85% of the population aged 6 and over, and the Internet connection rate reaches 99.2%. However, despite the global ICT infrastructure, various types of digital divide are still emerging. According to National Information Agency (NIA)'s 2015 Information Divide Survey in Korea, the PC - based informatization level among the general public was 77.4% for elderly people, 83.5% for farmers and fishermen, 86.2% for disabled people, 87.7% for low-income people and 87.8% for married immigrants. In addition, the level of smart informatization is 55.2% for farmers, 56.3% for elderly people, 62.5% for disabled people, 68.5% for North Korean defectors, 73.1% for married immigrants and 74.5% for low-income people [17].

As can be seen from the results of this survey, the mobile informatization level of the vulnerable group is lower than that of PC environment. In other words, the digital divide in the wireless network environment has widened since the spread of smartphones. The previous studies on the digital divide mainly consisted of comparative studies among groups according to education, age, occupation, and region. However, the digital divide will vary substantially depending on the individual situation. In this study, we propose a model that calculates social damage cost of mobile digital divide (mobile divide) at individual level based on individual cognitive value. Through this model, we aim to derive the social cost to solve the digital divide and to provide basic data to judge the effectiveness of the solution of the digital divide.

This study set two research goals as follows. First, a social cost estimation model is set up to find the damage cost caused by the individual mobile divide. Second, we try to check the degree of damage according to the types of social damage caused by mobile divide. This study may suggest policy implications and implications for resolving

the digital divide [14]. In section two, we review the concept of digital divide, mobile divide, and social damage caused by digital divide. Section three describes the research procedures and methods, Section four discusses the results of the research, and section five concludes with some remarks.

2. LITERATURE REVIEW

2.1 Concept of digital divide

The concept of the digital divide was defined through several previous studies. The digital divide was first raised by scholars who viewed the information society with skeptical viewpoints, and they predicted that the digital divide between the social classes would be widened due to informatization [1]. The digital divide at the time of the emergence of the term "digital divide", it was interpreted as it arises from the difference in adoption of information technology, depending on socioeconomic differences, personal tendencies, and communication styles, focusing on differences in information accessibility among social groups [16]. In terms of the accessibility of the digital divide, Yoo(2002) pointed out that the digital divide is generally a result of unequal opportunities for accessing to information and communication equipment [22]. This means the opportunity to access the information communication device itself, which is the most front stage in the various information activities such as information production, distribution and use, is unequal. In sum, the digital divide can be defined as the gap between the groups that can access ICT and the groups that do not.

The problem of information gaps is also becoming an important issue for developed countries and international organizations. OECD (2001) defined it as the differences between individuals, households, enterprises and regions due to different socio-economic conditions in 'Understanding the digital divide' [18]. The U.S Chamber of Commerce defined it as the gap between the groups that access technology through telephone, computer, and the Internet [2]. Korea also enacted the 'Information Dispute Resolution Act' in 2001 and defined the digital divide as the difference in the opportunities to access or use information and communication services through information and communication networks due to economic, regional, physical, or social conditions.

The digital divide has begun to expand with the development of information and communication technologies and the emergence of mobile devices

and smart devices. The recent digital divide problem has begun to be studied not only in terms of accessibility but also in terms of usability. The digital divide nowadays is a concept involving quantitative and qualitative gaps, includes the process of utilizing information gained from accessing and creating added value [20]. The research on digital divide mainly focused on the accessibility of information, and there have been various policy efforts to reduce the digital divide by solving information accessibility. Recently, in order to emphasize the qualitative aspect of information utilization, attention is paid not only to accessibility but also to utilization of information [8].

In addition, the digital divide is mainly caused by demographic factors, especially by gender, age, education level, income, race, region, etc. [6]. There is also research that the introduction of information and communication technology has intensified income and information inequality further. The income of higher educated people who are engaged in information-related industry has increased due to the informationization, while the income of low educated people who are engaged in simple labor occupation has decreased [1].

2.2 Mobile Divide

As shown in Table 1, the concept of digital divide has been changed as the development of information communication devices from PC to Internet, starting from the knowledge divide which is the difference of knowledge about the initial information communication technologies. Recently, the appearance of mobile devices and smart devices result in the mobile divide. The emergence of mobile devices and smart devices is expected to solve the digital divide problem, but it is getting worse. In other words, the diffusion of smart devices does not completely eliminate the digital divide. The smartphone holders perform more information activities than the mobile phone holders and there is a difference in information utilization within the groups that can access information [10]. Especially in Korea where the aging is progressing rapidly, the utilization rate of smartphone among elderly people in the vulnerable class is considerably inferior to that of other developed countries [5]. In other words, the problem of the digital divide in smartphone utilization is more important than the gap between users and non-users [3]. The mobile divide has a characteristic of 'double gap'. It is highly likely that the people who are not able to access the Internet or have low ability to use the mobile device are lagging behind in the mobile society and might be completely

excluded from the society. Groups that fail to reduce unnecessary transaction costs through mobile devices may completely lose the opportunity to rise in status [11]. This is because new information communication devices such as smart phones and tablets are used firstly for those who have already used information devices and acquire information and knowledge. Therefore, before the digital divide is overcome, new information divide can be created again [7].

Table 1 – Classification Of Digital Divide

Terms	Knowledge Divide	Information Divide	Mobile Divide
Major Discussion Periods	1970s	1990s	2000s
Information and Communication Technology	Mass Media	Wired-Based Information and Communication Technology	Wireless Based Information and Communication Technology
Dimension of Divide	Quantitative and Qualitative Differences in Information Access and Utilization		
Definition	Digital Divide Caused by Mass Media	Digital Divide due to Digital Devices in Wired Environment	Digital Divide due to Mobile Devices in Wireless Environment

Lee & Lee (2014) [9]

In other words, it was expected that the spread of smart devices would alleviate the digital divide, but the digital divide became more intense in terms of information utilization and a new problem of a vicious cycle of digital divide also occurred. In terms of usability, the research on the digital divide problem will be needed not only by group comparison but also by interpersonal comparisons, so we will examine the mobile divide at the individual level.

Table 2 – Social Damage By Digital Divide

Social Damage	Contents	Reference
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Work (Educational) and economic Constraints	In the information society, the digital divide widens economic inequalities by restricting job opportunities and educational opportunities.	Seo, 2000 [20]
Social (political) participation	The digital divide creates a political communication gap and affects political knowledge and social participation.	Van Dijk & Jan, 2005 [21]
Family Issues	As the digital divide gets worse, the harmfulness of family and less conversation are caused by the difference of information sharing ability between parents and children.	Gang, 2006 [4]
Consumer tiering	Information-vulnerable groups also become vulnerable groups in acquiring consumer information, resulting in a consumer tiering problem due to the digital divide	Park & Lee, 2004 [19]
A vicious cycle of Digital Divide	Information divide result in a vicious cycle in which information poverty is structured by stereotyped social habits	Jun & Hong, 2014 [7]

2.3 Social damage caused by digital divide

The digital divide causes not only a simple gap due to access and utilization of information, but also causes various social problems like Table 2. As we have seen, not only does the vicious cycle of digital divide create new digital divide but also creates various social problems such as social, political, economic and family problems. The digital divide is structurally expanded to economic inequality, educational and cultural inequalities, and the digital divide in the information society enlarges economic inequalities by restricting job opportunities and educational opportunities [20]. In addition, due to the digital divide, political communication gaps arise, which affects political knowledge and social participation [21]. The digital divide affects family problems and consumption problems. Due to differences in information sharing and ability

between parents and children, family harmony is impeded and less conversation can occur [4]. A consumer group may become a vulnerable group and the problem of consumer stratification by the digital divide may occur [19]. In addition, there is a vicious cycle caused by the digital divide. The information divide leads to a vicious cycle in which information poverty is structured by the deepening of the poor people's life due to stereotyped social habits such as economic condition, education, and occupation [7].

Like the results of previous studies, the digital divide causes various social problems such as social, economic, political, and family problems. Therefore, this study estimates the cost of social damage according to the digital divide by classifying the types of social damages of individuals using mobile devices.

3. RESEARCH METHOD

3.1 Research procedure and social damage cost estimation model

The goal of this study can be classified into two stages: estimation of social damage cost due to mobile information gap and derivation of damage degree by social damage type due to mobile information gap. The study procedure is shown in Figure 1.

First, based on the previous studies, the damage cost estimation model based on the mobile divide at the individual level is established and the damage cost is calculated. The model for calculating the damage cost is as follows. This study focuses on the difference of mobile divide between mobile device and mobile network data. In order to calculate the individual mobile divide, we investigate the price and satisfaction of mobile devices in current wireless network environment such as smart phone, smart pad (tablet PC) and notebook, and the differences are calculated. Then, we investigate the type of data communication used and its cost, satisfaction level, and investigate the desired type and cost of the data communication to be used, and calculate the difference between them. We compare the differences in the mobile environment, which is perceived by the individual, as the cost, and define it as the cost of damage according to the individual mobile divide. In order to calculate the damage cost according to the mobile divide, the damage cost according to the mobile divide of the individual is calculated by reflecting the weights according to the satisfaction of the current prices of the variables defined above (Formula 1 in Figure 2). Then, the average cost is calculated by summing the costs according to the individual digital divide calculated as in (Formula 2), and dividing it by the total number of survey respondents. Then, the domestic social cost according to the digital divide is calculated by multiplying the average cost calculated in (Formula 3) by the number of the target population in the domestic market, that is, the total number of the Korean population. In addition, based on the output model, social cost is calculated according to the digital divide by gender, age, and region.

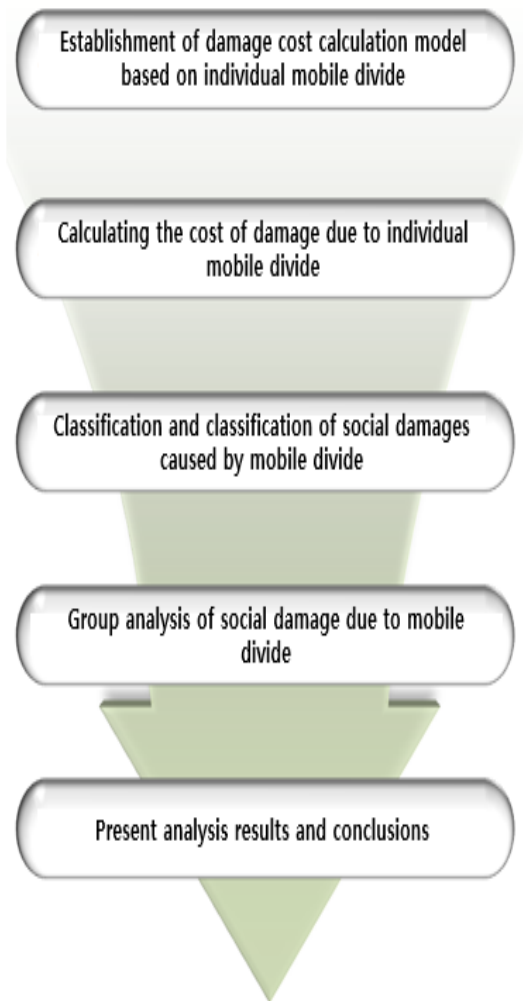


Figure 1 – Research Process

3.2 Data collection

$$P = (f_m(\alpha_m - \beta_m) \times \gamma_m) + (f_t(\alpha_t - \beta_t) \times \gamma_t) + (f_n(\alpha_n - \beta_n) \times \gamma_n) + (f_c(\alpha_c - \beta_c) \times \gamma_c) \dots \text{(Formula 1)}$$

$$\text{Sample Cost} = (P1 + P2 + \dots + Pn) \div SP \dots \text{(Formula 2)}$$

$$\text{Total Cost} = \text{Sample Cost} \times TP \dots \text{(Formula 3)}$$

P = Individual cognitive digital divide cost

f = digital divide cost by item (m=mobile, t=tablet, n=notebook, c=communication charge)

α = hope price

β = currently use price

γ = satisfaction (weight)

SP = Total Survey Respondents

Sample Cost = Average cost of Total Survey Respondents

TP = Total Available Population

Total Cost = Cost of eliminating the digital divide

Figure 2 – Social Damage Cost Estimation Equation

Next, the degree of damage according to the types of social damage due to mobile divide is derived. Based on the previous studies, the types of social damage from the mobile divide are divided into five categories: work (education) and economic activities, social participation activities (politics, economics, issues), cultural life and consumption activities, family issues and interpersonal relationships, and medical services. In order to derive the degree of damage individuals perceive for each type, an independent sample t-test is conducted by classifying the mobile divide into groups based on the damage cost calculated in the previous step to check the difference between the group experiencing digital divide and those not experiencing it.

The purpose of this study is to calculate the social damage cost according to the mobile divide and the degree of damage according to the types of social damage due to the mobile divide at the individual level. For this purpose, the survey was conducted through Embrain, a specialized research company.

A total of 800 data were collected. The sample of collected data was 408 (51%) male and 392 (49%) female. According to the age group, 16% was under 10, 30s was 34%, 40s was 40%, 50s was 38%, and more than 60s was 16%. By region, the metropolitan areas (Seoul, Gyeonggi, and Incheon) accounted for 51%.

Based on the collected data, we try to figure out the degree of social damage perceived by the individuals classified by the type of social damage and calculate the social cost according to the mobile divide at the individual level. In addition, we divide this into sex, age, and region, and calculate the social cost according to the mobile divide of each group.

Table 3 – Statistics Of The Sample

Classification		Frequency (persons)	ratio
Sex	Male	408	51%
	Female	392	49%
Age	Less than 10	72	16%
	20's	139	30%
	30's	156	34%
	40's	183	40%
	50's	175	38%
	More than 60	75	16%
Residence	Metropolit an area	407	51%
	Non-metropolit an area	393	49%

4. ANALYSIS AND RESULTS

4.1 Calculating social damage costs

The collected data was reflected in the model of this study, and the cost of social damage due to the mobile divide at the individual level was calculated.

According to the analysis, 398 out of 800 respondents felt the gap between mobile devices (mobile phones, tablet PCs, notebooks) and wireless communication rates.

First, the damage cost due to the mobile divide for one person was calculated like the following example equation (Formula 1).

$$PI = \{(1,000,000 - 700,000) \times 0.8\} + \{(700,000 - 450,000) \times 0.7\} + \{(2,000,000 - 1,500,000) \times 0.9\} + \{(46,200 - 39,600) \times 0.8\}$$

Next, to calculate the average individual damage cost due to the mobile divide from all survey respondents, the costs of each respondent were summed, and then the value was divided by the total number of survey respondents, 800 (Formula 4).

$$\text{Sample Cost} = (870,280 + \dots + 58,145) / 800$$

(Formula 4)

As a result of calculating the average damage cost for all survey respondents, the amount of 118,550(KRW) was calculated. The social damage cost can be calculated by multiplying the average cost of damage by the total number of people in Korea except 0 ~ 9 years. Finally, the cost of social damage due to the mobile divide was derived as shown in (Formula 5).

$$\text{Total Cost} = 118,550 * 47,223,185$$

(Formula 5)

As a result, the damage cost according to the mobile information gap at the individual level of Korea was calculated as 5,598,312,005,431(KRW).

Next, we calculated the difference of the damage cost of the information gap between age, gender, and region. First, to calculate the cost of damages caused by the mobile divide according to gender, it

was classified into two groups, male and female, and the damage cost according to the mobile divide was calculated and the difference between the two groups was confirmed. As a result, the average cost of male respondents was 133,710(KRW). The total male damage cost can be calculated by multiplying the calculated cost by the total number of men in Korea as shown in (Formula 6).

$$\text{Total Cost} = 133,710 * 23,523,048$$

(Formula 6)

As a result, the damage cost due to the mobile divide of male was 3,145,272,340,569(KRW).

Likely, the average cost of female individual respondents was 102,771(KRW). The calculated cost is multiplied by the total number of female users in Korea as shown in (Formula 7).

$$\text{Total Cost} = 102,771 * 23,700,137$$

(Formula 7)

As a result, the damage cost due to the female mobile divide was 2,435,689,742,144(KRW). The difference between males and females is 709,582,598,425(KRW), which means that males are more likely to suffer from the mobile divide than female.

Table 4 – Cost Of Damage Due To Sex (KRW)

Classification	Average cost of survey respondents	Total cost
Male	133,710	3,145,272,340,569
Female	102,771	2,435,689,742,144

Next, to calculate the cost of damage due to the age - related mobile divide, the damage cost according to the mobile divide was divided into two groups of less than 30 years old and more than 40 years old. As a result, the individual average cost of the survey respondents under 30 years old was 132,798(KRW). The cost was calculated by multiplying the calculated cost by the total number of people under the age of 30 or less as shown in (Formula 8).

$$\text{Total Cost} = 132,798 * 19,623,121$$

(Formula 8)

As a result, the damage cost due to the mobile divide of 30 or less was 2,605,913,093,973(KRW).

Next, the average cost for individual respondents in their 40s or older was 106,473(KRW). The cost was calculated by multiplying the calculated cost by the total number of the available population over 40s as shown in (Formula 9).

$$\text{Total Cost} = 106,473 * 27,600,064$$

(Formula 9)

As a result, the damage cost due to the mobile divide of groups over 40 was 2,938,683,796,310(KRW).

The difference between the two groups was 332,770,702,337(KRW), which means that more than 40 years old people feel the mobile divide more than those in their 30s or less.

Table 5 – Cost Of Damage Due To Age (KRW)

Classification	Average cost of survey respondents	Total cost
Less than 30	132,798	2,605,913,093,973
More than 40	106,473	2,938,683,796,310

Next, we calculated the cost of damages caused by the mobile divide between the metropolitan area and the non-metropolitan area, and then confirmed the difference between the metropolitan area and the non-metropolitan area. As a result, the average cost of survey respondents in the metropolitan area was 117,814(KRW). The cost was calculated by multiplying the calculated cost by the total number of the available population in the metropolitan area as shown in (Formula 10).

$$\text{Total Cost} = 117,814 * 23,390,470$$

(Formula 10)

As a result, the damage cost due to the mobile divide in the metropolitan area was 2,755,728,970,452(KRW).

Next, the average cost of individual survey respondents in the non-metropolitan area was 119,312(KRW). The calculated cost was multiplied by the total number of the population in the non-metropolitan area, as shown in (Formula 11).

$$\text{Total Cost} = 119,312 * 23,832,715$$

(Formula 11)

As a result, the damage cost due to the mobile divide in the non-metropolitan area was 2,843,533,258,379(KRW).

The difference between the two calculated amounts is 87,804,287,927(KRW), which means that people living in the non-metropolitan area feel more the mobile divide than people living in the metropolitan area.

Table 6 – Cost Of Damage Due To Region (KRW)

Classification	Average cost of survey respondents	Total cost
Metropolitan area	117,814	2,755,728,970,452
Non-metropolitan area	119,312	2,843,533,258,379

4.2 Degree of damage by types of social damage

The second objective of this study is to perform the independent sample t-test to check the degree of damage according to the types of social damage caused by the individual mobile divide.

First, in order to conduct the independent sample t-test, we divided the groups into two groups: those who feel that there is the mobile divide and those who do not. As a result of classification, 398 respondents felt that there was the mobile divide among a total of 800 questionnaires, and 402 persons who did not feel the mobile divide.

Table 7 – Mobile Divide Group Classification

Classification	Frequency (persons)	ratio
Mobile Divide(Yes)	398	50%
Mobile Divide(No)	402	50%

The independent sample t-test was conducted to verify the difference between the two groups. The significance level of 90% was calculated for social

participation activities, family issues and interpersonal relationships, and medical services. The t-value of the social participation activity was 3.09 (p-value is 0.002), and the t-value of the family issues and interpersonal relationship was 1.80 (p-value is 0.74). Finally, the t-value of medical service was 2.01 (p-value is 0.44). In other words, the group with mobile divide felt to be more vulnerable to social participation activities, family issues and interpersonal relationships, and medical services due to the mobile divide than those who without mobile divide. However, there was no significant difference between the two groups in the work (education) and economic activities with 0.535 p-value and cultural life and consumption activities with 0.555 p-value.

Table 8 – Independent Sample T-Test Results By Type Of Social Damage

Type of damage	group	Avg	SD	t-value	p-value
Work (Educational) and economic activities	Mobile Divide (Yes)	3.66	0.86	0.62	.535
	Mobile Divide (No)	3.62	0.92		
Social (political) participation activities	Mobile Divide (Yes)	3.49	0.89	3.09**	.002
	Mobile Divide (No)	3.28	0.95		
Cultural life and consumption activities	Mobile Divide (Yes)	3.81	0.83	0.59	.555
	Mobile Divide (No)	3.78	0.82		
Family issues and interpersonal relationships	Mobile Divide (Yes)	3.96	0.74	1.80*	.074
	Mobile Divide (No)	3.85	0.88		
Medical Services	Mobile Divide (Yes)	2.56	0.95	2.01**	.044
	Mobile Divide (No)	2.42	0.92		

P<.01*, <.005**, <.001***

5. CONCLUDING REMARKS

This study suggested a social damage cost estimation model according to the mobile divide in the individual level and analyzed its calculation. The results of this study are summarized as follows. First, we calculated the social damage cost due to the mobile divide at the individual level. As a result of the analysis, the average value of social damage cost according to the mobile divide for a person was calculated as 118,550(KRW), and the total social damage cost for the total available population in Korea was calculated as 5,598,312,005,431(KRW). We also calculated the social cost due to the information gap between groups by gender, age, and region. As a result, the average divide value of a male was calculated as 133,710(KRW), and the total social damage cost of all males in Korea was 3,145,272,340,569(KRW). The average divide value of a female was calculated as 102,771(KRW), and the social damage cost for all females in Korea was calculated as 2,435,689,742,144(KRW). The difference between men and women was 709,582,598,425(KRW). This shows that men are more sensitive to ICT and ICT technology and need more advanced information and communication devices and more data capacity than women. Next, as a result of classification by age groups, the average divide value in their 30s or less was 132,798(KRW), and the total social damage cost under 30 years in Korea was 2,605,913,093,973(KRW). The average divide value of 40 years or older was calculated as 106,473(KRW), and the total social damage cost of over 40 years old in Korea was calculated as 2,843,533,258,379(KRW). In addition, the difference of the social damage cost between 30s and 40s was 332,770,702,337(KRW), which means that the people in their 40s or older feel the mobile divide more than those in their 30s or less. This means that people under the age of 30 feel less needs because they use relatively the latest information communication devices and high capacity or unlimited data rates. Finally, for the comparison between the metropolitan area and the non-metropolitan area, the average divide value of a resident in the metropolitan area was 117,814(KRW), and the total social damage cost in the metropolitan area in Korea was 2,755,728,970,452(KRW). The average divide value of a resident in non-metropolitan area was 119,312(KRW), and the total social damage cost in the non-metropolitan area in Korea was 2,843,533,258,379(KRW). The difference was 87,804,287,927(KRW), which means that the residents of the non-metropolitan area feel a greater

mobile divide than those living in the metropolitan area. This implies that the ICT infrastructure in Korea is mainly concentrated in the metropolitan area, and the mobile divide is felt to be large due to the lack of infrastructure in local small towns and rural areas.

Next, in order to analyze the degree of damage caused by mobile divide, we classified the groups according to the mobile divide types and conducted an independent sample t-test. As a result of the analysis, it was found that the people who feel the mobile divide more suffered from social participation activities, family issues and interpersonal relationships, and medical services than those who did not.

Through this study, it was possible to estimate the level of the cost to solve the social damages caused by the mobile divide, and the types of the user who is suffering from the mobile device. First, it can be understood that the cost for solving the social damage due to the mobile divide, which is perceived by the individual, is about 120,000 KRW per person in Korea. Also, it can be seen that a cost of about 5.6 trillion KRW is needed to solve the mobile divide for the whole nation. In the meantime, the direction of the government policy to solve the digital divide tended to concentrate mainly on the socially weak class, but the general people like the result of this study also felt various damage in everyday life due to the digital divide. In particular, many people feel that they seem to be alienated from the digital divide because they feel that they are suffering from social participation activities, family issues and interpersonal relationships that require communication technologies with people. In addition, since the aging society is accelerating, the interest in health and healthcare services are rapidly increasing. So appropriate government policies are needed. As a result of this study, it seems that a huge budget is needed to solve the mobile divide. Sometimes it need the time lag between the investment and its outcome [12]. Therefore, it is necessary to establish a policy considering broad supports and solutions for communication and medical services in accordance with the aging society. In the advancing smart society, it is needed to make a proper policy approach not only for the social underprivileged but also for the general public so as not to lag behind the access and utilization of information.

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