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Analysis on public perception, user-satisfaction, and publicity for WEEE collecting system in South Korea: A case study for Door-to-Door Service

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ABSTRACT

The South Korean government is applying the Target Management System (TMS) for collecting and recycling electrical and electronic equipment waste under the Waste Electrical and Electronic Equipment (WEEE) Directive. Based on the TMS, approximately 280,230 t of WEEE-compliant waste was recycled in 2017. Building on these recycling achievements, Korea government established a secondary long-term target about 8.6 kg/cap yr. by 2023 as there is sufficient interest in building and managing an efficient WEEE collecting channel in Korea. In this study, we investigate the current status of public perception, user satisfaction, and public relation (PR), as well as strategies that focus on promoting the door-to-door (D-to-D) service, a free public collecting channel in Korea. A survey questionnaire was conducted using the computer-assisted telephone interviewing (CATI) method with stratified sample of 2000 interviewees. The survey results indicated that nearly one in two people (48.2%) were aware of the D-to-D service, and this percentage was higher than the annual surveys for the last three years. In addition, 90.7% of the users of the D-to-D service expressed a positive opinion, particularly with regards to the service being available for free. From the PR perspective, 58.9% of respondents felt that current PR level were unsatisfied despite many outstanding advantages of the D-to-D service, and 86.0% of respondents stated that the frequency of the PR activities for the D-to-D service should be increased. These results are expected to utilize as basic information to establish future-strategies for improving the service quality of D-to-D system with vulnerability complement.

1. Introduction

Since the 1980s, the usage and replacement cycle of electrical and electronic equipment (EEE) has gradually shortened due to steady population and economic growth in South Korea (Kim et al., 2007; Min, 2007). In response, the Korean government passed the *Waste Management Act* (1992) to systematize the collecting and recycling system for large amounts of waste electrical and electronic equipment (WEEE) (Lee et al., 2007; Jang, 2010; Korea Legislation Research Institute (KLRI), 2018a,b,c). In 2003, Extended Producer Responsibility (EPR) system was implemented to impose responsibility for collecting and recycling on manufacturers and importers based on assigned products quantity from the sale volume (Park, 2002, 2007). In 2014, a Target Management System (TMS) was introduced which sets an annual collecting and recycling target rate for manufacturers and importers, further increasing national recycling performance (Park, 2009; Park et al., 2019). Starting from a recycling target of 3.9 kg/cap·yr. in 2014, the target has continuously increased to 5.4 kg/cap·yr. in 2017, and 6.0 kg/cap yr. in 2018 (Manomaivibool and Ho, 2014; Park et al., 2018; KLRI, 2018a,b,c; Ministry of Environment, 2017). Statistics from the Ministry of Environment (MOE) and the Korea Electronic Recycling Cooperative (KERC), show that approximately 93% of the WEEE collecting and recycling target was achieved in 2017 (= 5.4 kg/cap·yr.), or about 277,830 metric tons of e-waste collected and recycled based on the population of 51.45 million in Korea (KERC, 2017; Ministry of Interior and Safety, 2018). Achieving the MOE collecting and recycling target of 8.0 kg/cap·yr. in 2020 requires an even more efficient collecting system and increased recycling plant capacity.

Achieving the increased collecting and recycling target requires evaluation of the current WEEE collection system coupled with plans

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for improvement and expansion. Currently, the WEEE collecting routes in Korea are divided into four categories which include the following (Kim et al., 2013; Manomaivibool and Ho, 2014) :

(1) Take-back system: The manufacturer, importer, and sellers of EEE directly collect the end-of-life home appliances when installing new products in the customer's house (Atasu et al., 2009; Bahers and Kim, 2018). Also, take-back indicated not that have a one-to-one obligation but that voluntary participation of the manufacturer, importer and sellers based on EPR system;

(2) Door-to-Door (D-to-D) system: KERC directly managed this WEEE collecting system using a consignment operation with a nationwide call center and logistics network (Kim et al., 2013; Kim, 2016);

(3) Local authorities' system: Based on the WEEE collection and recycling obligation of local authorities which operate their collecting systems by imposing consumer fees (Jang and Kim, 2010); and

(4) Private collecting system: Any other collecting method not listed above and substantially classified as informal sector collection, as opposed to formal sector collection as listed in items (1)–(3) (Chi et al., 2011; Manomaivibool and Ho, 2014; Gu et al., 2016).

Although securing and managing various collecting routes is very important to achieving the Korean national recycling target, the local authority's system and private collection system have fundamental problems. Currently, local government willingness to participate in the WEEE collecting actions is entirely dependent on a local government's free will, without the MOE's management. In other words, although the role of local government was specified in the *Waste Management Act* (1992), there are no punishment or enforcement provisions if local governments do not implement collections (KLRI, 2018a,b,c). The private collection channel has bigger problems than the others. The volume and material flow of WEEE collected through this channel cannot be estimated and included in national statistics, and it is recycled in an illegal form, posing a great threat to humans and the environment (Park et al., 2018). Therefore, the MOE and local authorities must both maintain their systematic management and expansion of the WEEE collecting system in the formal sector as well as incorporate and institutionalize the informal sector (Jang and Kim, 2010; Chi et al., 2011).

Many previous studies have focused on the research methodologies such as "Material Flow Analysis (MFA)" or "Regression Analysis" to predict WEEE generation or potential risks for WEEEs that are illegally recycled in informal sectors. Due to the lack of official statistics such as WEEE generation and its flow, on informal sector, these methodologies have emerged as alternative approach to access the information of informal sector instead of official statistics. However, it is also possible to develop a strategy to expand the area of formal sector by surveying and analyzing the current status of collecting and recycling of WEEE in formal sector. In other words, it is very rare to attempt to supplement the drawbacks of the channel through the diagnosis with survey for actual institutionalized WEEE collection channels (user awareness or satisfaction) because it is difficult to access the actual users with experience in discarding end-of-life appliances. Nevertheless, we examined the public perception, satisfaction, and public relation (PR) level for D -to-D service, WEEE free collection channel in formal sector, to encourage inflow of WEEE from informal to formal sectors. These survey results can be used as important evidence and decision-making tools to encourage the stream to shift to formal sectors for WEEE that are illegally recycled in informal sectors.

Several earlier studies used questionnaire surveys to analyze public perception, knowledge of recycling end-of-life materials, and public participation in recycling systems (Ramayah et al., 2012; Thomas and Sharp, 2013; Saphores et al., 2012). These studies showed that not only did WEEE recycling promote moral norms, educate the public about the benefits of electronic waste recycling, and make manufacturers' e-waste recycling more convenient, but that awareness of recycling behaviors has implications for school or governmental agencies in educating and encouraging positive recycling behavior (Ramayah et al., 2012). Several other studies described specific strategies to improve the WEEE collection achievement and public relation (PR) paths, concluding that government must enhance the WEEE collection strategies by focusing on consumers' discard-behavior patterns (Afroz et al., 2013; Dias et al., 2018a,b; Dias et al., 2018a,b). The strategies for promoting WEEE collection face some limitations, which include the following: (1) A study of the overall public perception of WEEE recovery and recycling does not necessarily describe in-depth analysis for specific WEEE recycling systems; and (2) Previous studies, although they emphasized the value of education by governmental agencies, failed to provide publicity strategies using tools such as media and promotional literature.

Recent research on improving public awareness of WEEE collection and recycling systems has explored combining economic approaches, such as recycling cost-supporting incentives, or lower participation due to economic disincentives, such as return fees, an extra trip (collection activity) and price fixing (Barr et al., 2003). Although creating economic incentives on a large scale for fostering WEEE recycling has not been considered, several current studies have focused on the economic approaches with incentives to successfully improve WEEE recycling in the formal sector (Milovantseva and Saphores, 2013; Yin et al., 2014; Ylä-Mella et al., 2015). Several prior studies targeting the perception and satisfaction survey as a qualitative approach in waste collection systems have used the Contingent Valuation method (CVM) technique to determine whether people are willing to pay for environmental measures (Barr et al., 2003; Zeng et al., 2010; Wang et al., 2017). However, these studies with an economic viewpoint were conducted to promote the formalization of the informal sector for WEEE collecting and recycling (Bateman et al., 2002; Ezebilo, 2013). Therefore, using CVM methodology is unnecessary in this study due to its focus on investigating public perception and satisfaction for the D -to-D service, which is an actual WEEE collecting system in the formal sector of Korea. The WEEE collecting system of the formal sector in Korea is one of the most successful examples in the developed and developing world because manufacturers, importers, and sellers pay all the costs for WEEE collecting through building the infrastructure under the Extended Producer Responsibility (EPR) system. Thus, this study is focused on examining the public's perception, satisfaction and PR strategies of the D -to-D service, one of the WEEE collection channels in the formal sector, to determine future directions for improvement of the D -to-D service by defining its current status.

This study presents survey results on public perception and satisfaction with information regarding the D -to-D service as a WEEE collecting system in the formal sector, as well as the publicity methods preferred by respondents to promote improving WEEE collection performance. Advantages and disadvantages were collected to utilize as basic data for improving customer satisfaction and accessibility (usage rate) of the D -to-D service. All descriptions in this research are commonly derived from statistical analysis based on well-designed questionnaire and telephone interviews with total 2000 respondents. Our results provide critical information and insights for decision makers, such as those at the MOE and KERC, in the D -to-D service and identifying PR vulnerabilities.

2. Current status of EPR in Korea

The EPR system requires manufacturers and importers of new products under the EPR requirements to recycle certain waste from products or packaging materials. The MOE has included EEE products as target items in the EPR test-operation period since 2003 and included EEE as official items in the official-operation period since 2008. As of 2018, the EPR mandatory items in EEE products comprise four groups (large-size, mid-size, small-size and telecommunications group) with a total of 27 items, including refrigerators, washing machines and air conditioners (Table S1; see Supplementary). Based on the WEEE EPR system, major roles of each entity (organization) were as follows: 1) consumers have the role to thoroughly separate and discharge WEEE or

recycling resources, 2) manufacturers and importers have the role to thoroughly fulfill the responsibility for collection and recycling, individually or by joining a Producer Responsibility Organization (PRO), 3) the Korea Electronics Recycling Cooperative (KERC; as a PRO) has to implement management for physical collecting, recycling and financial mechanisms, 4) the Korea Environment Corporation (KEC) (2019) and Ministry of Environment (MOE) not only accept and/or approve the sales & import records and have responsibility for the fulfillment of the plans of producers, but also supervise administration of EPR operations.

The EPR system for WEEE was developed on the basis of the *Act On Resources Circulation Of Electrical And Electronic Equipment Available*, which was established in 2008. According to this act, mandatory recycling quantities for each category of equipment was calculated as follows (KLRI, 2018a,b,c):

· Mandatory Recycling Quantity (MRQ) = Annual Recycling Targets (ART) × Population × α (coefficient)

Where α is the ratio of the equipment in each group (large-size, mid-size, small-size and telecommunication group) of EEE manufacturers marketed for recycling in the prior year. Every December or after January, the MOE officially announced the "Annual Recycling Target" and "Population" information, cited by the Korea National Statistical Office (KNSO). Table S2 (see Supplementary) show that chronological changes during that period from 2014 to 2018 for "Annual Recycling Target" and "Population". If an EEE manufacturer or importer subject to mandatory recycling fails to perform their duty to collect, transfer and recycle under the *Act On Resources Circulation Of Electrical And Electronic Equipment Available* (2008), or a PRO (KERC) fails to perform its duty to collect, transfer and recycle on behalf of its members, the MOE shall impose a fine of an amount calculated from aggregating the expenses incurred in recycling waste not recycled out of the mandatory recycling quantity with an amount calculated in accordance with standards shown in Table S3, with the prescribed value not to exceed 30% of such expenses (KLRI, 2018a,b,c).

Every five years, the MOE determines and publishes a long-term target per capita for recycling of EEE in consideration of the following factors such as amount of EEE shipped by manufacturers and importers, estimated amount of WEEE generated, separation results of recyclable resources, recycling performance of WEEE in domestic, recycling conditions (i.e., condition of recycling technologies developed, and size of the recycling plants with facilities). Based on the long-term target with various factors, MOE publishes an Annual Recycling Target (ART) per capita every year. The MOE can establish and revise long-term targets per capita and the ART through field investigations and consultation with central administration, local government and recycling agencies, as well as producers, importers and sellers. In 2014, the MOE published the first long-term target for WEEE recycling, which increased from 3.9 kg/cap·yr. in 2014 to 6.0 kg/cap·yr. in 2018. Five years after the announcement of the first long-term target, the MOE announced the second long-term target, at January 2019, as 8.6 kg/cap·yr. by 2023.

Based on the *Act On Resources Circulation Of Electrical And Electronic Equipment Available* (2008), the MOE calculates and announces unit-costs for recycling (unit-cost of recycling) and collection (unit-cost of collection), considering various social and economic conditions, such as inflation, oil prices, market prices of recyclable materials, etc. (KLRI, 2018a,b,c; Korea Resource Recirculation Information System (KRRIS), 2018). The unit-cost information for recycling and collection announced by the MOE was utilized as a criterion to impose charges when manufacturers or the KERC fails to perform their annual duties to collect, transfer and recycle WEEE (KLRI, 2018a,b,c). The unit-costs for recycling and collection can vary according to the type of EEE categorized as four groups from the *Act On Resources Circulation Of Electrical And Electronic Equipment Available* (2008) (Table S3; see Supplementary). When EEE manufacturers, importers and sellers subject to mandatory collection and recycling join the KERC, they pay a contribution. This cost is cheaper than the unit-cost for recycling (Table S3; see Supplementary), implying that this economic advantage serves as an incentive to encourage manufacturers, importers and sellers to participate in the KERC.

EEE producers, importers and sellers prefer to join the KERC, paying the contributions, because it is easier to achieve their collection and recycling quantities in an EPR system. The main sources of funding for WEEE collecting and recycling are manufacturers, importers and sellers in Korea (Manomaivibool and Ho, 2014). The KERC strives to achieve WEEE collection and recycling goals by reasonably spending the funds collected from manufacturers, importers and sellers. In 2012, the Korea Association of Electronic Environment (KAEE), the predecessor to the KERC, developed the D-to-D system as a free reservation service for the collection of end-of-life home appliances. This service is available to anyone who could not use "take-back" or "local authority" collecting channels. The D-to-D service is operated by the KERC using the funds from contributions by manufacturers, importers and sellers (Park et al., 2018).

D-to-D service was developed as a formal collection route because existing collection services had several issues, such as illegal disposal and export of e-waste (Kim, 2016). The problem is not that WEEE is traded in the market as a valuable resource, but that unauthorized recyclers selectively take only the high-value components and do not manage other components or materials, which results in waste (Manomaivibool and Ho, 2014; Kim, 2016). As independent businesses, private recyclers irregularly collect WEEE and promote their information, typically using a one-ton truck with a microphone for collecting and promotion. Although it depends on the socioeconomic conditions (oil and resource prices), EEE type, region, housing type of discarder and business practices of private recyclers in the informal sector, potential discarders can usually receive a small profit when they transport the end-of-life appliance to a private recycler (facility). However, if the private recycler collects at the discarder's house, some money will be paid by the potential discarder as a transport fee. Thus, occasionally the use of informal WEEE collection routes may lead to small amount of monetary benefits for the discarder rather than using the take-back system (free of charge), D-to-D service (free of charge) or the local authority's channel (cost to the discarder). It is difficult to predict informal e-waste recycling processes and determine possible adverse environmental impact. The MOE and KERC recognize the environmental value to be gained by preventing unpredictable environmental hazardous actions (i.e. emission of refrigerant into the atmosphere, landfill of heavy metals and illegal incineration) caused by illegal recycling in the informal sector.

To solve these problems, the D-to-D service was designed to collect WEEE, for free, from all citizens and all regions of Korea. In other words, the main expected effect of D-to-D service is to build a social system for eco-friendly WEEE recycling by simply taking away the opportunity costs that WEEE could be passed on to unlicensed recycling operators. It is estimated that D-to-D service could collect approximately 2 million units of WEEE annually, as of 2018. The annual D-to-D collection target, estimated annually by the KERC, is not mandatory for announcement, and is predicted by considering the growth rate and collection performance of the D-to-D collection service over the last year.

3. Method

3.1. Study area

Since the pilot introduction for the D-to-D service was implemented in 2012 by the MOE and the Korean Association of Electronics and Environment (KAEE; KERC was formerly the KAEE) in Seoul as a formal D-to-D business under the MOE, the service has systematically developed and expanded to all regions of Korea. The survey area consequently was all of Korea. In 2017, the nationwide study area consisted of 16 administrative districts with a total area of 99,720 km^2 serving around fifty million people. The questionnaire in this study divided the

country into 16 administrative districts (cities or provinces) and the adjacent administrative districts categorized into six groups to draw interpretations and conclusions.

The survey, conducted in November 2017, included a subsection of all Korean residents who were able to access the D-to-D service prior to that date. The criteria for free collection activity of the D-to-D service applies the pick-up of large-size appliances such as refrigerators, air conditioners, washing machines, televisions, and vending machines discarded as a type of individual product; and mid- or small-size appliances such as vacuum cleaner which can be collected for free when more than five appliances are gathered. These operating policies of the D-to-D service apply equally nationwide. Therefore, there are no differences for characteristics or types of end-of-life appliances based on regional collection features.

3.2. Survey design

We conducted the survey using the Computer Assist Telephone Interviewing (CATI) method with professional experts for a target of 2000 samples. The CATI method was considered a cost-effective approach that can access numerous samples and produce instant results (Kissinger et al., 1999). The main characteristic of the CATI is that the interviewer follows a script provided by a software application. CATI is a structured system for collecting small-amounts of data by telephone with rapid collection and editing of data, designed to enable interviewers to educate timely respondents about characteristics of survey target. (Choi, 2004). The survey was conducted via a stratified sampling of respondents and designed to reflect four socioeconomic characteristics including gender, age, region, and employment status. In case of gender, samples were designed to reflect the balance of the gender ratio between male and female. Respondents' ages were categorized by decade, with those over 60 years of age as one cohort, and those between 15 and 29 years old making up the cohort < 30 years of age. The regional numbers of respondents were allocated according to their regional populations as a proportion of the total population of Korea. In particular, areas with large populations such as Seoul and Kyeonggi-do Province had more respondents than other regions while there were fewer samples in regions such as Jeju Island with a lower population (Table 1). Finally, the questionnaire was designed to classify the respondents into five job type categories, including office /management worker, manufacturer/sales/service worker, homemaker, student and unemployed using a multiple-choice item based on the CATI method. The distribution of the job types for all respondents is shown in Table 1.

Additional survey items (in Supplementary) regarding the route of recognition of D-to-D service and reasons why users were satisfied with this service were also designed with multiple choice and criterion responses based on the CATI method. In this study, surveys for three topics, public perception, PR level and necessity of PR activity of D-to-D service, were administered to 2000 respondents, and a survey for user satisfaction was administered only to respondents who had used D-to-D service in the past. In this study, respondents' responses were categorized and analyzed according to the CATI survey method, and additional analysis of data was implemented using IBM SPSS statistics software (Version 20).

3.3. Questionnaire

Questionnaires were administered to respondents via a computer-generated voice by telephone using the CATI methodology. The questions were asked in Korean, and the respondents submitted a single answer among several options by pressing a digit on their telephone. In addition, for the questions surrounding the D-to-D service, respondents were allowed to submit two or more opinions. Ultimately, aside from demographic questions, we divided the core questionnaire responses into four parts which include the following: (1) public perception level and route of recognition of the D-to-D service; (2) user satisfaction level with the D-to-D service; (3) PR related to the D-to-D service; (4) awareness of known disposal methods for end-of-life appliances; and (5) subjective opinions of the D-to-D service (Table S4; see Supplementary).

Table 1
Basic survey information and respondents' characteristics.

Component Rates in Each Group (%)			
	Categories		
	Response	No. of Respondents (n = 2000)	Percentage (%)
Survey method	CATI		
Survey Target	Inhabitants in the area where D -to-D business is conducted		
Survey design	2000 samples		
Gender			
	Male	986	49.30
	Female	1014	50.70
Age			
	15-29	178	8.90
	30-39	342	17.10
	40–49	454	22.70
	50–59	446	22.30
	> 60	580	29.00
Job			
	Office/ Management worker	681	34.00
	Manufacturer/ sales/service worker	544	27.20
	Homemaker	492	24.60
	Student	54	2.70
	Unemployed	218	10.90
	Other	11	0.60
Geographical groups			
Seoul-si (province)	Group 1[a]	200	10.00
Pusan-si	Group 2[b]	130	6.50
Daegu-si	Group 2	120	6.00
Incheon-si	Group 1	120	6.00
Gwangju-si	Group 4[d]	105	5.25
Daejeon-si	Group 3[c]	105	5.25
Ulsan-si	Group 2	100	5.00
Kyunggi-do	Group 1	220	11.00
Gangwon-do	Group 5[e]	110	5.50
Chungcheongbuk-do	Group 3	110	5.50
Chungcheongnam-do	Group 3	115	5.75
Jeollabuk-do	Group 4	110	5.50
Jeollanam-do	Group 4	110	5.50
Gyeongsangbuk-do	Group 2	120	6.00
Gyeongsangnam-do	Group 2	125	5.26
Jeju-do	Group 6[f]	100	5.00

[a] Respondents were divided into six groups by geographic proximity according to administrative classification in Korea: Seoul-si, Incheon-si, and Kyunggi-do were categorized as Group 1.
[b] G2: Pusan-si, Daegu-si, Ulsan-si, Gyeongsangbuk-do, and Gyeongsangnam-do were categorized as Group 2.
[c] G3: Daejeon-si, Chungcheongbuk-do, and Chungcheongnam-do were categorized as Group 3.
[d] G4: Gwangju-si, Jeollabuk-do, and Jeollanam-do were categorized as Group 4.
[e] G5: Gangwon-do was categorized as Group 5.
[f] G6: Jeju-do was categorized as Group 6.

3.3.1. Public perception level and routes of recognition

The first part of the questionnaire consisted of public perception levels and how the respondent had learned of the D-to-D service. All respondents were asked whether they knew about the D-to-D service as a route for collecting end-of-life home appliances free of charge. Then, respondents who were aware of the D-to-D service were asked about

routes of recognition available to learn about the D-to-D service. Finally, the respondent chose the most effective method in their opinion that should be utilized to recognize the D-to-D service.

3.3.2. User satisfaction level with the D-to-D service

The second part of the questionnaire was designed to investigate the level of user satisfaction and specific reasons to be satisfied for those respondents who had used the D-to-D service at least once. The satisfaction level was measured, targeting respondents who answered that they had experience using D-to-D service, using a 4-point scale ranging from satisfaction to dissatisfaction. If a respondent indicated they were satisfied with the D-to-D service, they were further asked the reason or reasons for rating their level of satisfaction as high; respondents could choose one or more options from a list of seven choices.

3.3.3. PR related to the D-to-D service

The third part of the questionnaire investigated the PR level of the D-to-D service and was administered to all respondents regardless of whether or not they had experience using the D-to-D service. Respondents were asked their opinion on current PR activities surrounding the D-to-D service using a 5-point scale ranging from enough to not enough publicity. Respondents were additionally required to answer whether it was necessary to add to or strengthen current PR strategies to raise public awareness of the D-to-D service. The answers for the secondary question were selectively categorized based on a 5-point scale.

3.3.4. Mean test by group characteristics

After data collection, a mean analysis (*t*-test) was conducted to determine whether there were statistically significant differences between respondents in our main survey results for public perception, user satisfaction, PR levels and the necessity of PR activities. In short, we evaluated the statistical significance between survey result and social-factors, age and region, by using *t*-test in order to use them as a basis for establishing strategies to improve future service. For implementing the *t*-test, age group of “over 60 age” was divided into two groups which their 60 s and 70 s group, because number of respondents in "over 60 age" was the largest group (n = 580) than other age groups. After group dividing, thoroughly observe differences in response characteristics for public perception, user-satisfaction, PR level, and PR necessity as compared to other age groups. The *t*-test was performed using the mean value of raw data on a scale of 3–5 points. However, because the number of samples of the respondents varied by age and region, an un-paired *t*-test is conducted.

4. Results

4.1. Geographic composition of questionnaire respondents

The basic characteristics and geographical composition of the respondents are listed in Table 1. Total respondents were chosen across Korea, with the number of respondents ranging from 100 (Ulsan-si) to 220 (Kyunggi-do) based on the population of each area. The survey included 16 regions comprised of target cities (or provinces) categorized into six groups: Group 1 comprised nearly 27% (n = 540) of the total respondents from Seoul-si, Incheon-si, and Kyunggi-do; Group 2 comprised 28.76% (n = 595) of the total respondents from Pusan-si, Daegu-si, Ulsan-si, Gyeongsangbuk-do, and Gyeongsangnam-do; Group 3 comprised approximately 16.5% (n = 330) of the total respondents from Daejeon-si, Chungcheongbuk-do, and Chungcheongnam-do; Group 4 comprised 16.25% (n = 325) of the total respondents from Gwangju-si, Jeollabuk-do, and Jeollanam-do; Group 5 comprised 5.50% (n = 110) of the total respondents from Gangwon-do; and Group 6 comprised 5.25% (n = 105) from Jeju Island.

4.2. Demographic composition of questionnaire respondents

The demographic composition of the respondents was 49.3% (n = 986) male and 50.7% (n = 1014) female as listed in Table 1. The respondents’ ages were grouped into five categories which were as follows: the first group, 15–29 years of age, comprised 8.9% (n = 178); the second group, 30–39 years of age, comprised 22.7% (n = 454); the third group, 40–49 years of age, comprised 22.7% (n = 454); the fourth group, 50–59 years of age, comprised 22.3% (n = 446); and the fifth group, respondents 60 years of age and over, comprised 29.0% (n = 580) of the total respondents. In the group of individuals over 60, 337 respondents were in their 60 s, and 243 respondents were in their 70 s or older.

In terms of job status, the *Office/Management Worker* made up the highest number of total respondents at 34.0% (n = 681). The *Manufacturer/Sales/Service Worker* and *Homemaker* groups were 27.2% (n = 544), and 24.6% (n = 492) respectively. The remaining groups included *Unemployed* (10.9%, n = 218); *Student* (2.7%, n = 54); and *Others* (0.6%, n = 11).

4.3. Public perception

In the public perception survey component, responses took the form of a 3-point scale, which included *Very Acquainted*, *Somewhat Acquainted*, and *Not Acquainted*. We considered the respondents who replied either *Very Acquainted* or *Somewhat Acquainted* as awarded-respondent for the D-to-D service, while respondents who replied as *Not Acquainted* were considered unawarded-respondents. In the survey results, 964 respondents (48.2%) were aware of the D-to-D service and the remaining 1036 respondents (51.8%) were not aware of the D-to-D service (Table 2).

In terms of demographic characteristics such as gender, age, and region, the results are summarized as follows: female respondents (50.2%) were more aware of the D-to-D service than male respondents (46.1%) by gender. Respondents in the 40–49 years old age group (62.1%) expressed the highest rate of public perception for the D-to-D service, followed by the 50–59 years old age group (55.4%), followed by the 30–39 year old age group (54.4%), the 60 years of age and older age group (34.7%), and finally the 15–29 year old age group (27.0%). The region with the highest rate of public perception of the D-to-D service was Region 6 (Jeju-do) scoring 51.0%. In decreasing order, the regional results were as follows: Region 2 (Pusan-si, etc., 50.9%); Region 5 (Gangwon-do, etc., 49.1%); Region 1 (Seoul-si etc., 48.3%); Region 3 (Daejeon-si etc., 44.2%); and Region 4 (Gwangju-si etc., 42.8%) (Table 2).

A mean comparison (*t*-test) test was conducted to investigate the differences of public perception between several groups, mainly variables of age and region. The *t*-test of public perception related to different age groups of the respondents showed no significant difference in public perception between respondents in their 30 s and 50 s and a significant difference (*p-value* $\leq$ 0.10 or 0.05) between respondents in all other age groups (Table S5; see Supplementary). A *t*-test investigating differences between regional groups showed a significant difference between some groups ($p \leq 0.10$ or 0.05) as follows: G2 and G3 ($p \leq 0.05$), G2 and G4 ($p \leq 0.05$), G1 and G4 ($p \leq 0.10$) and G4 and G6 ($p \leq 0.10$) (Table S5; see Supplementary).

4.4. Route of the D-to-D recognition

The 964 respondents who responded that they were aware of the D-to-D service were then asked where they learned about the service. The highest cited source of recognition was *Mass Media* (24.0%), followed by *Promotional Literature* (19.2%), promotional materials distributed by KERC, and *Inquiries to Local Government* (18.7%). The two next highest sources were very similar with respondents scoring *Acquaintances* at 14.8% and *Internet Searches* at 14.0%. The two lowest sources included

Table 2
Public perception for the D-to-D service based on respondents' social characteristics.

Categories		Number	Response Rate Percentage (%)			
	Response	No. of Respondents (n = 2000)	*Very Acquainted*	*Somewhat Acquainted*	*Not Acquainted*	Perception Rate[a]
Gender	Male	986	19.5	26.6	53.9	46.1
	Female	1014	20.2	30.0	49.8	50.2
Age Range	15–29	178	8.5	18.5	73.0	27.0
	30–39	342	20.2	34.2	45.6	54.4
	40–49	454	24.0	38.1	37.9	62.1
	50–59	446	23.6	31.8	44.6	55.4
	> 60	580	17.1	17.6	65.3	34.7
Region	Group 1 (Seoul-si, etc.)	540	18.5	29.8	51.7	48.3
	Group 2 (Pusan-si, etc.)	595	19.2	31.7	49.1	50.9
	Group 3 (Daejeon-si, etc.)	330	19.4	24.8	55.8	44.2
	Group 4 (Gwangju-si, etc.)	325	18.5	24.3	57.2	42.8
	Group 5 (Gangwon-do, etc.)	110	24.6	24.5	50.9	49.1
	Group 6 (Jeju-do, etc.)	100	23.1	27.9	49.0	51.0
The rate of the public perception for D-to-D service	**48.2**[a]					

[a] Bold indicates the public perception rate as the sum of *Very Acquainted* and *Somewhat Acquainted* response rates or 48.2% (*Not Acquainted* rate: 51.8%).

Blogs & SNS (4.1%), and *Others/Don't Recall* (5.2%).

The most interesting result is that of respondents with experience using the D-to-D service. They were more likely to be aware of the D-to-D service through *Inquiries to Local Government* (32usti.1%) and *Internet Searches* (22.3%) than to others such as *Mass Media* (11.6%) and *Promotional Literature* (13.4%) (Table S6; see the Supplementary). This result indicates not only that those who want to properly dispose of end-of-life appliances successfully found a convenient disposal method through making inquiries to their local government and searching for themselves, but that additional or continuous marketing activities are needed to increase public awareness and recognition of the D-to-D service.

The survey of public perception of the D-to-D service has been conducted annually since 2015, and the results are shown in Fig. 1. The status of public perception of the service, which was 39.2% in 2015, increased to 42.6% in 2016, and continued to increase to 48.2% in 2017. At the present time, one in two people in Korea are aware of the D-to-D service. The number of samples in 2015 and 2016 were 1200 and 1,500, respectively. In the 2015 and 2016 surveys the criteria for classifying respondents' social characteristics including gender, age, and geographic characteristics were the same as those used in the 2017 survey (Groups 1–6, described in *3.1. Geographic Composition of Questionnaire Respondents* and listed in Table 1).

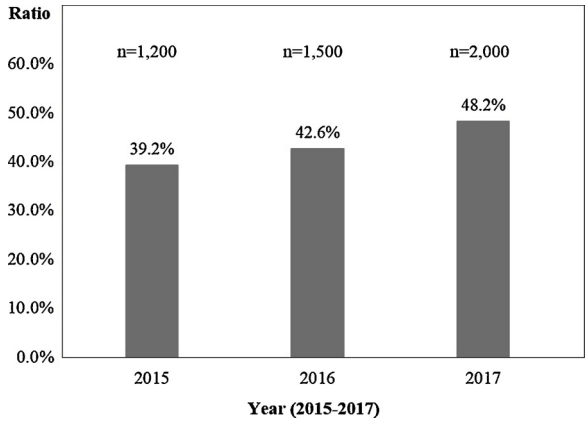

Fig. 1. Survey results from the *public perception* of D -to-D service surveyed 1200, 1,500, and 2000 samples in last three years (2015–2017); this indicated that awareness was steadily increased in during that period.

4.5. User satisfaction level

Only 114 respondents (5.7%) had experience using the D-to-D service (Table 3). Satisfaction level was surveyed for these respondents based on a 4-point scale, which revealed the following results: *Very Satisfied*, 54.8% (n = 62); *Satisfied*, 35.9% (n = 41); *Neutral*, 6.7% (n = 8); and *Not Satisfied*, 2.8% (n = 3). In total, 90.7% (n = 103) of respondents were satisfied using the D-to-D collecting service. This means that actual users of the D-to-D service were extremely satisfied with it.

The result of a t-test for user-satisfaction of D-to-D service depending on the age groups showed that there was no significant difference between any group ($p \leq 0.05$). However, results of a t-test examining differences by region showed that there were significant differences between four pairs of groups: G1 and G2 ($p \leq 0.05$), G1 and G6 ($p \leq 0.10$), G2 and G4 ($p \leq 0.10$) and G2 and G5 ($p \leq 0.10$) (Table S7; see Supplementary). This can be explained by comparing each mean value. Based on the overall average of 4.534 (5-point indicating "Very Satisfied"), means values in the G1 (*mean* = 4.682), G4 (4.625), and G5 (4.888) groups were relatively higher than overall average or the other groups that G2 (4.286), G3 (4.429), and G6 (4.385) (Table S7; see Supplementary).

The vast majority of respondents (90.7%) had a positive experience with the D-to-D end-of-life appliance pickup service and offered their reasons for satisfaction with the service. The most important reason cited was that the service was *Free* (43.5%), followed by *Direct Communication* between the service customer and the collector during the process (26.6%). Three additional reasons were mentioned at similar rates, including *Speedy Customer Service* (8.7%), the ability of the customer to *Adjust the Visiting Schedule* by contacting the collector (8.2%), and *Customer Convenience* (7.7%). However, only 5.2% of respondents specified *Kindness* as a reason for satisfaction with the service. More specific results for respondents' satisfaction are listed in Table S8 (see the Supplementary).

4.6. Public relations satisfaction level

All respondents (n = 2000) were asked to specify their level of satisfaction with the current PR levels of the D-to-D service using a 5-point scale with the following values: 1-point indicating *Very*

Table 3
User-satisfaction for the D-to-D service based on respondents' social characteristics.

Categories		Number	Response Rate Percentage (%)			
Response		No. of Respondents (n = 112)	*Very Satisfied*	*Satisfied*	*Neutral*	*Not Satisfied*
Gender	Male		51.0	38.8	8.2	2.0
	Female		58.7	38.1	1.6	1.6
Age Range	15–29		44.4	34.7	16.4	4.5
	30–39		52.6	37.2	10.2	–
	40–49		57.1	35.7	6.2	–
	50–59		54.1	40.5	4.1	1.3
	> 60		56.0	32.0	4.0	8.0
Region	Group 1		66.7	29.3	3.1	0.9
	Group 2		47.5	44.5	6.8	1.2
	Group 3		57.5	35.0	5.0	2.5
	Group 4		52.5	34.2	11.8	1.5
	Group 5		70.8	22.8	6.0	0.4
	Group 6		44.1	42.9	5.9	7.1
Average rate (%) for each satisfaction level			**54.8**	**35.9**	**6.7**	**2.8**

Table 4
Current PR level for the D-to-D service based on respondents' social characteristics.

Categories		Number	Percentage (%)							
		No. of respondents (n = 2000)	1[a]	2[b]	3[c]	4[d]	5[e]	Positive[f]	Negative[f]	Mean[g]
Gender	Male	986	28.0	35.8	22.5	9.8	3.9	13.7	63.8	2.3
	Female	1014	23.8	33.6	25.5	12.1	4.9	17.1	57.4	2.4
Age Range	15–29	178	24.7	41.0	25.9	6.7	1.7	8.4	65.7	2.2
	30–39	342	28.7	34.5	23.7	9.9	3.2	13.2	63.2	2.2
	40–49	454	23.6	35.2	27.8	11.7	1.7	13.4	58.8	2.3
	50–59	446	22.9	36.3	23.5	11.9	5.4	17.3	59.2	2.4
	> 60	580	28.6	31.2	21.2	11.8	7.2	19.0	59.8	2.4
Region	Group 1	540	28.3	36.9	21.1	10.7	3.0	13.7	65.2	2.2
	Group 2	595	23.5	33.4	25.7	12.6	4.8	17.3	57.0	2.4
	Group 3	330	26.4	34.2	26.7	8.8	3.9	12.7	60.6	2.3
	Group 4	325	25.8	35.4	24.3	8.6	5.8	14.5	61.2	2.3
	Group 5	110	22.7	39.1	19.1	11.8	7.3	19.1	61.8	2.4
	Group 6	100	28.0	25.0	26.0	17.0	4.0	21.0	53.0	2.4
Cognition-status	Well-	964	12.7	31.3	33.4	16.2	6.4	22.6	44.0	2.7
	Some-	1036	38.1	37.9	15.3	6.2	2.5	8.7	76.0	2.0
Experience of use of D-to-D	Use	112	6.3	27.8	27.7	24.1	14.3	38.4	33.9	3.1
	Not-use	1,888	27.0	35.1	23.9	10.2	3.8	14.0	62.1	2.3
Average rate (%) for each cognition path			**24.6**	**34.3**	**24.4**	**11.8**	**4.9**	**16.7**	**58.9**	**2.4**

[a] 1 indicates the answer as Completely not good about the question as "How satisfied are you with the current PR level for 'Door-to-Door' service?" .
[b] 2 indicates the answer as Not good about the same question as above.
[c] 3 indicates the answer as Neutral about the same question as above.
[d] 4 indicates the answer as Good about the same question as above.
[e] 5 indicates the answer as Very good about the same question as above.
[f] Response numbers 1 & 2 were categorized as "Negative", and numbers 4 & 5 were categorized as "Positive".
[g] Mean values of the total response numbers from 1 to 5.

Unsatisfied, 2-point indicating *Not Satisfied*, 3-point indicating *Neutral*, 4-point indicating *Satisfied*, and 5-point indicating *Very Satisfied*. The results show that 34.3% (n = 685) of respondents chose the 2-point score, *Not Satisfied*. The next highest responses were *Very Unsatisfied* and *Neutral* opinions with 24.6% (n = 491), *Satisfied* (11.8%, n = 235), and *Very Satisfied* (4.9%, n = 98). To generalize, 1178 respondents (58.9%) were unsatisfied with the current PR level, while only 333 respondents (16.7%) stated that the PR level for the D-to-D service was satisfactory. On the other hand, 24.4% (n = 488) of respondents answered that they do not know whether they're satisfied. The mean value of the 5-point scale based on the 2000 respondents averaged 2.4 (Table 4). There were significant differences between the group of individuals who were 15–29 years old and those in their 40 s ($p \leq 0.10$), 50 s ($p \leq 0.05$), 60 s ($p \leq 0.10$) and 70 s ($p \leq 0.05$). Also, the mean value of the group in their 30 s was significantly different from the group in their 50 s ($p \leq 0.05$) and the group in their 70 s ($p \leq 0.05$). When examining differences by region, there were significant differences between four pair-groups: G1 and G2 ($p \leq 0.05$), G1 and G4 ($p \leq 0.10$), G1 and G5($p \leq 0.05$) and G2 and G3($p \leq 0.10$). This indicates not only that current PR level for the D-to-D service was not satisfied with the expectation of the respondents, but also that this trend was relatively strong in the 15–29 years old group and in regions such as G1 (Seoul-si, etc.) and G2 (Busan-si, etc.) (Table S9; see Supplementary).

Interesting results emerged from the subset of 114 survey respondents who had used the D-to-D service. In that subset, 43 respondents (38.4%) felt the current PR level was satisfactory, while 38 respondents (33.9%) stated the current PR level was unsatisfactory. This result indicated that those with experience using the D-to-D service found a higher level of satisfaction from the PR standpoint, while those without experience of the service were less likely to be satisfied with the current PR level for the D-to-D service (Table 4).

4.7. Necessity of the public relations activities

All respondents (n = 2000) were asked about the necessity of additional PR activities using mass media for the D-to-D service. The

Table 5
Survey results of the necessity of PR activities for D-to-D service based on respondents' social characteristics.

Categories		Number	Percentage (%)							
		No. of respondents (n = 2000)	1[a]	2[b]	3[c]	4[d]	5[e]	Positive[f]	Negative[f]	Mean[g]
Gender	Male	986	1.1	3.4	9.4	35.0	51.1	86.1	4.5	4.31
	Female	1014	0.7	2.8	10.5	41.2	44.8	86.0	3.5	4.27
Age Range	15–29	178	0.0	3.9	19.1	44.4	32.6	77.0	3.9	4.06
	30–39	342	1.5	2.9	12.9	35.1	47.6	82.7	4.4	4.25
	40–49	454	0.7	2.2	9.0	38.5	49.6	88.1	2.9	4.34
	50–59	446	0.4	2.2	6.8	36.3	54.3	90.6	2.6	4.42
	> 60	580	1.4	4.3	8.6	39.1	46.6	85.7	5.7	4.25
Region	Group 1	540	1.1	3.1	12.2	38.1	45.5	83.6	4.2	4.24
	Group 2	595	1.3	3.1	11.6	36.2	47.8	84.0	4.4	4.28
	Group 3	330	1.8	3.9	9.4	38.2	46.7	84.9	5.7	4.24
	Group 4	325	0.3	3.4	7.1	40.6	48.6	89.2	3.7	4.34
	Group 5	110	0.0	2.7	4.5	33.6	59.2	92.8	2.7	4.49
	Group 6	100	0.0	3.0	8.0	33.0	56.0	89.0	3.0	4.42
Cognition-status	Well-	964	0.8	3.1	10.3	38.1	47.7	85.8	3.9	4.29
	Some-	1036	1.0	3.1	9.7	38.2	48.0	86.2	4.1	4.29
Experience of use of D-to-D	Use	112	0.0	5.4	10.7	38.4	45.5	83.9	5.4	4.24
	Not-use	1888	1.0	3.0	9.9	38.1	48.0	86.1	4.0	4.29
Average rate (%) for each cognition path			**0.8**	**3.3**	**10.0**	**37.8**	**48.2**	**86.0**	**4.0**	**4.30**

[a] 1 indicates the answer as Completely not need the additional Public Relation (PR) activity about the question that "Do you think need additional PR activities?".
[b] 2 indicates the answer as Not need about the same question as above.
[c] 3 indicates the answer as Neutral about the same question as above.
[d] 4 indicates the answer as Need about the same question as above.
[e] 5 indicates the answer as Very need about the same question as above.
[f] Response numbers 1 & 2 were categorized as "Negative", and numbers 4 & 5 were categorized as "Positive".
[g] Mean value of the total response numbers from 1 to 5.

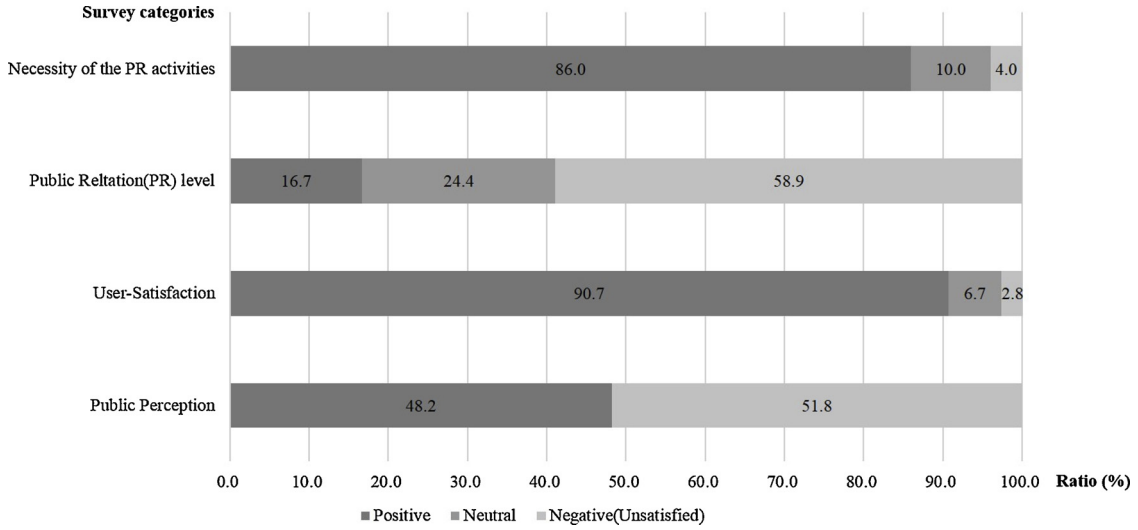

Fig. 2. Summary of the response results for *Public perception*, *User-satisfaction*, *PR level*, and *Necessity of the PR activities*; types of the answer were divided into three such as Positive (i.e., *acquainted*, *Satisfied*), negative (i.e., *not-acquainted*, *not-Satisfied*), and Neutral (*unknown*,).

results used a 5-point scale, ranging from 1-point meaning *Very Unnecessary* to 5-points meaning *Very Necessary*; the higher the point value, the higher the expressed PR requirement. With regards to necessity, 964 respondents (48.2%) felt that more PR activities for the D-to-D service were greatly required, and 755 respondents (37.8%) stated that activities were needed across all types of media, indicating that most respondents (86%, n = 1719) felt there was a need for additional PR activities for the D-to-D service. On the other hand, 200 respondents (10%) were neutral with regards to the necessity for any additional PR activities. Only 81 respondents responded that PR activities were unnecessary—among them, 65 respondents (3.3%) responded with *Unnecessary*, and another 16 respondents (0.8%) responded with *Very Unnecessary* (Table 5). Response results about that not only the necessity of PR activities, but also public perception, user-satisfaction, and current PR were simply summarized in Fig. 2.

According to the t-test result in the PR necessity part, Respondents who were mainly in their 40 s, 50 s and 60 s age group and in both G4 and G5 regions emphasized that additional PR activities of D-to-D service is highly needed to the public. In comparing the necessity of PR activities by age group, our results show that individuals between 15–29 years old showed significant differences from all other groups ($p \leq 0.05$ or 0.10), except the group including individuals in their 70 s ($p = 0.240$). Individuals in their 30 s, 40 s and 50 s also were significantly different from all other groups ($p \leq 0.05$ or 0.10), except those in their 60 s ($p \geq 0.10$). Individuals in their 60 s were significantly different when compared to those aged 15–29 years ($p = 0.000$) and those in their 70 s ($p = 0.001$).

Regarding regional (groups) differences in necessity of PR activities, There were significant differences in the nine groups in the total of fifteen pairs of groups, and no significant difference was found in other

six groups. In the Table S7 (see the Supplementary), overall average was 4.335 (5-point indicating "Very necessary"), and the G5 (*mean* = 4.491), G6 (4.420), and G4 (4.338) groups were relatively higher than overall average or the other groups such as G1 (4.235), G2 (4.284) and G3 (4.239); implying that respondents who inhabited in three (G5, G6, and G4) region strongly insisted that additional PR activities is very needed to public. As the categorization depending on mean values of the groups, there were no significant differences ($p \geq 0.10$ or 0.05) in the lower mean groups as follows; G1-G2 ($p = 0.165$), G1-G3 ($p = 0.473$), G2-G3 ($p = 0.224$) respectively. Like the low mean groups, there also were no significant difference ($p \geq 0.10$ or 0.05) in the between high mean groups such as G4-G6 ($p = 0.180$) and G5-G6($p = 0.244$) respectively. However, groups 2 (*mean* = 4.284) and group 4 (4.338) were categorized by overall average (4.335) to relatively high and low, but the two values were not significantly different due to close the overall average thus, the *t*-test analysis revealed no significant ($p = 0.165$) differences between the groups.

5. Limitations and suggestions

This study has some limitations due to the use of the CATI method. The authors utilized an external specialist group for CATI to reduce human errors. To complete a perfect telephone survey, excellent and fast typing skills are required, and the authors clearly recognize that human errors cannot be avoided during the telephone communication.

In terms of content for the EPR system in Korea, the authors tried to communicate in depth the current state of the EPR system and WEEE collecting and recycling in Korea. We have not been able to deliver full information for the informal sector of Korea. There are limitations not only due to insufficient statistical data, but also due to difficulties obtaining consent for field investigations. However, the authors do not intend to indiscriminately criticize the informal sector, which is obviously a large WEEE collection and recycling route in Korea. This study should be interpreted as expressing concern about some cases that can cause extremely harmful effects to the environment or humans, not as a criticism of private recyclers' rights to collect and recycle WEEE properly in the informal sector.

In this study, respondents who were either group 15–29 years old or over in their 70 s were less aware of the D-D service and responded that the level of PR for the service was insufficient. This is clear evidence depicting significant differences between age groups, and it should serve as motivation for improving public perception of the D-to-D service. This study highlights that television and radio are the most efficient means for PR of D-to-D service, but also emphasizes that additional PR activities are needed for vulnerable age groups, such as people between 15–29 years and over 70 years. Promotion of D-to-D services could be enhanced by using SNS, mobile (card) news, and development of emoticons for the famous mobile messenger (i.e., "Kakao-Talk" and "Line") to target individuals between 15–29 years of age. Also, we propose publishing promotional materials in daily newspapers to target individuals over 70 years of age.

The user satisfaction level of the D-to-D service was an average of 90.7% (for '*very satisfied*' and '*satisfied*'), which indicates that most of the users were satisfied with this service. On a five-point scale questionnaire, 114 users with experience in the use of D-to-D service responded with an average score of 4.434 (5 point indicated '*very satisfied*'). Even with the *t*-test results divided by age groups, there were no significant differences in user satisfaction. However, there were statistically significant differences in user satisfaction depending on the region. The *t*-test results showed that mean values, in 5-point scale surveys, of G2 (Busan-si, etc. *mean* = 4.286), G6 (Jeju-do, *mean* = 4.385) and G3 (Daejeon-si, etc. *mean* = 4.429) were lower than total averages including other regions (*mean* = 4.434) of respondents. We can infer a need to monitor the customer response status of the visiting engineer in these area because, aside from an advantage of being free of this service, customers prefer the advantage of being able to book and communicate directly with visiting engineers. In particular, according to Table S8 (See Supplementary), the most important satisfaction factor for respondents in both G3 (57.9%) and G6 (58.3%) regions was the "free cost". Also, this opinion rate, in G3 and G6, of the "free cost" were relatively higher than overall average (43.5%). However, it is not positive signal because "free of charge" was an inherent characteristic of the D-to-D service, apart from the customer interactions of the visiting engineer. Thus, this study can help to classify regions with low user satisfaction (service quality) and help develop an appropriate strategy to improve.

As mentioned earlier, group under the age of 29 showed relatively low public perception (27.0%, *mean* = 1.730) than other age groups (51.6%, *mean* = 1.524) in the Table 2 and Table S5 (see the Supplementary) respectively. This is also consistent with *t*-test results examining the current PR level of the D-to-D service, as individuals under the age of 29 expressed significantly more negative opinions about D-to-D service PR level than other age groups. However, this similarity between public perception and PR level was not seen in the group over age 70. The mean value (mean = 2.416) of the group of over 70 was relatively higher than the mean value (2.324) from all groups, so the group over age 70 viewed D-to-D service PR levels in a relatively positive way (no need additional PR activities). Obviously, it is common fact that respondents in the group with low awareness to D-to-D service will require additional PR activities but, this phenomenon was not observed in the group in their over 70 s. this non-symmetric responses between public perception and PR necessity parts, opposite the results of public perception, can be seen the only over 70 s group. Here, we can carefully estimate the asymmetry of the response as due to human error in the respondent group because this asymmetry occurred from the oldest group (over the 70 years old). This reasoning provides a basis for analogy because the homogeneity of responses in individuals in their 30 s, 40 s and 50 s is maintained to some extent and does not show extreme opposition (Table S5, Table S10).

6. Conclusions

The main purposes of our study were to investigate public perceptions and user-satisfaction with the D-to-D service managed by MOE and KERC and to gather public opinion on the necessity for additional PR activities for aiming to improve service quality of D-to-D system. This study implemented a telephone survey using the CATI method nationwide in South Korea in 2017 to establish a strategy for improving and expanding the D-to-D collection method, one of the WEEE collecting channels in Korea.

Based on the survey results, we determined that the D-to-D service is increasingly well-known throughout Korea. In our survey, 48.2% of respondents were aware of the existence and operation of the D-to-D service, which was the highest level of awareness in the previous three years. The most effective route of D-to-D recognition was mass media such as television and radio (24.0%), followed by promotional literature (19.2%), inquiries to local authorities (18.7%), acquaintances (14.8%), and internet (14.0%). However, users described a few online paths such as blog and Social Network Service (SNS) (4.1%) as relatively low-level information sources, illustrating the need for more PR activities targeting online paths.

Our results demonstrate that satisfaction level of actual users of the D-to-D service is high, with 90.7% expressing *Satisfied* or *Very Satisfied* opinions. The survey reveals that the greatest perceived advantages of the D-to-D service include that the service was free of charge (43.5%) and that it provided a direct contact system between customers and visiting engineers (26.6%). Three additional reasons were cited at a similar rate, including provision of speedy customer service (8.7%), the ability to adjust the visiting schedules (8.2%), and convenience (7.7%). Interestingly, despite the fact that kindness is an important requirement in providing customer satisfaction, kindness as a factor scored very low (5.2%). However, based on the suggested plan to include teaching

content related to kindness to visiting engineers, this weak point should be systematically overcome.

According to the survey results, the overall perceived level of PR was quite unsatisfactory, with results of *Dissatisfaction* at 58.9% and *Satisfaction* at 16.7%. However, in the case of respondents with actual experience as a D-to-D service user, the PR level is not heavily skewed, with similar PR levels of 33.9% (*Satisfaction*) and 38.4% (*Not-satisfaction*). This demonstrates that respondents who have already used D-to-D service are less likely than others to feel there is a lack of publicity for the service they already know. On the other hand, 86.0% of respondents recommended that additional PR activities for the D-to-D service were very necessary across all media types.

Since the D-to-D service started in 2014, the annual usage rate, criteria in the volume of WEEE collected, of the service as a percentage of the total amount of WEEE collecting events in the formal sector steadily increased to 27.3% in 2017. To continuously improve the D-to-D service as a well-constructed WEEE collecting channel, this study will be utilized as important evidence to contribute the establishing the future plan of WEEE collection strategies by defining public perception, user satisfaction, PR level, and necessity of additional PR activities for D-to-D service. Our research demonstrates an important need for additional PR activities about the D-to-D service to the public, especially using mass media such as television or radio, powerful means. We confirmed that consumers who actually use the D-to-D services express a high level of satisfaction and PR response and recommend that visiting engineers receive kindness education or training for maintaining and improving the high customer satisfaction score. It is expected that raising consumer awareness and PR activities will lead to more environmentally sound behavior and, ultimately, improved WEEE collection efficiency as an alternative collection channel.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resconrec.2019.01.018.

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