

The Effect Of Public Awareness On E-Waste Disposal Practices In Kicukiro District, Kigali City, Rwanda

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Abstract: E-waste is one of the most emerging environmental problems in cities and the effectiveness of management systems largely depends on users' understanding of the dangers of e-waste and appropriate ways and places for its disposal. The current study sought to examine the influence of public awareness on e-waste disposal behavior in the district of Kicukiro, Kigali city, Rwanda. A mixed research approach entailed the use of structured questionnaire and key informant interviews. In all, 384 questionnaires were administered in the districts of Kicukiro, Gikondo, Kigarama and Gatenga and 356 valid questionnaires were received with a response rate of 92.7%. Quantitative data analysis involved the use of descriptive statistics and Pearson correlation while thematic analysis was used to analyze qualitative data from interviews. Findings revealed that 78.7% of the participants had heard about e-waste but environmentally undesirable behaviors were evident: 30.9% kept e-waste in their houses, 25.3% mixed them with household waste and 21.1% sold them to informal e-waste collectors while only 7.0% used collection centers. Lack of collection centers was the major problem (36.5%), lack of awareness (25.3%), poor enforcement (16.9%), costs (11.2%) and convenience (10.1%). Awareness showed a significant and positive relationship with proper disposal behavior ($r = 0.64$, $p < 0.001$). The interviews revealed that awareness was more of general nature than practical and that behavior was largely influenced by infrastructure, enforcement, and convenience. The research comes to the conclusion that while awareness is necessary, it alone is not sufficient, and that education needs to go hand-in-hand with provision of accessible means for collecting e-waste, along with better implementation of regulations and take-backs by producers.

Keywords: E-waste; Public awareness; Disposal practices; Recycling & Environmental management

1. Introduction

The rapid adoption of electrical and electronic devices has led to an equivalent growth in end-of-life products, resulting in electronic waste becoming one of the fastest growing waste streams on earth [1]. Electronic waste refers to electrical and electronic equipment which is considered to be obsolete, broken or no longer useful. Contrary to most common municipal wastes [2], electronic waste comprises recyclable material and hazardous material. The metals and other valuable fractions in the waste can be recycled whereas lead, mercury, cadmium, and brominated compounds pose a risk to the environment as well as human health due to burning, disassembly, and disposal of the equipment in inappropriate ways [3]. The problem is especially difficult in the context of rapidly urbanizing poor and developing countries that lack adequate infrastructure and information regarding collection and proper handling of the electronic waste [4]. On the other hand, decisions within households regarding how obsolete items will be stored, repaired, donated, sold, recycled or disposed are based on knowledge, convenience, perceived responsibility,

costs and access to collection facilities [5]. Public awareness, therefore, becomes a significant behavioral dimension of the management of e-waste, yet public awareness does not necessarily mean responsible behavior [6].

The Rwandan government has created the policy framework for managing electronic waste, having invested in recycling capacity through formal channels [7]. Yet, the capital city Kigali remains a major contributor of e-waste from the country owing to its density of population and economic activities as well as high use of electronic appliances [8]. The case of the district of Kicukiro is a good illustration of an urban area in which there are densely populated neighborhoods, institutions, businesses and workshops along with high consumption of electrical and electronic items [9]. The study hence investigated awareness and disposal methods of e-waste in Kicukiro district in relation to each other [10]. In particular, it aimed to: 1) determine the level of public awareness of e-waste; 2) find out the common disposal methods and problems faced due to the inappropriate disposal; and 3) establish the relationship between public awareness and disposal methods.

The study provides local evidence that will help in formulating strategies for educating the public, waste collection systems, and policies on producer responsibility. The study follows the analytical framework of Theory of Planned Behavior, which recognizes the connection between knowledge and attitude with intention and behavior, but understands that perceived behavioral control and opportunities influence the implementation of intentions [11].

2. Materials and Methods

2.1 Description of the Study Area

The research took place in Kicukiro District, which is among the three districts that make up Kigali City in Rwanda [12]. Kicukiro District is an area that experiences very fast growth with regards to urbanization, residential development, business activities, education facilities, public and private institutions, and industries/services provision. All these factors increase the level of possession of electrical and electronics appliances and the chances of having outdated equipment in homes and institutions. Four sectors Kicukiro, Gikondo, Kigarama, and Gatenga were chosen for the research.

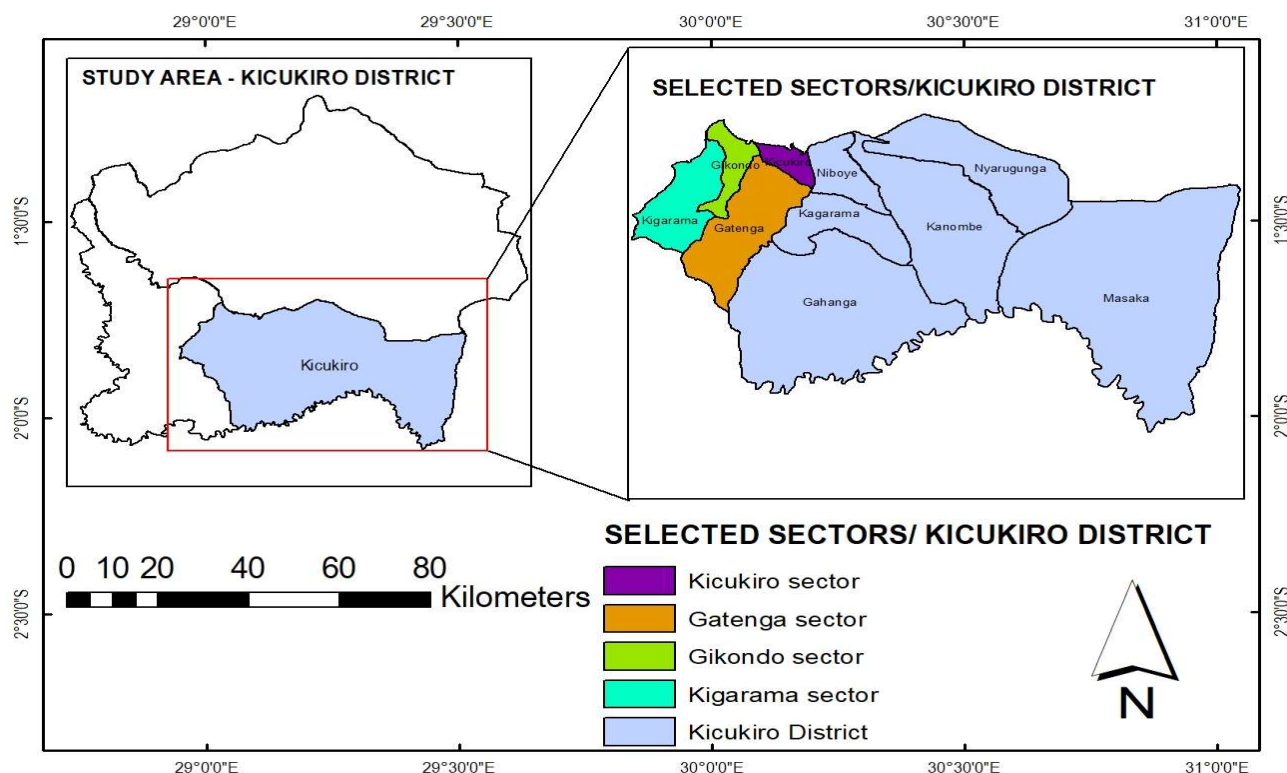


Figure 1. Location of Kicukiro District and the four selected study sectors.

2.2 Research Design and Study Population

A combination of both qualitative and quantitative research designs entailed carrying out a cross-sectional survey and semi-structured interviews respectively [13]. The cross-sectional survey helped to determine awareness and disposal behavior of the respondents, whereas the semi-structured interviews were to obtain the opinions of the institutions regarding disposal. The study population consisted of people/households, public institutions, private institutions, NGOs, workshops within the chosen sectors [14]. The research design was suitable since disposal behavior is quantifiable as well as the continued improper disposal.

2.3 Sampling, Data Collection and Analysis

The study was conducted on a sample size of 384 respondents. In order to have an even distribution of the respondents among the selected sectors, 96 questionnaires were provided to each of the sectors [15]. This was further stratified and purposively sampled to have representation from all the types of generators of e-waste [16]. Out of the total number of 384 questionnaires distributed, only 356 were completed and analyzed giving a response rate of 92.7%.

Table 1. Questionnaire distribution and response rate by sector.

Sector	Distributed	Returned	Response rate (%)
Kicukiro	96	90	93.8
Gikondo	96	88	91.7
Kigarama	96	89	92.7

Gatenga	96	89	92.7
Total	384	356	92.7

Data were collected through the use of structured questionnaires and key informant interviews. The structured questionnaire measured respondents' socio-demographic profile, their knowledge about e-waste, the sources of information, their disposal practices, barriers and their attitude toward e-waste management. Key-informant interviews sought information regarding awareness, institutional roles, the collection system, regulation and implementation challenges. Secondary data were collected from policy and regulatory frameworks as well as existing literature on e-waste management.

Data collected from questionnaires were edited, coded and analyzed using descriptive and inferential statistics. Frequencies and percentages were computed to provide summary measures of socio-demographic profile, awareness level and disposal behavior. Pearson's product-moment correlation was used to measure the direction and strength of the association between awareness level and proper disposal behavior. This was tested for significance at 5% level. Data from interviews were transcribed, coded and analyzed using common themes; qualitative data served as an interpretive source to complement survey findings [17]. Principles of ethics include voluntary participation, confidentiality, anonymity and academic use of the data collected.

3. Results and Discussion

3.1. Respondent Characteristics

The valid sample size was 356 participants. Of the total, 58.98% were female and 41.02% male. The highest number in terms of age fell between 26 to 35 years old (42.13%) followed by 36 to 45 years old (28.09%), 18 to 25 years old (20.22%) and those above 45 years old (9.56%). In terms of education, relatively more respondents have higher education levels: 41.0% secondary education, 38.8% university education, 11.8% primary education and 8.4% postgraduate education.

Table 2. Socio-demographic characteristics of respondents (n = 356).

Variable	Category	Frequency	Percent
Gender	Female	210	58.98
	Male	146	41.02
Age	18–25	72	20.22
	26–35	150	42.13
	36–45	100	28.09
	Above 45	34	9.56
Education	Primary	42	11.8
	Secondary	146	41.0
	University	138	38.8
	Postgraduate	30	8.4
Respondent type	Public institutions	50	14.04
	Private institutions	128	35.95
	NGOs	40	11.23
	Individuals	138	38.76

The distribution of respondents within economically active age groups is pertinent since these age groups tend to use and buy phones, computers, and household electronic products. This implies that even though the level of formal education is relatively high among the respondents, there could not have been improper disposal due to the lack of education among the respondents. Previous studies have shown that environmental awareness contributes to recycling intentions [18], while participation depends on availability and behavior.

3.2. Level and Sources of Public Awareness

In total, 280 participants (78.7%) claimed that they were aware of the existence of e-waste, whereas 76 participants (21.3%) were unaware. While this proves high awareness of the problem, from the interviews, it was clear that such awareness was often superficial and respondents were able to recognize obsolete electronics as waste while they did not always know about the dangerous elements or proper methods of disposal [19]. Such a difference is vital since the awareness of the harmfulness of e-waste does not equal to an actual method of disposal.

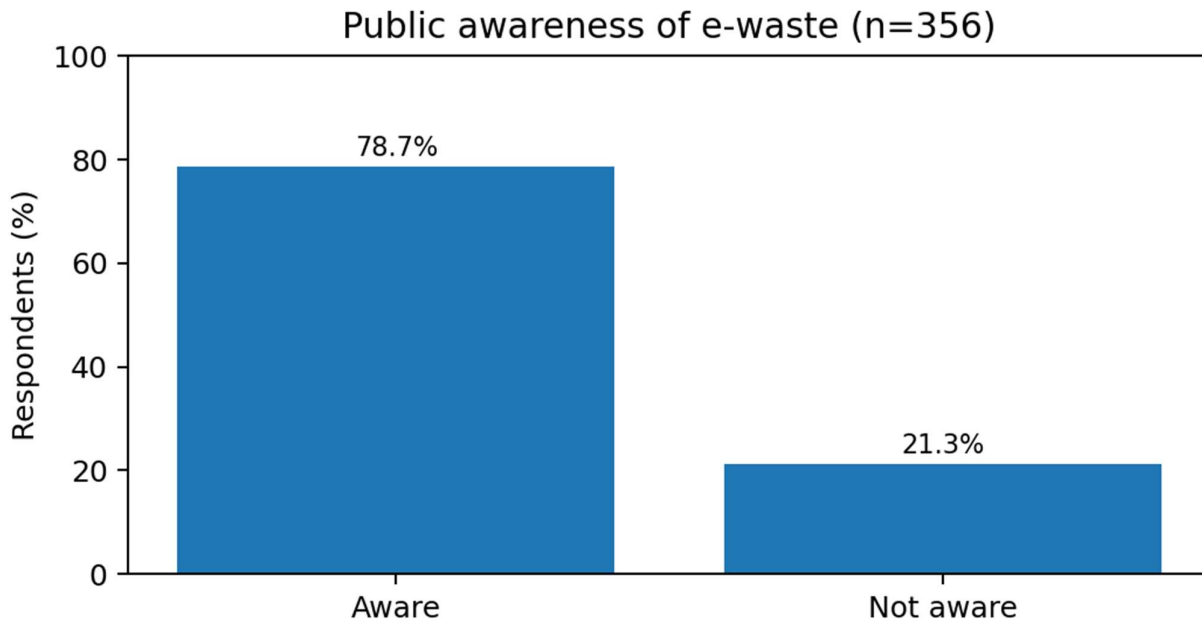


Figure 2. Reported awareness of e-waste among respondents.

Table 3. Main reported sources of e-waste information.

Source	Frequency	Percent
Radio/TV	120	33.7
Social media	85	23.9
Schools	60	16.9
Community meetings	45	12.6
NGOs	30	8.4
Others	16	4.5

The most frequent sources of information were radio and television (33.7%), while the lesser sources were social media (23.9%) and school (16.9%). Meetings at the community level and NGOs accounted for a smaller proportion. It appears that awareness has been created not through educational programs but through mass and informal information dissemination methods [20]. This is significant as unidirectional communication could have led to awareness but does not provide the necessary behavioral cues for waste sorting, storing and handing over to authorized waste collectors [21]. As per findings from environmental-behavioral studies, information alone is less effective in changing behavior if there are no opportunities for the desired action.

3.3. E-Waste Disposal Practices

The survey revealed a combination of recycling methods that are circular and environmentally unsustainable methods of disposing of items. Storage of obsolete electronic devices was found to be the most commonly used method at 30.9%. Twenty-five percent of respondents disposed of their e-waste by mixing it with normal household waste while 21.1% sold obsolete items

to informal collectors. In comparison, repair/reuse was done by 11.2%, collection center use by 7.0%, and donation by 4.5%. The above statistics show that well over three-quarters of the respondents resorted to the three methods.

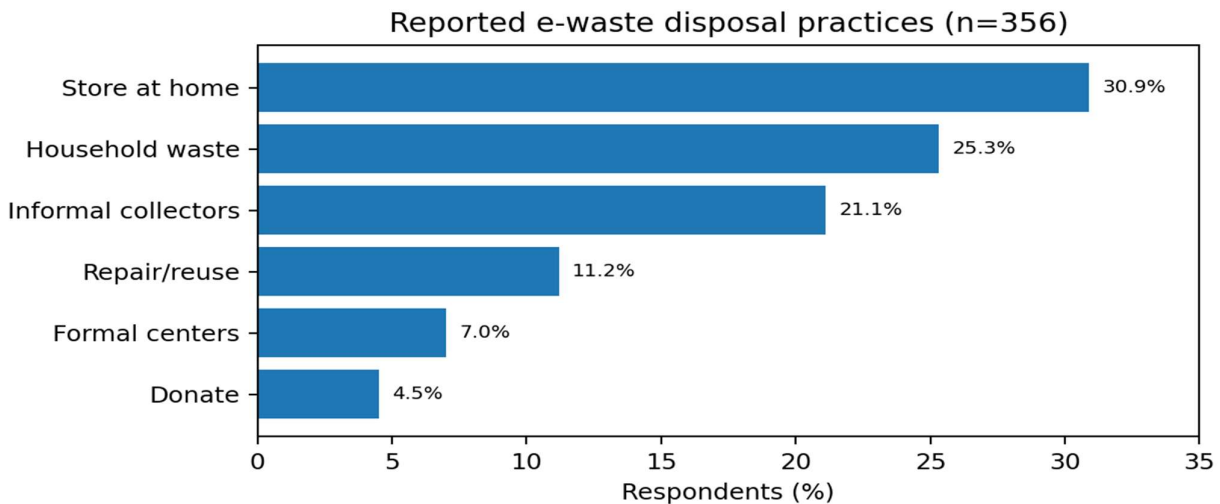


Figure 3. Reported e-waste disposal practices in Kicukiro District.

Table 4. Reported e-waste disposal methods.

Method	Frequency	Percent (%)	Cumulative (%)
Store at home	110	30.9	30.9
Mix with household waste	90	25.3	56.2
Sell to informal collectors	75	21.1	77.3
Repair/reuse	40	11.2	88.5
Formal centers	25	7.0	95.5
Donate	16	4.5	100.0

While home storage delays the environmental release, it leaves the issue for later disposal and may accumulate a backlog of equipment which is not in use. The mixing of electronic waste with regular waste poses a more serious problem since there is an increased chance of harmful components reaching disposal streams [22]. The informal sale may be useful in facilitating repair and recycling but may pose additional risk where there are no regulations on disassembly and recycling. Such risks have been observed in African systems of e-waste where there is a significant economic role of informal activities [23].

3.4. Barriers to Proper Disposal

The lack or unavailability of collection facilities emerged as the main challenge to proper e-waste disposal in this study. Lack of collection facilities was the choice for 36.5%, lack of knowledge 25.3%, lack of enforcement 16.9%, cost 11.2%, and lack of convenience 10.1%. This hierarchy indicates that lack of knowledge is an issue, however, the major obstacle is physical rather than psychological [24]. A person may be aware of e-waste dangers but keep storing their electronic gadgets because the nearest collection center is far away or simply not known to him/her.

Table 5. Reported reasons for improper e-waste disposal.

Reason	Frequency	Percent (%)
Lack of collection centers	130	36.5
Lack of awareness	90	25.3
Weak enforcement	60	16.9
Cost	40	11.2
Convenience	36	10.1

This understanding was further corroborated by the interview data. Public awareness was found to be inconsistent and not practical enough; however, infrastructure, enforcement, coordination and incentives among all the stakeholders were stressed. National policies may define the obligations [25]. however, the actual implementation will depend on collection infrastructure visibility, coordination between institutions and trust in them [26]. These findings are consistent with general findings stating that sustainable e-waste management in developing cities is possible only if infrastructure, governance, financing and user behaviors receive equal attention [27]. In terms of policy implication, awareness campaigns cannot be considered separately from other measures [28]. If an awareness campaign informs people about safe disposal of e-waste but does not communicate where, when and how much it will cost, the campaign might not work. The most effective way to inform people would be through provision of locations for the collection, take back days, retailer or producer returns programs and responsibilities.

3.5. Relationship Between Public Awareness and Disposal Practices

As per the findings from the cross tabulation of the thesis, it was found that the individuals who had greater levels of awareness about the disposal of e-waste would adopt the right approach to disposal by either repairing, recycling, reusing, or adopting the process of formal collection, but the individuals who had less awareness would dispose of e-waste along with their normal waste.

Table 6. Summary of the relationship between public awareness and proper disposal practices.

Statistic	Result	Interpretation
Pearson correlation (r)	0.64	Strong positive association
Significance (p)	< 0.001	Statistically significant
Valid survey responses	356	High-response cross-sectional sample

The correlation coefficient of 0.64 suggests that the higher awareness, the better the behavior of responsible disposal. Statistically significant correlation gives us ground to believe in relevance of the main postulate of the research: the awareness of the problem makes a difference. However, correlation cannot be considered proof of cause-and-effect relations between awareness and better disposal. Barrier results show that access, regulations, and price make the difference as well. This finding must be considered in the context of an overall institutional framework within which the behavioral relation is taking place. This finding fits into the paradigm of the Theory of Planned Behavior, when information/knowledge can help in forming positive attitudes/ intentions but behavior depends on perception of control and enabling factors. It is also consistent with normative approaches where knowledge about negative consequences of actions and responsibility can trigger people's environmental behavior [29]. The message is that the intervention must address all three dimensions: cognitive, normative, and structural ones. People should know why e-waste needs to be handled in a special way, feel responsible for this issue, and have a chance to do that.

3.6. Discussion: Awareness and the Knowledge Action Gap

The key strength of the study is its demonstration of an obvious knowledge-action gap. The knowledge was relatively widespread; however, formal disposal practices were not frequent. Thus, one cannot rely on the assumption widely used in environmental programs, namely that knowledge leads to action automatically. For instance, 78.7% of Kicukiro District residents knew about the problem of e-waste, but only 7.0% used the formal way of their collection. This illustrates that knowledge needs to be assessed regarding its depth and practicality and not just mere awareness of some term.

There may be different reasons behind the existing gap. Firstly, the knowledge gained via radio, TV or social networks may be rather superficial and general. For instance, it may be known that the e-waste is dangerous without knowing the name of collectors, the process of take-back and distinguishing devices which can be repaired from those that have reached the end of their life cycle. Secondly, storage of the devices at home may be reasonable for households due to the following factors: resale value of the device, spare parts or sentimental value. Thirdly, there might be certain costs (time, travel, etc.) involved in formal disposal practices.

These findings align with the results reported internationally showing that the readiness of people to recycle electronics is influenced by their environmental attitude as well as the practicality of the collection process [30]. The findings shed light on why even very educated respondents may resort to inappropriate means of disposal. While education enhances the perception of risks, it does not eliminate logistical barriers. The effective communication process should therefore be solution-oriented by providing specific information on what types of devices are acceptable for disposal, collection centers and their hours of operation, contact information and any incentives provided for bringing back old devices. In the case of Kicukiro district, the findings support moving from awareness to awareness linked with service. This would mean that awareness campaigns should go hand-in-hand with actual collection campaigns. The findings could also inform how program managers evaluate outcomes of these campaigns based on quantitative criteria such as quantities collected, participation rates and repeat use.

3.7. Discussion: Disposal Pathways and Circular-Economy Implications

The prevalence of home storage, mixing of household waste, and informal selling has major repercussions on resource efficiency. Some components and materials from electronic waste can still be put to good use via repairing, refurbishing, reusing, and recycling. The 11.2% figure of respondents who report repairing/reusing and 4.5% for those who donate their electronics shows that there are some circular practices being observed, although they are overshadowed by other means that might lead to loss of resources or improper treatment.

Repair is especially significant since it prolongs the useful life of a product and postpones its disposal. In places where buying new electronics is expensive, repair is cost-efficient and creates local employment opportunities. Thus, policies ought to not consider all used electronics as waste. The difference should be made between working used goods, repairable products, and real end-of-life electronics. This way, reuse would be promoted and hazardous dumping, or even the importation and trading of used, dysfunctional electronics disguised as such would be avoided [31]. It is also possible to build on existing regulations of used electrical and electronic equipment in Rwanda.

While the high rate of selling waste to informal collectors may seem to carry risks, the presence of such collectors is both an advantage and a potential threat. They create an adequate system for collecting waste and are able to recycle equipment and other reusable materials. It would not be wise to exclude them since it may have some negative impact on collection efficiency and income [32]. A better solution would be to gradually formalize these collectors by registration, training and requiring occupational safety standards, traceability, and partnerships for delivery of collected waste to authorized recyclers [33]. At the same time, the district may use the principle of extended producer responsibility (EPR), which will help to redistribute part of the work from consumers and local administrations to producers, importers and distributors [34]. The EPR principle may serve as an effective financial source for collection, take-back programs, providing consumers with relevant information, and environmentally sound treatment. In terms of convenience, return points should be located close to markets and repair service centers; they should have appropriate signs and no disposal fees for returned waste.

3.8. Discussion: Governance, Enforcement and Institutional Coordination

The regulatory structure of Rwanda's electronic waste governance sets out environmental obligations and technical requirements, but the study finds that implementation at the local level is still a critical issue [35]. Respondents saw inadequate enforcement as a hurdle, while interviewees noted insufficient monitoring, infrequent awareness initiatives and lack of coordination among stakeholders. Enforcement is needed, but it is not an automatic process. This will depend on whether the public, collectors, retailers, organizations and recyclers know what is expected of them.

The enforcement should be proportional and must be accompanied by provision of services. It is pointless to penalize people for disposing of their old electronics improperly when they have nowhere to go to properly dispose of them. What should be done first is to make it possible for people to act in accordance with the rules, followed by stricter oversight and enforcement of violations of the rules.

Coordination among institutions might be achieved by collecting statistics on a district level. Collection facilities, licensed transporters, recyclers, large organizations, and producers might provide information on the volume collected, categories of devices, and destinations. This will be useful in planning and identifying gaps in services as well as measuring the success of awareness campaigns. The traceability is especially relevant in relation to hazardous categories and the effectiveness of EPR implementation.

Based on the findings, it is also recommended to incorporate electronic waste management into the process of environmental education and sustainable consumption promotion. Schools and universities may become long-term sources of knowledge about proper management, while public events and mass media might be able to disseminate information faster [36]. Since both media and social networks had proven to be relevant sources of information, they should be involved in promoting actual opportunities of collecting e-waste.

4. Conclusions and Recommendations

In order to determine whether the level of public awareness affects the practice of disposing of e-waste in Kicukiro District, Kigali City, this study was conducted. From the findings, the levels of public awareness are high but not all-inclusive, and the major practices related to e-waste disposal include storage at home, mixing e-waste with other household garbage and informal collection. The high level of positive relationship between awareness and proper disposal of e-waste ($r = 0.64$, $p < 0.001$) confirms that public awareness does influence the practice of e-waste disposal. In addition, the major barrier lack of collection centers proves that awareness alone does not offset poor accessibility of services.

Five major recommendations can be drawn from the results obtained. First, REMA, Kicukiro District and their partners should provide specific rather than general sensitization about the hazards of e-waste, acceptable devices and how to dispose of them. Second, the collection points or the take back days should be increased in the selected sectors in order to connect them with repair, reuse and recycling services. Third, illegal dumping and commercial activities related to hazardous practices of e-waste should be penalized while providing appropriate disposal alternatives.

Forth, the processes of EPR and retailer take back should be improved in such a way that producers and distributors would help in the costs of collection and consumers' awareness. Fifth, informal collectors should be engaged via training, registration and cooperation for collection convenience along with traceability and environmental safety. Further research should involve longitudinal and intervention studies to evaluate if service-based awareness campaigns lead to persistent behavior change. Research could include measurement of actual e-waste streams, willingness to pay or participate in take-back systems, and the involvement of informal collectors. Since this research study involved self-reported behavior, further research should involve collection data where possible.

5. Supplementary Information

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Conflicts of Interest: I declare no conflict of interest.

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