E-waste Awareness and Management Among People Engaged in E-waste Selling, Collecting, Dismantling, Repairing, and Storing Activities in Addis Ababa, Ethiopia

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ABSTRACT: Associated with the increasing demand and supply of short life-span electrical devices, e-waste generation is rapidly increasing. This created a special business for some informal groups: dismantlers, e-waste sellers, repairers, and storekeepers. The objective of this study was to assess the awareness, management strategies, and associated influencing factors among the central role players of the e-waste-related business. A cross-sectional study was used to assess the awareness and management of 345 purposely selected e-waste workers including all those who are actively engaged in e-waste buying, selling, dismantling, storing, and transferring. A questionnaire was used to obtain the required information. The findings show that about 92% of the dismantlers, 70% of the sellers, and 55% of the repair and maintenance workers have poor awareness. The awareness level of the respondents is strongly associated with the newness of the issue ($V = 0.64$) and lack of concern ($V = 0.44$), and moderately associated with educational status ($V = 0.31$), their lack of access to information (0.31), job type (0.28) and income level (0.26). The e-waste management among the study groups was limited to unsafe disposal (50%), unsafe storage (36%), and transfer (14%) to other users. The analysis showed that there is a statistically significant association between their job type and management systems ($chi^2(6) = 139$, $P < .005$, $V = 0.45$). Cramer's V ($V = 0.45$) shows a strong association between their job type and the e-waste management strategies. The awareness level of the respondents is very poor and influenced by several complex factors. During the study period, no study groups were practicing any of the proper e-waste management at all.

KEYWORDS: E-waste, e-waste management, e-waste awareness, electronic repairers, waste electronics, Addis Ababa

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Introduction

All over the world, electronic devices or electrical appliances have become obligatory in our daily lives, which has led to an exponential demand for electronic equipment and a rapid increase in the rate of electronic waste (e-waste) generation.[1] E-waste, also known as Waste Electrical and Electronic Equipment (WEEE), consists of electrical and electronic devices including all individual components such as batteries at the end of their useful life.[1-3] E-waste is one of the fastest-growing municipal waste streams. According to the global e-waste monitor 2020 report, on average, the total weight of global WEEE consumption increases annually by 2.5 million metric tons.[4] The annual growth rate is 3% to 5%, which is approximately 3 times faster than other municipal solid waste. Globally, an estimated amount of 50 million metric tons of e-waste was estimated in 2018.[1] The massive production driven by a mounting demand combined with rapid product obsolescence makes discarded electronics the fastest growing waste stream all over the world.[5] E-waste contains over 1000 different substances, many of which are highly toxic; and it produces much higher volumes of waste than any other consumer goods.[6] Mismanagement of these hazardous materials causes serious human health and environmental complications.[7] Improper management of e-waste also contributes to global warming.[4]

In Ethiopia, the demand for electronic devices is alarmingly increasing; particularly the demand is escalated with the changes in the lifestyle and the easily available cheap electronic equipment, modernization, and globalization. In 2011, Oko Institute and PAN-Ethiopia reported that the nation has more than 4300 tons of e-waste in stores.[8] In the country, the e-waste generation is exacerbated by the huge import of secondhand electronic devices, low-quality equipment donations from developed nations, and importing of planned and rapid obsoleting devices. In all corners of Ethiopia, including the rural society, there is no house without electronic items at least second-hand or obsolete devices. Furthermore, evidence shows that a considerable volume of very old electronics and electrical equipment is smuggled into the country from Somalia (via Jigjiga), Djibouti (via the Afar region), from Kenya (via Borena).[5] This is ultimately leading to the circulation and accumulation of non-functional, broken, and impaired electronics everywhere in cities and towns.

The major role players in the e-waste circulation in the society are the dismantlers (scavengers), repair and

maintenance workers, e-waste-sellers, and storekeepers. These informal groups collect, scavenge, dismantle, buy and sell, transfer or store all types of e-wastes. Dismantlers, locally called Qorale, scavenge or buy any kind of broken and non-functioning electronic devices and electrical equipment from house to house in residential and commercial areas, and dismantle it by breaking into pieces to get important metals. Currently, they started aggressively burning to recover important components including the wires. Storekeepers in institutions are the major responsible bodies in e-waste-management. Sometimes, when they are ordered, they indiscriminately discard obsolete devices and appliances mixed with any other solid waste into collection spots, Sometimes, institutes sell or donate their non-functioning electronics to other institutes or organizations, or keep it in the unsafe store for unlimited years. Repair and maintenance shops are usually confined to e-waste. The major source of the spare parts for repair and maintenance is the obsolete and non-functioning electronic devices and electrical appliances they buy from individuals, households, dismantlers and stores. They are the major destinations and sources of e-waste.

Although the only e-waste refurbishing company established by World Bank is located in Addis Ababa, its reachability and capacity is very limited. However, the informal groups are much more active and distributed throughout the nation. Although the e-waste amount is increasing rapidly throughout the country, practical measures on the ground are insignificant. Awareness is one of the major challenges in e-waste management throughout the world. Individual consumers' lack of awareness and a basic public sense among the city residents pose a hurdle in e-waste management.[9] The awareness of consumer plays a major role to affect e-waste management and routing the waste to the legal collection centers and recyclers for safe disposal.[10]

In Ethiopia, environmental issues in general, e-waste concern in particular, have the least attention hitherto. We have not ever heard repeated discussions or expert opinion on the e-waste issue in any media. Thus, public perception/awareness and government concern about the hazards and risks of e-waste is at its bud and largely unknown. Particularly, e-waste issues among the central role players of e-waste-related activities are completely unknown, probably due to the wide awareness and information gaps among the stakeholders. Majority of the assessments on e-waste in Ethiopia are done in Addis Ababa; mainly focusing on e-waste awareness and management in local technical schools, households and a few sub-cities in Addis Ababa.[11-16] There have not been any studies focusing on the awareness and management of e-waste targeting the main role players in e-waste-related business. The solid waste management protocol of the City of Addis Ababa does not give emphasis to informal e-waste sectors. Therefore, the main objective of this study is to examine e-waste-related awareness and management, and associated determinants among the informal e-waste workers, the people who play key roles in e-waste-related businesses.

Research Method

Sampling design and data sources

This study was carried out in Addis Ababa, the capital city of Ethiopia. A cross-sectional study design was used to assess the e-waste awareness and management of purposely-selected e-waste workers including those who are actively engaged in e-waste buying, selling, dismantling, storing, and transferring activities. The primary data were obtained by using a structured questionnaire. The questionnaire tools were designed to assess socio-economic status of the target groups, the basic e-waste-related awareness, and associated influencing factors, and e-waste management strategies and its determinants among the study groups. Awareness and e-waste management are dependent variables that are influenced by several independent variables. The type of job, work experience, educational status, lack of access to information and concern and newness of the issue are independent variables influencing awareness level of respondents, whereas the specific job type, concern, presence of container, gender, lack of law enforcement, e-waste-related awareness are identified as independent variables for e-waste management.

The data were collected from 5 purposely-selected target groups in: electronic repair and maintenance workers in the city, storekeepers in government institutions, e-waste-sellers, and waste pickers/ dismantlers.

Sample size

Sample size determination was challenging because the exact number of these informal and unregistered groups particularly the movable groups such as the e-waste dismantlers and sellers was impossible. Therefore, for these groups, all possible efforts were exerted to get appropriate number of willing respondents. Three hundred forty-five individuals was included in the survey. Of which, 82 were storekeepers working in health and educational institutions, 100 were repair and maintenance workers randomly selected from 316 registered repairers and maintenance shops, 60 were scavengers and traditional dismantlers (Qorales), and 102 were old electronic and e-waste-sellers. Except for storekeepers, majority of the target groups were obtained from Adis Ketema Sub-city, Merkato, area where the biggest market of the country is located.

Statistical analysis

For the data analysis and visualization, Stata 14 and Minitab 16 software were employed. Pearson's Chi^2 test of independence was used to check whether a statistically significant association exists between e-waste awareness and variables that potentially can affect the awareness levels of the respondents. A similar analysis was also done for e-waste management strategies and associated variables. To examine the effect of significant factors on the awareness level of the respondents, ordered logistic regression was used; whilst important factors influencing e-waste management strategies individual e-waste workers was examined by using multinomial logistic regression.

Table 1. Socio-economic conditions of the respondents.

SOCIOECONOMIC CONDITION	CATEGORIES	PROPORTION (%)
Age (years)	<20	15
	21-30	47
	>30	38
Gender identification	Male	81
	Female	19
Job specification	Dismantlers	17
	Sellers	30
	Repairers	29
	Storekeepers	24
Educational status	Illiterate	7
	Elementary	27
	High school	34
	College	22
	University	10
Income level (ETB), (1USD=52 ETB)	<1000	18
	1001-3000	40
	3001-5000	20
	5001-10000	19
	>10000	3
Experience	<5 year	35
	5-10 year	46
	>10 year	19

Result and Discussion

Socio-economic status of the respondents

The response rate of the 344 questionnaires distributed to the study groups was 98.8% (340/345). Table 1 shows details of the socio-economic and emographic characteristics of the study participants. The assessment shows that 91.9% of the repair and maintenance workers, 86.8% of the storekeepers, 63.3% of the dismantlers, and 89.2% of the sellers are above the age of 21. Among the respondents, 81% were male implying that in an informal e-waste-related business, the participation of women is 4 times lower than men do, which may be due to the possible exposure of women to gender-related harassment and high-energy demand nature of the work. Education wise, about 93% of the respondents were at least finished elementary school education, and among them, 32% of them completed diploma and university level education, of which the majority are repairers and storekeepers in university and colleges. The minimum education level among the repairers and the storekeepers is a high school certificate, whilst dismantlers are the least educated group. About 45% of the respondents stayed from 5 to 10 years in the business. This is an indication of the fact that these youngsters start the business at a very young age by dropping their education at elementary or secondary school. The income level of the respondents varies from a minimum of less than 1000 ETB (the majority are waste-pickers and dismantlers) to above 10000 ETB (the majority are electronic repairers and maintenance workers).

Awareness of the respondents

Awareness about e-waste-related issues was evaluated using questions focusing on 5 aspects of awareness: definition, human health-related, environment-related, safety-related, and composition-related issues (Table 2). Only 28.5% of the respondents consider old, malfunctioned pieces of electronics

Table 2. The e-waste-related awareness level of the respondent (n=340).

CHARACTERISTICS	FREQUENCY (PERCENTAGE)		
	YES	NOT SURE	NO
Do you consider old electronics and electrical equipment as waste?	98 (28.49)	90 (26.16)	156 (45.35)
Do you think that e-waste has a risk to human health?	65 (18.90)	42 (12.21)	237 (68.90)
Do you believe that e-waste constitutes a local public nuisance?	73 (21.22)	30 (8.72)	241 (70.06)
Do you think that e-waste is a serious threat to the environment?	79 (22.97)	57 (16.57)	208 (60.47)
Do you believe that e-waste contains toxic substances?	26 (7.56)	123 (35.76)	195 (56.69)
Do you know that e-waste contains precious substances?	9 (2.62)	167 (48.55)	168 (48.84)
Do you think that mismanagement of e-waste has a risk to humans?	59 (17.15)	66 (19.19)	219 (63.66)
Do you know how much e-waste you generate?	43 (12.50)	168 (48.84)	133 (38.66)
Do you wear any protective shield when you handle e-waste?	40 (11.76)	60(17.65)	240 (70.59)
Are willing to give out or dispose of old and dis-functioning e-waste?	34 (9.9)	20 (5.8)	290 (84.3))

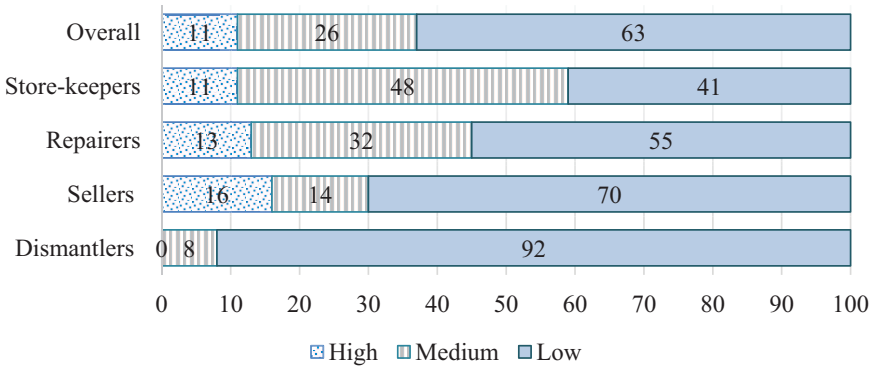

Figure 1. Awareness level of the respondents by job category.

and electrical items are part of waste; the rest 72% are not sure or do not believe that these items are part of wastes materials. For 68.9% of the respondents, e-waste has no serious effect on human health; and still, 12.2% are not sure that e-waste has a human health problem. More than 60% of the respondents did not know that e-waste has serious environmental consequences and 70% responded that e-waste does not create any public nuisance. The current poor awareness level of these key role-players of e-waste workers show that e-waste will stay the major public and environmental health risks in the country. A cross-sectional study reported that about 93% of the households at all income levels in Addis Ababa have no idea about the impacts of e-waste on human health and the environment.[17] A study carried out in 2 sub-cities in Addis Ababa reported that about 40% of the respondent households have no any idea about e-waste.[13]

Compared with studies in other countries, awareness about the impacts of e-waste on human health and environmental health is extremely low.[18] For example, a cross-sectional study carried out in Malaysia showed that 80% and 67% of the respondents are well aware that e-waste is hazardous and has serious impacts on humans and ecology respectively.[10] A study carried out in Uganda also shows that 64.8% of the consumers had good awareness of human health and environmental effects of e-waste.[19] Several authors reported that most informal e-waste recycling workers are not aware of environmental and health risks and do not know of better practices.[2,9,20,21]

Since the majority (92.4%) don't believe or are not sure that e-waste contains toxic substances and only 17% believe that e-waste may risk their health, the majority of them (70.6%) haven't ever used any protective wear; and 17.7% sometimes put on some kind of shield on their mouth while working with e-waste. Consequently, only about 17% of the respondents think that mismanagement of e-waste can have some kind of human health risk. About 84.3% of the respondents did not know the presence of the e-waste refurbishment center in Addis Ababa; the rest of them who know or who are not sure are among the dismantlers and storekeepers. This is because some of the dismantlers and storekeepers have direct or indirect contact with the refurbishing company.

Moreover, luckily, 97.4% of the respondents do not believe or are not sure that e-waste contains precious metals such as gold, silver, and platinum; and even those who know the presence of precious metals in their old electronics, none of them have ever dismantled or burnt to extract the metals. In many countries, e-waste recycling or dismantling is aimed to recover precious metals. If e-waste workers aware the presence of precious metals and the skills required to extract these precious metals, the impacts on the human health and environment will be exacerbated. Evidence from other nations clearly show that informal e-waste recycling severely affect the environment.[9,22-24] For instance, in Malaysia, 80% of the respondents know the presence of precious metals in the e-waste and thus e-waste dismantling as a source of the treasury.[10]

The awareness about the definition of e-waste, the volume of e-waste they generate, and the risks of e-waste on human health are strongly associated with the specific jobs they are engaged in. To evaluate the overall awareness level of the respondents, the responses were ordered into 3 scales (scores $\geqslant$3 is low; 4-7 = medium; 8-10 = high). Based on this category, 63% of the respondents scored low (answered only 1-3 out of 10 questions); about 26% scored medium (answered 4-7 out of 10 questions) and only 11% of them scored high (answered 8-10 of the questions correctly) (Figure 1). Figure 1 shows the awareness level of the respondents categorized by their job category.

Respondents vary by their awareness level considerably. About 92% of the dismantlers, 70% of the sellers, 55% of the repair and maintenance workers were found to have poor awareness. At a medium level of awareness, storekeepers, followed by repairers, are better than the others are, and dismantlers scored the lowest. Reports show that about 99% of store-keepers in Addis Ababa don't have the awareness about the impacts of hazardous substances and they haven't ever had training on e-waste.[17] At a high level of awareness, sellers followed by repairers are better than the others are because the majority of the repair and maintenance workers are high school and beyond. Findings show that e-waste repairers were better educated and aware than the dismantlers; and the repairers were significantly more aware of the likelihood of health-related risks associated with their jobs.[2,20,21]

Table 3. The Chi² test for association between awareness level of the respondents and influencing factors.

	FACTORS FOR AWARENESS	PEARSON CHI²	*P*-VALUE	CRAMER'S V
1	Job type specified	55.7	.000	0.28
2	Age	13.3	.010	0.14
3	Experience	19.04	.001	0.17
4	Income level	48.08	.000	0.26
5	Educational status	64.83	.000	0.31
6	Lack of information access	31.99	.000	0.31
7	Lack of concern	66.03	.000	0.44
8	Newness of the issue	143.03	.000	0.64

Table 4. Association of important variables influencing e-waste awareness.

ORDERED LOGISTIC REGRESSION LOG LIKELIHOOD = −210.2261			NUMBER OF OBS. = 344 LR CHI²(8) = 194.54 PROB > CHI² = 0.0000 PSEUDO R^2 = 0.3163	
OUTCOME VARIABLE	EXPLANATORY VARIABLES	COEF.	STD. ERR.	*P* > Z
Awareness	Job type	0.145438	0.193885	.453
	Age	−0.387292	0.303422	.202
	Gender	−0.153731	0.365939	.674
	Educational status	0.057324	0.179725	.750
	Access to information	0.785978	0.273414	.004
	Experience	0.234975	0.247879	.343
	Lack of concern	−1.847685	0.435125	.000
	Newness of the issue	−2.917683	0.328249	.000

Factors affecting the awareness

From the array of factors affecting the awareness level of the respondents, 8 of them were selected as the major factors in this study (Table 3). The chi² test showed that there is a significant association between awareness and all the selected factors ($P < .01$). According to Cramer's V value, the awareness level of the respondents is strongly associated with the newness of the issue ($V = 0.64$), relatively strong with lack of concern ($V = 0.44$), and moderately associated with educational status ($V = 0.31$), their lack of access to information (0.31), job type (0.28) and income level (0.26).[25] However, although the Chi² values are high and the *P*-value shows a statistically significant relationship, the association between awareness with age and experience is weak. A bivariate analysis conducted shows that age, marital status and educational status have association with the e-waste awareness levels electronic consumers.[19] Another survey carried out in the Pune City of India shows that education and income play positive role on individuals e-waste awareness.[10]

Ordered logistic regression analysis also showed that the overall effects of all the 6 assessed factors are statistically significant (chi² = 194.7, $P < .05$) (Table 4). However, only 3 factors, *access to information, lack of concern, and the newness of the issue* has a strong association with the awareness of the respondents. A unit change in the access to information (shifting from lack of access to getting access) increases the awareness level by 0.8 to the next higher level of awareness. Similarly, a unit change in the newness of the issue (when the issue becomes common), the awareness level increases by 2.85 to the next higher awareness level.

E-waste management practices

The common management strategy of e-waste includes reuse, regulated recycling, material recovery, incineration, and landfilling.[26,27] In this study, none of the groups employs neither of these methods. The e-waste management among the study groups was limited to unsafe disposal, unsafe storage, and transfer to other users, implying that there is no

Table 5. E-waste management among the respondents.

E-WASTE-RELATED BUSINESS WORKERS	E-WASTE MANAGEMENT			TOTAL
	UNSAFE DISPOSAL	UNSAFE STORAGE	TRANSFER	
Repairers	84(85)	13 (13)	2 (2)	99
Store-keepers	21 (25)	37 (45)	25 (30)	83
Dismantlers	47 (78)	13 (22)	0 (0)	60
Sellers	20 (21)	61 (60)	20 (20)	102
Total	173 (50.3)	124 (36)	47 (13.7)	344
Pearson $chi^2(6) = 139.03$; Pr = 0.000; Cramer's $V = 0.4495$				

proper management of e-waste at all. E-waste management in Africa is dominated by thriving informal sector collectors and recyclers in most countries; contrary to many developed nations, both organized take-back systems and license provisions for sorting and dismantling e-waste exist.[4] Generally, the e-waste management method of the study groups is 50% unsafe disposal, 36% unsafe storage, and 14% transfer by selling as second-hand item or give out to somebody or organization (Table 5).

About 85% of the electronic repair and maintenance workers and 78% of the traditional dismantlers mix with any other solid wastes and dispose to the local garbage collection site or arbitrarily throw to the surrounding area, which may or may not be taken by street sweepers. This is the reflection of the actual solid waste management practice in the community. No respondents have separate garbage containers for solid waste segregation. An assessment made on waste management in Addis Ababa University reported that recycling, re-using donating and reselling the e-waste has not been practiced in the university.[28]

Storing e-waste for unlimited time is very common among e-waste-sellers and institutions; however, a study showed that about 99% of the institutions in Addis Ababa don't have proper storage facilities.[17] According to a study carried out on e-waste management strategies in Ambo Town government educational institutes, the main reason of the poor waste management is the absence of legislations specifically dealing with e-waste.[29] The same author reported that the major reason for storing e-waste for unlimited time is the government order not to take any action except donation. A study carried out in Addis Ababa showed that 94% of every broken old electronics and electrical equipment (including those which are returned from repairers because of the high level of damage) hoping that it would benefit them/have value in the future.[17] The same author also showed that 96% of the low and middle-income households are not willing to dispose or give free any of their e-waste indicating the high potential for the informal market[17]; if they do not sell, they store it for an unknown time.

To evaluate whether there is a relationship between job type and their management means, Pearson's chi^2 test was done. The analysis showed that there is a statistically significant association between their job type and management systems ($chi^2(6) = 139$, $P < .005$, $V = 0.45$). Cramer's V ($V = 0.45$) shows a strong association between their job type and the e-waste management strategies.

Factors affecting the management of e-waste

Management of e-waste among the study groups is affected by several factors including job type, awareness level, educational status, gender, experience, absence of law enforcement, and presence of trash can (Table 6). Although the high Pearson's Chi^2 and the *P*-value show that management of e-waste is significantly associated with all the assessed factors, the effect strength of the variables varies. For example, the Cramer's V of the test, 0.56 shows a relatively strong association between e-waste management types and their job specification (Table 6). All the rest factors are associated with management, Cramer's V lies between 0.21 and 0.36 indicating moderate association with all the rest factors.[25] Lack of awareness and cautionary information on the management operations associated with e-waste can pose a potential threat to human health and the environment.[18]

Contribution levels of the factors to the poor e-waste management. To evaluate the magnitude of each factor, multinomial logistic regression was carried out (Table 7). From the 3 categories of outcomes, the model take unsafe disposal (1) as the base outcome; unsafe storage as an outcome 2, and transfer as outcome 3. For outcome 2, the analysis showed that unsafe storage was significantly affected by male ($b = -1.3$, se = 0.47, $P < .05$) education status ($b = -0.55$, se = 0.19, $P < .05$), experience level $b = 3.3$, se = 0.4, $P < .05$) presence of trash can ($b = -2$, se = 0.37, $P < .05$), absence of law enforcement ($b = 1.3$, se = 0.41, $P < .05$) and working conditions ($b = 0.77$, se = 0.31, $P < .05$). For example, the log-odds of practicing unsafe storage relative to unsafe disposal for males is predicted to be −1.32 points less than that of females. The negative slope suggests that fewer males practice unsafe storage and more males practice unsafe disposal as compared to females. For outcome 3, the analysis showed that transfer e-waste was significantly

Table 6. Factors affecting the management of e-waste.

	FACTORS FOR AWARENESS	PEARSON CHI²	*P*-VALUE	DF	CRAMER'S V
1	Job specification	218.93	.000	6	0.56
2	Age	29.98	.000	4	0.21
3	Gender	44.75	.000	2	0.36
4	Educational status	63.72	.000	8	0.30
5	Income level	43.01	.000	8	0.25
7	Experience	38.98	.000	4	0.24
8	Awareness	39.6	.000	4	0.24
9	Absence of container	16.53	.000	2	0.22
10	Lack of concern	38.57	.000	2	0.33
11	Absence of law enforcement	23.62	.000	2	0.26

Table 7. Association of different variables at each categories of e-waste management.

MULTINOMIAL LOGISTIC REGRESSION LR LIKELIHOOD = −262.248		NUMBER OF OBS. = 343 LR CHI² (12) = 151.44 PROB > CHI² = 0.000 PSEUDO R^2 = 0.2240		
MANAGEMENT TYPE	VARIABLES	COEFFICIENT	STD. ERR	*P*>|Z|
1 (Unsafe disposal)	Base outcome			
2 (Unsafe storage)	Job	0.3824056	0.2043702	.061
	Gender	1.030669	0.4785548	.031
	Income level	−0.8181951	0.1938387	.000
	Experience	1.585334	0.1938387	.000
	No garbage container	−1.550901	0.3340645	.000
	No law enforcement	1.265297	0.4115502	.002
	cons	−3.43843	0.8322609	.000
3 (Transfer)	Job	0.1585272	0.2578442	.539
	Gender	2.097158	0.5046221	.000
	Income level	−0.1192364	0.2260194	.598
	Experience	0.5829224	0.2753499	.034
	No garbage container	−0.2574651	0.4321598	.551
	No law enforcement	−0.3003895	0.4376827	.493
	cons	−4.623184	0.9939536	.000

affected by job ($b = -0.82$, se = 0.32, $P < .05$), gender (−2.6, se = 0.54, $P < .05$), educational status ($b = 0.7$, se = 0.25, $P < .05$) and lack of concern ($b = -3.4$, se = 1.1, $P < .05$). For example, the log-odds of transferring e-waste as a means of management relative to unsafe disposal for lack of concern is predicted to be −3.4 times less compared to unsafe disposal. The negative slope suggests that lack of concern is a stronger factor to unsafe disposal as compared to e-waste transfer as a means of e-waste management.

Conclusion

The awareness level of the respondents is significant poor and strongly associated with several complex factors indicating that there is wide knowledge gap between the different stakeholders

of e-waste issue including the major role-players in the e-waste business, and the need to take crucial measures by the government bodies. The wrong and inappropriate e-waste management among the study groups indicates that the solid waste management protocol of the city is not working at all. Moreover, the absence of proper e-waste management is an alarm to the existing environmental and human health risks.

This study did not include assessments on the occurrences of physical injuries and other chronic diseases because of the exposure to e-waste toxicity. Detailed studies on e-waste generation rate by all the informal e-waste workers is required to inform policy makers to revise the current solid waste management. Furthermore, detailed examination on e-waste awareness and management with intervention phase is required.[30]

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Author Contributions

Adane Sirage Ali brought the research idea, designed the proposal, data collection management, data analysis, and prepared manuscript. Zelalem Kibret Akalu edited the proposal, financial management, data entry, and reviewed the manuscript.

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