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## **Electronic waste control and management in Ghana: a critical assessment of the law, perceptions and practices**

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### **Abstract**

The aim of the study was to assess the impact of Ghana's hazardous and e-waste control and management Act 917 of 2016 on current e-waste management practices and the level of awareness among key stakeholders (general public, repairers, wholesalers/retailers, recyclers and importers of electronic items) in the Greater Accra Region of Ghana. Both quantitative and qualitative data were collected and examined in this study. Results showed a low level (12%) of awareness among stakeholders on the e-waste legislation. Almost 13% of respondents had been educated on e-waste management. Community engagement and the mass media were the main sources of information on e-waste. Significant associations between background information of respondents and awareness level on 'Ghana's Act 917' were observed. Relative to general e-waste issues, only education and stakeholder showed significant associations with e-waste legislation and management. The main e-waste disposal methods adopted by respondents were disposal at dumpsites (22.7%), repair and reuse (21.1%) and reselling (20.1%). Almost 10% of respondents made changes to their e-waste disposal practices over the past 5 years. These changes were mainly due to the economic benefits derived from reselling e-waste (37.6%) and the perceived adverse impacts of e-waste on the environment (23.9%). Overall, there is the need to intensify awareness on 'Ghana's Act 917' especially issues regarding sustainable e-waste management practices.

**Keywords:** e-waste policy; e-waste management; electronic items; e-waste disposal practices; stakeholders' perceptions; Greater Accra; Ghana

## 1. Introduction

Globally, there has been an increasing trend in the use of electrical and electronic equipment (EEE) over the past years (Shittu et al. 2021). For instance, the number of mobile users in the year 2020 stood around 7 billion; projections suggest further increase by several hundreds of million in the coming years (Statista 2021). Although the adoption of technology requiring the use of mobile phones and computers has contributed immensely to the development of the society, poor management of e-wastes has been associated with both environmental pollution (Caravanos et al. 2011; Li et al. 2011; Amfo-Otu et al. 2013) and health-related problems (Manmohit et al. 2018; Ohajinwa et al. 2019) in developing countries where infrastructure for effective recycling of e-waste is lacking. The situation in Ghana may not be different from other developing countries where large volumes of e-waste are generated annually. The amount of e-waste generated in Ghana has been estimated to be around 52,000 tonnes annually (Owusu-Sekyere et al. 2022) and expected to increase in future. Several strategies have been adopted in handling e-waste in Ghana; these include open burning, dumping e-waste alongside other solid waste at landfill sites, repairing them for reuse and/or selling to scrap dealers.

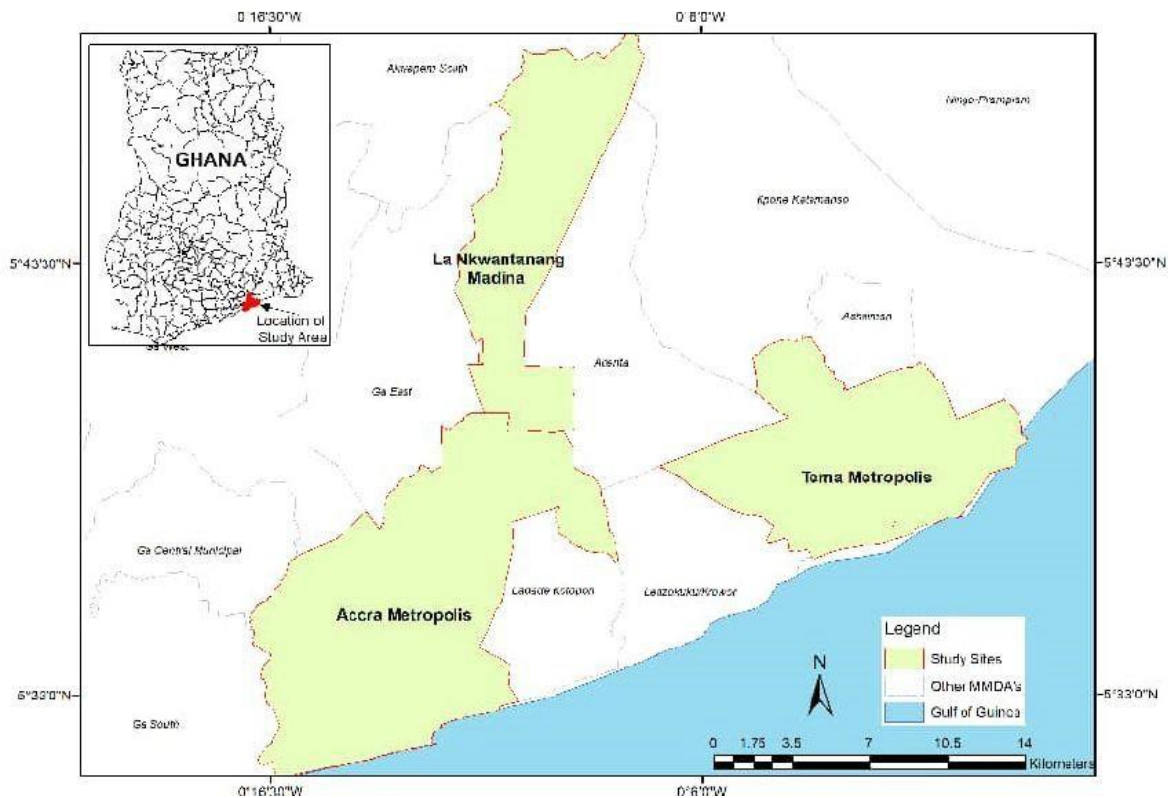
In order to address the problems associated with e-waste accumulation, a number of regulatory frameworks has been established in countries worldwide. For instance, the European Union (EU) introduced a regulatory directive, which requires producers and distributors of electrical and electronic equipment to establish a system for efficient collection and treatment of e-wastes (WEEE Directive 2012). Similarly, Federal States in the United States have passed legislation that enhances e-waste recycling and/or prohibits e-waste incineration or landfilling (Schumacher and Agbemabiese 2019). Thus, Ghana enacted the Hazardous and Electronic Waste Control and Management Regulations (LI 2250) or Act 917 of 2016. These laws require importers and producers to register with the Environmental Protection Agency (EPA) in Ghana for payment of a pre-emptive eco-tax on all imported electronics to generate sufficient funds for the implementation of the legal framework on e-waste management and the formalisation of informal actors (European Commission 2019).

Despite the introduction of e-waste legislations in Ghana, the problems of e-waste management still persist, thereby suggesting an indication of some levels of inefficiencies in the implementation of the regulatory framework. In order to confirm whether these policies are being effective in addressing the challenges confronting the industry, an assessment of the impact of the policy on current management practices is required. Information obtained from such assessments will be useful in making recommendations for future directions to improve the current e-waste management strategies of the government of Ghana; it may, consequently, improve the handling of e-waste in Ghana. Therefore, the overall goal of this study was to assess (1) the impact of the e-waste bill on current e-waste disposal practices and (2) awareness level among key stakeholders (who are the general public consumers, importers, repairers, retailers and recyclers of electrical and electronic gadgets) on Ghana's e-waste management policy.

## 2. Materials and methods

### 2.1 Study area

The La Nkwantanang-Madina Municipality and the metropolis of Accra and Tema within the Greater Accra region of Ghana (Fig. 1) were selected for the study. These areas were chosen at a random among the districts, municipals and metropolis of the densely populated Greater Accra Region of Ghana. The total population of the chosen demographic areas amounts to 706,724 individuals (GAD 2021; GSS 2021).



**Figure 1.** A map showing the selected areas for the study. Inset is the map of Ghana showing the location (in red) of the La Nkwantanang-Madina Municipal and the metropolis of Accra and Tema in the Greater Accra Region of Ghana.

### 2.2 Sampling

#### 2.2.1 Survey instrument and data collection

Primary data were obtained using questionnaires. Five sets of open and close ended questions were used to collect information from five groups of respondents, namely; electrical and electronic equipment (EEE) importers, wholesalers and retailers of EEE, EEE repairers, e-waste recyclers and the general public. The questionnaire employed in the present study was divided into five sections to capture information on (1) knowledge on e-waste, (2) e-waste disposal practices, (3) awareness on government's e-waste management strategies and (4) willingness to participate in sustainable e-waste management practices.

Using the convenience sampling approach, 1223 respondents were randomly selected and interviewed in the study areas (Fig. 1). The above sampling approach facilitated access to specific categories of

the population which included 342 respondents from the general public (who use electrical and electronic equipment), 145 importers, 287 wholesalers and retailers, 269 repairers and 180 recyclers. The large number of respondents was considered to significantly reduce error and bias in the data, based on sample size suggested in the report of Leedy and Ormrod (2005).

### 2.2.2 Data Analysis

The data collected were analysed using the Statistical Package for Social Studies (SPSS. v. 20.0) software. In this case, data were subjected to descriptive statistics. The Pearson Chi square was used to determine how likely the difference will arise between 'awareness on Ghana's e-waste legislation' and 'general e-waste management issues' for the background information of respondents (Gotelli and Ellison 2013).

### 3. Results

#### 3.1 Background information of respondents

Table 1 shows the background information of respondents. The respondents constituted 78.8% males and 21.2% females. Most (38.8%) of the respondents were between the ages of 25 and 34 years old. Majority (97.3%) of the respondents had some form of education (Table 1). In relation to marital status, most of the respondents were single (57.6%), when compared to the married (39.7%). The respondents (85.5%) were mainly employed in the informal sector.

Table 1. Background information of respondents

Variable	Category	Total number of Respondents	Percentage (%)
<b>Gender</b>	Male	964	78.8
	Female	259	21.2
<b>Age</b>	15-24	309	25.3
	25-34	473	38.7
	35-44	294	24.0
	45-54	117	9.6
	55 and above	30	2.5
<b>Educational level</b>	Primary	123	10.1
	Junior	310	25.3
	Secondary	515	42.1
	Tertiary	214	17.5
	MSLC	28	2.3
	No formal education	33	2.7
<b>Marital status</b>	Married	485	39.7
	Single	704	57.6
	Divorced	33	2.7
	Widow	1	0.1
<b>Occupation</b>	Formal	90	7.6
	Informal	1046	85.5
	Student	75	6.1
	Pensioner	4	0.3
	Unemployed	8	0.7

#### 3.2 Current e-waste management practices

Data regarding e-waste disposal methods in the study area are shown in Table 2. The main e-waste management approaches are largely disposal at the dumpsites (22.7%), repair and reuse (21.1%), and/or reselling (20.1%) of damaged electrical and electronic equipment (EEE). The e-waste control and management practices adopted by the general public consumers alone were mainly repair and reuse (94% in Table 2) or disposal at the dumpsites (80%). The latter also appeared to be the foremost practice among repairers (32.0%) or wholesalers/retailers (30.7% in Table 2). While recyclers resorted

to reselling (35.0%), importers normally repaired and reused (29.0%) or resold (29.7%) their e-waste (i.e., spoilt EEE). Although some respondents adopted other practices such as burying, burning, donating, dumping anywhere, dismantling, recycle and storage, these practices had lower frequencies (i.e., below 7%) relative to disposal at dumpsites, reselling, repair and reuse which had frequencies ranging between 20.1 and 22.7%.

Table 2. E-waste disposal methods

Disposal methods	General public consumers	Repairers	Wholesalers/ Retailers	Recyclers	Importers	Total
Bury	3 (0.9%)	-	2 (0.7%)	1 (0.6%)	2 (1.4%)	8 (0.7%)
Burn	21 (6.1%)	6 (2.2%)	13 (4.5%)	30(16.7%)	5 (3.4%)	75 (6.1%)
Donate	40 (11.7%)	6 (2.2%)	14 (4.9%)	3 (1.7%)	5 (3.4%)	68 (5.6%)
Anywhere	27 (7.9%)	4 (1.5%)	7 (2.4%)	1 (0.6%)	6 (4.1%)	45 (3.7%)
Dumpsite	80 (24.3%)	86(32.0%)	88 (30.7%)	13 (7.2%)	11 (7.6%)	278(22.7%)
Dismantle	6 (1.8%)	10 (3.7%)	14 (4.9%)	6 (3.3%)	6 (4.1%)	42 (3.4%)
Recycle	17 (5.0%)	7 (2.6%)	15 (5.2%)	28(15.6%)	16 (11.0%)	83 (6.8%)
Repair and reuse	94 (27.5%)	35(13.0%)	66 (23.0%)	21(11.7%)	42 (29.0%)	258(21.1%)
Reselling	43 (12.6%)	37(13.8%)	60 (20.9%)	63(35.0%)	43 (29.7%)	246(20.1%)
Storage	11 (3.2%)	18 (6.7%)	8 (2.8%)	14 (7.8%)	9 (6.2%)	60 (4.9%)

Table 3 shows responses relating to changes in e-waste disposal practices over the past years. Results generally indicated that most (90.43%) of the respondents had not change their e-waste disposal practices over the past years. The data also show that most (14%) of the respondents who had modified their e-waste disposal methods were in the general public category.

**Table 3.** Responses regarding changes in e-waste disposal practices over the past 5 years.

Variables	Responses	
	Yes	No
General public consumers	47 (14%)	295 (86%)
Recyclers	11 (6%)	169 (94%)
Repairers	24 (9%)	245 (91%)
Importers	9 (6%)	136 (94%)
Wholesalers/ Retailers	26 (9%)	261 (91%)
	117 (9.56%)	1106 (90.43%)

The data for the reasons why few respondents made changes in their e-waste management practices over the past 5 years are presented in Table 4. It is noteworthy that the data relate only to respondents who affirmed making changes in their e-waste disposal practices over the past 5 years. The result showed that income generation from reselling e-waste (37.6%) and the potential negative impact of e-waste on the environment (23.9%) are the main reasons that compel respondents to make changes in their disposal practices. Notwithstanding, a considerable proportion (i.e., about 24.8%) of the sampled population could not give any tangible reasons for making changes in their e-waste disposal practices (Table 4).

Table 4. Reasons for making changes in e-waste management practices among respondents

Response	General public consumers	Repairers	Wholesalers/retailers	Recyclers	Importers	Total
Generate income from reselling	22 (46.8%)	8 (33.3%)	10 (38.5%)	3 (27.3%)	1 (11.1%)	44 (37.6%)
Negative impact on the environment	9 (19.1%)	6 (25.0%)	8 (30.8%)	2 (18.2%)	2 (22.2%)	28 (23.9%)
Recycling purposes	3 (6.4%)	-	-	-	1 (11.1%)	4 (3.4%)
Realisation of its importance	1 (2.1%)	1 (4.2%)	-	-	-	2 (1.7%)
Profitable to repair and re-use	-	-	-	-	1 (11.1%)	1 (0.9%)
Negative impact on human health	-	-	1 (3.8%)	-	-	1 (0.9%)
Not profitable reselling	-	1 (4.2%)	-	-	-	1 (0.9%)
Return to dealer	-	-	1 (3.8%)	-	-	1 (0.9%)
Expensive repairing	-	-	-	-	1 (11.1%)	1 (0.9%)
Take up space	-	-	-	-	1 (11.1%)	1 (0.9%)
Easy access to repairers	-	-	1 (3.8%)	-	-	1 (0.9%)
Awareness on health implications	1 (2.1%)	-	-	-	-	1 (0.9%)
No response	11 (23.4%)	8 (33.3%)	5 (19.2%)	3 (27.3%)	2 (22.2%)	29(24.8%)

### 3.3 General knowledge in e-waste

#### 3.3.1 Awareness

The general knowledge level of respondents in e-waste are summarized in Table 5. The results show that almost half of the respondents have some levels of knowledge in e-waste. The proportion of the respondents who did not know that e-waste requires special treatment before disposal represented 37% of the total respondents. Similarly, 40% of respondents are not aware that improper disposal of e-waste can be harmful to the environment (Table 5). Although more than half (55%) of the respondents indicated that e-waste contains harmful substances, only 40% affirmed they were aware of the health-related risks associated with e-waste. The results also show that 87% of the respondents have not received education on e-waste.



Table 5. General knowledge in e-waste among respondents

Variable	Have you received any education on e-waste?		Do you know what e-waste is?		Do you know that e-waste requires special treatment before disposal?		Do you know that improper disposal of e-waste is harmful to the environment?		Do you know e-waste contains harmful substances?		Do you know the health risk associated with e-waste?	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
<b>Responses</b>	<b>Yes</b>	<b>No</b>	<b>Yes</b>	<b>No</b>	<b>Yes</b>	<b>No</b>	<b>Yes</b>	<b>No</b>	<b>Yes</b>	<b>No</b>	<b>Yes</b>	<b>No</b>
General Public	66 (19%)	276 (81%)	187 (55%)	155 (45%)	108 (32%)	234 (68%)	129 (38%)	213 (62%)	166 (49%)	176 (51%)	115 (34%)	227 (66%)
Recyclers	9 (5%)	171 (95%)	57 (32%)	123 (68)	80 (44%)	100 (56%)	51 (28%)	129 (72%)	98 (54%)	82 (46%)	44 (24%)	136 (76%)
Repairers	29 (11%)	240 (89%)	151 (56%)	118 (44%)	60 (22%)	209 (78%)	136 (51%)	133 (49%)	145 (54%)	124 (46%)	112 (42%)	157 (58%)
Importers	13 (9%)	132 (91%)	70 (48%)	75 (52%)	96 (66%)	49 (34%)	54 (37%)	91 (63%)	112 (77%)	33 (23%)	50 (34%)	95 (66%)
Wholesalers/ Retailers	37 (13%)	250 (87%)	163 (57%)	124 (43%)	114 (40%)	173 (60%)	121 (42%)	166 (58%)	152 (53%)	135 (47%)	114 (40%)	173 (60%)
<b>Total</b>	<b>154 (13%)</b>	<b>1069 (87%)</b>	<b>628 (51%)</b>	<b>595 (49%)</b>	<b>458 (37%)</b>	<b>765 (63%)</b>	<b>491 (40%)</b>	<b>732 (60%)</b>	<b>673 (55%)</b>	<b>550 (45%)</b>	<b>435 (36%)</b>	<b>788 (64%)</b>

The responses of respondents on Ghana’s e-waste legislation are in Table 6. It is noteworthy that the follow up question (i.e., “Do you know the aspects of the e-waste law that directly binds you?”) only related to those who had heard about the e-waste legislation in Ghana. The results show that only 12% of the respondents are aware of Ghana’s e-waste control and management legislation. Majority (63% in Table 6) of those who are aware of the legislation also know the aspect of the law that directly binds them. Besides 50% of the recyclers who affirmed in the negative, all the stakeholder categories (67%) admitted that having a legislation for e-waste management is good (Table 6).

Table 6. E-waste legislation in Ghana

Variable	Have you heard about Ghana’s e-waste legislation		Do you know the aspect of the e-waste law that directly binds you?		Is it good to have a legislation on e-waste	
	Yes	No	Yes	No	Yes	No
General public consumers	41 (12%)	301 (88%)	22 (54%)	19 (46%)	233(68%)	109(32%)
Recyclers	2 (1%)	178 (99%)	2 (100%)	-	90 (50%)	90 (50%)
Repairers	52 (19%)	217 (81%)	30 (58%)	22 (42%)	182(68%)	87 (32%)
Importers	13 (9%)	132 (91%)	11 (85%)	2 (15%)	130(90%)	15 (10%)
Wholesalers/retailers	36 (13%)	251 (87%)	25 (69%)	11 (31%)	183(64%)	107(37%)
Total	144 (12%)	1079(88%)	90 (63%)	54 (37%)	818(67%)	405(33%)

The knowledge level of respondents on the impacts of e-waste on the environment and public health are summarised in Table 7. Results showed that respondents generally perceived waste management problems (12.8%) and air pollution (11.4%) to be the two main environmental concerns associated with e-waste. The above pattern was consistent among all the categories of stakeholders. In the case of the health effects, 20.3% of the respondents generally perceived chronic diseases to be the major health concerns (Table 7). The above response was also consistent among all groups of the stakeholders. The other health effects mentioned by respondents generally had frequencies below 2% (Table 7).

Table 7. Awareness level of respondents on environmental and health effects of e-waste.

Effects	General public consumers	Repairers	Wholesalers /retailers	Recyclers	Importers	Total
<b>Environmental effect</b>						
Harmful to plants	17 (5.0%)	9 (3.3%)	18 (6.3%)	2 (1.1%)	5 (3.4%)	51 (4.2%)
Air pollution	51 (14.9%)	30(11.2%)	33 (11.5%)	16 (8.9%)	10 (6.9%)	140(11.4%)
No response	2 (0.6%)	32(11.9%)	10 (3.5)	9 (5.0%)	8 (5.5%)	57 (4.7%)
Waste management problems	44 (12.9%)	48(17.8%)	41 (14.3)	11 (6.1%)	12 (8.3%)	156(12.8%)
Water pollution	15 (4.4%)	11 (4.1%)	12 (4.2)	7 (3.9%)	8 (5.5%)	53 (4.3%)
Climate change	-	1 (0.4%)	1 (0.3)	-	1 (0.7%)	3 (0.2%)
Land degradation	-	5 (1.9%)	6 (2.1%)	6 (3.3%)	10 (6.9%)	27 (2.2%)
<b>Health effect</b>						

Chronic diseases	85 (24.8%)	67(24.9%)	51 (17.7%)	21(11.7%)	25 (17.2%)	249(20.3%)
Malaria	7 (2.0%)	2 (0.7%)	2 (0.7%)	1 (0.6%)	2 (1.4%)	14 (1.1%)
Birth defects	3 (0.9%)	9 (3.3%)	8 (2.8%)	-	2 (1.4%)	22 (1.8%)
Eye itching	-	6 (2.2%)	12 (4.2%)	2 (1.1%)	2 (1.4%)	22 (1.8%)
Headache	-	3 (1.1%)	-	-	-	3 (0.2%)
No response	29 (5.5%)	25 (9.3%)	41 (14.3%)	20(11.0%)	19 (13.1%)	124(7.7%)

### 3.3.2 Response to some policy issues in Ghana's e-waste legislation

Table 8 summarizes participants who responded to some key components of Ghana's e-waste policy. The majority of the respondents were generally in support (i.e., agreeing + strongly agreeing) of all the e-waste policies numbered 2 to 6, even though 6 to 27% of the respondents disagreed or strongly disagreed with these policies. In the case of policy number 1, those who disagreed (i.e., disagreed + strongly disagreed) were marginally more than those who were in support of this policy. The category of respondents who disagreed most on the policy numbered 1 were the repairers (Table 8). The proportion of respondents who were neutral on all the policies ranged from 2.4 to 7%.

Table 8. Respondents' response to some policy issues in Ghana's e-waste legislation. A = General public; B = Repairers; C = Wholesalers/retailers; D = Recyclers; E = Importers

Policy	Stakeholders	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Number 1: Used and malfunction e-products should not be imported into the country.	A	124(36.3%)	70 (20.5%)	12 (3.5%)	86 (25.1%)	50 (14.6%)
	B	31 (11.5%)	43(16.0%)	7 (2.6%)	108(40.1%)	80 (29.7%)
	C	98 (34.1%)	60 (20.9%)	3 (1.0%)	57 (19.9%)	69 (24.0%)
	D	46 (25.6%)	21 (11.7%)	6 (3.3%)	44 (24.4%)	63 (35.0)
	E	52 (35.9%)	14 (9.7%)	1 (0.7%)	35 (24.1%)	43 (29.7%)
	<b>Total</b>	<b>351(28.7%)</b>	<b>208(17.0%)</b>	<b>29 (2.4%)</b>	<b>330(27.0%)</b>	<b>305(24.9%)</b>
Number 2: A manufacturer, distributor or wholesaler of electronic equipment should take back used or discarded electronic equipment manufactured or sold by it for recycling purposes.	A	109 (31.9%)	102 (29.8%)	34 (9.9%)	58 (17.0%)	29 (8.5%)
	B	57 (21.2%)	97 (36.1)	9 (3.3%)	86 (32.0%)	20 (7.4%)
	C	72 (25.1%)	94 (32.8%)	13 (4.5%)	88 (30.7%)	20 (7.0%)
	D	44 (24.4%)	26 (14.4%)	14 (7.8%)	52 (28.9%)	44 (24.4%)
	E	54 (37.2%)	35 (24.1%)	10 (6.9%)	24 (16.6%)	22 (15.2%)
	<b>Total</b>	<b>336(27.5%)</b>	<b>354(28.9%)</b>	<b>80 (6.5%)</b>	<b>308(25.2%)</b>	<b>145 (11.9%)</b>
Number 3: Importers have to pay a levy for e-product imported into the country.	A	111(32.5%)	143(41.8%)	28 (8.2%)	29 (8.5%)	31 (9.1%)
	B	63 (23.4%)	148(55.0%)	3 (1.1%)	43 (16.0%)	12 (4.5%)
	C	60 (20.9%)	122(42.5%)	10 (3.5%)	55 (19.2%)	40 (13.9%)
	D	35 (19.4%)	68 (37.8%)	8 (4.4%)	40 (22.2%)	29 (16.1%)
	E	24 (16.6%)	49 (33.8%)	11 (7.6%)	43 (29.7%)	18 (12.4%)
	<b>Total</b>	<b>293(24.0%)</b>	<b>530(43.3%)</b>	<b>60 (4.9%)</b>	<b>210(17.2%)</b>	<b>130(10.6%)</b>
Number 4: E-waste should not be dumped alongside other waste.	A	138(40.4%)	114(33.3%)	33 (9.6%)	46 (13.5%)	11 (3.2%)
	B	69 (25.7%)	132(49.3%)	9 (3.4%)	48 (17.9%)	11 (4.1%)

alongside other waste.	<i>C</i>	98 (34.1%)	104(36.2%)	2 (0.7%)	37 (12.9%)	46 (16.0%)
	<i>D</i>	77 (42.8%)	70 (38.9%)	7 (3.9%)	12 (6.7%)	14 (7.8%)
	<i>E</i>	52 (35.9%)	66 (45.5%)	2 (1.4%)	12 (8.3%)	13 (9.0%)
	<b>Total</b>	<b>434(35.5%)</b>	<b>486(39.7%)</b>	<b>53 (4.3%)</b>	<b>155(12.7%)</b>	<b>95 (7.8%)</b>
Number 5: Consumers should pay for the safe disposal of their e-waste	<i>A</i>	53 (15.5%)	77 (22.5%)	37(10.8%)	84 (24.6%)	91 (26.6%)
	<i>B</i>	27 (10.0%)	110(40.9%)	14 (5.2%)	95 (35.3%)	23 (8.6%)
	<i>C</i>	72 (25.1%)	82 (28.6%)	4 (1.4%)	66 (23%)	63 (22.0%)
	<i>D</i>	29 (16.1%)	56 (31.1%)	20(11.1%)	33 (18.3%)	42 (23.3%)
	<i>E</i>	40 (27.6%)	41 (28.3%)	11 (7.6%)	36 (24.8%)	17 (11.7%)
	<b>Total</b>	<b>221(18.1%)</b>	<b>366(29.9%)</b>	<b>86 (7.0%)</b>	<b>314(25.7%)</b>	<b>236(19.3%)</b>
Number 6: E-waste recycling centers should be established by government.	<i>A</i>	187(54.7%)	137(40.1%)	13 (3.8%)	1 (0.3%)	4 (1.2%)
	<i>B</i>	121(45.0%)	119(44.2%)	5 (1.9%)	21 (7.8%)	3 (1.1%)
	<i>C</i>	130(45.3%)	94 (32.8%)	7 (2.4%)	15 (5.2%)	41(14.3%)
	<i>D</i>	80 (44.4%)	41 (22.8%)	4 (2.2%)	34 (18.9%)	21(11.7%)
	<i>E</i>	92 (63.4%)	46 (35.7%)	-	2 (1.4%)	5 (3.4%)
	<b>Total</b>	<b>610(49.9%)</b>	<b>437(35.7%)</b>	<b>29 (2.4%)</b>	<b>73 (6.0%)</b>	<b>77 (6.3%)</b>

### 3.3.3 Association between background information and awareness level on e-waste

Generally, six different significant associations were established (Table 9). There was a significant association between all the background information and the first variable (i.e., awareness on Ghana's e-waste legislation). In the case of the second variable (i.e., awareness on general e-waste management issues), significant associations were obtained for education and stakeholder only.

Table 9. Pearson Chi square analysis for the associations between the background information and awareness level on e-waste [Ghana's e-waste legislation and general e-waste issues]. P values < 0.05 are significant.

<b>Background information</b>	<b>Awareness on Ghana's e-waste legislation</b>	<b>Awareness on general e-waste management issues</b>
Gender	0.023	0.575
Age	0.000	0.096
Education	0.020	0.000
Stakeholders	0.000	0.000

### 3.3.4 Sources of information to respondents, who received education on e-waste and Ghana's e-waste legislation

Table 10 summarises the sources from where respondents obtained their information on e-waste. The results show that community engagement and the mass media are the main channels through which respondents accessed either general information on e-waste or information regarding Ghana's e-waste legislation. Generally, the number of respondents who obtained information through community engagement appeared to be slightly higher than the mass media for both cases (i.e., general information on e-waste and e-waste legislation). In the case of the e-waste legislation, some respondents (13.2%) also obtained information from their friends / colleagues.

Table 10. Source of information to respondent who received education on e-waste and Ghana's e-waste legislation.

Source	General public consumers	Repairers	Wholesalers/retailers	Recyclers	Importers	Total
<b>Source of information on e-waste</b>						
Media	36 (10.5%)	7 (2.6%)	14(14.8%)	3 (1.7%)	12(8.4%)	<b>72(46.8%)</b>
Community engagement	30 (8.8%)	22 (8.2%)	23 (7.9%)	6 (3.4%)	-	<b>81(52.5%)</b>
Friends/colleagues	-	-	-	-	-	-
No response	-	-	-	-	-	-
<b>Source of information on Ghana's e-waste legislation</b>						
Media	26 (7.6%)	17 (6.3%)	6 (2.0%)	-	1 (0.7%)	<b>50(34.7%)</b>
Community engagement	11 (3.3%)	18 (6.7%)	18 (6.3%)	1 (0.6%)	10 (6.9%)	<b>58(40.3%)</b>
Friends/colleagues	5 (1.5%)	4 (1.5%)	7 (2.4%)	-	3 (2.1%)	<b>19(13.2%)</b>
No response	1 (0.3%)	14 (5.2%)	4 (1.4%)	1 (0.6%)	-	<b>20(13.9%)</b>

## **4. Discussion**

### **4.1 Impact of e-waste legislation on waste management**

The overall goal of Ghana's e-waste legislation in 2016 was to provide a framework for control, management and proper disposal of e-waste in order to minimise the environmental and health-related problems associated with it (EPA-Ghana 2016). To achieve this goal, the Act 917 of 2016 has established several mechanisms to ensure sustainable e-waste management and safe disposal in Ghana. For instance, the Act provides for recycling of electrical and electronic wastes. The Act also establishes the obligation of taking back policy when a manufacturer, wholesalers or distributor of electronic and/or electrical products (i.e., e-products) fails in contributing to control of discarded e-products in the environment.

After juxtaposing current e-waste management practices in the study area with some important requirements (e.g., obligation of taking back policy or establishment of recycling facilities) in the e-waste Act, it appears that some inefficiencies in the implementation of the legislation are apparent. Indeed, the current survey on e-waste management practices in the study areas indicates that most people dispose e-waste at dumping sites. This practice is suggestive of lack or absence of e-waste recycling centres and also, indicates that the obligation of taking back policy is not effectively enforced. The disposal of e-waste at landfill sites is an unsustainable practice since e-waste will likely be mixed with other waste materials such as metals, glass and plastic, among others, thereby creating difficulty for proper incineration or recycling. Thus, the long-term effects can be the gradual release of poisonous elements into the soil and consequently, lead to the contamination of groundwater (Robinson 2009). Although the majority of the respondents had not received education on e-waste, changes in disposal practices over the past years have mainly been driven by economic and environmental concerns perceived by the individuals rather than the enforcement of the Act 917 of 2016 in Ghana.

### **4.2 Awareness level: implication for enforcement of the Act 917, 2016**

The low level of awareness on general e-waste issues and national e-waste legislation among respondents is consistent with previous studies in Ghana and other counties (Okoye and Odoh 2014; Owusu et al. 2017; Nuwematsiko et al. 2021). Although studies show that increased information and environmental awareness can stimulate public participation in sustainable waste management practices (Ramayah et al. 2012; Saphores et al. 2012), there is also evidence that public awareness on electronic waste management strategies has not always translated into positive change in behaviour of some people (Ylä-Mella et al. 2015). Besides awareness creation, enforcement of environmental regulations by law enforcement agencies has also been associated with the successful implementation of electronic waste management systems (Rautela et al. 2021). Again, our interactions with key stakeholders in the e-waste (or e-product) industry revealed that the current e-waste regulations are not sufficiently enforced. Thus, the lack of awareness on national e-waste policies and the unsustainable e-waste management practices among stakeholders might not only be related to the level of education as indicated by the association between education level and awareness level on national e-waste regulations in the present study. The low awareness may be related to the lack of publicity on national e-waste management systems as well as inefficient enforcement of the regulations by law enforcement authorities in Ghana, suggesting a long-term high tendency for stakeholders to indulge in unsustainable e-waste management practices which may have adverse consequences on human health and the environment. Results from the present study also highlights

the need to intensify awareness campaigns on general e-waste management issues among all the stakeholders in Ghana.

#### **4.3 Willingness to participate in sustainable e-waste management practices**

The preparedness of respondents to participate in sustainable e-waste management was assessed based on their responses to some key components of Ghana's e-waste management bill. Respondents were generally in support of policy issues that relates to sustainable management of e-waste: for example, relatively large proportion of respondents agreed and/or strongly agreed on the implementation of the e-waste policies (Table 8). However, the degree of acceptance or rejection of policies among respondents varied considerably. This could be mainly related to the perceived impacts of the policies on stakeholders, who were also the respondents in this study. These stakeholders who perceived that their businesses and livelihoods may be threatened in future vehemently opposed effective implementation of the policies. In the case where the government will be responsible for the costs of implementing the 'policy number 6 in Table 8', the majority of the stakeholders were overwhelmingly in support of it. These findings suggest that the various e-waste policies may vary in concerns and willingness of stakeholders to participate in the full implementation of Ghana's e-waste law.

In some jurisdictions, economic incentives have been used to promote pro-environmental behaviours (Ylä-Mella et al. 2015). For instance, the United Kingdom mobile phone take-back scheme has been effective in facilitating recycling of mobile phones and similar e-products (Ylä-Mella et al. 2015). This is largely because incentives such as discounts, free services for mobile phone usage and free options (such as free postage services or free courier collection) promote recovery of old mobile phones, malfunctioning e-accessories or e-products from the users (Ylä-Mella et al. 2015). Considering the numerous challenges associated with the implementation of the e-waste policies so far, Ghana may introduce similar strategies in the 'e-waste law' to achieve effective sustainable management of e-waste.

### **5. Conclusions**

Community engagement and the mass media are the primary sources of information on e-waste among respondents. Nonetheless, there is a low level of awareness on Ghana's e-waste legislation and general e-waste management issues among respondents in the study area. The e-waste management approach adopted by respondents has mainly been disposal at dumpsites and/or repair for reuse or reselling. About 10% of respondents made changes in their e-waste disposal practices after the enactment of the law in 2016. These changes were mainly associated with the economic benefits respondents derived from reselling e-waste or the potential negative impacts of e-waste on the environment largely perceived by the respondents. Significant associations between the background information of respondents and the awareness level on e-waste were observed, revealing that (i) gender, age and education of respondents as well as the stakeholders themselves will likely influence awareness on Ghana's e-waste legislation, whereas education and stakeholders other than gender and age will more likely influence awareness on general e-waste management issues. The degree of acceptance or rejection of policies seemed to be influenced by respondents' perceived threats of the policies on their livelihood. Thus, strategies such as incentives and free postal systems, among others may facilitate recovery of e-waste from users for proper disposal or recycling.

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## Compliance with ethical standards

*Funding:* no information is available.

*Competing interest statement:* authors declare that they have no conflict of interest.

*Human and animal rights:* Humans and animals were not used as objects of the study by any of the authors.

*Additional information:* Questionnaires used for data collection are available as supplementary materials, or can be requested from the authors.

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