

PERCEPTUAL ASSESSMENT OF EXTENDED PRODUCER RESPONSIBILITY FOR MANAGEMENT OF ELECTRONIC WASTE IN ILORIN METROPOLIS, NORTH CENTRAL NIGERIA

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ABSTRACT

Electronic waste (e-waste) generation and its unsustainable management are major problems in in Nigeria. Objectives of the Extended Producer Responsibility (EPR) policy launched in 2016 in Nigeria include promoting the knowledge of e-waste and its environmental hazards and, encouraging formal recycling among the people. This study reports knowledge of e-waste environmental hazards, information channels, and factors influencing the acquisition of knowledge on e-waste hazards among households in Ilorin metropolis. Both quantitative and qualitative methods were employed to collect and analyze data. The study involved a sample of 600 households for questionnaire administration and, 30 households for in-depth interviews. Quantitative data were analyzed using descriptive statistics and Binomial Logistic regression. In-depth interview data were analyzed using content analysis method. Findings revealed that only 28.5% of the respondents reported being knowledgeable about e-waste hazards. Sources of knowledge on e-waste hazards were interpersonal information and knowledge sharing (47.8%) and electronic products handling/safety brochures (15.4%). Furthermore, Binomial Logistic regression analysis signified that important factors that influenced the acquisition of knowledge on e-waste hazards among the study respondents (at $P \leq 0.01$) were gender, education, household headship type, and sector of employment of household heads. In sum, the level of awareness on e-waste hazards is low in the study community. The study recommends public awareness and sensitization strategies on e-waste hazards and, the mainstreaming of the subject matter of e-waste in the basic science and computer studies curricula at the Elementary and Junior Secondary School levels in the study community and at the national level in Nigeria.

Keywords: E-waste hazards, Constructivist Learning Theory, Knowledge of e-waste hazards, Ilorin metropolis, North Central Nigeria

INTRODUCTION

Urban communities generate waste of various types from the consumption of goods, from agricultural and industrial sources (Singh et al., 2017; Andeobu et al., 2021; Cai et al., 2023). These goods and products are consumed for diverse purposes such as human biological sustenance, healthcare, work/business, leisure/recreation and so on. Some of the industrial goods consumed regularly in the modern society include electrical and electronic (EE) products (Ikhlayel, 2018; Melchor-Martinez et al., 2021). Regular consumption of EE commodities has emerged as an important component of modern living (Almulhim, 2022). However, the waste generated during the post-consumption phase especially due to the inadequate disposal system, often leads health hazards to humans and problems to the ecosystem (Arya & Kumar, 2020; Awere et al., 2020; Bimir, 2020).

Electronic waste (e-waste) is generated by EE equipment and devices that are no longer useful to the users or consumers due to obsolescence, product(s) reaching End-of-Life (EoL) or through malfunctioning or irreparable damages (Leclerc & Badami, 2020; Miner et al., 2020; Lu et al., 2022). Some scholars such as Ghisellini et al. (2016); Islam et al. (2020) and Zhou et al. (2022) have argued that e-waste is one of the fastest-growing waste streams among households and businesses in urban communities). Undoubtedly, the management and disposal system for e-waste requires approaches that are different from organic types of municipal solid waste, because e-waste contains potentially environmentally hazardous components (Wang et al., 2021).

Many studies carried out outside in sub-Saharan Africa (for example Siddiqua & Faisal, 2020; Sonone et al., 2020; López-Botella et al., 2021) have reported that e-waste has the potential to constitute hazards to the eco-system and consequently have negative effects on the health of humans, livestock and aquatic creatures if it is not sustainably managed. Research results have also shown that some of the health-damaging and environmentally hazardous components of e-waste are the heavy metals and chemical materials/solvents that are used to produce EE products (Esmaeilzadeh et al., 2019; Madiha et al., 2022). The works of Xu et al. (2015) and Orisakwe et al., (2019) documented the list of potential environmental toxicants and pollutants in e-waste.

Okorhi et al. (2018) reported some of the popular EE equipment and devices that are utilized and generate e-waste in Nigeria. The findings by Okorhi et al. are representative of all the urban communities in Nigeria, including the community selected for the current study, Ilorin. Research reports revealed that Nigeria generated about 277,000 metric tons of e-waste in 2016 and, its yearly growth rate is consistent with the global projection of 3 - 4 % per annum (Baldé et al., 2017). A major factor that accounts for this growth rate is that for more than two decades Nigeria has become a principal destination for the dumping of e-waste generated in Western Europe and Asia, through the importation of obsolete and disused EE goods (locally referred to as second-hand commodities) by local merchants for the resource-poor EE consumers in Nigeria (Merem et al., 2021).

The 'green culture' has evolved globally to tackle all aspects of human activities that are ecosystem-unfriendly. Green culture encapsulates novel approaches that foster environmentally sustainable industrial production systems, consumption and post-consumption behaviours. These include concepts and practices such as the Circular Economy, Extended Producer Responsibility, sustainable lifestyles, sustainable diets and

nutrition, environmental innovativeness, environmental knowledge acquisition, sustainability awareness, eco-consciousness and, pro-environmental behaviour change (Wehr, 2011; Stahel, 2016).

Following the global trends in the adoption of the Circular Economy (CE) and Extended Producer Responsibility (EPR) for sustainable e-waste management, Nigeria launched the EPR policy in 2016 to contain the exacerbating problem of urban e-waste generation and to promote systems for its eco-friendly management (Woggsborg & Schröder, 2018; Ajani & Kunlere, 2019). Consequently, the EPR policy launched in Nigeria represented a landmark initiative by the government to promote sustainable e-waste management in the country. Part of the goals of the EPR policy in Nigeria is to articulate government and private sector-led interventions in e-waste control and sustainable management. One of the key components of EPR policy is to promote knowledge among the users/consumers of EE products on e-waste potential environmental hazards and sustainable post-consumption behaviour and habits in e-waste disposal (Woggsborg & Schröder, 2018; Ajani & Kunlere, 2019).

This study was guided by Constructivist Learning Theory (CLT). The theory has its roots in the sub-field of interpretive sociology. The major assumption of this theory is that humans (social actors) act toward objects and social phenomena based on the social knowledge that they have acquired about those objects/social phenomena, and the social meanings (through social constructivism) that they eventually attach to those phenomena. CLT posits that social knowledge is constructed by human social actors and not just haphazardly acquired by them. The theory has two important assumptions: first, prior knowledge always influences positively or negatively, the human capacity to acquire new knowledge, secondly learning is an active and ongoing process in the course of the human lifecycle (Narayan et al., 2013; Berger & Luckmann, 2016; Packer & Goicoechea, 2000).

Social knowledge can evolve reflexively as the cognitive capacity and experiences of the members of the social unit evolve. During the process of new knowledge acquisition, if the emerging new knowledge is not congruent with the current social cognitive system of the learner, the learner evaluates the incongruence and attempts to modify or align their previous knowledge with the new schema. Therefore, the process of making meanings is interpretive and dependent on the learner's life experiences and sociocultural attributes (Narayan et al., 2013; Berger & Luckmann, 2016; Packer & Goicoechea, 2000).

The relevance of the CLT theory to the current study is that humans employ their diverse endowments (cognitive capacity and social attributes) and prior life experiences to access and grasp new knowledge during the course of social life. Social knowledge about e-waste potential hazards (and their associated social meanings) can be transmitted through several sociocultural pathways, including traditional and modern channels and, using all types of languages spoken in a given community, including native language(s). However, the ability to receive or transmit knowledge on e-waste potential hazards will be restricted, when some members of society are unable to socially construct e-waste as environmental pollutants and hazardous materials when individuals, households and the community at large do not manage them in environmentally sustainable ways often specified in EE products' safety brochures.

Little is known about EPR at the community level in Nigeria, especially on the implementation of the policy on expansion of knowledge about e-waste and its environmental hazards if not sustainably managed. The acquisition of knowledge on e-waste potential

environmental hazards represents a fundamental step in the pro-environmental behaviour change towards eco-consciousness and eco-friendly habits on sustainable e-waste management among the consumers of EE products. Furthermore, literature revealed that the dimensions of knowledge on e-waste environmental hazards, information channels on knowledge acquisition, and factors influencing knowledge acquisition among EE consumers have received less research attention in Nigeria. This study was conducted to fill these identified gaps in the literature, and it focused on households in Ilorin metropolis, one of the largest cities in the north-central region of Nigeria.

The objectives of the study within the policy framework of EPR were to (1) assess the knowledge of environmental hazards associated with E-waste, (2) identify the information channels on e-waste hazards and, (3) examine the factors influencing the acquisition of knowledge on e-waste hazards in Ilorin. In developing countries (such as Nigeria) the awareness of the potential of e-waste as hazardous substances among consumers of EE products represents the first and most significant step in the pathway towards willingness to participate in environmentally sustainable approaches to manage e-waste during the post-consumption phase of EE commodities that the EPR policy was designed to achieve.

The present study tested three hypotheses (formulated in the null form) as stated below:

H₀ 1: Demographic attributes of the study participants (such as age, gender, marriage type, the headship of household, and others) do not have significant effects on knowledge of e-waste environmental hazards.

H₀ 2: Socioeconomic attributes of the study participants (such as education, income, and sector of employment) do not have significant effects on knowledge of e-waste environmental hazards.

H₀ 3: Cultural attributes of the study participants (such as religion, and ethnic group affiliations) do not have significant effects on knowledge of e-waste environmental hazards.

THE STUDY AREA

Ilorin is the capital city of Kwara State, North-Central Nigeria.. Ilorin is located between Latitude 8° 30' and 8° 50' N and Longitude 4° 20' and 4° 35' E with a land area of about 100km². It currently has an estimated population of about 3 million people (Fig. 1). The city covers parts of three Local Government Areas (LGAs); these are Ilorin West LGA, Ilorin East LGA and, Ilorin South LGA (National Population Commission, 2021). Ilorin is home to various ethnic groups in Nigeria such as Yoruba, Hausa, Fulani, Nupe, Kanuri, Igbo, Tiv, Idoma, and so on. Foreign nationals are also residents of the city. The traditional occupation of the natives is agriculture, comprising both arable and pastoral farming. In the area of modern trade and commerce, both the formal and informal sectors co-exist together in Ilorin metropolis (Gemna, 2012).

The socioeconomic attributes of the population in Ilorin that make the inhabitants to use EE products that generate e-waste is similar to those in other urban centres in Nigeria (see Okorhi et al., 2018). Modern-day homes, trade and commercial activities are utilizing equipment that are operated and powered by electronic components and electricity. Many of the individuals that are employed in the formal sector in Ilorin (government workers and private sector workers) have their own personal laptops for work. A majority of this category of people have procured the European and Asian used (and scrapped) laptops imported as second-hand goods into the Country. Some of the informal sector enterprise owners in Ilorin

that are engaged in commercial computer services are running their businesses with second-hand computers and printers. Many of these people have learnt the rudiments and are accustomed to servicing their electronic equipment on their own as a result of too frequent breakdown of electronic printers and electricity generators. For some other informal sector workers, most tools used by artisans (barbers, hairdressing salons, tailors, welders) have been upgraded by manufacturers into electronic and electrical equipment. Residential homes in Ilorin have several EE products (television, radio, fans, refrigerators/chest freezers, blenders, washing machines) for the comfort and leisure of family members. Due to poor income, many of these common-place home gadgets were purchased by households as second-hand goods (locally called *Tokunbo*) imported from Asia and Europe (see Omobowale, 2012; Merem et al., 2021).

Additionally, individual members of the community have massively adopted mobile (cell) phones. Some individuals bought their own cell phones as new products, some acquired their own as *Tokunbo*. These cell phones fall into state of disrepair and their lithium battery are spent over time too. In Ilorin, like every other major urban community in Nigeria, there is an acute problem of poor electricity supply, most households use gasoline electricity generators to power residential homes (at night), the same condition applies to small-scale businesses in the city at night. These generators have lifespan for their use. Many homes and small-scale businesses also rely on rechargeable (lithium battery powered) lamps and solar powered lamps as sources of lighting after sunset. Many people have purchased and are using rechargeable lithium power banks to store electricity to power their mobile phones when there is no grid-based electricity supply for days unending. These EE devices have lifespan for their use. Moreover, many of them were acquired in the first instance as *Tokunbo* or e-waste (see Omobowale, 2012; Okorhi et al., 2018; Merem et al., 2021). All these household-level and community-level experiences contribute to the generation and build-up of e-waste in Ilorin metropolis.

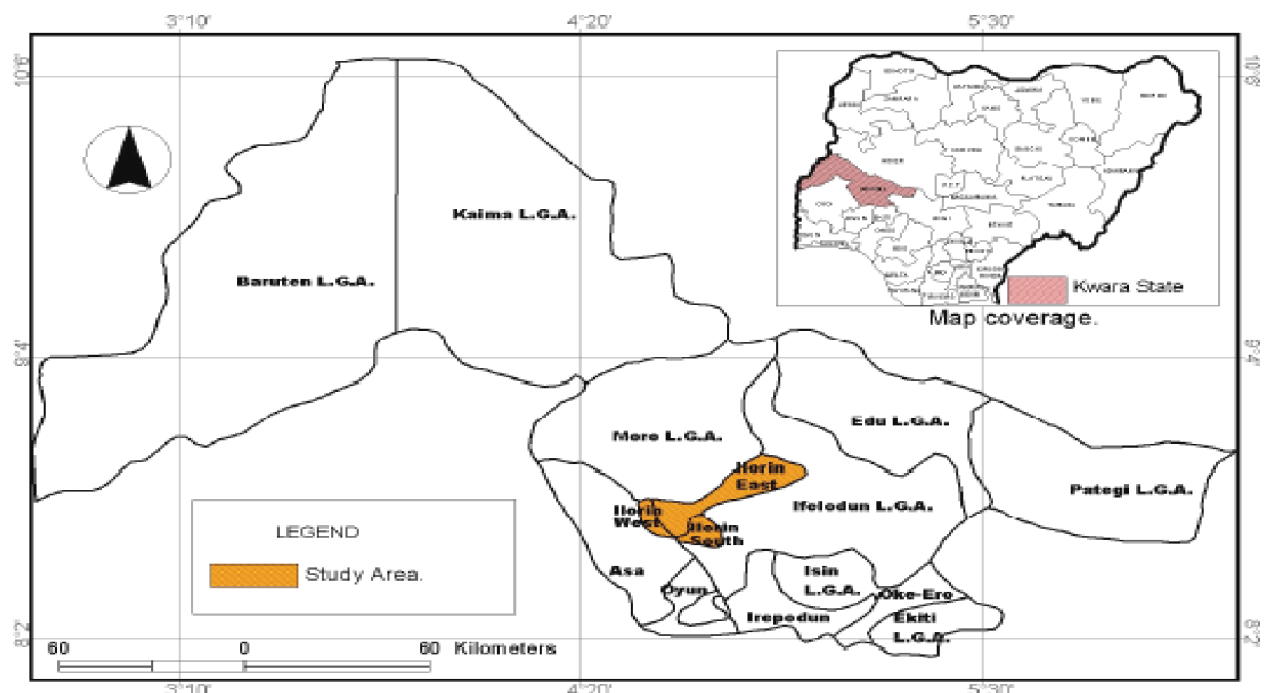


Fig 1. Map of Kwara State showing Ilorin (with Nigeria as inset)
Source: Adapted from Onifade et al., 2015

MATERIALS AND METHODS

Sample selection and sample size

This study utilized a cross-sectional research design and mixed-method approach. Ilorin metropolis spreads across Ilorin South, Ilorin West and Ilorin East LGAs (Fig. 2). LGAs are the lowest units of Nigeria's federal system of administration. The study employed a combination of multi-stage random and convenience sampling approaches to select the study participants. In the first stage, random sampling assisted in selecting two out of the three (3) LGAs. Consequently, both Ilorin South LGA and Ilorin East LGA were randomly selected.

The second stage of random sampling, the Enumeration Area demarcations (or Statistical Areas demarcations) of the two randomly selected study LGAs were obtained from the Kwara State office of the National Population Commission. From the Enumeration Area (EA) listing, Ilorin South LGA is demarcated into 1534 EAs, while Ilorin East LGA is demarcated into 1485 EAs (National Population Commission, 2021). Using the listing of EAs as a sampling frame, a random sample of 30 EAs per LGA was selected. This gave a total of 60 EAs.

The third stage of random sampling, the EA maps of the randomly selected EAs were procured from the National Population Commission. A majority of the EA maps only have the names of three to five streets clearly indicated on them. Consequently, from each of the EA map, a random sample of two streets was selected. Furthermore, from each street, five (5) households were selected using convenience sampling method. Convenience sampling was used at the last sampling stage because the researchers lacked sampling frame on the number of households per street in each EA. Data to build sampling frame on the number of households per street in each EA could not be procured by the researchers from the Kwara State office of the National Population Commission. This is because of the internal policy of the Commission that restricts the kind of data that could be obtained at state level.

The sampling exercise yielded a total sample size of 600 households for the quantitative study (questionnaire survey). The sample size of 600 study households for the quantitative survey (questionnaire) complied with the empirical methods suggested by Som (2020). Furthermore, regarding the qualitative component of the present study (in-depth interviews), the sampling steps discussed above were repeated. From the two study LGAs, a separate sampling process was carried out to choose 30 households for the qualitative segment of the current study. Therefore, the in-depth interviews (IDIs) involved a separately selected sample of study participants. These households are different from those that participated in the questionnaire administration.

Methods of Data Collection and Analysis

Both quantitative and qualitative methods were employed to collect and analyze data for the current study. This involved the use of both structured questionnaires and in-depth interview (IDI) instruments. The usefulness and limitations of these data collection instruments are fully discussed by authors such as Ritchie et al. (2013) Bryman (2016) and, Creswell and Plano-Clark (2017). The two data collection instruments were pre-tested among non-participating households in Ilorin to ensure their validity and reliability. The results of the

pre-testing exercise were used to fine-tune the instruments prior to the real survey. On data collection for the current study, pre-tested structured questionnaire was administered to 600 study households. In addition, pre-tested IDI instrument was also administered to a separately selected 30 households. The data collection instruments for this study (questionnaire and in-depth interview guide) included a section that sought the informed consent of the study participants before they participated in the study.

Analysis of the quantitative data entailed both descriptive and inferential statistics. The free online R Statistical software was employed for the analysis of the quantitative data. The qualitative data (IDIs) were collected by audio recording using mobile phones (consent of each interviewee was obtained before the commencement of the interview recording). Transcribed IDIs were thematically coded and analyzed using qualitative content analysis method. In the result section of this paper, data obtained from the qualitative method (IDIs) supplemented and shed more light on the information obtained from the structured questionnaire survey.

Specification of the Binomial Logistic Regression Model for statistical analysis

Binomial Logistic (Logit) regression can be estimated for univariate and multivariate datasets (Kleinbaum & Klein, 2010). Therefore, following Kleinbaum and Klein (2010) the Logit regression (for multivariate datasets) is estimated using the model presented in Equation 1 below:

$$\log \gamma \left(\frac{\pi}{1-\pi} \right) = \beta_0 + \beta_1 \chi_1 + \beta_2 \chi_2 + \beta_3 \chi_3 + \dots \dots \dots \beta_k \chi_k + \mu \quad \dots \dots \dots \text{(Equ. 1)}$$

Where, as in Equation 1

Y stands for a dichotomous dependent variable, Yes/No questionnaire response to the question that measures ‘awareness of e-waste hazards’ in the current study

π indicates the probability of an event

β_0 = Model intercept (or constant)

$\beta_1, \beta_2, \beta_3 \dots \beta_k X_k$ represents coefficients of the explanatory/predictor variables

μ = Error term for non-observable factors.

The explanatory (independent) variables that were employed in the Binomial Logit estimation for this study are defined as follows: χ_1 = Age of respondents; χ_2 = Gender; χ_3 = Marital status; χ_4 = Religion; χ_5 = Ethnic group membership; χ_6 = Education; χ_7 = Household headship; χ_8 = Marriage type; χ_9 = Household size; χ_{10} = Employment status; χ_{11} = Sector of employment; χ_{12} = Household income; χ_{13} = Secondary occupation/secondary income sources; χ_{14} = Tenancy type.

This paper paid attention to the recommendations by authors such as Hosmer et al. (1991) on the use of the Logit model in data analysis. The authors recommended the relevance of estimating and reporting the ‘fit of logistic regression model’ for validation of statistical analysis. In their opinion, this involves the estimation of summary (diagnostic) statistics such as deviance (D), chi-square (χ^2), degree of freedom (df), and Cook distance ($\hat{C}$) to illuminate the data’s ‘leverage and residual effects’ on the estimated regression coefficients. Theoretical details on these diagnostic and summary statistics and their importance for Logit regression result validation are discussed by Hosmer et al. (1991).

RESULTS AND DISCUSSION

Demographic and socioeconomic characteristics of the study respondents

From a total of 600 randomly selected participants for this study, 477 participants responded to the questionnaire survey. This represents a 79.5% response rate. Data on the demographic and cultural traits of respondents are presented in Table 1. On the demographic attributes of the respondents, data analysis showed that the mean age of study participants was 38.7 years. Respondents in the 41-60 years age bracket were the majority (38.2%, n=182). As regards the marital status of study participants, 62.5% (n=298) were married, and 15.1% (n=72) were singles. Respondents that reported widowed status were 10.9% (n=52) and, those that reported that they were divorced/separated were 9.4% (n=45). Data analysis further showed that the average household size among respondents was 7.14 persons.

Table 1: Demographic and cultural traits of the study respondents

Characteristics of respondents	Frequency count (n=477)	% of Respondents
Age (Years/Mean)	48.7	-
Gender		
Male	284	59.5
Female	193	40.5
Marital status		
Single	72	15.1
Married	298	62.5
Separated/Divorced	45	9.4
Widowed	52	10.9
No response	10	2.1
Religious affiliations		
Islam	268	56.2
Christianity	124	26.0
Traditionalists	67	14.0
Others (specify)	18	3.8
Ethnic group membership		
Yoruba	260	54.5
Igbo	68	14.3
Hausa/Fulani	54	11.3
Others (specify)	95	19.9
Marriage type (n=298)		
Monogamy	192	40.3
Polygyny	106	22.2
Average household size (mean)	7.14	-

Source: Survey data analysis, 2023

Regarding the cultural traits of the study participants (Table 1), the religious affiliation of many of the respondents was Islam (56.2%, n=268), this was followed by Christianity (26%, n=124), while the Traditionalists and adherents of other religions were 17.8%. Regarding the ethnic group membership of the respondents, more than half were Yoruba (54.5%, n=260), followed by Igbo (14.3%, n=68), Hausa/Fulani (11.3%, n=54), while the rest of the respondents (close to 20%) belonged other ethnic groups within Nigeria. The most popular marriage type among the married (n=298) respondents was monogamy (40.3%, n=192) which was followed by polygyny among other respondents (22.2%, n=106).

On the socioeconomic traits of the study respondents (Table 2), individuals with no formal education were very few (2.5%, n=12); those who completed Arabic schools (only) were 14.5% (n=69). Those with primary school completed (only) were approximately 13% (n=61) and, those who completed secondary/technical school were approximately 18% (n=84). The majority of the respondents (31.9%, n=152) had a Polytechnic Higher Diploma/First University degree (and other equivalent qualifications). Respondents with University postgraduate degrees

(Master/Doctoral) were below 10%. On the employment status of the respondents, 73.8% (n=352) reported that they were gainfully employed, while 23.9% (n=114) reported that they were unemployed/not gainfully employed. For those that reported being gainfully employed, the informal sector (comprising largely petty trading, artisanal occupations, daily wage earning and so on) engaged the majority of them (52.4%, n=250), while a sizeable proportion (32.9%, n=157) were also engaged in the formal sector. Fewer respondents (4.4%, n=21) reported that they were engaged in the Charity sector/Religious organizations (mostly religious Clergies like Islamic imams and pastors). On income level, a majority of the respondents (>80%) were in the low (0 – 1,500,000 Naira/annum) and middle-income categories (1,501,000 – 3,000,000 Naira/annum), while less than 15% were in the high-income category (above 3,001,000 Naira/annum).

Table 2: Socioeconomic characteristics of the study respondents

Characteristics of respondents	Frequency count (n=477)	% of Respondents
Highest level of educational attainment of household head		
No formal schooling	12	2.5
Arabic school completed	69	14.5
Primary school completed	61	12.8
Secondary/Technical College completed	84	17.6
National Diploma (and equivalents) completed	30	6.3
Higher Diploma/First university degree/Equivalents completed	152	31.9
Postgraduate (Master's/ Doctoral degree) completed	37	7.8
Professional Qualifications attained	27	5.7
Others (specify)	5	1.0
Employment status of household head		
Gainfully employed	352	73.8
Not gainfully employed/Unemployed/Retired	114	23.9
No response	11	2.3
Sector of employment of household head		
Informal (e.g. Petty Traders, Artisans, Daily Wage labourers and so on)	250	52.4
Formal (e.g. Public and Private sectors)	157	32.9
Religious organizations/Charity	21	4.4
No response	49	10.3
Secondary occupation/secondary income sources for the household head		
Yes	69	14.5
No	408	85.5
Income categories of household head (per annum)		
Low-income category(0 – 1,500,000 Naira)	232	48.7
Middle-income category(1,501,000 – 3,000,000)	191	40.1

Naira)		
High-income category (Above 3,001,000 Naira)	54	11.3
Number of years living in Ilorin (mean/years)	5.8	—
Type of housing		
One room with a shared facility	99	20.8
One-room mini-flat (self-contained)	157	32.9
2/3 Bedroom apartment/flat	177	37.1
Duplex	23	4.8
Others (specify)	21	4.4
Tenancy type		
Homeowner	136	28.5
Letting tenant	330	69.2

Source: Survey data analysis, 2023

Prevalence of use of EE Devices and knowledge of e-waste among the study respondents

All the respondents to this study (n=477) reported that in the last five years, they have consistently had access to EE equipment/devices and used them for various purposes at home and in work/business environments. Data analysis further showed that 68.5% (n=327) of the respondents reported that they know about e-waste and, also reported that they know that the EE devices/equipment they use at home and for work/small-scale business activities can produce e-waste at their EoL, or as a result of irreparable damages/obsolescence.

Knowledge of e-waste environmental hazards among the study respondents

Data analysis revealed that out of the 477 respondents to the survey, only 28.5% (n=136) reported that they know about e-waste environmental hazards and the possibility of e-waste containing heavy metals and chemical toxicants that are potentially hazardous to human health, livestock/pets and the ecosystem if they are not safely and properly disposed or managed (Fig. 2). Furthermore, disaggregation of the result on the level of knowledge of e-waste' hazards among respondents that reported awareness (n=136) was undertaken. Disaggregation was carried out based on gender, education, income, and sector of employment among study respondents (who reported knowledge of e-waste hazards). Based on gender categories, more male respondents (72.1%, n=98) compared to female respondents (27.9%, n=38) were aware of e-waste hazards. Based on education, the disaggregated analysis revealed that a higher proportion of respondents with education at the level of Polytechnic Higher Diploma/First University degree and above (83.8%, n=114) were aware of e-waste hazards compared to respondents with a lower level of educational attainment (16.2%, n=22).

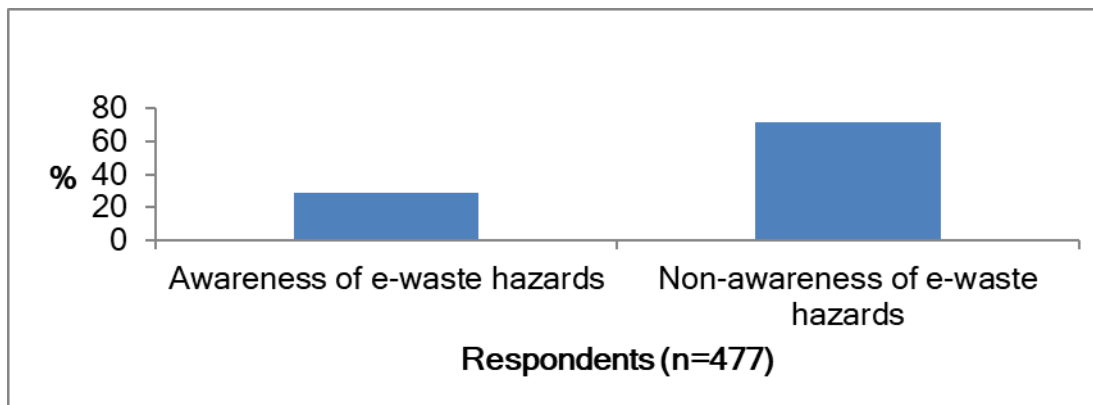


Figure 2. Level of knowledge of e-waste hazards among study respondents

Source: Survey data analysis, 2023

The disaggregated analysis further revealed that the level of knowledge of e-waste hazards was higher among respondents who occupied the average/high-income category (65.4%, n=89) than the respondents in the low-income category (34.6%, n=47). The disaggregated analysis further revealed that the level of awareness of e-waste hazards was higher among respondents who were engaged in the formal sector of employment (75%, n=102) compared to the respondents who were engaged in the informal sector of employment (25%, n=34).

Findings from the qualitative IDIs among respondents lent support to the results obtained from the questionnaire survey. Transcribed comments also highlighted variations in awareness level by gender, education and income categories. Some of the narrations by the interviewees are reported in excerpts:

A female/adult ID interviewee spoke as follows:

...I am not aware that some of the substances that the producers use to make electrical or electronic products can contain any material that can injure the health of human beings or damage our surroundings of living ... I have never heard any information or received any education that some of those products have injurious components ... I buy some of the products, use them and just dispose of them off when they are spoilt ... we largely keep many of those damaged electronic products at home for many months ...

(IDI/Female/Petty Trader/42 Years, Ilorin South LGA/EA 254)

Another female/adult IDI participants opined as follows:

... I have never heard any information that we should be mindful or careful with how we manage electronic products especially when they fall into a state of disuse through damage ... the example you gave that common Television sets that I have at home and also have in my business premises to entertain my clients or the mobile phones can contain hazardous materials when they are no longer useful is very unbelievable, whenever they are spoilt we keep Television sets at home or in the business premises for several years pending the time that we will have the money to buy another fairly used one ...

(IDI/Female/Hairdresser and Beautician/37 Years, Ilorin East LGA/EA 840)

A male/adult interviewee also explained as follows:

... To some extent, I am aware of the issue of electronic waste and its potential hazards at the end of the useful life of electronic products ... In my household, I try my best to ensure that we do not litter our living home with electronic waste ... I have spent some time educating my wife and children on the potential hazards of improper disposal of damaged electronic products ... Some of the components of those electronic devices must not be burnt in naked fire because the smokes they will emit can pollute the breathing air and damage human health ... I also know that some of them can even explode during burning and cause physical injury to people ...

(IDI/Male/Senior Public Servant/55 Years, Ilorin South LGA/EA 208)

The low level of knowledge of e-waste hazards among the study respondents portends the likelihood of poor handling and inappropriate e-waste management systems among the study households. Therefore, engaging the Constructivist Learning Theory that guided the current study (see Narayan et al., 2013; Berger & Luckmann, 2016; Packer & Goicoechea, 2000), this paper posits that substances (such as e-waste) that the study participants could not conceive as potentially hazardous through social knowledge and social meanings (social constructivism), would not be treated adequately with the appropriate precautionary measures, that it should necessarily be accorded. Through the mechanism of cycle of ignorance, individuals who are not aware of e-waste as a hazardous substance might not be able to lead other unknowing people to the level of gaining knowledge about it. Consequently, given the tendency of e-waste to contain materials that have the potential to pollute the ecosystem, and harm human/animal health, the poor level of knowledge demands remediation for the sake of the ecosystem and population health. Suggestions for remediation are discussed in the concluding section of this paper.

At the empirical level, findings from the present study on the level of knowledge on e-waste environmental hazards align with those of previous studies by Shaikh et al., (2020), Maphosa (2021), Nuwematsiko et al. (2021) and, Almulhim (2022). In their study in Pakistan, Shaikh et al. (2020) found that the majority of the urban poor (respondents) who participated were unaware of the human and environmental health hazards of e-waste, while Nuwematsiko et al. (2021) investigated the perceptions and knowledge of EE consumers and their practices of e-waste management in Kampala Uganda. The authors found that there was a high level of awareness of e-waste environmental hazards among respondents as more than 60% of respondents knew the health and environmental effects of e-waste. Almulhim (2022) in his study in Dammam City, Saudi Arabia reported that about three-quarters of his study participants were unaware of the potential health hazards of e-waste.

Channels of knowledge on hazards associated with e-waste

The reported major sources of information that facilitated knowledge of e-waste hazards (Table 3) include interpersonal information/knowledge sharing (47.8%, n=65), followed by information and warning on product packaging and, safety brochures (15.4%, n=21). Other relevant sources of knowledge that created awareness of e-waste hazards were praxis in the formal work environment (12.5%, n=17), and informal training/apprenticeship scheme (11%, n=15). Channels of awareness on e-waste hazards that were less important include mass media (4.4%,

n=6) and, formal training/schooling (3.7%, n=5). Ancillary channels, such as membership of trade associations, membership of cultural/religious groups and so on, covered 5.1% (n=7). Based on the result of the data analysis, government and EPR related channels were not effective avenues for the acquisition of knowledge on e-waste hazards (Table 3). This finding suggests that the EPR policy implementation has not made significant contributions to the promotion of knowledge on e-waste hazards.

Findings from the present study on major channels of information on e-waste potential hazards agree with findings from previous studies by Ali and Akalu (2022), and Nisha et al. (2022). These authors reported that social agents of communication in society such as occupational colleagues, business associates, mass media and, interpersonal information exchange systems among members of the society were important factors that facilitated awareness of hazardous and environmentally toxic substances among their study participants. The result on the level of relevance of information and warning on product packaging and, safety brochures suggest that contrary to its intended purpose by the manufacturers of EE commodities, its relevance in communicating knowledge of e-waste potential hazards is sub-optimal among the study population. EE products' safety manuals/brochures are designed by manufacturers to facilitate the acquisition of knowledge about potential hazards associated with EE products during the consumption and post-consumption phases.

Table 3: Sources of knowledge on e-waste hazards

Knowledge sources	Respondents (n=136)
Interpersonal information and knowledge sharing	65(47.8)*
Information and warnings on product packaging and, safety brochures	21(15.4)
Mass media	6(4.4)
Formal training	5(3.7)
Praxis in the formal work environment	17(12.5)
Informal Training and Apprenticeship Scheme	15(11.0)
Government and EPR related channels	0(0)
Other sources (e.g. Trade associations, membership of cultural and religious groups, and so on)	7(5.1)

Source: Survey data analysis, 2023

Note: *Figures in parentheses are percentages

However, Nigeria produces negligible EE goods internally, the bulk of the EE goods used in the Country (including the second-hand EE commodities) are imported from Europe, North America and Asia. All the foreign manufactured (and imported) EE products come with product safety manuals/brochures that are written mostly in European, Chinese and Arabic languages. The EE products do not come with product safety manuals/brochures written in any of the indigenous languages in Nigeria (not even in pidgin). Furthermore, due to poor safety and poor knowledge of the potential environmental effects of e-waste, the EE consumers and the informal-sector trained artisans (who assist in installing purchased EE devices) do not bother to read and safe-keep products' safety manuals and brochures for future reference. Above all, the second-hand EE

commodities (arguably e-waste of Europe, North America, and Asia) that constitute the bulk of current importations to Nigeria do not come with products' safety manuals and brochures.

Factors that influenced the acquisition of knowledge on e-waste hazards

The result of the Binomial Logit statistical analysis (Table 4) revealed that some explanatory variables (demographic and socioeconomic) such as gender, level of educational attainment, household headship type, marriage type, employment status, sector employment, and household income had positive relationships with knowledge of e-waste hazards among the respondents, while some of the predictor variables such as age, marital status, religious affiliations, household size, secondary occupation/secondary income sources and tenancy type had inverse relationships with awareness of e-waste hazards among the study respondents.

Table 4: Binomial Logit regression results on factors that influenced knowledge of e-waste hazards among the study respondents

Variables	Estimated Coefficients (β)	Estimated Standard Error	Odds Ratio
Age	-0.7028*	0.494	16.2
Gender	0.4706***	1.596	17.2
Marital status	-0.977	0.605	5.2
Religion	-1.7885*	0.408	6.7
Ethnic group membership	-1.0426	1.024	22.8
Education	1.0327***	2.383	15.3
Household headship (Male/Female headed)	0.0721***	0.816	6.3
Marriage type	0.3554	0.029	21.1
Household size	-0.022	2.296	16.4
Employment status	0.0153**	0.845	10.1
Sector of employment	0.1582***	1.493	8.9
Household income	0.9348**	0.251	2.3
Secondary occupation/secondary income sources	-2.702	0.633	4.4
Tenancy type	-0.3316*	2.418	18.9
Constant	-0.0036	0.404	
$D = 294.2$			
$\chi^2 = 282.8$			
$df = 278$			
$\hat{C} = 22.6, df \text{ for } \hat{C} = 8, P = 0.005$			

Source: Survey data analysis, 2023

Note: ***, **, * denotes statistical significance at $P \leq 0.01$; $P \leq 0.05$ and, $P \leq 0.10$ respectively.

The Binomial Logit regression estimation showed that gender, education, household headship type, and sector of employment were statistically significant at $P \leq 0.01$. Logit regression analysis

further revealed that the employment status of the respondents (whether they are gainfully employed or not) as well as household income were statistically significant at $P \leq 0.05$. Furthermore, age and the religious affiliations of respondents had a negative relationship with awareness of e-waste hazards and, were statistically significant at $P \leq 0.10$. This result indicates that younger respondents had a higher level of awareness of e-waste hazards than the respondents in the older age category.

The effect of religion indicates that although the population of Islamic adherents was high in the study community, religion did not exert an important influence on the level of awareness of e-waste hazards. Marriage type (monogamy/polygyny) had a positive relationship with the level of awareness of e-waste hazards among the respondents, but not statistically significant. Other respondents' characteristics such as household size, ethnic group membership, marital status, secondary occupation/secondary income sources, and tenancy type exhibited inverse relationships but were not statistically significant predictors of awareness of e-waste hazards.

Hypotheses testing

Hypothesis number 1:

H₀ 1: Demographic attributes of the study participants (such as age, gender, marriage type, the headship of household, and others) do not have significant effects on knowledge of e-waste environmental hazards.

The Logit regression estimation showed that gender and household headship (as demographic traits) have statistically significant effects at $P \leq 0.01$ on awareness of e-waste hazards. Furthermore, the age of respondents is also a predictor of awareness of e-waste hazards at $P \leq 0.10$. However, household size was not statistically significant. Based on this finding, hypothesis 1 of this study is rejected.

Hypothesis number 2:

H₀ 2: Socioeconomic attributes of the study participants (such as education, income, and sector of employment) do not have significant effects on knowledge of e-waste environmental hazards.

The Logit regression estimation showed that education and sector of employment were statistically significant at $P \leq 0.01$ and, the employment status of the respondents (whether respondents were gainfully employed or not) as well as household income were statistically significant at $P \leq 0.05$ for awareness of e-waste hazards. Based on this finding, hypothesis 2 of this study is rejected.

Hypothesis number 3:

H₀ 3: Cultural attributes of the study participants (such as religion and ethnic group affiliations) do not have significant effects on knowledge of e-waste environmental hazards.

Inferential statistical analysis revealed that the religious affiliations of respondents had a negative relationship with awareness of e-waste hazards and is statistically significant at $P \leq 0.10$.

However, factors such as ethnic group membership which is assumed to influence the social behaviours of people because of the cultural norms that influences the socialization process and attitude formation, were not statistically significant predictors of awareness. Based on this finding, hypothesis 3 of this study is accepted.

Findings from the current study on the statistically significant factors that influenced knowledge of e-waste hazards such as gender, education, household headship type, and sector of employment of household heads aligns with findings from previous studies by Mehmood et al. (2020), Mahyuni et al. (2021) as well as Shajua and Laohasiriwong (2021) on the social determinants of awareness and, perceptions on handling and management of environmentally toxic and hazardous substances. The authors reported in their respective studies in diverse research settings in Asia that important determinants of awareness of environmentally toxic materials among their study participants were factors such as socioeconomic (for example level of educational attainment and income), demographic (for example age and gender), and cultural factors (such as religion) among their study participants. Formal education that signified statistically significant influence in the current study present an opportunity to enhance the dissemination of information on the dangers inherent in environmentally unsustainable management of e-waste.

One of the limitations of the current study is that the inventory on the types and volume of e-waste generated by the study households in Ilorin were not measured. However, this provide an opportunity for further studies on e-waste in the study community. Additional areas of data gaps that call for further studies include assessment of the level of knowledge on e-waste and the popular methods of e-waste management among the study population. Further studies can also examine the level and pattern of usage of the EE products' brochures on eco-consciousness and pro-environmental attitudes, the safe handling and recommended disposal methods for e-waste during the post-consumption phase by the EE consumers.

CONCLUSION AND RECOMMENDATIONS

This study investigated the knowledge of e-waste hazards, information channels and, factors influencing knowledge in Ilorin, north-central Nigeria. From the outcome of the study, fewer respondents (< 50%) had knowledge that the EE devices and equipment they use (at home, for leisure and work/business purposes) can generate e-waste at their End of Life or due to irreparable damages and obsolesce. The most important social channels of awareness on e-waste hazards were interpersonal information and knowledge sharing as well as information and warnings on product packaging and, safety brochures. The later channels (product packaging and, safety brochures) showed a sub-optimal level of usefulness compared to the former. Government and EPR related channels were not important sources of information on e-waste environmental hazards suggesting that the EPR policy has been poorly implemented since 2016. The level of awareness of e-waste hazards is low in the study community. This may have negative effects on the willingness of the residents in Ilorin to appreciate and participate in environmentally sustainable approaches for its management.

Urban dwellers in Nigeria have entered into a world that extensively utilizes EE devices and equipment for work/business and leisure. Furthermore, ICT has penetrated extensively and, the diffusion process for technologies related to the "Internet of Things" (IoT) has commenced. Tons

of e-waste are accumulated yearly. The problem of e-waste generation is compounded by the fact that the bulk of the EE devices/equipment that are imported into the country are outright e-waste of Europe/North America to cater for the needs of resource-poor EE consumers. Therefore, for a sustainable environment and good population health, there is a need for additional low-cost approaches to complement the EPR policy in Nigeria. In consideration of the fiscal crisis facing all the tiers of government in Nigeria (including the three municipal/Local Government Councils governing the study community), efforts at the policy level to promote pro-environmental behaviour change on e-waste hazards should target low-cost mass awareness and sensitization strategies through the local electronic mass media (such as radio programmes) and, deployment of awareness creating posters, produced in local languages and the locally spoken *pidgin*, at public places in all the Local Government Councils in Ilorin.

Furthermore, based on the findings from this study, formal education was a significant predictor of acquisition of knowledge on the environmental hazards of poorly managed e-waste. Therefore, to foster positive pro-environmental attitudes among the urban residents towards sustainable e-waste management it is imperative for the government to mainstream the subject matter of e-waste generation and its potential hazards in the basic science and computer studies curricula at the Elementary and Junior Secondary School levels in the study community and, in Nigeria at large. Currently, the school curriculum on basic science and computer studies at the Elementary and Junior Secondary School levels is completely silent on e-waste and its potential hazards to human health and the ecosystem. Through this channel, children and adolescents, who constitute more than 60% of the demographic structure of Nigeria, will acquire knowledge/awareness on e-waste hazards and the best e-waste management practices early in life and, grow into leadership positions (at the household and community levels) with sufficient level of awareness on e-waste and its potential environmental hazards.

Additionally, the school children have added opportunities to help sensitize non-literate adults/parents at home and at the community level on e-waste and its potential environmental hazards, thereby assisting in enhancing information sharing on e-waste hazards. From past experience in Nigeria, the use of this type of low-cost school curricula-based approach to disseminating knowledge/good practices in the areas of personal hygiene, environmental sanitation, and other behaviour change campaigns has yielded good results at the household and community levels in the national fight to reduce the epidemiological incidence rate of many infectious diseases. By adapting and utilizing the same curriculum-based approach, sustainable success can be achieved in the fight against the challenge of the low-level knowledge of e-waste hazards and, the tendency towards inefficient handling of e-waste by households and urban communities. Among the urban poor in Nigeria, it is common knowledge that non-bulky e-waste (such as EoL transistor radios, searchlights, mobile phones and devices, lithium batteries/power banks) are deliberately kept within the living apartments for toddlers and growing children to use as play toys.

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