The Impact of Situation Awareness on E-Waste Management Practices

Mustapha Shehu[1], Jibrin Mohammed [2], and Saleh Abdullahi Toro[3]

1 Department of Management & Information Technology,
Abubakar Tafawa Balewa University, Bauchi-Nigeria

DOI: https://doi.org/10.56293/IJASR.2022.5538

IJASR 2023
VOLUME 6
ISSUE 4 JULY – AUGUST **ISSN: 2581-7876**

Abstract: Electronic waste possesses toxic substances that have detrimental effects on human health and the natural surroundings. The escalating volume of e-waste production poses an amplified threat to both developed and developing nations. The purpose of the study was to explore how the awareness of the situation regarding e-waste influences the practice of e-waste management among electronic technicians in Bauchi metropolis. The study utilized Situational Awareness Theory (SAT) to determine the influence of awareness on e-waste management practices among electronic technicians. The study was conducted using a cross-sectional survey approach, and proportionate random sampling was utilized to guarantee fair representation across various groups. A total of 265 questionnaires were administered, and 248 (93.6%) were successfully returned. After addressing concerns such as missing data, outliers, and normality through statistical methods, 238 responses (89.8%) were considered valid for determining unidimensionality via principal component analysis and varimax rotation. IBM Statistical Package for Social Sciences (SPSS) version 20 was utilized to facilitate the process. The research model was evaluated using Partial Least Square Structural Equation Modelling (PLS-SEM) version 3.2.6. The result of hypothesis testing showed that Awareness on Environmental Risk, have significant effect on e-waste management practice. Thus, an increase in the awareness of the negative impact of e-waste on the environment will improve e-waste management practice among electronic technicians. The findings of this study will support decision makers towards enacting policy that will further enhance proper e-waste management practice not only by electronic technicians but by all information technology users.

Keywords: E-waste; E-waste Management Practice; Awareness Health Risk; Environmental Risk.

1. Introduction

The prevailing belief that newer electronics are superior or better has led to a constant influx of new electronic gadgets into the market, while older ones quickly become outdated. The consequence of such apparent success is an inevitably and ever increasing amount of obsolete or discarded electronic products known as electronic waste (e-waste) (Okoye & Odoh, 2014). The short life span of most electronic products is a major driver of the growing e-waste problem (Ewuim, Akunne, Abajue, Nwankwo, & Faniran, 2014) as considerable number of electronic products are becoming obsolete in increasingly shorter periods of time due to intense competition among electronic manufacturers (Adesina, 2012). As a result, e-waste is becoming the fastest growing waste stream in the industrialized world (Chaturvedi et al., 2011).

E-waste consists of valuable and hazardous materials that necessitate specific handling and recycling techniques to prevent environmental pollution and adverse impacts on human health. (Robinson, 2009). The dismantling and recycling of e-waste in an unprofessional manner in poor and developing countries poses serious threats to human health and the environment (Laissaoui & Rochat, 2008).

The perilous elements found in e-waste encompass substances such as lead, mercury, beryllium, cadmium, and brominated flame-retardants, among others. Conversely, the valuable components include iron, aluminum, nickel, copper, gold, silver, platinum-group metals like platinum, palladium, rhodium, ruthenium, iridium, and osmium, (Ogungbuyi, Nnorom, Osibanjo, & Schluep, 2012).

Africa has been identified as a destination for the disposal of hazardous chemicals and e-waste from industrialized nations, where up to 80% of the world's high-tech waste finds its way into Asia and Africa. (Ewuim et al., 2014).

Countries such as China, Ghana, India, Nigeria, Philippines, Thailand, and Vietnam are witnessing high volume of informal recycling of e-waste (Orisakwe et al., 2020).

The so-called "bridging the digital divide" only helps to open up "a digital dump" in developing countries, especially Nigeria (Obaje, 2013). In particular, Nigeria is one of the top dumping grounds for toxic, chemical and electronic waste from the developed countries (Adaramodu et al., 2012).

On annual basis over 60,000 tons of e-waste are shipped via the ports of Lagos into Nigeria, in addition to e-waste import from neighbouring countries (Miner et al., 2020).

Despite the danger e-waste, it was observed that electronic technicians who mingle and piled this type of waste seem oblivious and unwary of the hazardous nature of e-waste. Similarly, there is dearth of literature on how awareness influences e-waste management practice in developing nations especially among electronic technicians. It is based on the foregoing that the study investigates the influence of awareness of e-waste on management practice among electronic technicians in Bauchi metropolis.

2. Literature Review

This section reviews relevant literatures based on the objectives of the study and relevant theories which support the study.

E-waste management

Electronic waste, also referred to as waste electrical and electronic equipment (WEEE), encompasses electrical or electronic equipment that has been discarded as it is no longer functional or needed by the end-users (Miner et al., 2020). Thus, E-waste is a term that is used loosely to refer to obsolete, broken, or irreparable electronic devices like televisions, computer Central Processing Units (CPUs), computer monitors (flat screen and cathode ray tubes), laptops, printers, scanners, and associated wiring (Luther, 2010). A more technical definition of e-waste is any obsolete or discarded products that have their primary functions provided by electronic circuitry and components (Sivakumar et al., 2012).

E-waste Management is the activities that involve safe collection, transportation, segregation, dismantling, reduction, reuse, repair of e-waste in an environmental friendly manner (Sivakumar et al., 2012). In industries, e-waste management begin at the point of generation through waste minimization techniques by reducing the toxic material used in manufacturing electronic products (Partheban & Selvan, n.d.). It is generally undertaken to reduce their effects on health and the environment and likely to recover valuable resources from them. E-waste can be reused, refurbished, or recycled in an environmentally sound manner so that they are less harmful to the ecosystem (Bala & Goel, 2012). Joseph (2007) using less toxic, easily recoverable/recyclable materials and designing electronic products for re-use, repair and/or upgradeability as some of the key options to deal with e-waste.

Around 53.6 million metric tons (Mt) of e-waste, excluding PV panels, were generated in 2019, equivalent to an average of 7.3 kilograms per person. It was estimated that by 2030, the total e-waste generated will surpass 74 Mt. This alarming trend indicates an annual increase of nearly 2 Mt in the global quantity of e-waste. (Forti et al., 2020). Generally, managing e-waste includes strategies for reducing the total waste generated, in line with the 4R principle - 'Reduce, Recover, Reuse and Recycle'. The following section discourse global e-waste management.

Global e-waste management

Despite some governments forbidding the export of e-waste to developing nations, exportation is on the rise due to economic incentives of informal recycling (Namias, 2013). Developed nations benefit from cheap labour costs in developing nations, while the imported e-waste creates jobs for developing nations and provides second hand products for reuse. It is estimated that 50% to 80% of the e-waste collected in the U.S. is exported to developing countries such as China, India and Pakistan, due to low-cost labour and less stringent environmental regulations (Namias, 2013). The e-waste generated in the U.S. is pre-processed domestically and then sent overseas for end-processing, including the recovery of precious and special metals. The recycling of e-waste in the U.S. is limited due to: (1) insufficient collection (2) no federal legislation or policy mandating e-waste recycling (3) lack of recycling and recovery technologies and (4) illegal export of hazardous e-waste to developing countries where recycling processes pose serious risks to human health and the environment (Namias, 2013).

The U.S Environment Protection Agency (EPA) report on e-waste shows that in 2011, the U.S generated about 3.41 million tons of e-waste, of this amount, only 850,000 tons or 24.9 % was recycled, the rest was trashed in landfills or incinerators (U.S. EPA, 2013). The situation is similar in Malaysia where e-waste recycling is at infancy without sophisticated technologies to carry out complete recycling process in a material recovery facilities (John et al., 2010). Improper recycling and disposal operations found in different cities of India often involve the open burning of plastic waste, exposure to toxic solders, dumping of acids, and widespread general dumping (Sivakumar et al., 2012).

Health and environmental implication of e-waste

E-waste is a global issue that mostly affect developing countries due to the many toxic and hazardous materials that are sources of environmental pollution, contamination of groundwater and surface water, thus harmful to human health (Terada, 2012). An investigation uncovered that a significant portion of electronics designated for recycling in the United States ultimately finds its way to Asia, where they are either improperly disposed of or recycled without adequate consideration for environmental protection or the health and safety of workers involved in the process (Bala & Goel, 2012).

There has been a notable rise in studies examining the negative health impacts of e-waste. These studies consistently emphasize the risks posed to human health by well-known toxins, such as lead. Recent research has revealed that unregulated e-waste recycling is linked to a growing prevalence of adverse health effects, including detrimental birth defects (Forti et al., 2020).

As of 2007, it was estimated that around 440,000 people were engaged in informal e-waste collection, and around 250 thousand people were engaged in informal e-waste recycling (Feng et al., 2013). Informal recycling focuses on extracting re-use and scrap values from e-waste without environmental protection measures, emissions controls or measures to protect the health and safety of workers with devastating consequence to local environments and the health of workers in Guiyu in Guangdong Province and Taizhou in Zhejiang Province (Feng et al., 2013). (Feng et al., 2013)(Feng et al., 2013)(Feng et al., 2013)(Feng et al., 2013)Electronic products are a complex mixture of several hundred tiny components, many of which contain deadly chemicals whose long term exposure can damage the nervous system, kidney and bones and the reproductive and endocrine systems and some of them are carcinogenic (Needhidasan et al., 2014). Moreover, the practice of landfilling e-waste results in the leaching of harmful substances into groundwater. Additionally, when Cathode Ray Tubes (CRTs) are crushed or burned, they release toxic fumes into the atmosphere. Furthermore, the improper disposal of e-waste contributes to soil acidification, further exacerbating environmental concerns. (Borthakur & Singh, 2012; Joseph, 2007; Ramachandra & Saira, 2004).

Research Framework

The research framework of this study was grounded in Situational Awareness Theory (SAT). The fundamental idea behind Situational Awareness (SA) was the notion of being aware of the enemy's actions before they themselves become aware (Gilson, 1995). The idea did not get much attention in the technical and academic literature until the late 1980's, and has become a hot topic ever since (Stanton, Piggott, & Chambers, 2001). Despite having its roots in aviation, the concept is equally applicable to human supervisory control for land based industries (Kaber & Endsley, 1997). Endlsey, (1988) describes SA as the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future.

Consequently, the concept of awareness of health and environmental risks were derived from SAT as depicted in Figure 1.

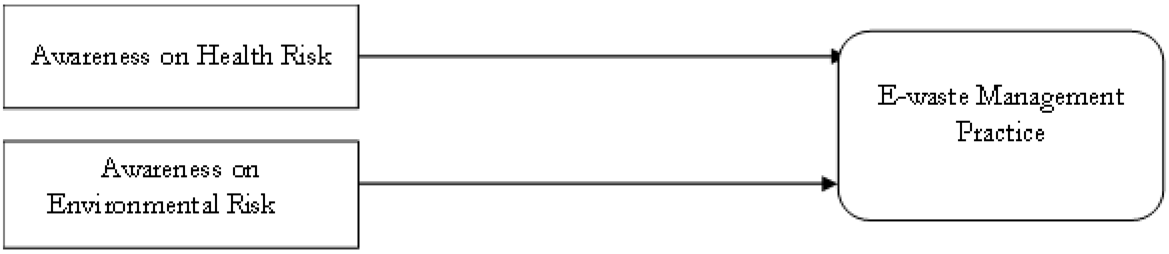

Figure 1. Research framework

The majority of electronic consumers are not aware of the health hazards associated with e-waste leading to its improper disposal (Shamama et al., 2014). According to Lundgrin (2012) there is generally low public awareness of the hazardous nature of e-waste.

Similarly, Okoye and Odoh (2014) conducted a study which revealed that a significant number of participants lacked awareness regarding the harmful effects of e-waste and its potential implications for their personal health, resulting in improper handling practices. In contrast, Augoustinos (2013) discovered that risk perception had little significance as a predictor of adaptive behaviors. Not all situations require awareness to prompt action; individuals may engage in certain actions without necessarily possessing prior knowledge or awareness. Thus, it is hypothesized that:

Hypothesis 1: Awareness of health risk significantly influence e-waste management practice.

In the industrial management perspective, awareness on e-waste has increased and this can be seen from 2005 when e-waste was first introduced in Environmental Quality Scheduled Wastes Regulations (EQSWR) but the level of public awareness is still low as people are still disposing e-waste with other household wastes, storing e-waste in their premises, and giving e-waste to scrap collectors (Kalana, 2010). Also, lack of awareness of e-waste recycling in emerging economies, led to the inability to establish innovation hubs and centres of excellence where e-waste will be appropriately handled (Schluep et al., 2009). Another study showed that there is a significant relationship between the level of environmental awareness and the frequency of reported environment related behaviour (Sengupta et al., 2010). Furthermore, low public awareness of health hazards, environmental consequences, and federal regulations of e-waste, led to poor e-waste management systems (Shah, 2014). Hence, it is hypothesized that:

Hypothesis 2: Awareness on environmental risk significantly influence e-waste management practice.

3. Methodology

A cross-sectional survey research design was employed for data collection from a population of 805. The population of the study comprises all electronic technicians engage in the repair of Computers, GSM, and Television residing within Bauchi metropolis. In the context of this research Bauchi metropolis comprise wuntin dada, wunti market, muda lawal market, central market, sabon kasuwa, railway market, yelwa/gwallameji, fadaman mada, tundun salmanu, nassarawa/jahun/gwallaga/kobi, Bakaro/Kofar Dumi/Karufi/ Kandahar, Gombe road/Ran Road. There was no accurate documentation of the total population of this category of technicians, thus, a census was carried out to ascertain the population of technicians within Bauchi metropolis. Bauchi metropolis was selected for this study because e-waste generation is assume to be more concentrated in the capital cities (Carisma, 2009). The sample size of the study is 265 and was determined using Krejcie and Morgan, (1970) method for determining sample size. Employing proportionate stratified random sampling technique, 265 questionnaires were administered to respondents with the aid of a research assistant to the different respondents ranging from computer technician (50), television technician (70) and GSM technicians (145). A total of 252 (95%) questionnaires were returned, out of which four were deemed unusable because majority of the questions were unanswered. Thus, a total of 248 (93.6%) surveys questionnaire were used in the analysis. The summary of the profile of valid responses as indicated in table 1 shows that all the 238 (100%) respondents were male, this could be attributed to the nature of the job. Female were naturally reluctant to practice such occupation that requires dismantling of electronic devices. Also, most of the respondents fall within the age bracket of 30 to 39 and 20 to 29 constituting about 45.8% and 41.2% respectively. In terms of educational qualification, 40.3% possess diploma and 31.4% had senior secondary school certificate. In terms of specialization, GSM technician accounted for about 57.6% followed by TV technicians 24.8% and Computer technicians 17.6%. The experience of majority of the respondents falls within 6 to 10 years constituting 45% followed by those on the less than 5 years bracket constituting 39.1%.

Table 1. Demographic Characteristic of the Sample

	Variable	Options	Frequency	Percentage (%)
1	Gender	Male	238	100
		Female	0	0
2	Age	20-29	98	41.2
		30-39	108	45.8
		40-49	26	10.9
		50 and Above	5	2.1
		Total	238	100
3	Level of Education			
		Primary	9	3.8
		Secondary	77	32.4
		Diploma	96	40.3
		HND	24	10.1
		Degree	22	9.2
		Others	10	4.2
		Total	238	100
4	Specialization			
		Computer Technician	42	17.6
		TV Technician	59	24.8
		GSM Technician	137	57.6
		Total	238	100
5	Years of Experience			
		Less than 5 years	93	39.1
		6-10 years	107	45.0
		11-15 years	34	14.3
		16 years and above	4	1.7
		Total	238	100

The measurement instrument used in this study was adapted from extant literature. Awareness of e-waste hazards was classified into health and environmental risk, and were adapted from several studies (Pradeep Kumar, Govindaradjane, & Sundararajan, 2013; Sikdar & Vaniya, 2014; Shah, 2014; Bala & Goel, 2012; Okoye & Odoh, 2014). Finally, the items used as a measure for the dependent variable (e-waste management practice) were adapted from (Pradeep Kumar et al., 2013; Shah, 2014; Sikdar & Vaniya, 2014). The scale measuring the awareness was assessed on a five-point Likert scales, with response ranging from not at all aware (1) to extremely aware (5).

Furthermore, the model for the study was evaluated using Partial Least Square-Structural Equation Modelling (PLS-SEM) using *SmartPLS 3.2.4*. PLS is widely used in Information System (IS) research to test the statistical quality and standard of result (Donny et al., 2009). PLS SEM is used because among others it support small sample size, data that are not normally distributed and where the primary objective of the research is prediction and explanation of target constructs (Hair et al., 2014). Nevertheless, IBM Statistical Package for Social Sciences (SPSS) version 21 was used in data coding and data cleaning.

4. Results

This section begins with data examination as the initial step in any analysis. It involves evaluating the impact of missing data, identification of outliers, and testing the assumption underlying most multivariate techniques. The missing data found in the study were 5 (2%) and falls under Missing Completely at Random (MCAR). The missing responses were replaced with a random number within the range of the scale as suggested by (Sekaran, 2003).

Standardised residual value and box plots were used to detect univariate outliers and Mahalanobis distance to detect multivariate outliers. The normal outliers detected were eliminated using the procedures suggested by Tabachnick and Fidell, (2007). The Mahalanobis distance of the study was found to be 15.397, which is below the stated threshold of 18.467 (Tabachnick & Fidell, 2007), as such there is no case of multivariate outlier. Finally, the study tested the assumption of univariate analysis using skewness, kurtosis and Kolmogorov Smirnov as stipulated by Hair, Black, Babin and Anderson (2010). The result of the normality test reveals absence of deviation. Histogram of multiple regression was used to assess multivariate normality of the data under study, and it appeared to be normally distributed. This was further confirmed by visual inspection of the histogram of the data. Thus, the assumption of homoscedasticity is met since it is interrelated with the assumption of multivariate normality. Furthermore, the Normal P-P Plot of the study reveals that the points lie in a reasonably straight diagonal line from bottom left to top right indicating that the assumption of linearity is met. Having fulfilled parametric assumptions, the following sections present an assessment of the research model.

Measurement (outer) model Assessment

According to Hair *et al.* (2014) outer loading for individual indicator should be greater than 0.70, although indicators with loadings between 0.40 and 0.70 should be considered for deletion only when it can lead to an increase in the composite reliability or the average variance extracted above the suggested cut-off value. Table 2 shows that the loadings for most of indicators are above the threshold. Overall, the loadings for all the indicators have met the requirement.

Table 2. Internal Consistency and Convergent Validity

Constructs	Indicators (Items)	Loadings	AVE	Composite Reliability
Awareness HR	AHR2	0.918	0.594	0.811
	AHR4	0.742		
	AHR5	0.624		
Awareness ER	AER1	0.661	0.517	0.809
	AER2	0.815		
	AER3	0.750		
	AER4	0.635		
E-waste MP	EMP3	0.747	0.507	0.752
	EMP4	0.786		
	EMP5	**0.585**		

Furthermore, item's reliability, composite reliability and AVE are used for measuring convergent validity. AVE is the dominant factor among them with threshold value greater than 0.5 (Hair *et al.*, 2014). The requirement for items reliability and composite reliability are fully met. A satisfactory level of convergent validity is maintained since the AVE values of all constructs are above the suggested threshold value of 0.50 as depicted in table 2. Fornell and Larcker (1981) suggested that the square root of AVE value for each construct should be greater than the value of its correlations with other constructs. As illustrated in Table 3, the diagonal values are higher than the values in their respective rows and columns indicating that the requirement for discriminant validity is fulfilled.

Table 3. Discriminant Validity (Fornell-Larcker Criterion)

Construct	AHR	AER	EMP
AHR	**0.771**		
AER	0.531	**0.719**	
EMP	0.226	0.429	**0.712**

Structural (Inner) Model Assessment

Having established the validity and the reliability of the measurement model, an assessment of the structural model was carried out. Since Path coefficients is estimated in PLS based on Ordinary Least Square (OLS) regression, the level of collinearity among predictor variables need to be assess in order to ensure that the results are free from bias (Hair *et al.*, 2014). According to Hair *et al.* (2014) multicollinearity exist if Variance Inflation Factor VIF of a given exogenous variable is above 5 (i.e. VIF > 5). Table 5 shows that there was no evidence of multicollinearity amongst the exogenous variable because the construct with the highest VIF is AER (VIF 1.611) and falls below the threshold.

Predictive Relevance of the Model

Coefficient of determination (R^2) is the most commonly used measurement to evaluate structural model (Hair *et al.*, 2014). Providing an acceptable rules of thumb for R^2 values is complicated as this depends on the model complexity and the research discipline (Hair *et al.*, 2014). However Cohen, (1988) recommended R^2 values between 0.10 to 0.29 as small, 0.30 to 0.49 as medium, and 0.50 to 1.0 as large. As can be seen table 4, the R^2 value for this study was found to be 0.250 meaning that 25% of the variance in E-waste management practice is explained by the independent variables (exogenous variables). Judging by the rules of thumb stated earlier the model is considered to have small predictive power. In a similar way, it is important to assess the contribution of each independent (exogenous variable) variable to the dependent variable (endogenous variable) by ascertaining the effect size (f^2). Hair *et al.*, (2014) suggested that exogenous (f^2) values of 0.02, 0.15, and 0.35 indicate small, medium, or large effect, respectively, on an endogenous construct.

Based on the result presented in table 4, AHR ($f^2 = 0$) have effect size below the minimum threshold of 0.02, thus it has no impact on the endogenous variable when omitted. However, AER ($f^2 = 0.081$) has small impact on the endogenous variable when omitted.

Furthermore, the study utilized blindfolding procedure to obtain the Q^2 by omitting *9*th data points in the endogenous construct's indicators. According to Fornell and Cha (1994) a cross-validated redundancy (cv-red) value of > 0 shows that there is predictive relevance while a value of < 0 indicates that the model lacks predictive relevance. As can be seen in table 4, the Q^2 value (0.115) is above 0, indicating substantial evidence of predictive relevance of the model.

Similarly, the result in table 4 showed that AER ($q^2 = 0.035$) has small effect size since the q^2 of the variable is slightly above the minimum threshold of 0.02, thereby having small predictive impact on the endogenous variable. On the contrary, AHR ($q^2 = 0$) has effect size of predictive relevance below the minimum threshold of 0.02, thus it has no predictive impact on the endogenous variable.

Table 4 Model Quality Statistics

Endogenous Construct	Exogenous Constructs	R2	Q2	Effect **(f^2)** **Sizes-R^2**	**Effect Sizes-Q^2 (q^2)**
EMP	AHR	0.250	0.115	0	0
	AER			0.081	0.035

Hypotheses Testing

Hypotheses testing is done in Smart PLS by using standard bootstrapping procedure with 5,000 subsamples. The significance of paths coefficients of the study were obtained through t-value ($t \geq 1.96$) and p-value ($p < 0.05$) as suggested by (Hair et al., 2011). The result in table 5 reveals that Awareness on Environmental Risk (β=0.316, std. error= 0.073, t= 4.296, p 0.000) has positive and significant influence on E-waste Management Practice. While Awareness on Health Risk (β=0.010, std. error= 0.071, t-value= 0.147, p 0.883) has no significant influence on E-waste Management Practice. Therefore, hypothesis 2 was accepted whereas hypothesis 1 rejected.

Table 5 Hypotheses Testing

Hypothesis	Path Coefficient	Std Error	t-values	P Values	VIF	Decision
Awareness HR -> E-waste MP	0.010	0.071	0.147	0.883	1.395	Rejected
Awareness ER -> E-waste MP	0.316	0.073	4.296	0.000	1.611	Accepted

5. Discussion of Results

The goal of this study was to empirically ascertain the influence of e-waste awareness on E-waste management practice among electronic technicians in Bauchi Metropolis. Considerable number of the studies and reports dwell on E-waste recycling, Extended Producer Responsibility (EPR) and Restriction of Hazardous substance RoHs. Thus, there are few empirical studies on E-waste management practice. The variables under this study exhibit good reliability, convergent validity, and discriminant validity.

The result of the first hypothesis showed that Awareness on Health Risk (AHR) does not have significant influence on E-waste Management Practice ($\beta = 0.010$, t-value = 0.147, $p > 0.05$). This outcome could be attributed to the fact that, there is very low public awareness of health hazards, environmental consequences, and federal regulations of e-waste (Shah, 2014). Also, the finding support the study of Augoustinos (2013) that found risk perception as insignificant predictor of adaptive behaviours. It is not in all scenarios that awareness leads to action, a person can perform a behaviour or action without necessarily having prior knowledge or awareness.

Moreover, an evaluation of the second hypothesis testing ($\beta = 0.316$, t-value = 4.296, $p < 0.05$) showed that Awareness on Environmental Risk (AER) influences E-waste Management Practice. This finding is consistent with previous studies on awareness. A study by Schmidt (2007) showed that students awareness on environmental issues influences pro-environmental attitude and behaviour. Another study showed that there is a significant relationship between the level of environmental awareness and the frequency of reported environment related behaviour (Sengupta *et al.*, 2010). Also, a study conducted by Sengupta *et al.* (2010) found a significant relationship between environmental awareness and environmental behaviour.

6. Conclusion

This study brings together the possible factors that could influence e-waste management practice among technicians in Bauchi metropolis, and then investigate the cause-and-effect relationships among them. The measurement model was assessed for scale validity and reliability, since the items used in this study were adopted and modified from previous studies. Awareness on Environmental Risk (H_2) had significant effect on e-waste management practice. On the contrary, hypothesis H_1 has no effect on e-waste management practice. Altogether, the study attained R2 value of 0.250 connoting that 25% of the variance in e-waste management practice, was explained by the independent variables. Awareness on Environmental Risk has the highest ($\beta = 0.316$) contribution to the dependent variable. While, Awareness on Health Risk ($\beta = 0.010$), happened to have insignificant contribution. In addition, the result indicated that the research model has substantial evidence of predictive relevance (Q2 = 0.115). Thus, the findings suggested that Awareness on Environmental Risk has significant influence on e-waste management practice among electronic technicians in Bauchi metropolis. Therefore, an increase in the level awareness of e-waste environment risk will increase the level of e-waste management practices.

References

1. Adaramodu, A. A., Osuntogun, A. O., & Ehi-Eromosele, C. O. (2012). Heavy Metal Concentration of Surface Dust Present in E-Waste Components: The Westminister Electronic Market, Lagos Case Study. *Resources and Environment*, *2*(2), 9–13. https://doi.org/10.5923/j.re.20120202.02
2. Adesina, O. S. (2012). The Negative Impact of Globalization on Nigeria. *International Journal of Humanities and Social Science*, *2*(15), 193–201.
3. Augoustinos, M. (2013). Heat Waves and Climate Change : Applying the Health Belief Model to Identify Predictors of Risk Perception and Adaptive Behaviours in Adelaide , Australia. *International Journal of*

Environmental Research and Public Health, *10*, 2164–2184. https://doi.org/10.3390/ijerph10062164
4. Bala, S., & Goel, S. (2012). A Study of E-Waste Management in Relation to Awareness of College Students. *International Journal of Educational and Psychological Research (IJEPR)*, *1*(2), 31–35.
5. Carisma, B. (2009). *Drivers of and barriers to E-waste Management in the Philippines* [Unpublished Theses]. Lund University.
6. Chaturvedi, A., Arora, R., & Killguss, U. (2011). E- waste recycling in India – bridging the formal – informal divide. In S. Mukherjee & D. Chakraborty (Eds.), *Environmental Scenario in India: Successes and Predicaments* (1st ed., Issue Mehra 2004, pp. 203–216). Routledge.
7. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.
8. Donny, C. L., Ivan, K. L., & Ernest, J. (2009). An Extended UTAUT Model for the Study of Negative User Adoption Behaviours of Mobile Commerce. *The 9th International Conference on Electronic Business*.
9. Ewuim, S. C., Akunne, C. E., Abajue, M. C., Nwankwo, E. N., & Faniran, Olalekan, J. (2014). Challenges of E-Waste Pollution to Soil Environments in Nigeria- A Review. *Animal Research International*, *11*(2), 1976–1981.
10. Feng, W., Ruediger, K., Daniel, A., & Jinhui, L. (2013). *E-waste in China : A country report*.
11. Fornell, C., & Cha, J. (1994). Partial Least Squares. In R. P. Bagozzi (Ed.), *Advanced methods of marketing research* (pp. 52–78). Blackwell.
12. Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Market Research*, *18*(1), 39–50.
13. Forti, V., Baldé, C. P., Kuehr, R., & Bel, G. (2020). *The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential. United Nations University (UNU)/United Nations Institute for Training and Research (UNITAR) – co-hosted SCYCLE Programme, International Telecommunication Union (ITU) &* (3rd ed., pp. 1–119). Bonn.
14. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate Data Analysis* (7th ed.). Pearson Prentice Hall.
15. Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2014). *A Primer on Partial Least Squares Structural Equation Modeling (PlS-SEM)*. Sage.
16. Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice*, 139–151.
17. John, B. C., Siwar, C., Ahmad, F. M., & Rawshan, A. B. (2010). Bridging the Gaps : An E - waste management and recycling assessment of material recycling facilities in Selangor and Penang. *International Journal of Environmental Sciences*, *1*(3), 383–391.
18. Kaber, D. B., & Endsley, M. R. (1997). Out-Of-The-Loop Performance Problems and the use of Intermediate Levels of Automation for Improved Control System Functioning and Safety. *Process Safety Progress*, *16*(3), 126–131.
19. Kalana, J. A. (2010). Electrical and Electronic Waste Management Practice by households in Shah Alam , Selangor , Malaysia. *International Journal of Environmental Sciences*, *1*(2), 132–144.
20. Krejcie, R. V, & Morgan, D. W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, *30*, 607–610.
21. Laissaoui, S. E., & Rochat, D. (2008). *Technical report on the assessment of e-waste management in Morocco* [GEN]. Moroccon Cleaner Production Centre and Empa.
22. Lundgrin, K. (2012). *The global impact of e-waste Addressing the challenge*.
23. Luther, L. (2010). *Managing Electronic Waste: Issues with Exporting E-Waste*.
24. Miner, K. J., Rampedi, I. T., Ifegbesan, A. P., & Machete, F. (2020). Survey on household awareness and willingness to participate in e-waste management in jos, plateau state, Nigeria. *Sustainability (Switzerland)*, *12*(3). https://doi.org/10.3390/su12031047
25. Namias, J. (2013). *The Future of Electronic Waste Recycling in the United States : Obstacles and Domestic Solutions*. University of Columbia.
26. Needhidasan, S., Samuel, M., & Chidambaram, R. (2014). Environmental Health Electronic Waste – An Emerging Threat to the Environment of Urban India. *Journal of Environmental Health Science & Engineering*, *12*(36), 1–9.
27. Obaje, S. O. (2013). Electronic Waste Scenario in Nigeria : Issues , Problems And Solutions. *International Journal of Engineering Science Invention*, *2*(11), 31–36.
28. Ogungbuyi, O., Nnorom, I. C., Osibanjo, O., & Schluep, M. (2012). *e-Waste Country Assessment Nigeria*.
29. Okoye, A., & Odoh, C. (2014). Assessment of the level of awareness of E-waste Management and concern for the environment amongst the Populace in Onitsha, Southern Nigeria. *Journal of Environmental Protection*,

5, 120–134.
30. Orisakwe, O. E., Frazzoli, C., Ilo, C. E., & Oritsemuelebi, B. (2020). Public Health Burden of E-waste in Africa. *Journal of Health and Pollution*, *9*(22), 1–12. https://doi.org/10.5696/2156-9614-9.22.190610
31. Partheban, P., & Selvan, S. T. (n.d.). An effective management of E - Waste as a part of Construction materials. *1st International Conference & Exhibition on Solid Waste & Environment*, 1–10.
32. Pradeep Kumar, S., Govindaradjane, S., & Sundararajan, T. (2013). Management Strategies for Various E-Waste Generators in Puducherry Region - A Case Study. *International Journal of Emerging Technology and Advanced Engineering*, *3*(1), 546–551.
33. Ramachandra, T. ., & Saira, V. . (2004). Environmentally Sound Options for Waste Management. *Envis Journal of Human Settlements*, *130*(5), 38–40.
34. Robinson, B. H. (2009). E-waste: An Assessment of Global Production and Environmental Impacts. *The Science of the Total Environment*, *408*(2), 183–191.
35. Schluep, M., Hagelueken, C., Kuehr, R., Magalini, F., Maurer, C., Meskers, C., Mueller, E., & Wang, F. (2009). *Recycling – from E-waste to Resources: Sustainable Innovation Technology Transfer Industrial Sector Studies*.
36. Schmidt, J. E. (2007). From Intentions to Actions : The Role of Environmental Awareness on College Students. *Journal of Undergraduate Research*, 1–4.
37. Sekaran, U. (2003). *Research Methods for Business* (4th ed.). Hermitage.
38. Sengupta, M., Das, J., & Maji, P. K. (2010). Environmental Awareness and Environment Related Behaviour of Twelfth Grade Students in Kolkata : Effects of Stream and Gender. *ANWESA*, *5*, 1–8.
39. Shah, A. (2014). *An Assessment of Public Awareness Regarding E-Waste Hazards and Management Strategies*. Gujarat University.
40. Shamama, F., Zeba, K., & Ahmad, K. M. (2014). Global E-waste Problem and Obligation of Libraries towards its Awareness. *International Journal of Digital Library Services*, *4*(2), 138–152.
41. Sikdar, M., & Vaniya, S. (2014). The New Millennium and Emerging Concerns. *International Journal of Scientific and Research Publications*, *4*(2), 1–12.
42. Sivakumar, T., Vijayaraghavan, G., & Vimal-Kumar, A. (2012). Global Challenges in E-waste Management: Indian Scenario. *International Journal of Advanced Engineering Technology*, *2*(4), 10–15.
43. Stanton, N. A., Piggott, J., & Chambers, P. R. G. (2001). Situational Awareness and Safety. *Safety Science*, *39*, 189–204.
44. Tabachnick, B. G., & Fidell, L. S. (2007). *Using Multivariate Statistics* (5th ed.). Pearson.
45. Terada, C. (2012). Recycling Electronic Wastes in Nigeria: Putting Environmental and Human Right at Risk. *Northwestern University Journal of International Human Rights*, *10*(3), 154 – 172.
46. U.S. EPA. (2013). *Facts and Figures on E-Waste and Recycling.*