FACTORS INFLUENCING COMMUNITY AWARENESS ON E-WASTE MANAGEMENT AND DISPOSAL IN COLLINS CHABANE LOCAL MUNICIPALITY, LIMPOPO PROVINCE OF SOUTH AFRICA

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Abstract. Electronic waste (e-waste) equipment are the fastest growing categories of municipal solid waste. This study was undertaken to assess the factors influencing community awareness on e-waste management and disposal in Collins Chabane Local Municipality, Limpopo Province of South Africa. A proportionate sampling technique was used to obtain the study sample size of 357 respondents in the four wards of the study area. A Statistical Package for Social Sciences (SPSS) version 29 was used to analyse data, along with descriptive statistics and a binary logistic regression model (logit). Results of the study revealed that there is less awareness on e-waste management and disposal since about 47% of respondents kept e-waste in their houses, while 7.3% disposed of it with general waste. Repairing and recycling of the e-waste had a statistical significant influence on the community's awareness on e-waste management and disposal. The study recommends that awareness on the management and disposal of e-waste should be awarded to the Collins Chabane Local Municipality community, through campaigns and information sharing sessions.
Keywords: *electronic waste, electronic equipment, recycling, logistic regression model, disposal*

Introduction

Globally, the rate of electronic waste (e-waste) has escalated twice as fast a decade ago (Barapatre and Rastogi, 2022), e-waste has become a global challenge that needs to be aggressively addressed and needs a global solution. Current electronical product design features and changes in technology and wireless services often make it difficult, if not impossible, for people to avoid frequent replacements of functional electronic equipment (King et al., 2006). According to Vats and Sigh (2024), some of the many reasons behind the generation of a huge quantity of e-waste are globalisation, transfer of technology, abrupt changes in technology, affordable price of new equipment with more features than the old one, decreased lifespan of equipment and illegal dumping of e-waste from developed countries. However, the benefits of technological innovations must be accessible in ways that generate less e-waste. Unlike municipal solid wastes, electronic products such as computers, fluorescent lights, televisions, and cellphones contain toxic substances, and it is therefore very important to manage e-waste effectively and correctly to avoid environmental pollution (Aparcana, 2017; Chinyere and Afeez, 2019).

When an electrical and electronic equipment reaches the end of its useful lifespan, it becomes waste which is known as e-waste. The term e-waste has many definitions, however, in this study it is defined as obsolete electronics that have reached the end of

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their lives and can no longer be cared for as they used to (Baldé et al., 2017). E-waste includes a wide range of discarded electrical and electronic equipment such as household appliances like ovens, televisions, computers, monitors, laptops, cellphones, and toasters (Awashti, 2017). E-waste has increased rapidly in the last decade globally (Barapatre and Rastogi, 2022).

According to Joseph (2007), the future of e-waste management in developing countries depends not only on the effectiveness of local government or operators of recycling services but also on the attitude of citizens and community participation. Lack of education or awareness on the effects of e-waste on consumers, health hazards, improper e-waste disposal practices, lack of environmental policies addressing e-waste, and failure to enforce the e-waste policies also contribute to improper e-waste management (Barapatre and Rastogi, 2022). Lack of knowledge and low level of community awareness of e-waste can lead to increased mismanagement of e-waste by local government (Joseph, 2007). Masoabi (2020), stated that raising awareness on good practices of e-waste management and disposal challenges could play a key role in curbing the effects of e-waste on human health and the environment.

Thus, this study sought to determine the factors influencing the community awareness on e-waste management and disposal in the Collins Chabane Local Municipality, Limpopo Province of South Africa. It was necessary to conduct this study to gain a better understanding of how the residents of Collins Chabane Local Municipality handle e-waste and, furthermore, to equip them with the necessary knowledge on how to handle e-waste to prevent the numerous health challenges that are related to e-waste.

Material and methods

Study area

The study was conducted in the Collins Chabane Local Municipalities in Limpopo, South Africa in 2023 as shown in *Figure 1*. Collins Chabane Local Municipality covers about 5,467.216 square kilometer (km^2) of land with a population of approximately 372,728 people, which has increased from 646 to 17,136 as revealed by the census conducted in 2022 (STATSSA, 2022).

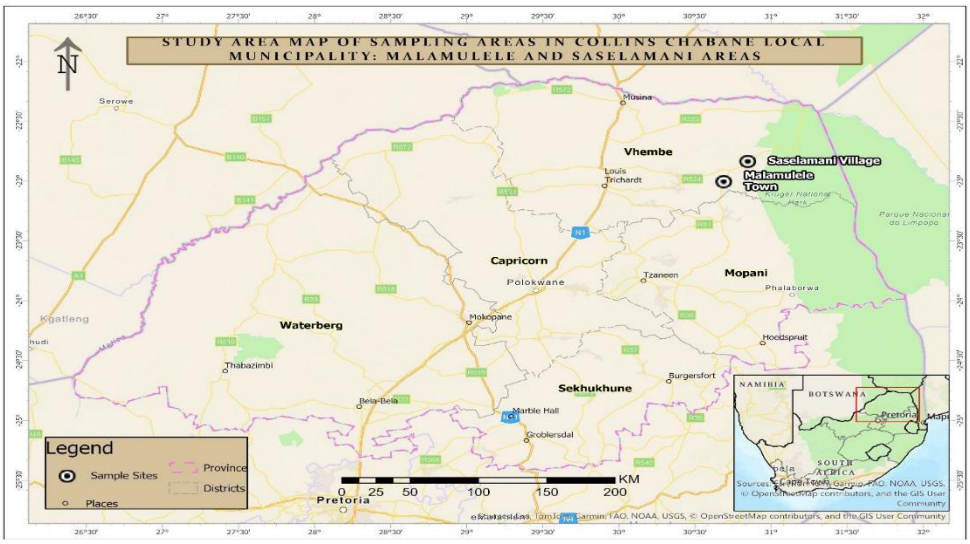

Figure 1. *The Collins Chabane Local Municipality map (IDP, 2019)*

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Sampling procedure

The estimated number of households in this study area, which forms part of four wards, is 9,900 (IDP, 2019). Ward 1 has an estimated population of 2,460 households, Ward 2 has 2,455, Ward 3 has 2,285, and Ward 4 has 2,700 households (IDP, 2019). Stratified random sampling was employed since the households were from different wards. The total population of the study area was stratified into four strata: Wards 1, 2, 3, and 4 as presented in *Table 1*.

Table 1. *Stratification table stratum*

Population	Ward 1	Ward 2	Ward 3	Ward 4
Population size (households)	2460	2454	2286	2700
Sampling fractions	½	½	½	½
population size (to sample from)	**1230**	**1227**	**1143**	**1350**

Source: Survey data (2023-2024)

The Krejcie and Morgan (1970) method for determining sample size study, which was employed in a recent study by Mthombeni et al. (2022) was adopted. The method illustrated that a population size of 4 950, a sample size of 357 needs to be obtained in a study.

The formula is constructed as follows:

$$s = X^2NP(1-P) \div d^2(N-1) + X^2P(1-P) \quad \text{(Eq.1)}$$

The proportionate sample size technique was further used to determine the samples for each of the four strata in *Table 2*. Furthermore, random sampling was used to select the 357 respondents from the community, to eliminate any bias and give each respondent an equal chance to participate in this study.

Table 2. *Population and sample framework*

Strata (Ward)	Population	Sample Size
Sample size for Ward 1	1230	(1230/4 950) X 357 = 89
Sample size for Ward 2	1227	(1227/4 950) X 357 = 88
Sample size for Ward 3	1143	(1143/4 950) X 357 = 83
Sample size for Ward 4	1350	(1350/4 950) X 357 = 97
Total	**4950**	**357**

Source: Survey data (2023-2024)

Data collection

Data was collected using semi-structured questionnaires. The questionnaire was divided into sections according to question themes, namely respondents 'socio-economic questions, e-waste awareness and management, e-waste disposal and recycling. Some respondents were interviewed face-to-face at their residential areas. Those who were not comfortable being in a one-on-one interview provided telephone numbers and were interviewed telephonically.

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Data analysis

The primary data from the completed semi-structured questionnaires were organised, coded, processed and analysed attentively. The Statistical Package for the Social Sciences (SPSS) version 29 was used for this purpose.

The binary logistic regression (Logit Model) was used to analyse the factors influencing community's awareness on e-waste management and disposal. Descriptive statistics were used to analyse and present the socio-economic characteristics of the respondents in the study area, by means of percentages presented in the form of pie charts, tables and histograms.

The Logit Model was employed to analyse the dichotomous outcome variables, meaning that the dependent variable had only two outcomes. The probability of the respondents who were awareness of e-waste disposal was 〖P〗 = 1, or the respondents who were not awareness of e-waste disposal was 〖P〗 = 0. In the Logit Model, the log-odds of the outcome were modelled as a linear combination of the predictor variables. The logit function is specified as the inverse of the sigmoidal "logistic" function or logistic transform used in mathematics, and particularly in statistics. When the function parameter represents a probability p, the logit function gives the log-odds, or the logarithm of the odds p/(1 − p).

The logit of a number p between 0 and 1 is given by the formula according to the model adopted from studies by Hosmer et al. (2008); Wooldridge (2009); and Mohale and Mthombeni (2024):

$$logit_{\ (p)} = log\left(\frac{p}{p-1}\right) = log_{(p)} - log(1-p) = -log\left(\frac{1}{p} - 1\right) \qquad \text{(Eq.2)}$$

The "logistic" function of any number is given by the inverse-logit:

$$logit^{-1}\ (\alpha) = \frac{1}{1+exp(-\alpha)} = \frac{exp(\alpha)}{exp(\alpha)+1} \qquad \text{(Eq.3)}$$

If p is a probability, then p/(1 − p) is the corresponding odds; the logit of the probability is the logarithm of the odds. Similarly, the difference between the logit of two probabilities is the logarithm of the odds ratio (R), thus providing shorthand for the correct combination of odds ratios simply by adding and subtracting:

$$log\ (R) = log\left(\frac{P_1/(1-P_1)}{P_2/(1-P_2)}\right) = log\left(\frac{P_1}{1-P_1}\right) - log\left(\frac{P_2}{1-P_2}\right) = logit(p1) \text{ - } logit(p2) \qquad \text{(Eq.4)}$$

So, putting all this together, the key equation, usually termed the "multivariate logistic regression equation" or "multivariate logistic regression model" to which one fits the data, is as follows:

$$log\left(\frac{p}{p-1}\right) = (\alpha) + b_1x_{i1} + +b_2x_{i2} + \cdots + +b_px_{ip} \qquad \text{(Eq.5)}$$

where Pi is the probability that Yi is 1.

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Pi/ (1-Pi) is called the "odds". In the analysis, the function is estimated with the minimum likelihood method and if Y=1, respondents who were awareness of e-waste disposal; and if Y=0, respondents who were not awareness of e-waste disposal.

Results and discussion

Socio-economic analysis

The results of the study in *Table 3* revealed that 44.7% male respondents participated in the study, compared to 51.5% female respondents. The numbers of male and female respondents participated in the study were almost equal. Again, 3.8% of the respondents preferred not to state their gender. Similar findings were reported by Mahat et al. (2019) where 51.4% males and 48.6% females participated in the study about e-waste disposal awareness amongst the Malaysian community. Respondents between the age category 36 to 45 and 46 to 55 years amounted to 20% and 22.6%, respectively, and the minority of the respondents in this study were above 60 years old at 11.2%. Most of the respondents at 47% had a secondary level educational background. Kitila and Woldemikael (2019), stated that communities with higher educational qualifications in Kampala had a negative impact on e-waste management and disposal methods. Again, Mkhwanazi (2021), reported that respondents with higher education levels in eThekwini Municipality in KwaZulu-Natal Province, South Africa, were not able to separate their waste. Thus, this suggests that the management of e-waste is not influenced by the level of education but rather by ignorance.

Table 3. *Respondents 'socio-economic analysis*

Variables	Description	Percentage (s)
Gender	Male	44.7%
	Female	51.5%
	Prefer not to say	3.8%
Age	18 – 25 years	17.7%
	26 – 35 years	14.4%
	36 – 45 years	20%
	46 – 55 years	22.6%
	56 – 60	14.1%
	Above 60 years	11.2
Educational level	No formal education	9%
	Primary level	7%
	Secondary level	47%
	Tertiary level	37%
Occupational status	Employed	28.8%
	Unemployed	35.9%
	Self employed	13.5%
	Pensioner	10.6%
	Disable grant	0.6%
	Student	10.6%
Household size	1 - 2 members	22.5%
	3 – 4 members	28.5%
	5 – 6 members	49%
	More than 7 members	0%

Source: Survey data (2023-2024)

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The majority of the respondents in the study area shown in *Table 3* were formally and self-employed at 42.3% and 28.8% of the respondents were unemployed. Most of the respondents at 49% indicated that their household consisted of five to six members. Level of income from employment have an influence on the socio-economic status of people, and it can also influence on the amount of e-waste a household can generate (Uhunamure et al., 2021). A study by Viljoen et al. (2021), affirmed that socio-economic status can influence how e-waste is generated within the community. Most of the respondents at 49% indicated that their household consisted of five to six members.

Types of e-waste generated at Collins Chabane Local Municipality

The results of this study in *Figure 2* shows that bigger household appliances, such as refrigerators, TVs, freezers, electric stoves and washing machines, constitutes a higher percentage (65.3%), whereas smaller household appliances such as kettles, irons, fans, hair dryers, toasters, grillers, lights, and microwave ovens constitutes 34.4%, with garden appliances consisting of 0.3%. Vats and Sigh (2014), reported that manufacturers are introducing new technologies daily due to high demand, as the use of the electronic equipment is not only outdated, but not compatible to the new technological requirements. This process accumulated a huge quantity of e-waste comprising numerous equipment, small and large, such as washing machines, vacuum cleaners, televisions, halogen lamps, electric shaws, sports equipment, medical devices, and monitoring and control equipment.

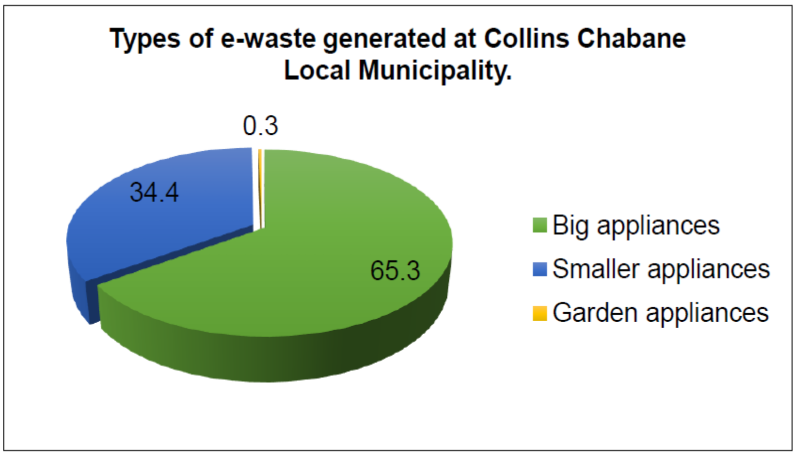

Figure 2. *Types of e-waste generated at Collins Chabane Local Municipality*

E-waste management methods used in the study area

Proper management of e-waste is integrated into knowledge, perception, and thorough e-waste education, which is neglected and overlooked in developing countries (Mahat et al., 2019; Uhunamure et al., 2021). *Table 4* illustrates the management of e-waste at Collins Chabane Local Municipality and points out that 47% of residents keep e-waste in their houses, while 22.9% prefer to sell their unwanted electronics. Mahat et al. (2019), stated that the e-waste disposal method that is often practiced in a community is to sell electronic goods as used appliances. This is followed by swapping them with new appliances, dropping them off at a recycling centre, keeping them in a store or outdoors, donating to charities, disposing of them together with other trash and giving them to

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friends or relatives. Ledwaba and Sosibo (2016), reported that South African local municipalities have not yet implemented the collection of e-waste in the same way as the collection of municipal solid waste, due to insufficient instruments relevant to managing e-waste, and Collins Chabane Local Municipality is no exception.

Table 4. *E-waste management methods used in the study area*

E-waste management methods	Percentage (s)
Keep them in storeroom (home)	47%
Sell them	22.9%
Dispose with general waste	7.3%
Donate them	17.5%
Others (we do not know)	5.3%

Source: Survey data (2023-2024)

E-waste recycling knowledge of the respondents

Figure 3 illustrates that 53% of the respondents stated that they are not aware of any e-waste recycling company in the study area. Although about 4% of them are aware of e-waste recycling companies found in the study area, 28% stated that they are aware of the e-waste recycling company, however, the recycling company is situated far from the study area. Respondents who stated that there is no e-waste recycling company in the area amounted to 15%.

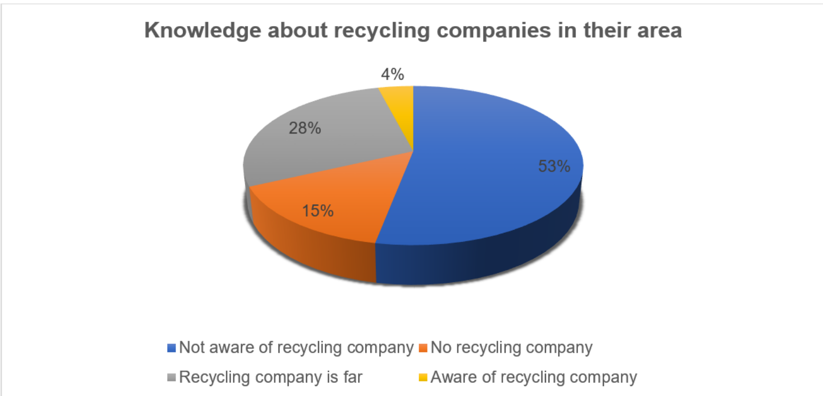

Figure 3. *Recycling knowledge of the respondents*

Factors influencing the community awareness on e-waste disposal

The results of the study in *Table 5* indicated that the variable age of the respondents had a statistically significant effect on awareness of e-waste disposal, with a positive coefficient. This implies that as the respondents get older by years the more, they become aware of e-waste disposal methods. The variable electronics recycling was found to be statistically significant, with a positive coefficient. This implies that a unit increase in the recycling of e-waste resulted in an increase in the respondent’s awareness of e-waste disposal. Alabanza et al. (2022), stated that e-waste generated from ICT and laptops has greater potential to be recycled. Furthermore, Ichikowitz and Hattingh (2020), attested

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that precious metals like gold, silver, and copper can be recovered from cellphones, laptops, televisions, LCDs, and desktops. Moreover, both Rahul et al. (2022) and Attia et al. (2024), also attested that recycled e-waste has the highest potential for recovering valuable materials that can be reused. However, study by Ichikowitz and Hattingh (2020), revealed that residents of Mangaung were concerned about recycling e-waste such as cellphones and laptops since they believed that those devices carried personal information, and therefore, they would rather keep them in their home storage than recycle.

Table 5. *Factors influencing the community awareness of the e-waste management and disposal*

Variables	Coefficient	Std. Error	t	Sig.
Gender	-0.339	0.210	2.619	0.106
Age	0.211	0.094	5.086	0.024*
Educational level	0.031	0.150	0.042	0.837
Employment	0.178	0.083	4.547	2.352
Household size	-0.310	0.202	0.304	0.125
Causes of e-waste	0.078	0.201	0.150	0.698
No. of electronics in a household	0.102	0.211	0.234	0.628
Frequency of changing electronics	0.176	0.234	0.561	0.454
Electronics recycling	0.975	0.248	15.453	0.001***
Knowledge of the recycling station	0.634	0.429	2.181	0.140
Repair of broken electronics	-0.485	0.151	10.371	0.001***
Consent	-0.339	0.044	-7.742	0.001

Note: *, **, *** represent significant levels at 10%, 5% and 1% respectively. Source: Survey data (2023-2024)

The results of the study in *Table 5* indicated repair of broken electronics in a household had a statistically significant influence on the respondents' awareness on e-waste disposal, with a negative coefficient. This implies that the respondents who repaired or fixed their broken electronics were less likely to be aware of the e-waste disposal methods. Repairing is simply the correction of specified faults in a product, and it is a logical approach to not disposing electronic products and extend the product's life (King et al., 2006).

Conclusion

It is evident from the findings of the study that most respondents at 65.3% owned bigger household appliances such as refrigerators, TVs, freezers, electric stoves and washing machines. In this study, respondents (4%) who knew and made use of e-waste recycling companies were the minority. Those results revealed that there is less awareness on e-waste management and disposal since about 47% of residents keep e-waste in their houses, while 22.9% prefer to sell them. Repairing and recycling of the e-waste showed statistically significant in the study. This implies that respondents who repaired or fixed

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their broken electronics were less likely to be aware of the e-waste disposal methods. Therefore, it is recommended that an awareness on the management and disposal of e-waste should be awarded to the Collins Chabane Local Municipality community, through campaigns and information sharing sessions. Incorrect management and disposal of e-waste in a general waste municipality bin must be prohibited, since e-waste carries toxic and hazardous attributes or components. Specific e-waste bins must be provided and placed in noticeable areas within the study area to encourage a good and correct e-waste disposal practices.

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