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Examining Household Intentions for E-Waste Recycling using Logistic Regression: A Case Study in Ipoh

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Abstract: Electronic waste (e-waste) has emerged as a significant environmental issue worldwide due to the rapid technological advancements and the resulting increase in electronic device consumption. Improper disposal of e-waste poses serious environmental and health risks, as it contains toxic substances that can contaminate soil, water, and air if not managed properly. This study aimed to identify the key factors influencing e-waste recycling intentions among households in Ipoh, Perak. A sample of 400 respondents was selected through convenience sampling, with data collected through a cross-sectional design. Binary logistic regression was applied with independent variables, which are attitude, subjective norms, perceived behavioural control, perceived convenience, awareness of consequences, and perceived knowledge towards e-waste recycling intention. Results indicated that only variable subjective norms and perceived convenience of the recycling process contribute significantly to e-waste recycling intention among the households in Ipoh, Perak. The findings are anticipated to guide future strategies, policies, and educational initiatives to enhance e-waste recycling intentions and contribute to broader environmental sustainability goals.

Keywords: Electronic waste, Environment sustainability, Perceived convenience, Recycling intentions, Subjective norms.

1 Introduction

Electronic waste, commonly referred to as e-waste, was a growing environmental problem that had gained significant attention in recent years. As technology advanced, electronic products becomes more accessible, affordable, and quickly outdated, resulting in a significant increase in e-waste globally. E-waste encompasses a broad range of electronic devices, including mobile phones, computers, televisions, and other electronic appliances that are no longer in use or have reached the end of their useful life [1]. Outdated electronic products can be offered to others who might still find value in them. Additionally, many merchants provide trade-in programs or incentives for individuals wishing to upgrade their electronics, enabling retailers to reuse or repurpose older models. However, when a product is completely worthless or broken, it must be disposed of properly rather than simply being thrown in the trash.

In Malaysia, 280,000 tonnes of e-waste are produced overall, representing 8.8 kg of e-waste per person [2]. As Malaysia transitions from a middle-high to a high-income country, e-waste is expected to increase further [2]. Malaysia has become one of the largest e-waste generators in Southeast Asia, with a growing volume of e-waste generated every year, as stated by the Department of Environment. According to Associate Prof. Dr Ahmad Fariz Mohamed, a senior fellow of the Institute for Environment and Development (LESTARI) at Universiti Kebangsaan Malaysia in 2022, personal electronic devices, or household e-waste items such as mobile phones, laptops, and televisions, contain

toxic and hazardous chemicals that can cause severe environmental pollution and pose a threat to human health. Chromium, mercury, cadmium, lead, beryllium, phthalates, polyvinyl chlorides, brominated flame retardants, and antimony are among the toxic metals and chemical substances frequently used in these components. Exposure to these harmful elements can damage the heart, liver, kidneys, brain, and skeletal system. It can also significantly impact the neurological and reproductive systems, resulting in illnesses and birth abnormalities. Therefore, proper management and recycling of e-waste have become critical to protecting the environment and human health, making e-waste recycling behaviour a crucial issue globally.

Intentions are self-instructions to perform behaviours or to achieve certain outcomes [3] and are assumed to capture the motivational factors that influence a behaviour [4]. Therefore, research on e-waste recycling intention had been conducted to gain a deeper understanding of the factors that shape individuals' and businesses' attitudes towards e-waste recycling. These factors include a lack of awareness about the importance of e-waste recycling, limited access to recycling facilities, and the costs associated with e-waste recycling. By identifying these barriers, researchers can develop strategies to overcome them and encourage more individuals and businesses to recycle their electronic devices. Another goal of e-waste recycling intention research is to identify the causes of e-waste recycling intentions, such as environmental concerns, social norms, and financial incentives. By understanding what motivates individuals and businesses to recycle their electronic devices, researchers can develop effective strategies and policies that capitalise on these drivers to promote sustainable e-waste management practices.

Recycling is the process of converting used waste into new objects to prevent the wastage of useful materials and reduce the use of natural resources. It is also one of the safest ways to discard used products [5]. Intention refers to people's willingness and effort to perform a behaviour [6]. Therefore, the intention to recycle is a person's plan to convert waste materials into new useful objects. This concept has been widely targeted by past researchers. Intention reflects the idea that people plan or intend to carry out certain actions. According to the Theory of Planned Behaviour (TPB), the link between attitude and conduct is crucial, with behaviour intention being the major determinant of action [6]. The TPB has also been used in research to examine consumers' intentions to engage in green behaviour. The TPB outlined three crucial factors that influence intention: attitude, subjective norms, and Perceived Behavioural Control (PBC) [7]. In other studies, the TPB has been utilised to predict human behaviour, incorporating these three variables [8]. Researchers have applied TPB to evaluate individuals' intentions and behaviour regarding water conservation, recycling, and other environmentally friendly actions. Some researchers argue that subjective norms are the weakest factor influencing recycling intentions [9].

Subjective norms are social pressures or influences that cause a person to do or not do something [10]. The term "norm" could be defined as a cohesive glue that encourages a person to actively participate in a group, share and take responsibility for their actions in the group [1]. Meanwhile, perceived norm is a subjective norm that can be described as a person's intention to do a specific behaviour in response to the expectations of others [10]. Social pressure, as well as subjective norms, had an advantageous effect on e-waste recycling behaviour, especially when it came from family, friends, and eighbors. Besides that, the degree to which a person has control over a situation, referred to as perceived behaviour control, may also have an impact on the intention to recycle [1]. Comparatively speaking, someone who feels they have limited influence over current or potential setbacks is more likely to exhibit recycling behaviour than someone who is confident in their ability to execute recycling activity [10].

According to [1], convenience had been shown to significantly influence behaviour throughout the processing stage, making recycling simpler, encouraging people to recycle more and facilitating the implementation of new rules regarding e-waste [11]. A state of convenience was when something could be done easily and without trouble [1], which meant that convenience was a simple and extremely useful aspect when doing something. In addition, awareness was one of the key elements affecting people's intention to recycle [12]. This study showed that being aware of recycling influenced a range of behaviours, including having a favourable intention to recycle. Individuals with a higher risk perception

were less likely to perform an act, while those with lower risk perceptions had increased behavioural intentions as a result. Hence, when people knew about the risk of not recycling e-waste, they tend to have thought about doing e-waste recycling. The phrase "perceived knowledge" refers to one's perception or belief that they possess the knowledge necessary to assess several things within a given category [13]. According to [9], knowledge is an essential but insufficient predictor of recycling intention, and knowledge might have acted as an antecedent to the Theory of Planned Behaviour framework. For example, learning how to recycle could have improved one's perception of behavioural control, which could have led the behaviour to become a habit.

The lives of humans and other living things on the globe could also be protected by recycling e-waste. Hence, by knowing more about the predictors of recycling intention to e-waste recycle, the authorities, such as the government, could learn about what aspects they need to focus on to encourage people in Malaysia to start recycling. As a result, this research encourages everyone at any age to have more interest in e-waste recycling. Some people might have known about e-waste recycling, but they do not practice it in their daily lives. Therefore, this research helps in adding knowledge about the perspective towards e-waste recycling, and people will begin to recycle regularly.

A Descriptions of Data

Data for this study was gathered through 400 online questionnaires utilising convenience sampling. The data collection process employed open-ended and close-ended structured questionnaires, which were completed by respondents from households in Ipoh, Perak. The study's dependent variable was recycling intention, while the independent variables were attitude, subjective norms, awareness of consequences, perceived knowledge, and perceived convenience.

B Theoretical Framework

Figure 1 presents the theoretical framework in this research. The independent variables were attitude, subjective norms, perceived behavioural control, awareness of consequences, perceived convenience, and perceived knowledge. Moreover, the dependent variable is the intention to adopt a zero-waste lifestyle.

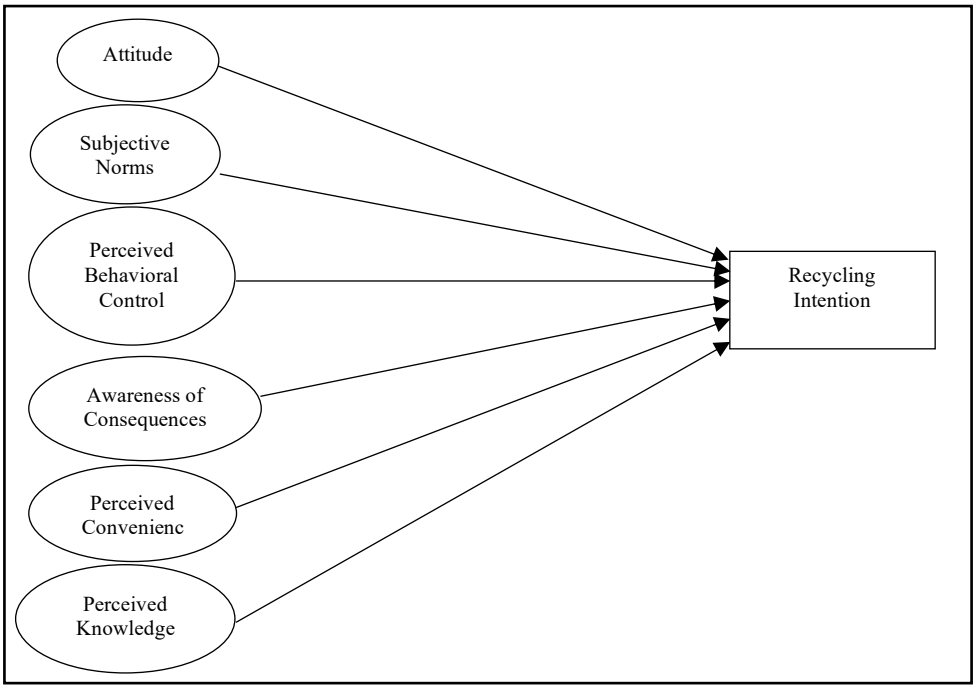

Figure 1: Theoretical Framework of the Study

C Binary Logistic Regression

According to [5], a statistical technique for examining the relationship between one or more independent variables and a binary dependent variable is called logistic regression. Logistic regression was intended for outcomes that are binary, such as true or false, 0 or 1, as opposed to linear regression, which was appropriate for continuous dependent variables. When there were two possible outcomes for a binary or categorical dependent variable, logistic regression was employed. For instance, using study hours to predict if a student would pass (1) or fail (0) an exam.

The logistic regression model used the logit function, which was the natural logarithm of the event's probability, to transform the linear combination of independent variables [14]. The anticipated values between 0 and 1 were constrained by the logit function. With all other variables held constant, logistic regression calculated coefficients for each independent variable, which indicated the change in the dependent variable's log odds for a one-unit change in the independent variable [14].

The odds ratio, which represented the multiplicative change in odds connected to a one-unit change in the independent variable, was obtained from the coefficients. A higher odds ratio indicated a higher probability of the event happening, whereas a lower odds ratio indicated a lower probability [15]. The evaluation of model fit was done by methods such as maximum likelihood estimation. The Wald test, deviance statistics, and likelihood ratio test were examples of common evaluation metrics. The discriminating power of the model was assessed using area under the curve (AUC) and receiver operating characteristic (ROC) curves [14]. The direction and strength of the link between independent factors and the outcome's log odds could be understood with the use of coefficients and odds ratios.

The logistic regression general model was:

$$\mathbf{log}\, it\left(p\right) = \mathbf{log}\left[\frac{p\left(x\right)}{1-p\left(x\right)}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \mathbf{...} + \beta_k X_k \tag{1}$$

Then, to simplify the above model, p could be calculated with the following formula, which was simply another rearrangement of the above formula:

$$p = e^{\frac{\left(\beta_0+\beta_1 X_1+\beta_2 X_2+\mathbf{...}+\beta_k X_k+\varepsilon\right)}{\left(1+e^{\left(\beta_0+\beta_1 X_1+\beta_2 X_2+\mathbf{...}+\beta_k X_k+\varepsilon\right)}\right)}} \tag{2}$$

where,

p	=	The probability of successes of dependent variable
e	=	The base of natural algorithms
β_0	=	The constant of the equation
$\beta_1, \beta_2, ..., \beta_k$	=	The coefficient of the predictor or independent variable
$X_1, X_2, ..., X_k$	=	The predictor or independent variable

2 Results and Discussion

A Binary Logistic Regression

In the descriptive analysis, the respondents' demographic profile will be explained and analysed to capture the overall characteristics of each of the respondents. A total of 412 respondents participated in

the survey, comprising 60% women and 40% men. The largest proportion of respondents falls within the 21–25 age group, constituting 39.1%. Two other age groups, 18-20 and 26-30, each accounted for 21.6% of the respondents, while 17.7% were aged above 30. Regarding marital status, the majority of respondents were single (59.7%), while married respondents constituted 40.3%. In terms of educational attainment, 41% of respondents held a degree, followed by 28.6% with SPM qualifications and 23.5% with STPM/Diploma credentials.

Occupationally, half of the respondents were students (43.2%), followed by private employees (28.4%), with only 1.7% being retired employees. Concerning monthly income, over half of the respondents reported a monthly income of RM0.00, while 9.7% earned RM1500 and 7.8% earned RM3000. The most prevalent family size among respondents was five members (32%), followed by families with three members (28.9%) and four members (19.4%). Geographically, 21.6% of respondents resided in Pekan Baru, with a few respondents living in Manjoi (15%) and Buntong (12.4%).

B Reliability Analysis

A reliability test was conducted to measure whether the variables used in the study are reliable or not. Cronbach's alpha is commonly benchmarked by analysts at 0.7 [16]. The items were sufficiently consistent at this level and above to suggest the measure's reliability. Before proceeding with the analysis for this study, a pilot study was conducted to make sure that all variables used for the analysis are reliable. A total of 30 respondents were selected to answer the questionnaire for the pilot study. The reliability test results for both the pilot study and the actual study are presented in Table 1 below. Cronbach's alpha values for both the independent and dependent variables exceeded 0.7. Thus, it can be inferred that all variables demonstrated reliability and consistency.

Table 1: Reliability Test for Pilot Study and Actual Study

Variable	No of Items	Cronbach's Alpha (Pilot Study)	Cronbach's Alpha (Actual Study)
Attitude	6	0.823	0.964
Subjective Norms	6	0.824	0.858
Perceived Behavioral Control	6	0.904	0.842
Awareness of Consequences	6	0.876	0.986
Convenience	6	0.951	0.819
Subjective Knowledge	6	0.862	0.981
E-waste recycling intention	6	0.890	0.863

C Model Evaluation

Logistic regression was employed to identify the factors influencing e-waste recycling intentions. Table 2 presents the statistical analysis of the relationship between independent variables (attitude, subjective norms, perceived behavioural control, awareness of consequences, convenience, and perceived knowledge) and the dependent variable, intention towards e-waste recycling.

Two variables stood out as statistically significant in the logistic regression model: subjective norms and convenience. Their p-values of 0.004 and 0.001, respectively, fell below the 5% level of significance, indicating a significant relationship with the intention towards e-waste recycling. This outcome aligns with the study objective, highlighting subjective norms and convenience as influential factors in e-waste recycling intention. Conversely, four variables showed no statistical significance and did not impact individuals' intentions towards e-waste recycling.

In this scenario, subjective norms have an odds ratio of 1.882, indicating a substantial impact, with an 88.2% increase in the odds of the intention towards e-waste recycling for every unit rise in subjective norms. This means that for each unit increase in the strength of the subjective norm, the odds

of having the intention to recycle increase by 88.2%. It also suggests a strong positive relationship between subjective norms and recycling intention, whereas when people feel more socially pressured or expected to recycle, they are much more likely to form an intention to do so. Moreover, convenience has an odds ratio of 1.731, indicating a significant positive influence, with a 73.1% increase in the odds of the intention towards e-waste recycling for every unit rise in convenience. This indicates that for every one unit increase in the perceived convenience of e-waste recycling, the odds of having the intention to recycle increased by 73.1%. It suggests that people are significantly more likely to intend to recycle when they perceive that recycling is easy or accessible.

Table 2: Logistics Regression Results

Variable	B	Sig.	Exp (B)
Attitude	0.187	0.333	1.206
Subjective Norms	0.632	0.004	1.882
Perceived Behavioral Control	0.074	0.648	1.076
Awareness of Consequences	0.185	0.306	1.204
Perceived Convenience	0.549	0.001	1.731
Perceived Knowledge	-0.368	0.052	0.992
Constant	18.480	<0.001	0.000

The Omnibus Test was used to make sure that the independent variable can accurately predict the dependent variable. It also shows whether there is a statistically significant relationship between the dependent variable and the independent variables. According to Table 3 below, the p-value for the Omnibus Test of the model, which is less than 5% level of significance, indicates that there is sufficient evidence to support the idea that predictions for intention towards e-waste recycling can be improved by using the independent variables' information.

In addition, the Hosmer and Lemeshow Test is a statistical test that determines if logistic regression models fit well with the data. It is used frequently in risk prediction models and can determine how well the data fits the model with a goodness of fit test. Based on Table 3 below, the p-value was 0.999, which is greater than 5% level of significance, indicating that there is enough evidence to conclude that the logistic regression is a good fit for the data in the model.

Table 3: Hosmer and Lemeshow Results

Model Evaluation	Sig.
Omnibus Test	<0.001
Hosmer and Lemeshow	0.999

The predictive efficiency model was used to compare the predicted value for e-waste recycling intention among households based on the logistic regression model with the actual observed value in the data set. Sensitivity was used to indicate the probability that the test will correctly classify households as having intentions, while specificity was used to indicate the probability that the test will correctly identify households who do not have intentions. Based on Table 4, the model exhibits a sensitivity of 98.9%, a specificity of 72.0%, and an overall percentage of 97.3%. Consequently, it can be inferred that this model demonstrates high predictive efficiency, given that the overall accuracy is very high.

Table 4: Classification Table

Predictive Efficiency Model	Percentage
Sensitivity	98.9%
Specificity	72.0%
Overall	97.3%

Cox and Snell, as well as Nagelkerke, were utilized to illustrate the extent to which the model could explain variation in the predicted variable. These metrics were employed to evaluate the strength of the relationship between the model and the data, with values spanning from 0% to 100%. According to Table 5, the Cox and Snell R2 values were 0.318 and the Nagelkerke R2 was 0.857. These R2 values collectively suggest that 85.7% of the variance in e-waste recycling intention can be explained by all the factors considered, with the overall variance being approximately 31.8%.

Table 5: Model Summary

R^2	Value
Cox and Snell R square	0.318
Nagelkerke R Square	0.857

3 Conclusion

The main objective of this study was to identify the factors influencing e-waste recycling intentions among households in Ipoh, Perak. The results highlight the significant roles of subjective norms and perceived convenience in shaping these intentions, which aligns with the findings of a previous study [1]. Initially, descriptive analysis was conducted to assess the characteristics of the respondents targeted in the study. The distribution revealed that 60% of the respondents were female, while the remaining 40% were male. Additionally, various demographic factors such as age, marital status, education level, occupation, monthly income, family size, and location were also examined.

The focus of this study was to pinpoint the determinants of e-waste recycling intentions. The analysis indicates that households in Ipoh, Perak, demonstrated an inclination to recycle e-waste, primarily influenced by subjective norms and the perceived convenience associated with the recycling process. Subjective norms represent individuals' perceptions of social expectations or influences regarding e-waste recycling, which contribute to a sense of social responsibility and impact participation in recycling practices. Moreover, convenience emerges as a significant factor, as the ease and accessibility of the recycling process affect individuals' willingness to engage in e-waste recycling activities.

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Conflict of Interest Statement

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

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