# Determinants of E-Waste Recycling Behaviour among Residents in Klang Valley, Malaysia

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## ABSTRACT

E-waste is among the most rapidly rising kinds of solid waste globally due to the decreasing lifespan of electronic devices. The accumulation of e-waste poses serious threats not only to the ecosystem but also to the well-being of individuals, making it essential for residents to engage in effective e-waste recycling practices. To foster community sustainability, it is necessary to understand the determinants that influence residents' e-waste recycling behaviour. The primary aim of this study is to explore the determinants of shaping residents' e-waste recycling behaviour in the Klang Valley area. The extended Theory of Planned Behaviour (TPB) was employed to examine the influence of key variables, including attitude, subjective norms, perceived behavioural control, and convenience of recycling, on both the intention to recycle e-waste and actual e-waste recycling behaviour. Data was collected from 237 respondents via an online questionnaire. The results showed that attitude, subjective norms, and perceived behavioural control have a significant impact on the e-waste recycling intention among residents of the Klang Valley. Furthermore, a significant relationship was found between e-waste recycling intention and recycling behaviour. The study also revealed that the convenience of recycling did not significantly influence the intention to recycle e-waste among residents of the Klang Valley area. Likewise, sociodemographic characteristics have no correlation with e-waste recycling behaviour apart from the gender variable. These findings help various stakeholders understand an effective e-waste recycling mechanism that can support the community in achieving its sustainable development goals by 2030.

**Keywords:** electronic waste; e-waste recycling behaviour; waste disposal behaviour

## INTRODUCTION

### Global and Local Context of E-Waste

Electronic waste (e-waste) has emerged as a pressing environmental concern, attracting significant global attention in recent years. As one of the fastest-growing categories of solid waste, e-waste has exhibited a dramatic upward trajectory over the past two decades. This rapid increase is primarily attributed to the accelerated production of advanced technological devices and appliances. These innovations, while enhancing functionality and convenience, have concurrently shortened product life cycles. As a result, consumer demand for the latest electronic models has surged, fostering a cycle of frequent replacements and upgrades. This consumption pattern significantly contributes to the growing volume of e-waste worldwide [1]–[3]. Thus, this pattern of consumption not only encourages unsustainable practices among consumers but also escalates electronic waste generation worldwide.

The rapid advancement of technology, coupled with growing global dependence on electronic devices, has led to a significant increase in the rate of e-waste disposal worldwide. The Global e-waste Monitor report indicates that the world generated 62 million tonnes in 2022, representing an increase of approximately 82% from 2010, and is projected to reach 82 million tonnes by 2030 [4]. Asia leads globally as the primary producer of electronic waste, accounting for 24.9 million tonnes. This is followed by America, Europe and Africa, with 13.1 million tonnes, 12 million tonnes and 2.9 million tonnes, respectively [4]. The scenario in Malaysia reflects the global trend and a noticeable rise of e-waste generation within the region. According to the 2020

Global E-Waste Monitor Report, Malaysia generated 364,000 tonnes of e-waste in 2019, equivalent to 8.8 kg per capita [5]. In 2021, a significant amount of 2,459 tonnes of electronic waste was identified as originating from residential sources in Malaysia [5]. This noticeable figure underscores the growing issue of e-waste produced by individuals across the country. It is also predicted that Malaysia could create nearly 24.5 million units of e-waste by 2025 [6]. These figures indicate that e-waste has been discarded rather than being recycled.

Countries worldwide are facing substantial challenges in effectively managing e-waste due to the increasing rate of e-waste disposal. The United States Environmental Protection Agency has indicated that global e-waste generation continues to rise by 5% to 10% annually, while its recovery rate is approximately 10% [7]. Furthermore, the worldwide recycling rate is only between 17% and 22% when conducted properly. This indicates that around 80% of e-waste has either remained untreated or has been processed informally rather than following the appropriate recycling or disposal methods [8]. Likewise, Malaysia is currently able to recycle merely 10% of the entire e-waste produced. The currently low recycling rate underscores a pressing need for enhanced e-waste recycling practices and management strategies to address the issue effectively.

Overall, recycling and waste segregation are crucial in Malaysia, as 80% of waste that ends up in landfills consists of recyclable materials [9]. This means that e-waste must not be disposed of alongside other solid waste under the Environmental Quality (Scheduled Waste) Regulation 2005 [10]. Various studies on the management of household e-waste have found that Malaysians prefer to either retain their outdated electronic products at home or dispose of them with other types of solid waste, rather than recycling them properly through designated e-waste recycling centres [10]–[11]. These inadequate practices highlight that proper e-waste recycling efforts in Malaysia are still hindered.

The mismanagement of e-waste has become a significant challenge for Malaysia in achieving the Sustainable Development Goals (SDGs) by 2030 [12]. This trend poses serious long-term consequences for both human health and the environment, primarily due to the presence of hazardous substances such as mercury (Hg), lead (Pb), and cadmium (Cd) in e-waste [13]–[14], causing the hazardous substances accumulation within the food web as well as contamination of ecosystems [15]–[17]. This results in adverse effects on human health, including complications like neurological disorders in children, high rates of spontaneous miscarriage, premature births, and lowered birth weights [17]–[18]. These environmental and human health concerns underscore the need for proper e-waste handling to mitigate the hazardous consequences of improperly discarded electronic products.

Based on the growing purchase of electronic items, the amount of e-waste generated from households is substantially increasing. This situation is attributed mainly to insufficient knowledge and improper disposal behaviour. This current household e-waste practice presents significant challenges to effective waste management and contributes to the expansion of hazardous landfills throughout Malaysia [20]. Therefore, a comprehensive understanding of e-waste recycling behaviour is critical to tackling the issue.

**Understanding Community-Level E-Waste Recycling Behaviour**

Community involvement has become critical in ensuring effective e-waste management at the household level [21]. Current statistics revealed that only 20% of the e-waste generated by residents has been recycled [22], showing a significant gap in e-waste recycling practices. Moreover, a previous study found that discarding e-waste into the trash is one of the preferred practices among residents [11]. To address this challenge, it is essential to foster a deeper understanding of residents' recycling behaviour. Examining the behaviour helps identify the specific psychological barriers that the public faces when engaging in recycling practices [23]. These barriers may include the lack of awareness about the impact of e-waste, cultural attitudes towards recycling, and the absence of easily accessible recycling facilities. By recognising these barriers, stakeholders can develop targeted strategies to solve the hindrances and promote supportive recycling initiatives that encourage community participation [24].

Selangor emerged as the leading state in Malaysia, generating 1,581.2 metric tonnes of scheduled household waste in 2023. However, there is a notable scarcity of research specifically addressing e-waste recycling behaviours in Malaysia [25]. Some studies suggest that additional factors should be integrated into the standard

TPB theory and examined, particularly in different regions, to provide a more holistic insight into actual e-waste recycling practices in Malaysia. Reference [26] conducted a study on e-waste recycling behaviour utilising the extended TPB in Malaysia; however, there remains a lack of studies focusing on residents' e-waste recycling behaviour in the Klang Valley area employing the extended TPB. Addressing this gap could provide valuable insights into developing effective e-waste management plans that cater to the specific needs of the local community.

**The Theory of Planned Behaviour Framework (TPB) and Hypotheses Development**

TPB surveys were widely used to analyse behaviour in various fields such as education, health, environment, consumer behaviour, and transportation studies. This framework aims to predict the behaviours associated with health practices, including quitting smoking and dietary choices, as well as environmental behavioural studies such as recycling. The 12th Malaysia Plan has set a recycling rate target of 40% by 2025; thus, it is essential to get an understanding of public consciousness, disposal behaviours, and environmentally responsible behaviours in fostering sustainable e-waste management [28]. This paper was conducted to assess the determinants of e-waste recycling behaviour through the extended Theory of Planned Behaviour (TPB), which aims to highlight the underlying reasons driving residents' decisions on e-waste recycling [29]–[30]. Especially in the study of recycling behaviour, various external factors, such as policy interventions, economic incentives, and convenience, influence an individual's recycling decision [31]. As the purchase of electronic items increases, the study of extended TPB in the context of e-waste recycling behaviour should be conducted to identify the influencing factors on the residents' e-waste recycling practices. In this study, the convenience of recycling is included in the extended TPB to assess the residents' e-waste recycling behaviour in the Klang Valley area, since previous studies found that the convenience of recycling emerged as the most crucial factor that encourages the individual's recycling practice [32]–[33]. Based on the conceptual framework (Figure 1), this paper aims to analyse the association between the sociodemographic factors and the e-waste recycling behaviour, assess the direction of the relationship between the variables and examine the key determinants of the residents' e-waste recycling behaviour in the Klang Valley area.

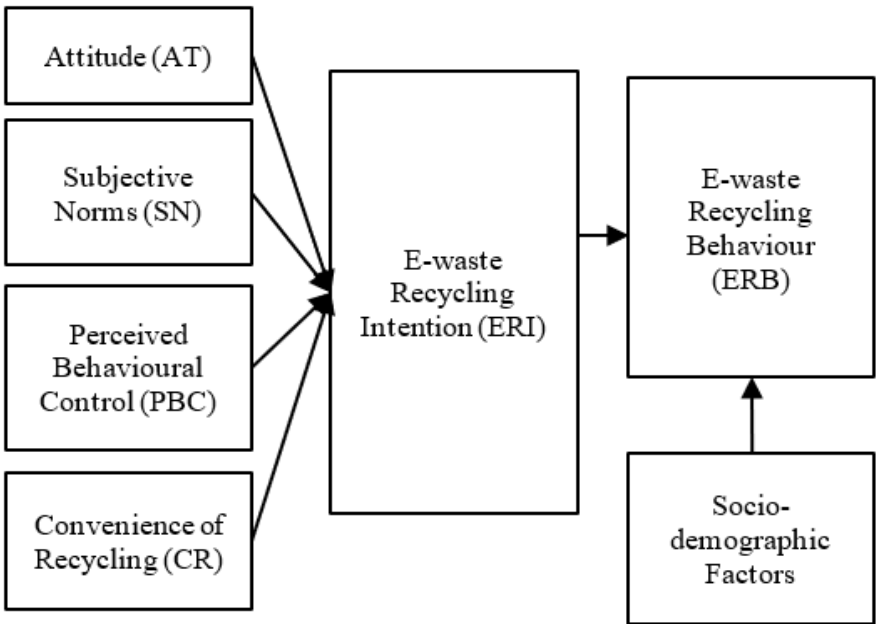


Fig. 1. Conceptual framework

**1) Attitude (AT):** The attitude of the individual reflects their tendency to perform the appropriate behaviour [33][35]. Previous studies on recycling indicate that attitude is one of the significant determinants of recycling intentions towards behaviour [36]–[37].

**H1:** There is a significant relationship between attitude and e-waste recycling intention among the residents in Klang Valley.

**2) Subjective Norms (SN):** Previous research has found that subjective norms can be a strong motivator for engaging in waste segregation and recycling [39].

**H2:** There is a significant relationship between subjective norms and e-waste recycling intention among the residents in the Klang Valley.

**3) Perceived Behavioural Control (PBC):** Several studies have shown that perceived behavioural control has a significant influence on the intention and actual behaviour related to waste management [40].

**H3:** There is a significant relationship between perceived behavioural control and e-waste recycling intention among the residents in the Klang Valley.

**4) Convenience of Recycling (CR):** Certain research indicated that convenience is a significant factor in waste management behaviour [41]–[42].

**H4:** There is a significant relationship between convenience of recycling and e-waste recycling intention among the residents in the Klang Valley.

**5) E-waste Recycling Intention (ERI):** It is indicated that intention has a positive relationship with recycling behaviour [43].

**H5:** There is a significant relationship between e-waste recycling intention and e-waste recycling behaviour among the residents in the Klang Valley.

**6) The Effect of Socio-demographic Factors on E-Waste Recycling Behaviour (ERB):** Various studies revealed that sociodemographic factors significantly influence recycling behaviour [41]–[43]. Therefore, this study intends to test whether:

**H6:** There is a correlation between sociodemographic factors and e-waste recycling behaviour among the residents in Klang Valley.

## MATERIAL AND METHODS

### Population of the Study

The study was conducted in the Klang Valley area of Malaysia, which comprises five districts in Selangor: Gombak, Klang, Petaling, Sepang, and Hulu Langat, as well as two Federal Territories—Putrajaya and Kuala Lumpur. This area was selected as the focus of the study due to its status as the most developed, densely populated and rapidly expanding region in Malaysia compared to other areas of the nation. The total population living in the Klang Valley area is approximately 8.8 million [45].

### Data Collection

A purposive sampling method was applied to gather respondents aged 18 years and above living in Klang Valley. While this method enabled the targeting of individuals with relevant characteristics for the study, it limits the generalisability of the findings to the broader Malaysian population. Future research should consider using probability-based sampling techniques to enhance representativeness and external validity [46]. This study employed quantitative research design using structured questionnaires adapted from prior validated studies. A pilot study involving 30 respondents was conducted to assess the instrument's reliability and refine its items. Cronbach’s alpha was calculated for each construct, and only items with a coefficient of 0.70 or higher were retained in the final questionnaire, confirming acceptable internal consistency. The finalized questionnaire consisted of 45 items organised into two main sections, as detailed in Table I. Part A collected respondents' sociodemographic information. Part B included six constructs: attitude, subjective norms, perceived behavioural control, convenience of recycling, intention, and behaviour. All items in Part B were assessed using a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The survey was distributed to 384 residents, currently residing in the Klang Valley area, who were above 18 years old and who must own electronic items within their home, to be eligible to participate.

### Data Analysis

The collected data were analysed using descriptive statistics, Pearson correlation, and multiple regression analysis through the IBM Statistical Package for the Social Sciences (SPSS). Descriptive statistics were employed to summarise the demographic characteristics of the sample population. Pearson correlation analysis was conducted to examine the direction and strength of the relationships among the constructs derived from the Theory of Planned Behaviour (TPB). Multiple regression analysis was applied to identify the most significant independent predictors influencing the dependent variable, thereby offering insights into the relative contribution of each construct to the explained variance in recycling behaviour.

## RESULTS AND DISCUSSION

### Demographic Characteristics

Among the 237 samples, the majority were female (74.7%). The higher participation rate of females compared to males in the recycling survey is attributed to their traditional role in household management and a more proactive attitude towards recycling [48]. Most participants (50.2%) were between 20 and 29 years old, followed by 21.5% in the 30–39 age group. The majority had a bachelor's degree (56.1%). The most significant number of respondents were students (51.1%). Another notable portion of participants came from the government sector (21.1%) and the private sector (14.8%). This indicates a relatively high engagement level from the younger generation due to their digital literacy and active involvement in social media platforms, which makes them more likely to participate in online surveys [49].

Table I Respondents' Demographic Profile

| | Frequency | Percentage (%) |
|---|---|---|
| **Gender** | | |
| Female | 177 | 74.7 |
| Male | 60 | 25.3 |
| **Age** | | |
| 19 years and below | 34 | 14.3 |
| 20- 29 years | 119 | 50.2 |
| 30- 39 years | 51 | 21.5 |
| 40- 49 years | 26 | 11.0 |
| 50- 59 years | 5 | 2.1 |
| 60 years and above | 2 | 0.8 |
| **Education** | | |
| Secondary/ High School | 13 | 5.5 |
| College/ Vocational education/ Foundation | 39 | 16.5 |
| Bachelor's Degree | 133 | 56.1 |
| Master's degree/PhD | 52 | 21.9 |
| **Employment** | | |
| Student | 121 | 51.1 |
| Retired | 1 | 0.4 |
| Not working | 8 | 3.4 |
| Non-Government | 11 | 4.6 |
| Government | 50 | 21.1 |
| Private | 35 | 14.8 |
| Government | 11 | 4.6 |
| **Income** | | |
| RM 0 - RM 2,559 | 139 | 58.6 |
| RM 2,560 – RM 3,439 | 32 | 13.5 |
| RM 3,440 – RM 4,309 | 17 | 7.2 |
| RM 4,310 – RM 5,249 | 10 | 4.2 |

| | | |
|---|---|---|
| RM 5,250 – RM 6,339 | 7 | 3.0 |
| RM 6,340 – RM 7,689 | 7 | 3.0 |
| RM 7,690 – RM 9,449 | 16 | 6.8 |
| RM 9,450 – RM 11,819 | 5 | 2.1 |
| RM 11,820 – RM 15,869 | 1 | 0.4 |
| More than RM 15,870 | 3 | 1.3 |
| **Total** | **237** | **100** |

**Pearson Correlation**

**1) Correlation between ERB and Socio-demographic Factors:** In this study, the Pearson correlation was used to investigate the association between ERB and sociodemographic factors, as well as the relationship between A, SN, PBC, CR, ERI, and ERB. The results indicated that the data were normally distributed, as all items achieved $p > .05$ in the Kolmogorov-Smirnov test.

Based on the results (Table II), there is a significant correlation between gender and ERB ($r = .154$, $p = .018$), indicating a weak positive relationship. This finding is consistent with previous studies that gender plays a significant role in ERB [54]–[56]. Conversely, other factors such as age ($r = .066$, $p = .313$), education ($r = -.075$, $p = .252$), employment status ($r = .051$, $p = .431$), monthly income ($r = .039$, $p = .555$) and district ($r = -.040$, $p = .537$) showed no significant association with ERB in the Klang Valley area. This supports earlier research indicating that sociodemographic factors generally have a limited effect on ERB, except for education level in Malaysia [26]. Moreover, some research found that socio-demographic factors did not significantly influence ERB. Overall, the results showed that residents in the Klang Valley have poor performance in e-waste recycling, regardless of their socio-demographic profiles.

Table II Correlation between ERB and Socio-Demographic Factors

| **Socio-demographic Factors** | | **ERB** |
|---|---|---|
| **Gender** | Pearson Correlation | .154* |
| | Sig. (2-tailed) | .018 |
| | N | 237 |
| **Age** | Pearson Correlation | .066 |
| | Sig. (2-tailed) | .313 |
| | N | 237 |
| **Education** | Pearson Correlation | -.075 |
| | Sig. (2-tailed) | .252 |
| | N | 237 |
| **Employment** | Pearson Correlation | .051 |
| | Sig. (2-tailed) | .431 |
| | N | 237 |
| **Income** | Pearson Correlation | .039 |
| | Sig. (2-tailed) | .555 |
| | N | 237 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | |
| *. Correlation is significant at the 0.05 level (2-tailed). | | |

**2) Correlation between Dependent Variable and Independent Variables:** The correlation between the dependent variable (ERB) and the independent variables (AT, SN, PBC, CR, and ERI) was tested. Results (Table III) revealed that all independent variables have a positive relationship with the dependent variable. PBC ($r = .509$, $p < .001$) and CR ($r = .489$, $p < .001$) have a positive and significant correlation with ERB. A moderate positive correlation was discovered between ERB and SN ($r = .393$, $p < .001$) and ERI ($r = .368$, $p < .001$). However, AT shows a low correlation ($r = .165$, $p = .011$) with ERB. The results highlight that PBC and CR are the most critical factors in shaping better e-waste recycling behaviour. Previous studies also indicated that enhancing the individual's control over recycling and the accessibility and user-friendly recycling facilities encourage the residents to recycle their e-waste more effectively [33], [57].

Table III Correlation between ERB Dependent Variable and Independent Variables

| | | ERI | AT | SN | PBC | CR |
|---|---|---|---|---|---|---|
| **ERB** | Pearson Correlation | .368** | .165* | .393** | .509** | .489** |
| | Sig. (2-tailed) | <.001 | .011 | <.001 | <.001 | <.001 |
| | N | 237 | 237 | 237 | 237 | 237 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | |

**Multiple Linear Regression**

Multiple linear regression was applied in various research to analyse one dependent variable with various independent variables. Past studies on TPB have employed multiple regression to compare the results more easily [58]–[61]. Reference [62] articulated that parametric tests can be appropriately employed for Likert scale ordinal data if the data are normally distributed. Before conducting multiple regression analysis, multicollinearity among independent variables was identified. Since all the independent variables achieved more than 0.1 tolerance levels and all VIF values were below 10. That indicates that there is no multicollinearity issue in this study.

Multiple regression analysis was implemented to examine the impact of independent variables (AT, SN, PBC and CR) on the dependent variable (ERI) and how ERI affected ERB. Table IV explains that 48.3% of ERI ($R^2$ = .483) is accounted for by the predictors (AT, SN, PBC, CR) while around 50% can be attributed to other factors. Among the independent variables, AT (t=5.178, p=<.001) and PBC (t=4.472, p=<.001) exhibited a significant positive relationship with ERI. Moreover, SN (t = 2.566, p = .011) also has a moderately significant positive relationship with ERI. This finding contrasts with a previous study in Malaysia, which indicated that AT, SN, and PBC had no significant relationship with ERI in the Malaysian context [26]. On the other hand, this outcome is aligned with earlier findings [38], [64].

The result of the CR (t = 0.526, p = 0.600) indicated that it has no significant influence on ERI. This finding agrees with other prior studies that suggest CR may not be a key driver of ERI [65]–[67]. This is likely due to external factors, such as incentives, social pressure, and other motivational elements, that encourage residents' recycling intentions. Further qualitative exploration is necessary to uncover the underlying reasons why convenience did not significantly influence intention in this context.

Table V illustrates the relationship between intention, as the independent variable, and e-waste recycling behaviour, as the dependent variable. Multiple regression analysis revealed a significant positive relationship between ERI and ERB, as indicated by the t-value (t = 6.067, p < .001). Furthermore, approximately 14% of the variation in ERB has been explained by ERI ($R^2$ = .135). This modest $R^2$ value indicates that a gap still exists between ERI and ERB in the Klang Valley area. Factors such as a lack of recycling facilities, awareness of e-waste hazards, practical barriers, and a preference for alternative disposal methods result in a misalignment between intention and actual e-waste recycling behaviour [51]–[67].

Table IV Regression of AT, SN, PBC, CR and ERI

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | 1.252 | .214 | | 5.843 | <.001 | | |
| | AT | .302 | .058 | .289 | 5.178 | <.001 | .717 | 1.394 |
| | SN | .114 | .045 | .171 | 2.566 | .011 | .503 | 1.988 |
| | PBC | .259 | .058 | .344 | 4.472 | <.001 | .377 | 2.655 |
| | CR | .026 | .050 | .040 | .526 | .600 | .388 | 2.578 |
| | R square | .483 | | | | | | |
| Dependent Variable: ERI<br>Predictors: (Constant), A, SN, PBC, CR | | | | | | | | |

Table V Regression of ERI and ERB

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 2 | (Constant) | .408 | .355 | | 1.149 | .252 | | |
| | ERI | .546 | .090 | .368 | 3.067 | <.001 | 1.000 | 1.000 |
| | R square | .135 | | | | | | |
| Dependent Variable: ERB<br>Predictor: (Constant), ERI | | | | | | | | |

Table VI Summary Results of the Hypothesis

| | **Hypothesis** | **Results** |
|---|---|---|
| **H1** | There is a significant relationship between attitude and e-waste recycling intention among the residents in the Klang Valley. | Supported |
| **H2** | There is a significant relationship between subjective norms and e-waste recycling intention among the residents in the Klang Valley. | Supported |
| **H3** | There is a significant relationship between perceived behavioural control and e-waste recycling intention among the residents in the Klang Valley. | Supported |
| **H4** | There is a significant relationship between convenience of recycling and e-waste recycling intention among the residents in the Klang Valley. | Rejected |
| **H5** | There is a significant relationship between e-waste recycling intention and e-waste recycling behaviour among the residents in the Klang Valley. | Supported |
| **H6** | There is a correlation between socio-demographic factors and e-waste recycling behaviour among the residents in the Klang Valley. | Rejected |

## CONCLUSIONS

This research employed the Extended Theory of Planned Behaviour (TPB) to gain insight into the actual e-waste recycling practices in the Klang Valley area by identifying the factors influencing individuals' recycling intentions and behaviour. The findings showed that only gender has a significant relationship with the ERB in the Klang Valley area, while the other sociodemographic factors showed no impact. The result of the Pearson correlation analysis between the independent variables (A, SN, PBC, CR, and ERI) and the dependent variable (ERB) showed that all variables have a positive and significant relationship with one another. Notably, PBC and CR emerged as the strongest relationships with the ERB among the residents in the Klang Valley area. Furthermore, A, SN, and PBC are the strongest predictors of ERI among the residents of Klang Valley, apart from CR. Additionally, ERI is a significant determinant of ERB, despite a gap between ERI and ERB, as indicated by the R-squared value ($R^2 = .135$).

This study contributed to both practical and theoretical implications for different stakeholders, such as academics, the government, and industry players, in implementing an effective e-waste recycling initiative for the Klang Valley area to promote a sustainable community. Based on the findings, government agencies are encouraged to implement targeted policy interventions such as incentive-based recycling schemes, mobile collection services, and community-level awareness campaigns. These initiatives can help translate positive intentions into actual behaviour by addressing convenience-related barriers and enhancing public motivation. Future studies may consider triangulating findings with observational or actual behavioural data to address this limitation. Finally, the study findings could help to understand how the external and internal factors influence the individual e-waste recycling behaviour. Moreover, future studies could benefit from integrating environmental knowledge or awareness as a variable, which may help further explain behavioural gaps and provide a more comprehensive understanding of e-waste recycling behaviour.

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