Analysis of Plastic Waste Management among Rural Residents in Kuala Penyu, Sabah, Malaysia

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ABSTRACT

Plastic pollution has become a serious environmental issue, particularly affecting the ecological integrity of coastal and rural areas in emerging countries. This study explores on rural inhabitants' knowledge, attitudes, and practices (KAP) regarding plastic waste management in Kuala Penyu District, Sabah, Malaysia. As a location with a dispersed population and major eco-tourism assets, such as Pulau Tiga Park, effective waste disposal is critical to local sustainability. Structured surveys were distributed to a random sample of 100 residents as part of a quantitative research design to assess cognitive and behavioural drivers of plastic waste management. Descriptive statistics revealed that participants had a high level of knowledge. A correlation analysis found a significant, positive, and moderate association between knowledge and practice. Furthermore, simple linear regression revealed that knowledge is a strong predictor of behavior, accounting for 33.5% of the variance in waste management practice. In contrast, while attitude was a statistically significant predictor, its predictive power was noticeably lower, accounting for only 11.9% of the variation. The findings imply that in rural Sabah, factual comprehension and awareness are more powerful drivers of behavioural change than evaluative perceptions. To overcome the practice gap, policy interventions should shift away from general knowledge toward practical, infrastructure-based education and the provision of accessible waste management facilities.

Keywords: Plastic waste management, Kuala Penyu, rural sustainability, Knowledge-Attitude-Practice (KAP), Sabah.

INTRODUCTION

Environmental pollution is no longer a dilemma that only affects wealthy countries; it is now a pressing issue in emerging countries. This worldwide transition needs a more in-depth assessment of regional environmental implications, as different regions face unique waste management difficulties. Historically, the primary causes of pollution have been fossil fuel burning and industrial effluents. However, fast economic growth, particularly in manufacturing, has introduced synthetic materials that pose new environmental risks. Plastic pollution is a leading cause of environmental damage. Plastics' adaptability has made them useful in industries ranging from automotive to beverage packaging; yet, this convenience comes at a significant environmental cost. The subsequent accumulation of waste made of plastic these days poses a serious threat to both terrestrial and marine ecosystems, requiring significant academic and policy initiatives.

The global production rate of plastics has increased to almost 400 million metric tons per year, contributing to the continuous plastic pollution problem. The large volume of waste generated has resulted in waste accumulation at multiple ecological levels, harming both urban and isolated coastal areas. Pottinger et al. (2024) found that without immediate governmental intervention, the volume of mismanaged plastic is expected to quadruple to 121 million metric tons by 2050. Furthermore, an estimated 12 billion metric tons of plastic may collect in landfills and natural areas.

In many regions, continue to be poor public participation in plastic recycling. This issue is caused by a variety of circumstances, including a lack of awareness, insufficient infrastructure, and economic hurdles. Many people,

particularly in developing countries, have a limited understanding of plastic waste risks and the benefits of recycling (Kibria et al., 2023). The lack of public knowledge is exacerbated by government policies that are inconsistent and poorly conveyed, failing to properly engage and educate citizens (Chen et al.,2021). Infrastructure limits are a significant barrier. The lack of suitable collection, sorting, and recycling facilities makes successful recycling logistically difficult (Zheng et al., 2023). In low- and middle-income countries, relying on informal recycling systems diminishes institutional control and recycling process quality (Gill et al., 2021).

This paper's main objective is to assess rural communities' knowledge and practices regarding the management of plastic waste. This study systematically evaluated the degree to which members of these communities comprehend and practice plastic waste management strategies.

LITERATURE REVIEW

According to recent data, global plastic production has reached nearly 400 million metric tons per year, reflecting an exponential increase in both waste generation and plastic manufacturing. As only 9% to 15% of the plastic produced worldwide is recycled, the rise in production has significantly outperformed recycling efforts. As a result, an increasing amount of plastic waste continues to pile up in landfills, dumpsites, and natural environments (Eze et al., 2021; Kwon et al., 2024; Singh & Walker, 2024).

The volume of plastic waste is increasing in line with population expansion and increasing individual plastic usage, resulting in the third largest source of waste worldwide. Global municipal solid waste, including plastic and other waste types, increased from 635 million tons in 1965 to approximately 1999 million tons in 2015. By 2050, it is expected to reach nearly 3539 million tons (H. L. Chen et al., 2021). Ocean plastic pollution, greenhouse gas emissions, and wider ecological and human health effects are all further exacerbated by this surge in plastic manufacturing and waste generation. Plastic pollution is a serious worldwide environmental problem, considering almost all of the plastic waste ends up affecting ecosystems due to the comparatively poor recycling rates (Yu et al., 2023). Mismanagement of plastic waste continues as a global issue despite advancements in recycling technologies and legislative actions. According to Pottinger et al. (2024), improper handling of plastic waste is predicted to triple by 2050, worsening climate change and environmental deterioration as a result of rising greenhouse gas emissions from plastic waste and production.

The issue of managing plastic waste requires a priority on personal accountability as a fundamental component. Even though legislative actions are crucial, they cannot provide a complete solution if the law does not sufficiently address the root causes of plastic pollution. Two essential elements that have a reciprocal impact on plastic waste management are knowledge and practical application. In the management of plastic waste, there is a reciprocal interaction between knowledge and actual application. Understanding the environmental risks associated with plastics and the origin of plastic waste is essential for creating and implementing effective remedies in practice. Additionally, waste management practices are influenced by community awareness and knowledge of environmental impacts. Increased participation in waste management practices, especially with regard to plastic packaging waste, is correlated with community knowledge of sustainable development goals (Opusunju et al., 2024). This is an example of how practical measures that promote sustainable plastic waste handling are spread through knowledge.

Understanding the risks associated with plastic waste has a significant impact on the usage, recycling, and handling of plastic materials. Policies and behaviors aimed at reducing plastic use and enhancing recycling practices are influenced by knowledge of the health and adverse effects associated with plastic waste. Effective policy development requires an investigation of community knowledge and behaviors with regard to waste plastic management. The assumption that information may possess a significant effect on behavior is generally supported by research, albeit this link can be complicated and nuanced. Research suggests that increasing knowledge may encourage information reuse, which eventually leads to behavior change, particularly in organizational contexts (Majchrzak et al., 2013). Understanding potential risks raises awareness and spurs initiatives to reduce plastic consumption and improve waste segregation and recycling for end-of-life care (Khan et al., 2019). In Nigeria, a study demonstrated a high level of public awareness regarding plastic pollution, which correlated with a greater understanding of plastic pollution and motivated in environment-related activities

(Ibrahim et al., 2025). It promotes responsible behaviors like proper waste segregation, use of recycling facilities, and involvement in sustainability initiatives. Increased awareness also promotes stakeholder collaboration, which is crucial for enhancing waste management infrastructure and system efficiency (Pambudi et al., 2025; Xevgenos et al., 2015).

METHODOLOGY

Study Area

The Kuala Penyu District is located in the southwest of Sabah. The district, which covers roughly 45,326 hectares, is divided into two main administrative divisions: Kuala Penyu and Menumbok District Offices. It is roughly 120 kilometers from Kota Kinabalu's city center, with journey times ranging from two to three hours by road. As of 2023, the district's population is 24,200 people from several ethnic groups, including Dusun Tatana, Brunei, and Bisaya (Oluk, 2025).

This region has a dispersed settlement structure, with 34 villages in Kuala Penyu and 20 in Menumbok. The majority of these settlements are located near the seashore or in agricultural areas. Agriculture, fishing, and tourism are the key sources of income for the Kuala Penyu District's population. The tourist industry, particularly ecotourism, has a substantial impact on the local economy, attracting both domestic and foreign visitors to sites such as Pulau Tiga Park and beautiful beaches. Menumbok also acts as a significant logistics hub and the primary entry to Labuan Island.

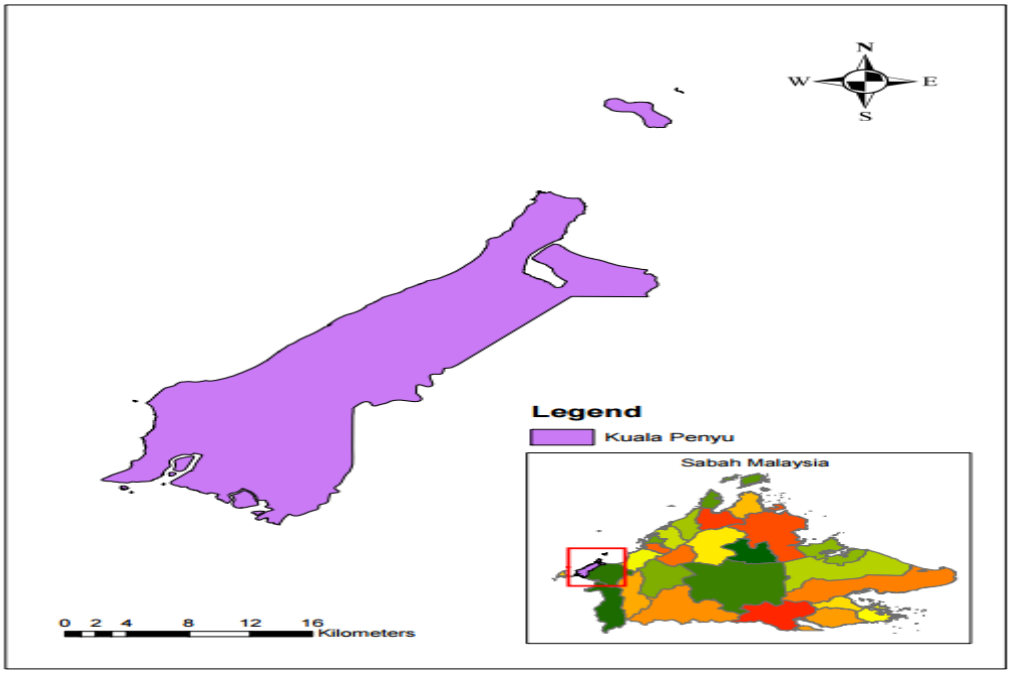

Figure1. Research Area

Waste management is becoming an issue in Kuala Penyu due to low public awareness. On plastic management, the main obstacle to efficient plastic waste management is inadequate infrastructure. Therefore, the Kuala Penyu District Council has enacted bylaws, including the Uniform By-Laws of 2016 (Segregation and Disposal of Organic Waste), to address the issue. In order to guarantee the district's environmental sustainability, these regulations are intended to systematically regulate the separation of organic waste.

Research Design

A thorough understanding of quantitative research techniques is essential for well-informed analysis. This information enables both practitioners and scholars to draw significant conclusions and make important decisions (Lim, 2024). The management of plastic waste in Kuala Penyu was thoroughly examined in this study

utilizing quantitative approaches. Standardized questionnaires that produced quantitative information were utilized to measure the Knowledge, Attitude, and Practice (KAP) components.

Data Collection Methods

Over the course of five days, a diverse sample of Kuala Penyu people participated in this study. Their contributions enhance the study's overall conclusions and offer insightful information. Using a random sampling technique, 100 individuals were chosen from the Kuala Penyu community. According to Hair et al. (2019), simple regression analysis typically requires a minimum sample size of around 50 samples, with approximately 100 samples generally considered adequate for most research situations. In order to ensure representativeness in research and significantly lower the possibility of selection bias, random sampling is fundamental. Every member of the target population has an equal chance of being chosen, which improves the findings' generalizability and fortifies their validity and reliability (Eachus & Peters, 1995). This method was critical for effectively capturing various perspectives on plastic waste management behaviors across diverse demographic groups, including age, gender, education, and income levels, as demonstrated by the respondents' socio-demographic profile. Rahman et al. (2025) added, demonstrated that a sample size of 100 obtained through random sampling is acceptable for preliminary studies examining public knowledge of plastic pollution. The sample size employed in this research is sufficient to support the statistical analysis and provide meaningful insights into plastic waste management practices among rural residents in Kuala Penyu.

The questionnaire used in this study was divided into four sections: Section A addressed the demographic background of the respondents; Section B assessed respondents' knowledge; Section C examined their attitudes; and Section D focused on practices related to plastic waste. Items in Sections B, C, and D utilized a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Data Analysis Methods

Correlation and regression analyses were used to evaluate the relationships between knowledge, attitudes, and actions associated with plastic waste management. This approach seeks to provide a thorough understanding of how these variables interact and influence one another in the context of plastic waste management. Statistical analyses, such as Pearson's and Spearman's correlations and linear regression, were used to assess the relationships and predict effects of the variables.

RESULTS AND DISCUSSION

Reliability Analysis of the Research Instrument

Before the primary data analysis, a reliability test was performed to ensure that the survey scale was internally consistent. Cronbach's alpha coefficients were used to assess reliability in the three major constructs: knowledge, attitude, and practice. As indicated in Table 1, the constructs' reliability coefficients ranged from 0.684 to 0.787. The Knowledge variable had the strongest internal consistency, with a Cronbach's alpha of 0.787 (10 items). The Practice variable likewise has a decent reliability of 0.746 (10 items). Although the attitude variable had a slightly lower coefficient of 0.684 (10 items), it was still within the acceptable range for social science research, showing that the questionnaire is a valid tool for measuring plastic waste management perspectives in Kuala Penyu.

Table 1. Reliability Statistics for KAP Constructs (N=100)

Variable	Number of Items	Cronbach's Alpha	Internal Consistency
Knowledge	10	0.787	Acceptable/Good
Attitude	10	0.684	Acceptable
Practice	10	0.746	Acceptable/Good

Socio-Demographic Profile of Respondents

Table 2 shows the demographic characteristics of the 100 respondents from Kuala Penyu. The survey included a range of backgrounds in terms of gender, age, education, and household income. The sample consisted of 58% female and 42% male responders. In terms of age distribution, most respondents (38%) were between the ages of 19 and 29, followed by those aged 30-39 (17%) and those aged 50 and up (16%). Only 14% of respondents were under 18 years old. The educational backgrounds of the communities differ significantly. The educational backgrounds of the respondents differ significantly. The majority of respondents had finished their secondary school, with 38% possessing an SPM qualification. Notably, 33% of respondents had completed higher education, including Diploma (13%), Bachelor's Degree (19%), and Master's Degree (1%). In terms of economic status, the majority of respondents (35%) reported monthly household incomes ranging from RM 1,001 to RM 2,000. This is followed by respondents earning between RM 500 and RM 1,000 (19%) and RM 2,001 to RM 3,000 (16%). Only 8% of them reported having a household income of RM 5,000 or above.

Table 2: Socio-Demographic Profile (N=100)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	42	42.0
	Female	58	58.0
Age	< 18	14	14.0
	19 – 29	38	38.0
	30–39	17	17.0
	40 – 49	15	15.0
	50 <	16	16.0
Education	No Formal Education	10	10.0
	SPM	38	38.0
	STPM	13	13.0
	Diploma	13	13.0
	Bachelor's Degree	19	19.0
	Master's Degree	1	1.0
	Others	6	6.0
Monthly Income	RM 500 and below	10	10.0
	RM 500 – RM 1,000	19	19.0
	RM 1,001 – RM 2,000	35	35.0
	RM 2,001 – RM 3,000	16	16.0
	RM 3,001 – RM 4,000	10	10.0

	RM 4,001 – RM 5,000	2	2.0
	RM 5,000 and above	8	8.0

Relationship Between Knowledge and Practice

The main objective was to determine the relationship between participants' knowledge scores and self-reported behaviors. Descriptive analysis of continuous variables revealed the mean knowledge score is 4.02 (SD = 0.62) and the mean practice score is 3.75 (SD = 0.63), showing that participants had a high level of proficiency overall (Table 3).

Pearson's Product-Moment Correlation and Spearman's Rank-Order Correlation were used to examine the relationship between respondents' knowledge level and plastic waste management practices in Kuala Penyu. The descriptive data indicate that respondents had a high level of knowledge (M 4.02, SD = 0.62) and a moderate-to-high level of practice (M= 3.75, SD = 0.63). As shown in Table 3, there was a significant, positive, and moderate correlation between knowledge and practice. The Pearson correlation coefficient was $r(98) = .58$, $p < .001$, while Spearman's rho showed a slightly stronger correlation ($r(98) = .59$, $p < .001$). These results indicate that as respondents' knowledge of plastic waste management increases, their practice in plastic waste management also tends to increase. The findings of this study demonstrated a significant positive correlation between knowledge and practices, suggesting that a well-informed population is more likely to engage in favorable behaviors. A correlation coefficient in the range of .58 to .59 indicates that knowledge accounts for a substantial portion of the variance in practice, although it is not the sole determinant.

The result is aligned with other research findings on the role of awareness and education in environmental behavior. Knowledge and understanding of plastic waste often led to more responsible behaviors, such as recycling, reuse, and proper disposal. Education is a significant factor in altering people's knowledge, attitudes, and behavior toward plastic waste management. Studies have highlighted that teaching strategies, such as direct instruction, hands-on activities, and simulation games, can effectively improve knowledge and promote sustainable behaviors related to plastic waste (Chow et al., 2017). These contribute significantly to reducing plastic pollution, mitigating the negative effects on ecosystems, and promoting a circular economy (Debasree Lodh, 2024; Shamsuddoha & Kashem, 2024). However, lack of infrastructure and awareness has been a major barrier to effective plastic waste management, especially in developing countries. This implies that increasing knowledge and awareness can directly address these challenges by encouraging individuals to participate more frequently in sustainable waste management actions and avoiding landfills or open burning (Fayshal, 2024; Kibria et al., 2023).

In summary, an increase in knowledge correlates with higher engagement in sustainable plastic waste management, which is consistent with the literature emphasizing education, awareness, and technological advancements as key drivers for improving overall waste management efficacy (Chow et al., 2017; Debasree Lodh, 2024; Kibria et al., 2023).

Table 3. Correlation Analysis between Knowledge and Practice (N=100)

Descriptive Statistics			
	Mean	Std. Deviation	N
Knowledge	4.0160	.62210	100
Practise	3.7450	.62690	100
Correlations			
		Knowledge	Practise

Knowledge	Pearson Correlation	1	.579**
	Sig. (1-tailed)		.000
	N	100	100
Practise	Pearson Correlation	.579**	1
	Sig. (1-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (1-tailed).

			Knowledge	Practise
Spearman's rho	Knowledge	Correlation Coefficient	1.000	.593**
		Sig. (2-tailed)	.	.000
		N	100	100
	Practice	Correlation Coefficient	.593**	1.000
		Sig. (2-tailed)	.000	.
		N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

The Relationship between Knowledge and Practice

A simple linear regression was conducted to determine whether the respondents' knowledge scores predict their practice (Table 4). The regression model was statistically significant, $F(1, 98) = 49.375$, $p < .001$), indicating that knowledge was a robust predictor of practice. The findings revealed a significant, positive, and moderate correlation between knowledge and plastic waste management practices ($r = .579$, $p < .001$). Furthermore, the regression model indicated that knowledge serves as an important predictor, explaining 33.5% of the variance in the practice score ($R^2 = .335$, $p < .001$). This strong predictive influence suggests that cognitive understanding is the main driver of plastic waste management in Kuala Penyu. Residents with a better understanding of the negative impact of plastics are more likely to adopt sustainable practices, such as recycling and waste reduction. The individual contributions of the predictors are detailed in the coefficients table. Knowledge was a significant positive predictor (beta = .579, $t = 7.027$, $p < .001$). The unstandardized coefficient (B = .583) indicates that for every one-unit increase in knowledge, practice scores are likely to increase by 0.583 units if all other factors remain constant.

The regression analysis provides critical insights into the behavioural dynamics of the respondents. The finding that knowledge significantly predicts practice ($p < .001$) aligns with the theoretical framework that informed awareness is a prerequisite for intentional action. While the relationship is robust, the R value of.335 is particularly notable. This suggests that, while knowledge is a fundamental driver, it accounts for roughly one-third of the variety in practices. This shows that the "Knowledge-Practice" relationship is significant, but not absolute. The remaining 66.5% of variance is most likely attributable to external factors that are not captured by this model.

The unstandardized coefficient (B = .583) suggests a positive effect of the educational initiatives. As every unit of knowledge gained translates to over half a unit of improved practice, interventions focusing on education are

statistically validated as an effective means of behavior change. However, the constant value of 1.403 suggests that even at minimal knowledge levels, there is a baseline level of practice, likely influenced by general social norms or intuition rather than by specialized knowledge. As knowledge is a significant predictor (t = 7.027), continuing to enhance knowledge remains a priority. In order to bridge the remaining practice gap, future programs must extend beyond simply conveying information and explore structural or environmental adjustments. This is because knowledge is unable to fully explain behavior.

Table 4. Relationship between Knowledge and Practice

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.579[a]	.335	.328	.51381
a. Predictors: (Constant), knowledge				

Attitude as a Predictor of Practice

To determine the extent to which psychological factors influence waste management behavior, a simple linear regression was performed with attitude as the independent variable and practice as the dependent variable.

As shown in Table 5, the model summary has an R value of .345 and an R of .119. This suggests that attitude accounts for 11.9% of the variation in plastic waste management practices among respondents in Kuala Penyu. ANOVA results ($F(1, 98) = 13.251$, $p < .001$) show that the regression model is statistically significant and presents a better fit than a model without predictors.

The coefficient analysis found that attitude had a substantial positive influence on practice (beta = .345, t = 3.640, $p < .001$). The unstandardized coefficient (B =.384) indicates that for every one unit rise in positive attitude, management practice should improve by 0.384 units.

Table 5: Linear Regression Analysis for Attitude and Practice (N=100)

Predictor	Unstandardized B	Std. Error	Standardized β	t	Sig. (p)
(Constant)	2.289	0.404		5.661	.000
Attitude	0.384	0.105	0.345	3.640	.000

Note: R = .345; R^2 = .119; Adjusted R^2 = .105. Dependent Variable: Practice.

The regression analysis shows that attitude is a significant predictor of plastic waste management practices in Kuala Penyu ($p < .001$), its predictive power (R^2 = 11.9) is lower than that of knowledge, which explains 33.5% of the variance in the previous model.

The low R2 indicates a "gap" between how citizens perceive plastic waste and how they manage it. This suggests that, even if an individual has a strong pro-environmental attitude, they may fail to execute proper waste disposal due to external constraints. In a rural area such as Kuala Penyu, these limits frequently include a lack of accessible recycling infrastructure and restricted collection services. Knowledge has a higher standardized beta (beta =.579) than Attitude (beta =.345), implying that factual understanding and awareness are more powerful drivers of behavioural change than solely emotive or evaluative attitudes.

Since attitude accounts for only about 12% of behavior, initiatives giving practical knowledge and improving the local infrastructure may be more beneficial. Policymakers should focus on bridging this gap by ensuring that the community's favorable attitudes are backed by the tools and procedures needed to turn those attitudes into consistent practices. Infrastructure restrictions, such as inaccessible recycling facilities, can lead to unsystematic

disposal methods, such as burning, while entrenched beliefs about single-use plastics and a "throwaway culture" impede segregation efforts.

Implications for Local Waste Management

The uniform By-Law of 2016, established by the Kuala Penyu District Council (MDKP), aims to regulate waste segregation and disposal practices within the district. However, the effectiveness of these regulations may be limited by structural barriers and weak enforcement in rural coastal areas. Although residents demonstrate relatively high levels of environmental knowledge and willingness to support sustainable policies, a persistent knowledge and practice gap remains, as awareness does not always translate into action when waste management infrastructure and monitoring systems are insufficient.

The fact that knowledge is a stronger predictor than attitude in this study has significant policy implications for the state. Interventions should move beyond "awareness-raising" posters and focus on practical education and infrastructure development.

Since respondents demonstrated a high level of knowledge, the local government should prioritize providing the necessary tools, such as community recycling bins and more frequent collection routes, to allow residents to act on what they already know. Strengthening the link between attitude and practice requires a multi-pronged approach that combines educational workshops with visible and accessible waste management facilities.

CONCLUSION

This study highlights that while rural residents in Kuala Penyu possess a high level of knowledge, there remains a significant gap in the practical application of sustainable waste management. Statistical analysis confirms that knowledge is a much stronger predictor of behavior. This suggests that caring for the environment is insufficient when faced with rural structural barriers. However, knowledge alone is insufficient for achieving sustainable plastic waste management. Thus, local policy interventions should prioritize the provision of accessible waste management facilities and hands-on, skill-based teaching beyond general awareness initiatives. Bridging the "Attitude-Practice" gap is essential for Sabah's coastal areas to sustain their long-term environmental viability. Future research should involve a larger and more geographically diverse sample to enhance the representativeness of findings across rural communities in Sabah.

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