

## ORIGINAL ARTICLE

# The Role of Knowledge and Attitude on Waste Recycling Practices During the Post-pandemic Covid-19 Period Among Selected Communities in Selangor

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## ABSTRACT

**Introduction:** COVID-19 has led to a significant increase in household waste generation, ranging from 10% to 30% in certain regions. **Objective:** This study aims to investigate the impact of knowledge and attitude on waste recycling practices in selected communities in Selangor during the post-pandemic period. **Methods:** A comprehensive waste analysis was conducted in six residential areas in urban Selangor, sampling waste from 25 households. A survey was administered to 244 respondents who had resided in the study area for at least one year and were familiar with the recycling programs and facilities. Data collection involved door-to-door surveys and online platforms. **Results:** The study revealed a weekly generation of 124.89 kg of solid waste, equivalent to 0.14 kg per person or 0.71 kg per household per day. Of this, 101.45 kg was recycled, resulting in an 81% recycling rate, averaging 0.11 kg per person or 0.58 kg per household per day. Paper accounted for the highest proportion of recycled waste (51%), followed by plastic (19%) and used items such as clothes (19%). Respondents displayed good knowledge (76.6%) and attitude (90.6%), but recycling practices were poor (61.9%). Significant associations were observed between knowledge and gender, attitude and factors such as age, race, monthly household income, and house type, and practice and factors such as residential location, gender, and the number of household members. **Conclusion:** Despite the pandemic, communities exhibited a high recycling rate, reflecting positive knowledge and attitude. However, bridging the knowledge-implementation gap is essential for improving recycling practices.

**Keywords:** Knowledge; Attitude; Practice; Recycling; COVID-19

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## INTRODUCTION

The global solid waste problem is escalating, and municipalities are bearing the brunt of its effects. Municipal solid waste (MSW) generation consistently rises each year as a result of urbanization, industrialization, lifestyle changes, and economic expansion (1). Additionally, the COVID-19 pandemic has altered global waste production patterns, which have increased dramatically due to the lockdown and other community infection prevention measures (2).

COVID-19 has caused unanticipated variations in the amount and type of waste (3). Since the COVID-19 outbreak, plastic garbage has been generated at a pace of 1.6 million tonnes per day. Every day, around 3.4 billion disposable face masks and shields are discarded. Meanwhile, COVID-19's PCR kits generated 15,000 tonnes of plastic garbage, of which 97% was disposed of by waste incineration (4). During the pandemic, unexpectedly high demand for masks, hand sanitizers, gloves, and other vital items has considerably increased the number and volume of single-use plastics (5). In addition, lifestyle changes, notably in the provision of everyday necessities, such as home delivery services, have increased the quantity of paper and plastic packaging waste generated. According to reports, South Koreans' online purchases of food and other necessities increased

by 92.5% and 44.5%, respectively, due to COVID-19 (6).

The introduction of the lockdown policy has halted and restricted the community's recycling efforts. The focus on recycling as a waste management strategy is not exclusive, but it is an integral part of a comprehensive approach that also includes waste reduction and reuse. According to several studies, this has raised significant worries regarding using conventional equipment, such as garbage compactors, for fear of viral transmission through the air (4). For instance, the Oregon Beverage Recycling Cooperative (OBRC) in the United States has received 45% less recycling waste during the pandemic. Even if the redeeming centres were reopened, recycling waste would gradually diminish (5). Nevertheless, despite the COVID-19 pandemic in 2020, Malaysia's recycling rate increased from 30.7% in 2020 to 31% in 2021 (7). Even though the rate surpassed the 30% objective set for 2020, it lags well behind other affluent nations such as Singapore (59%) and Korea (49%) and Taiwan (60%) (8). In accordance with the 12th Malaysia Plan, the Solid Waste Management and Public Cleansing Corporation (SWCorp) has raised the target recycling rate to 40% by 2025. This goal can only be reached if progressive measures are introduced, and individuals commit to recycling efforts (9). However, the COVID-19 outbreak could impede or delay this accomplishment. In addition, the activity and rate of recycling during COVID-19 remained undetermined due to a claimed lack of data.

Recycling is defined as waste collection strategies and actions that allow materials to be reused and secondary raw resources to be recovered, reducing greenhouse gas emissions (10). However, recycling requires considerable effort on the part of the individual because domestic waste must be separated, prepared, and stored (11). Many environmental problems and human health dangers may result from improper solid waste disposal and an increase in solid waste in landfills (12). Virus-contaminated biomedical waste combined with solid waste can pose significant health and safety risks to individuals, particularly sanitation workers (5). Moreover, pollution from the MSW might increase the likelihood of disease transmission, leading to outbreaks of infectious diseases (4). Therefore, proper waste disposal and management are critical components of an effective response. Authorities have proposed that medical, residential, and toxic waste disposal be recognized as an essential and urgent public service to reduce secondary health and environmental repercussions (3).

Few studies have been conducted to evaluate the influence of COVID-19 on recycling efforts,

particularly in developing nations such as Malaysia. Due to unsystematic analysis and ad hoc recordkeeping by local authorities and private organizations, our nation lacks precise and well-established data on solid waste management and recycling. In addition, the community's knowledge, attitude, and practices (KAP) are a prerequisite for implementing comprehensive and participatory solid waste management solutions, such as recycling programmes and legislation (13). A lack of public comprehension and knowledge will result in a dearth of participation and inefficient policies. There needs to be more than just infrastructure as one of the programmes for solid waste management to guarantee the success of recycling. Understanding the public's knowledge, attitude, and behaviour requires additional effort. According to the Theory of Planned Behaviour, the interaction between attitude and subjective norms may affect individuals' recycling practices. Subjective norms are essential for convincing individuals to recycle. Possessing a positive outlook might increase the likelihood of individuals recycling and motivate those who are aware of the advantages of recycling (14).

This study aims to assess the waste generation and knowledge, attitude and practices on recycling activity during the COVID-19 endemic among community in the urban area. The findings of this study provide baseline data on recycling practices during the COVID-19 endemic which address recycling issues such as low public participation and commitment, lack of responsibility in handling solid waste, public perception of solid waste as the responsibility of local municipalities, undermining solid waste management concerns, and ineffective education. In fact, with increased consumption and solid waste output rates, source separation and recycling procedures offer a sensible approach, clear policy and plan solutions (1). As Malaysia tries to portray itself as a developed nation, governments and other important stakeholders have prioritized sustainable waste management. Malaysia still has to catch up in sustainable waste management methods, particularly recycling, despite the government's efforts, such as implementing new rules and pursuing privatization.

Examining the roles and significance of recycling information in influencing people's recycling behaviour through their perceptions, the findings of this study also guide the development of a well-informed communication plan. Additionally, the objective was to contribute to the present understanding of the effects of information on recycling behaviours while making recycling more convenient and accessible to the community.

## MATERIALS AND METHODS

### Study location

The study was conducted in an urban area of Selangor, known as Bandar Baru Bangi (BBB). Selangor is reported to be a state with the highest daily solid waste generation in Peninsular Malaysia (15). Unlike several other states and federal territories in the country, Selangor does not enforce the Solid Waste and Public Cleaning Management Act 2007 (Act 672); hence, it is not mandatory for households to sort their waste at the source. Bandar Baru Bangi (BBB) is known as an industrial area dominated by electrical and electronics industries, manufacturing industries and plastic industries (16). It also known as Knowledge City where various universities are located. It is a township situated in Hulu Langat District, the south-eastern part of Selangor between Kajang and Putrajaya and 25 km away from the capital city of Kuala Lumpur.

### Study design and sampling method

This study utilized a cross-sectional study design approach conducted between September 2022 and January 2023. The selection of residential areas was based on a combination of stratified and purposive sampling methods. Out of the total sixteen residential area locations, six areas (Section 2, Section 3, Section 4, Section 7, Section 8, and Section 9) were chosen using a stratified sampling approach, taking into consideration the presence of diverse recycling facilities such as recycling centers, donation points for clothes and electric appliances, recycling campaigns, and recycling drop-off points (refer to Figure 1). To ensure representation of various dwelling types, including bungalows, terraces, semi-detached houses, condominiums, and apartments, a cluster sampling method was employed.



**Figure 1** : Location of the study area in Bandar Baru Bangi, Selangor.

The selection of respondents in this study employed a convenience sampling method, whereby participants were chosen based on their accessibility and willingness to participate. The study focused on

Malaysians aged 18 to 60 who had been residents of the study area for at least one year, ensuring a degree of familiarity with the recycling programs and facilities available in the research area.

The primary objective of the initial phase in this study was to evaluate the composition of post-pandemic waste within a designated study area through the analysis of waste samples collected from 25 randomly selected residences. This subset of 25 households constituted a portion of the overall survey respondents, resulting in a total of 244 participants. The collection of data on household waste generation aimed to gather valuable information and insights regarding the quantity, composition, and patterns of waste generated by households. These insights played a crucial role in the development of recycling programs, the promotion of waste segregation practices, and the encouragement of sustainable consumption behaviors. In the second phase of the study, a combination of door-to-door surveys and the distribution of questionnaires through online platforms such as WhatsApp, Twitter, Telegram, and Facebook were employed to investigate the knowledge, attitude, and behavior of the community towards recycling.

### Data collection

#### *Waste generation sampling and weighing*

The waste generation sampling and weighing procedure was adopted and adapted from the Guidelines for Solid Waste Management Assessment (Baseline Survey) (17) in order to assess the weekly waste composition and volume generated by the community. In this study, five (5) types of houses were selected (bungalow, terrace, semi-detached, condominium, and apartment). In total, 25 families were participated for waste generation and characterization analysis. The homeowners that were willing to donate their rubbish were given two different coloured plastic bags to segregate the general waste (non-recyclable items) and the recyclable items. The collected wastes were sorted by the researcher and weighed using DICKSON analogue weighing scale 3kg. The weight was recorded every day for seven consecutive days at a designated time to account variance during the week based on UN ESCAP data recording formats.

#### *Questionnaire*

A survey questionnaire was adopted and modified from the Guidelines for Solid Waste Management Assessment (Baseline Survey) (17) and from several previous research on solid waste management and recycling (14, 18-20). The questionnaire was available in Malay and English language and consists two sections. In the first section, respondents were asked to provide socio-demographic characteristics information, including age, gender, race, education

level, housing type, monthly average household income, number of household members and residential location. The second part of the questions consisted of 30 questions involving ten questions in for each knowledge, attitude and practice. The assessment on the KAP as follow:

**Knowledge (K):** There were ten questions in this section. Each knowledge question consisted of two options which were yes, and no. A score of 1 was given for the correct answer, while a 0 score was given for the false answer. Bloom’s cut-off point was adopted and modified for knowledge items with a score of 1 to 10 (21). The knowledge level was classified as good (score 80% and above), moderate (60% to 79%) and poor (less than 60%).

**Attitude (A):** This part consisted of 10 positive attitude statements. The attitude was measured by using a 5-point Likert-type scale. The rating scale of attitude was measured as 5 (strongly agree), 4 (agree), 3 (neutral), 2 (disagree) and 1 (strongly disagree). The mean scale value that classified attitude into three levels was adapted from the KAP study on E-waste disposal among the community in Malaysia (22).

**Practice (P):** 10 positive practice items were designed to be answered using a Likert scale of 5 (daily), 4 (weekly), 3 (monthly), 2 (yearly) and 1 (never). The mean scale value that classified practice into three levels was adapted from the KAP study on E-waste disposal among the community in Malaysia (22).

The content of the questionnaire was validated and revised by an expert in waste management, a professor from the Faculty of Forestry and Environment at Universiti Putra Malaysia. The pre-test was conducted by selecting 30 participants from the study area. The reliability of the pre-test questionnaire was analyzed using Cronbach’s alpha in IBM SPSS Statistics Version 28.0. Cronbach’s alpha values were between 0.796 and 0.801, indicating satisfactory and good internal consistency. Meanwhile, a zero-point calibration was performed on the analogue scale used for waste generation sampling and weighing.

**Statistical analysis**

The data obtained were analyzed using SPSS software (IBM Statistical Package for Social Sciences statistics, version 28.0 and Microsoft Excel 365. Descriptive analysis, Chi-square test and Spearman correlation were applied to analyze the data at a significance level of  $p < 0.05$ .

**Ethics statement**

The ethical approval was obtained from the Ethics Committee for Research Involving Human Subjects of University Putra Malaysia (JKEUPM) with the reference number JKEUPM-2022-397. A written informed consents were sought from respondents before they participated in the study. Participation in this study was voluntary.

**RESULTS**

**The sociodemographic characteristics of the respondents**

In total, 244 respondents were involved in this study. The majority of respondents are from Section 3 (n = 50, 20.5%), followed by Section 4 (n = 47, 19.3%) and Section 7 (n = 44, 18.0%). The majority of respondents are female (n = 129, 52.9%), aged between 18 to 24 (n = 55, 22.5%), with the education level of Diploma and Degree (n = 168, 68.9%). Respondents in this study consist of 54.5% Malay (n = 133), 25.4% Chinese (n = 62) and 20.1% Indian (n = 49). The average monthly household income of the majority community is between MYR 2001–MYR 3999 (n = 59, 24.2%). Most respondents live in terrace houses (n = 77, 31.6%) with 4 to 6 household members (n = 148, 60.7%) (Table II).

**Solid waste generation estimation and characterization during COVID-19**

Table III displays the community’s estimation of their solid waste generation. Most respondents (n = 114, 46.7%) generated between 0.5 kg to 1 kg/day of food leftovers. Garden waste generation is mostly less than 1 kg/week (n = 171, 70.1%). They used less than or equal to five pieces of plastic bag/week (49.4%) and bought plastic bottles less than or equal to five bottles/week (75.4%). On the other hand, most

**Table I : Cut-off point for KAP score**

Knowledge		Attitude		Practice	
Score	Level	Mean scale	Level	Mean scale	Level
8–10	Good	3.67–5.00	Good	3.67–5.00	Good
6–7	Moderate	2.34–3.66	Moderate	2.34–3.66	Moderate
0–5	Poor	1.00–2.33	Poor	1.00–2.33	Poor

**Table II : Sociodemographic characteristics of the respondents (n = 244)**

Variable	Description	Frequency (n)	Percentage (%)
Residential location	Section 2	35	14.3
	Section 3	50	20.5
	Section 4	47	19.3
	Section 7	44	18.0
	Section 8	37	15.2
	Section 9	31	12.7
Gender	Male	115	47.1
	Female	129	52.9
Age	18-24	55	22.5
	25-29	46	18.9
	30-34	37	15.2
	35-49	43	17.6
	50-65	39	16.0
	>65	24	9.8
Education level	No formal education	2	0.8
	Primary	2	0.8
	Secondary	38	15.6
	Diploma/Degree	168	68.9
	Master/PhD	34	13.9
Race	Malay	133	54.5
	Chinese	62	25.4
	Indian	49	20.1
Monthly household income	<RM 1000	5	2.0
	RM 1000-RM 2000	23	9.4
	RM 2001-RM 3999	59	24.2
	RM 4000-RM 5000	51	20.9
	RM 5001-RM 10000	56	23.0
	>RM 10000	50	20.5
House type	Bungalow	41	16.8
	Semi detached	47	19.3
	Terrace	77	31.6
	Condominiu	34	13.9
	Apartment	45	18.4
Number of household members	1 to 3	63	25.8
	4 to 6	148	60.7
	> 6	33	13.5

respondents estimated that they used less than one ream of paper waste per week, less than or equal to five glass bottles per week and less than 0.5 kg of metal or tin per week. In terms of waste related to COVID-19, most respondents generated less than or equal to five pieces of gloves (n = 231, 94.7%) and face masks (n = 106, 43.4%) during the endemic period. Most respondents (n = 207, 84.8%) disposed of less than or equal to two bottles of sanitizer per week.

Table IV presents the results of the total solid waste (recyclable and non-recyclable) generated from 25 selected houses for seven consecutive days with 129 household numbers. A total of 251.44 kg of solid waste was generated over seven days, with an average of 17.84 kg per day. The waste generation rate was 0.14 kg/person/day or 0.71 kg/house/day. The highest generation of solid waste was towards the end of the week, which is Saturday (28.35 kg),

**Table III : Solid waste generation estimation during COVID-19 (n = 244)**

Type of waste	Description	Frequency (n)	Percentage (%)
Food leftovers	Less than 0.5 kg/day	83	34.0
	Between 0.5 kg to 1 kg/day	114	46.7
	More than 1 kg/day	47	19.3
Garden waste	Less than 1 kg/week	171	70.1
	Between 1 kg to 2 kg/week	56	23.0
	More than 2 kg/week	17	7.0
Plastic bag	Less than or equal to 5 pieces/week	120	49.2
	Between 6 to 10 pieces/week	104	42.6
	More than 10 pieces/week	20	8.2
Plastic bottle	Less than or equal to 5 bottles/week	184	75.4
	Between 6 to 10 bottles/week	50	20.5
	More than 10 bottles/week	10	4.1
Paper	Less than 1 ream/week	221	90.6
	Around 1 ream/week	20	8.2
	2 ream or above/week	3	1.2
Glass	Less than or equal to 5 bottles/week	230	94.3
	Between 6 to 10 bottles/week	12	4.9
	More than 10 bottles/week	2	0.8
Metal or tin	Less than 0.5 kg/week	207	84.8
	Between 0.5 kg to 1 kg/week	30	12.3
	More than 1 kg/week	7	2.9
Glove	Less than or equal to 5 pieces/week	231	94.7
	Between 6 to 10 pieces/week	10	4.1
	More than 10 pieces/week	3	1.2
Face mask	Less than or equal to 5 pieces/week	106	43.4
	Between 6 to 10 pieces/week	87	35.7
	More than 10 pieces/week	51	20.9
Sanitizer bottle	Less than or equal to 2 bottles/week	227	93.0
	Between 3 to 4 bottles/week	15	6.1
	5 bottles or above/week	2	0.8

Friday (21.57 kg) and Sunday (20.64 kg). Less waste was generated in the middle of the week, on Wednesday (11.86 kg).

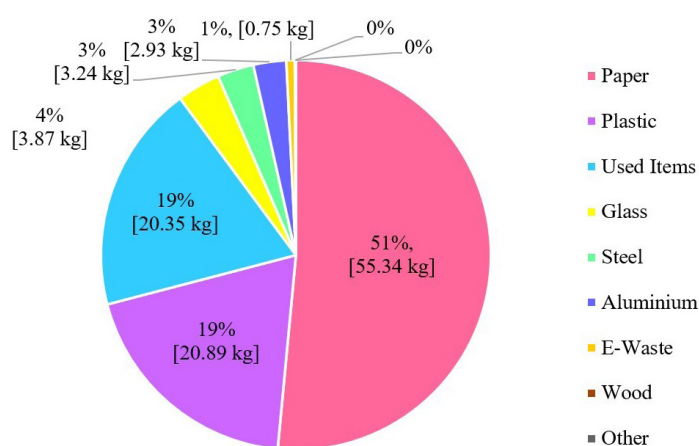
From the total solid waste generated a week (124.89 kg), 81% of the waste (101.45 kg) was recycled. The average waste being recycled was 14.49 kg per day. The recycled waste generation rate was 0.11 kg/person/day or 0.58 kg/house/day. The notable amounts of recycled waste disposed of within this area encompassed paper (55.34 kg), plastic (20.89 kg), and used items (20.35 kg). Furthermore, other recyclable waste materials accounted for glass (3.87 kg), steel (3.24 kg), aluminum (2.93 kg), e-waste (0.75 kg), wood (0.07 kg), and miscellaneous waste (0.03 kg) (Figure 2).

The majority of respondents (44%) indicate they dispose of the recycled waste in a recycling drop-off point in their residential area, followed by recycling bins (41%) and recycling centre (8%). Few respondents have their own recycle bin (1%), and 6% do not know the availability of a recycling facility in their residential location.

The recycling facilities are less than 500 m from their residential area for most respondents (n = 94). Some (n = 63) have recycling facilities between 600 metres to 1 kilometre away, and 41 respondents have recycling facilities between 2 to 7 kilometres. Only two respondents have recycling facilities more than 8 kilometres from their housing area. Most respondents (78%) indicated no recycling program

**Table IV : Total solid waste generation (recyclable and non-recyclable items) and recycle waste (kg) per day (n = 129)**

Houses type	Family size	Day 1 (Sun)	Day 2 (Mon)	Day 3 (Tue)	Day 4 (Wed)	Day 5 (Thu)	Day 6 (Fri)	Day 7 (Sat)	Total weight, kg
<b>Total solid waste generation (recyclable and non-recyclable items) (kg/day)</b>									
Bungalow (n = 6)	31	6.01	2.32	2.72	2.56	3.82	6.14	11.04	34.55
Terrace (n = 7)	40	3.53	3.65	3.70	2.66	3.06	4.34	7.31	28.14
Semi-detached (n = 6)	29	6.08	3.07	2.93	1.79	5.41	4.27	4.44	27.91
Apartment (n = 6)	29	5.08	4.33	5.39	4.90	2.26	6.88	5.6	34.36
Total household number/total weight/day (kg)	129	20.64	13.32	14.67	11.87	14.48	21.57	28.35	124.96
Waste generation rate	0.14 kg/person/day or 0.71 kg/house/day								
Houses type	Family size	Day 1 (Sun)	Day 2 (Mon)	Day 3 (Tue)	Day 4 (Wed)	Day 5 (Thu)	Day 6 (Fri)	Day 7 (Sat)	Total weight, kg
<b>Total recycle waste (kg/day)</b>									
Bungalow (n = 6)	31	4.33	1.43	1.56	1.87	2.85	5.33	10.25	27.53
Terrace (n = 7)	40	2.606	2.43	2.56	1.66	1.89	3.52	5.59	20.18
Semi-detached (n = 6)	29	5.08	2.22	2.16	1.42	5.05	3.71	4.03	23.60
Apartment (n = 6)	29	4.4	3.4	5.04	4.39	1.73	6.22	5.09	30.18
Total household number/total weight/day (kg)	129	16.35	9.43	11.28	9.30	11.46	18.73	24.91	101.45
Waste generation rate	0.11 kg/person/day or 0.58 kg/house/day								



**Figure 2 :** Recyclable waste generation in the community (n=129).

in their residential area, while 22% stated otherwise. Some of the programs mentioned by the community were recycling used cooking oil, furniture, used clothes, and general appliances, and green buying. These programmes were primarily conducted at the mosque or masjid, a place for Muslim prayer or at

the recycling centre. The green club also conducts programmes in the residential area. The respondents also indicated that no recyclable items collection in the residential area (64%), while 36% of respondents stated the opposite. The frequency of recyclable item collection indicated by the respondents varies between once every week (n = 19) to thrice every week (n = 10).

**Level of knowledge, attitude and practice on recycling among community during COVID-19**

The majority of respondents have good knowledge of recycling during COVID-19 (n = 187, 76.6%), with a mean score (SD) of 8.40 (1.25). As for the attitude, the majority of the respondents (n = 221, 90.6%) have a good attitude, with a mean score (SD) of 4.32 (0.91). Nevertheless, the community's practice of recycling during the COVID-19 endemic was low (n = 151, 61.9%) with a mean (SD) score of 2.23 (0.87).

Table V displays the mean scores for each knowledge, attitude, and practice question. Regarding knowledge, all responders are aware that incorrect COVID-19

waste disposal will spread the disease. Respondents also stated that recycling helps conserve the environment by lowering landfill waste and pollution ( $0.96 \pm 0.19$  and  $0.94 \pm 0.23$ , respectively). Moreover, respondents are aware of local recycling centers ( $0.93 \pm 0.26$ ). Regarding attitude, most respondents concur that recycling should be an integral part of their lives ( $4.45 \pm 0.97$ ). Additionally, they concur that recycling is everyone's responsibility and saves the environment ( $4.42 \pm 0.99$ ). However, most respondents answered that they would not participate in recycling if recyclables were not collected ( $3.95 \pm 1.10$ ). Separating food waste from general waste ( $2.88 \pm 1.60$ ) and disposing of rubbish according to the category of recycle bins ( $2.75 \pm 1.40$ ) were among the most prevalent among respondents. The majority of respondents had multiple recycling

bins ( $2.41 \pm 1.56$ ). However, most respondents ( $n = 125, 51.23\%$ ) never engage in the local recycling programme or campaign and never compost their food or garden waste (127 out of 244 respondents, 52.05%). During the COVID-19 epidemic, the community never recycles ( $n = 108, 44.26\%$ ).

**Association between sociodemographic characteristics, level of knowledge, attitude and practice on recycling during COVID-19**

Table VI shows the association between the level of knowledge, attitude and practice by the sociodemographic characteristics. The knowledge scores were higher among residents in Section 8 compared to another residential areas in this study. Females aged 18 to 24 years old and respondents with no formal education were among the

**Table V : The mean scores for knowledge, attitude and practice questions**

Knowledge	Mean ± SD	Attitude	Mean ± SD	Practice	Mean ± SD
1. Is there any recycling facility around your housing area?	$0.93 \pm 0.26$	1. Labelling and color-coding of waste containers are important.	$4.41 \pm 1.02$	1. I recycle during COVID-19.	$2.08 \pm 1.23$
2. Are used disposable masks and gloves recyclable?	$0.75 \pm 0.43$	2. It is essential to use color-coding to separate COVID-19 waste from recyclable waste.	$4.35 \pm 1.03$	2. I isolate food waste from recyclable waste.	$2.88 \pm 1.60$
3. Are there generally three types of recyclable bins and an organic waste bin in Malaysia?	$0.80 \pm 0.40$	3. Separating wastes (hazardous wastes from non-hazardous wastes) facilitates safe recycling practice.	$4.39 \pm 1.02$	3. I dispose garbage according to the category of recycle bins.	$2.75 \pm 1.44$
4. Is the segregation of COVID-19 waste from recyclable household waste is effective safe recycling practice?	$0.57 \pm 0.50$	4. Special containers need to be placed in the community solely for the storage and collection of COVID-19 waste.	$4.23 \pm 1.08$	4. I compost food waste or garden waste.	$2.08 \pm 1.36$
5. Is the colour coding of containers not important in a safe waste control?	$0.82 \pm 0.40$	5. It is important to increase knowledge on recycling since the household waste mixed with COVID-19 waste.	$4.35 \pm 1.01$	5. I isolate the used mask from the recyclable waste.	$2.23 \pm 1.56$
6. Is the recycling of waste produced by COVID-19 patients allowed?	$0.84 \pm 0.40$	6. I would like to recycle my parcel packaging.	$4.19 \pm 0.98$	6. I have more than one bin to segregate waste for recycling in my house.	$2.41 \pm 1.56$
7. Does improper disposal of COVID-19 waste contribute to the spread of the epidemic?	$1.00 \pm 0.00$	7. I would recycle even if the pick-up services for recyclables were not available.	$3.95 \pm 1.11$	7. I participate in the recycling program or campaign.	$1.77 \pm 1.00$



8. Does food scraps produce bad or- ganic fertilizer for plants and soil?	0.78 ± 0.42	8. I believe recycling helps protect the en- vironment from being polluted.	4.42 ± 0.99	8. I send the used clothes to recy- cling facilities.	2.14 ± 0.92
9. Does good re- cycling practice helps reduce pol- lution?	0.94 ± 0.23	9. Recycling is the respon- sibility of every indi- vidual.	4.43 ± 1.02	9. I send the re- cyclable items to the recycling centre.	2.01 ± 0.95
10. Can recycling re- duces the amount of waste in land- fills?	0.96 ± 0.19	10. Recycling should be an essential part of our way of life.	4.45 ± 0.97	10. I buy recycled products.	1.94 ± 1.03

Note: The mean scores indicate; (a) Knowledge: 1 = Correct answer, 0 = wrong answer;

(b) Attitude and practice; Good (3.67 to 5.00), moderate (2.34 to 3.66) and poor (1.00 to 2.33)

respondents with high knowledge scores. Chinese (8.47 ± 1.21) were among those with higher knowledge scores compared to Malay and Indians. High knowledge scores also were recorded among respondents with an income of <MYR 1000 (8.80 ± 0.84) and living in a condominium (8.56 ± 1.16). The knowledge score was not different by the number of a household, where the score for small household members (1 to 3 people) was 8.40 ± 1.23 and for big household members (4 to 6 people) was 8.45 ± 1.22. A significant association between knowledge and gender was observed ( $p < 0.005$ ).

As for attitude, residents in Section 7 (4.52 ± 0.39) have higher attitude scores than those in other areas. Males have better mean attitude scores (4.35 ± 0.82) than women (4.29 ± 0.98). Respondents aged 30 to 34 have a better attitude score (4.61 ± 0.40) than the rest of the group. Similar to knowledge, respondents with no formal education are among those with high attitude scores (4.65 ± 0.07). As for race, Indians were recorded with the highest attitude scores (4.63 ± 0.36). Respondents with a household income of MYR 4000 to MYR 5000 (4.48 ± 0.58) and living in an apartment (4.63 ± 0.39) have higher attitude scores than the rest of the group. Similar to knowledge, there is no difference in the attitude score by the number of households. A significant association was observed between attitude, age, race, monthly household income, and housing type.

The overall practice scores among respondents in this study were low. Residences in Section 4 have a better practice score (2.53 ± 0.95) than the rest of the group. Females recycle more (2.39 ± 0.93) than males (2.05 ± 0.75). A slightly different trend from attitude and knowledge, the practice among respondents aged 50 to 65 (2.40 ± 0.97) and those with an educational background of Master / Ph.D. (2.50 ± 0.88) were better compared to the rest of the group. Malays (2.31 ± 0.93) and household income of >MYR 10,000 (2.52 ± 1.03) shows a better practice score. Those residents at the terrace house (2.51 ± 1.01) and house members of

4 to 6 (2.33 ± 0.84) are likely to engage in recycling practice more than the rest of the group. Only residential location, gender, and household members were associated with the practice.

Our results show no significant association between knowledge with attitude ( $r^2 = 0.123$ ,  $p = 0.056$ ) and practice ( $r^2 = 0.107$ ,  $p = 0.094$ ). There is also no significant relationship between attitude and practice ( $r^2 = -0.063$ ,  $p = 0.330$ ).

## DISCUSSION

### Solid waste generation estimation and characterization during COVID-19

This study aimed to measure the waste recycling practice during COVID-19 endemic and the level of knowledge, attitude and practices (KAP) among the community in the urban area of Selangor, Bandar Baru Bangi. In this study, for solid waste generation, food waste is the highest waste produced in BBB, followed by face mask. The result of this study is in line with Zand et al. (23) which found residents of Tehran have generated more food waste since the prevalence of Coronavirus. This is due to the people tend to spend more time in their homes during the COVID-19, resulting in increased waste production (23). Moreover, food delivery and online shopping have expanded in Tehran City. There has been an increase in packaging wastes, including HDPE and PET, in Tehran City's waste stream during the COVID-19 outbreak. For face mask, as everyone is concern of health and hygiene during the COVID-19, resulting in increased in face mask wastes were reported. According to Khoo et al (2021), approximately 129 billion face masks and 65 billion gloves disposed was estimated within a month globally. However, improper management of used of face masks during the COVID-19 pandemic resulting in widespread of environmental pollution.

The total waste generated in the study area was 0.14 kg/person/day or 0.71 kg/house/day. According to Lagerkvist and Dahlen (24), the composition and

**Table VI : The association between level of knowledge, attitude and practice by the sociodemographic characteristics**

Sociodemographic characteristics	Knowledge Mean ± SD	x <sup>2</sup> (p value)	Attitude Mean ± SD	x <sup>2</sup> (p value)	Practice Mean ± SD	x <sup>2</sup> (p value)
<b>Residential location</b>						
Section 2	8.09 ± 1.52	15.035 (0.131)	4.35 ± 0.72	16.548 (0.085)	1.93 ± 0.65	19.535 (0.034*)
Section 3	8.12 ± 1.34		4.04 ± 1.16		2.23 ± 0.82	
Section 4	8.51 ± 1.20		4.42 ± 0.80		2.53 ± 0.95	
Section 7	8.66 ± 0.91		4.52 ± 0.39		2.14 ± 0.92	
Section 8	8.92 ± 1.01		4.19 ± 1.11		2.30 ± 0.85	
Section 9	8.03 ± 1.30		4.43 ± 0.98		2.15 ± 0.87	
<b>Gender</b>						
Male	8.12 ± 1.29	6.330 (0.042*)	4.35 ± 0.82	1.262 (0.532)	2.05 ± 0.75	14.515 (<0.001*)
Female	8.64 ± 1.17		4.29 ± 0.98		2.39 ± 0.93	
<b>Age</b>						
18-24	8.64 ± 1.18	8.561 (0.574)	4.06 ± 1.20	24.070 (0.007*)	2.28 ± 0.87	17.985 (0.055)
25-29	8.37 ± 1.34		4.36 ± 0.82		2.28 ± 0.87	
30-34	8.35 ± 1.09		4.61 ± 0.40		1.90 ± 0.77	
35-49	8.49 ± 1.20		4.15 ± 1.21		2.26 ± 0.86	
50-65	8.26 ± 1.31		4.53 ± 0.50		2.40 ± 0.97	
>65	8.04 ± 1.46		4.31 ± 0.45		2.19 ± 0.78	
<b>Education level</b>						
No formal education	8.50 ± 0.71	4390 (0.820)	4.65 ± 0.07	8.360 (0.399)	1.95 ± 0.07	13.434 (0.098)
Primary	7.00 ± 1.41		4.55 ± 0.64		2.25 ± 0.07	
Secondary	8.39 ± 1.22		4.33 ± 0.54		2.07 ± 0.83	
Diploma/ Degree	8.43 ± 1.25		4.31 ± 0.98		2.21 ± 0.87	
Master/Phd	8.29 ± 1.34		4.29 ± 0.92		2.50 ± 0.88	
<b>Race</b>						
Malay	8.38 ± 1.31	3.832 (0.429)	4.14 ± 1.13	17.226 (0.002*)	2.31 ± 0.93	5.275 (0.260)
Chinese	8.47 ± 1.21		4.44 ± 0.51		2.19 ± 0.77	
Indian	8.37 ± 1.15		4.63 ± 0.36		2.07 ± 0.80	
<b>Monthly household income</b>						
<RM 1000	8.80 ± 0.84	5.510 (0.855)	3.80 ± 1.63	22.144 (0.014*)	2.24 ± 0.95	8.370 (0.593)
RM 1000-RM 2000	8.61 ± 0.99		4.38 ± 0.63		2.10 ± 0.67	
RM 2001-RM 3999	8.31 ± 1.34		4.46 ± 0.53		2.09 ± 0.82	
RM 4000-RM 5000	8.45 ± 1.19		4.48 ± 0.58		2.32 ± 0.87	
RM5001-RM 10000	8.27 ± 1.31		4.22 ± 1.09		2.10 ± 0.77	
>RM 10000	8.46 ± 1.30		4.12 ± 1.24		2.52 ± 1.03	
<b>Housing type</b>						
Bungalow	8.10 ± 1.38	9.032 (0.340)	4.25 ± 0.80	20.070 (0.010*)	2.00 ± 0.74	15.405 (0.052)
Semi detached	8.34 ± 1.27		4.49 ± 0.68		2.13 ± 0.83	
Terrace	8.47 ± 1.29		4.03 ± 1.25		2.51 ± 1.01	
Condominium	8.56 ± 1.16		4.38 ± 0.66		2.22 ± 0.68	
Apartment	8.49 ± 1.10		4.63 ± 0.39		2.06 ± 0.77	
<b>Household members</b>						
1-3	8.40 ± 1.23	4.573 (0.334)	4.38 ± 0.80	7.900 (0.095)	2.06 ± 0.89	11.036 (0.026*)
4-6	8.45 ± 1.22		4.37 ± 0.82		2.33 ± 0.84	
>6	8.15 ± 1.44		3.96 ± 1.32		2.10 ± 0.88	

\*Significance level p < 0.05

household waste generation rate were influenced by lifestyle and behavioural factors. Waste generation was influenced by economic development such as goods' production and consumption. On the other hand, waste composition was determined by consumer product selection and packaging design. Solid waste was mostly generated on Friday and during the weekends. On these three days, people usually go out after a busy weekdays schedule. People spend time with their friends. Family also tends to do grocery shopping and spend time together as weekend is regard as family time. On the contrary, respondents produced least waste on Wednesday as it is the middle day of the week where people prefer to stay home and do not spend much.

The generation rate of recyclable waste by the community in this study was 0.11 kg/person/day or 0.58 kg/house/day. Despite of the limitation due to the pandemic, the recycling rate for the community in this study was high (81%). This possibly shows that respondents in this study generate more recyclable waste than non-recyclable waste during the pandemic. The majority of them also were aware of the existing recycling facilities in their residential area and most of the facilities are located near to their house. However, there are lack of recycling programs conducted in the community. This probably the most significant barrier to increase the recycling rate. As according to Wood (25), 42% of respondents globally mentioned lack of programs or services prevent them from recycling. Moreover, there is no designated recyclable items collection in the study area instead of personal recyclable waste lorry collector. The frequency of collection also varies depends on the waste collector. To date, there is no systematic recyclable waste collection system, no waste separation and recycling program such as kerbside recycling collection initiated.

The major recyclable waste generates by the community in this study was paper disposed from cardboard, paperboard, paper packaging and newspaper. The second highest recyclable waste was plastic from the plastic packaging, plastic bottle and plastic container. This is consistent with most of the previous studies which has reported that paper and plastic as the major recycable waste.

#### **Knowledge, attitude and practice (KAP) on recycling**

The research has revealed that the community of Bandar Baru Bangi, Selangor, is well aware of the recycling. The community revealed that they had good knowledge and attitude, but poor practices on recycling. A study by Noor (26) which conducted in Johor Bahru also showed majority of respondents had a basic understanding on recycling's main objective.

Ly (27) explained that people with idealistic attitude on waste segregation and recycling are more inclined to act in the future.

The role of intrinsic and extrinsic motivations in shaping individuals' engagement in recycling programs is a crucial aspect to consider. While intrinsic motivation tends to be less prominent among individuals in developing nations like Malaysia compared to developed countries, the influence of extrinsic motivation, particularly in terms of economic incentives, on recycling practices is worth investigating further. Additional research is warranted to explore the impact of extrinsic motivation on promoting recycling in Malaysia. Furthermore, in the context of the COVID-19 pandemic, leveraging social media platforms extensively to educate the public about recycling becomes imperative in order to enhance awareness levels.

In addition, most of the respondents did not separate household medical waste from general waste due to the lack of appropriate guidelines regarding the separation and collection of household medical wastes during the COVID-19 pandemic. Furthermore, the domestic hazardous waste remains an issue as face masks are frequently dumped together with recyclables and non-recyclables items which portrays that the community has little regard for the environment. Besides, the health concern of commingled COVID-19 waste with other household recyclable waste is also practically low as community neglect to segregate recyclable waste from COVID-19 waste where it can cause secondary transmission to humans especially to the recyclable waste collector. Unfortunately, due to lack practice on waste segregation and recycling during COVID-19, the recyclables waste was also treated as non-recyclable waste to avoid potential infection from waste (28).

#### **Association between sociodemographic characteristics, level of knowledge, attitude and practice on recycling during COVID-19**

A significant association was found between knowledge on recycling with gender. This conforms with the study conducted by Zand et al. (23), who reported that gender play a significant role in community's recycling knowledge. According to the findings of Zand et al. (23), 67.4% of women demonstrated awareness regarding the significance of safely disposing of PPEs and the appropriate disposal methods. In contrast, only 34.2% of male respondents exhibited satisfactory knowledge in this area. Previous investigations have indicated that women usually have better environmental knowledge than men. However, Almasi et al. (29) found that lack of

women's participation in the separation and recycling plan due to lack of an organized and cooperative plan on the part of municipalities, unsuitable scheduling of the plan, very little financial gain, the government not paying attention to recycling and educating citizens, lack of easy access to municipal solid waste trucks of the recycling organization, etc. Specifically, 53.99% of the women delivered the separated waste to incinerants and 39.03% delivered it to municipality recycling organization.

For attitude, there were significant associations towards age, race, monthly household income and housing type. This evidence is supported by Ugulu (30), who mentioned that younger people display a more favourable attitude toward recycling than older people. In terms of race, a study by Mutang and Haron (31) found out that Malays tend to have good recycling practice than other races. Different ethnic groups have different barriers or reasons for recycling attitude and have different lifestyle (32, 33). Khalil et al. (34) explained that the moderating result of the causal relationship between attitude and intention tends to weaken as a household's income level rises. Similar to this, the moderating result demonstrates significant and positive causal link between attitude to recycling and perceived lack of facilitating conditions in low income households; whereas the relationship is significant and negative in high income residents. Akil et al. (35) reported that majority of low income group recycle regularly compared to only 25% of high income group who recycle regularly. This is similar to Banga (36) who found that respondents with high income were less likely to recycle. Toit and Wagner (37) found out that housing type is the second strongest factor on recycling where people living in houses have more positive attitude in contrast to people living in townhouse or apartments as they felt less able to recycle due to small space and lack of assistance from managing agencies. People who live in bungalow and semi-detached have better waste segregation attitude than individuals living in other type of houses (37).

In terms of practice, significant associations were found with residential location, gender and number of household members. Respondents who live in close proximity to the recycling drops-off points has a good recycling practice. In addition, good recycling practice was observed when there are recycling community program in the residential areas such as used cooking oil collection and used cloth collection. This is consistent with a study by Akil et al., (35) that reported situational location barrier or service prevent the community from participation in recycling. Majority of research indicated that female is more likely to engage in eco-friendly behaviour particularly when it comes to personal and domestic activities such as recycling (38). Brough (39)

expressed that both women and men perceive eco-friendly behaviour as being more feminine. As a result, males unintentionally decided to engage in fewer green actions to maintain their masculinity. Singhirunnusorn (40) reported an association of family size with the recycling practice. Less number of households were the reason not to engage in recycling. Wang et al. (41) has reported that family size had significantly positive influence on waste separation practice. Chukwuone et al. (42) also mentioned that the involvement in waste separation practice depends on household size as more household duties can be assigned with larger household members.

There was no significant relationship between knowledge and attitude in this study. This result is consistent with Laor et al. (43) but inconsistent with Gusti (44) who indicate that knowledge and attitude on sustainable waste management was positively correlated. Ramayah et al. (45) study through the use of Theory of Planned Behaviour to investigate the behaviour of recycled environmental conscious individuals also proof that result is consistent with the theoretical assumptions. Our findings also indicated no significant relationship between knowledge and practice. This highlights that recycling practice does not depend on the people knowledge about recycling but rather depends on their willingness to recycle. This is supported by Azmin et al. (46) who indicate that by only having good knowledge and attitude does not result in good practice. However, Sobri and Rahman (47) reported the opposite where significant association was observed between the knowledge and practice. Attitude and practice of respondents in this study also were not associated. This is similar with Azmin et al. (46) that stated respondents had weak recycling practice despite having high knowledge and attitude. However, this is in contrasts with Wright (48) who indicate that people with a positive attitude and knowledge were more likely to recycle. Furthermore, a moderate association was found between attitude and practice due to individuals unreadiness to engage in environmental practice (49).

## CONCLUSION

As a conclusion, the recycling rate among the community was high (81%) despite of the limitation due to the COVID-19 endemic with the major recyclable items was paper and plastic. This possibly shows that people generate more recyclable waste than non-recyclable waste during the endemic. In addition, the availability of the recycling facilities near to their surroundings with the influenced of good level of knowledge and attitude of the community contribute to high recycling rate. However, this was not reflected by the practice score where majority of the respondents have low scores. Majority of the respondents never participate in the recycling program or campaign in their residential area and

never compost their food waste or garden waste, The community also never recycle during COVID-19 endemic. This study found that a significant association of between knowledge, attitude and practice with the sociodemographic characteristics of the respondents. Knowledge was significantly associated with gender. Attitude was associated with age, race, monthly household income and housing type while practice was associated with the residential location, gender and number of household members. However, there was no significant relationship between knowledge, attitude, and practice.

It is suggested that for future surveys to apply another study model to improve the quality of this study such as Theory of Planned Behaviour to have better understanding on community knowledge, attitude and practice on recycling. Theory of Planned Behaviour allows researcher to learn how people behave in various settings, situations and scenarios. Researchers will be able to identify obstacles in changing behaviour by obtaining information on attitudes towards norms, perceived control and behaviours. Larger sample size also provides a more accurate mean, easy to detect outliers and minimized margin of error.

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