Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Case Report

Analysis of the community behavioural patterns in management of household plastic waste due to the COVID-19 pandemic in Sri Lanka

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ABSTRACT

The COVID-19 pandemic has adversely affected human lifestyle in numerous ways and one such key affected social element is the management of household plastic waste. Due to its effective barrier properties against the COVID-19 virus, usage and consumption of personal protective equipment (PPE) and other single-use plastic (SUP) products have increased exponentially to meet the accelerated demand. Therefore, this paper analyses the changes in community behavioural patterns of household plastic waste management with the prevailing COVID-19 pandemic situation in Sri Lanka. The comparative analysis of majorly consumed plastic waste types, plastic disposal methods, and perceptions of existing policies before and after the pandemic are broadly discussed. A comprehensive questionnaire was conducted in a stratified randomly sampled community and analysed using SPSS. Disposable face masks (39.9%) and hand sanitiser products (33.0%) were popular plastic products during the pandemic. The frequency of handing over the waste to collectors and recycling centres decreased slightly, from 32.1% to 31.4% and 24.2%–19.8%, respectively. Conversely, respondents' preference for burning plastic waste increased from 23.4% to 27.0% after the pandemic. The plastic disposal methods from before and after the pandemic are significantly associated with income level ($p = 0.00$) and employment status ($p = 0.00$). No significant association was observed between the disposal method before the pandemic and the education level of respondents ($p = 0.185$). However, a significant association was evident between the disposal method after the pandemic and the education level of respondents ($p = 0.025$).

1. Introduction

The COVID-19 pandemic has quickly become the worst crisis of our lifetime, spreading to nearly all countries with a global death toll of more than 4.8 million and confirmed cases of more than 230 million people by October 2021 [1]. The use and consumption of personal protective equipment (PPE) and other single-use plastics (SUP) such as polythene bags, face masks, gloves, face shields, and hand sanitiser products have increased exponentially to supply the massive demand created by the pandemic. Therefore, one of the significant side effects of COVID-19 is the sudden surge in SUP product usage that threatens to intensify plastic pollution further. Thus, to sustain the demand for COVID-19-related plastic products (including PPE, face masks, gloves, and face shields), many government regulations were withdrawn or relaxed during the pandemic in many countries [2,3].

Additionally, due to the lockdown and travel restrictions, the usage of online shopping and delivery services has increased, resulting in an exponential growth in plastic bag usage [4]. COVID-19-related plastic waste is considered contaminated plastic waste (CPW) and should be handled with care because it can be a potential carrier to spread the novel coronavirus. Before the COVID-19 pandemic, plastic waste management was already considered a major environmental issue in terrestrial and marine ecosystems [5].

The global impact of plastic pollution has a detrimental effect on flora and fauna, social well-being, and community health [6]. To provide some examples, the waterproof nature of mismanaged plastic makes it an ideal breeding ground for mosquitoes, leading to the spread of disease, and the breakdown of plastics into macro- and microplastics

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can affect organisms through bioaccumulation and, more visibly, entanglement [7,8]. The scale and damage imposed by mismanaged plastic waste are already causing problems worldwide due to the durability and inexpensive nature of plastics and the changes in social practices of consumption [9,10].

The public fear of contracting the COVID-19 virus, paired with government-implemented lockdowns, has led to a drastic change in the lifestyles of people staying at home or working from home, through travelling less, shopping online more, and ordering takeaway food. These changes have shifted large amounts of waste from commercial sectors to households [11]. This increased accumulation of waste at the household level is due to the cheap and convenient method for containing products, the increased use of PPE, and the perception that SUP act as a hygienic barrier to protect against the virus. This increase can be genuinely appreciated as plastic bag bans implemented to stop plastic pollution have been quashed to allow people to use them for protection, given concerns regarding reusable bags [12,13]. This increase has been facilitated by the plastics industry, which has promoted the idea that plastic-based items are safe and hygienic [14,15]. Although these items' barrier properties can prevent the transmission of virus spread, they can also act as a viable transmission route for viruses through indirect transmission (fomite transmission) [16]. The COVID-19, SARS-CoV2 and MERS-CoV coronaviruses are viable on plastics [17,19]. According to the previous studies, the life span of SARS-CoV2 on plastic is seven days [20], while MERS-CoV remains viable at 48 hours at 20 °C and 40% relative humidity [18]. Although, the virus still infects cells even after its retention time [17]. Therefore, for plastics to be an effective barrier and reduce the spread, the general public needs to ensure that other mitigation behaviours are followed, e.g., handwashing, sanitation, and mask use [21].

Sri Lanka is one of the top eleven countries, indicating Asia's highest mismanagement of plastic waste [22]. Sri Lanka produces 2.6 million plastic waste per year [23]. Being a 3rd world developing country, Sri Lanka lacks adequate local waste collection facilities and treatment infrastructure [23]. Waste management systems are already at maximum capacity to deal with plastic waste locally as COVID-19 threatens to overcome the existing waste management systems due to further waste build-up. If the current trends continue, many plastics will end up in an open environment, threatening natural ecosystems [24,25].

Significantly few scholarly articles to date have addressed the impact of COVID-19 on household plastic waste in the local context. Furthermore, to our knowledge, none have identified community behavioural patterns. The case study expects to identify the community behaviour before and after the COVID-19 pandemic and provide a holistic view for the authorities to propose immediate action plans for plastic waste management and plastic-related policy implementation.

2. Methods

This study seeks to understand how the COVID-19 pandemic affects community behavioural patterns in household plastic waste management. Initially, by obtaining data through various government regulations and documents, a questionnaire was developed to investigate the community behavioural approach due to the pandemic situation regarding plastic waste. A pilot survey was conducted (with a sample size of 100) to validate the questionnaire further. The sampling method was stratified random sampling. The final questionnaire was distributed among randomly selected households. One thousand thirty-three responses were collected from the September 15, 2020 to the February 15, 2021.

2.1. Demographic profile of respondents

Among the respondents, 56.9% were male, and 43.1% were female. For the analysis, the data were categorised into ages 18–24, 25–30, and 31–75.47.1% of the respondents belonged to the 18–24 age group, and 27.5% and 25.4% belonged to the 25–30 and 31–75 age groups, respectively. Furthermore, most of the respondents (49.6%) were located around suburban areas, and 38.2% and 12.2% were from urban and rural areas.

Regarding the respondents' highest educational level, 64.1% had bachelor's degrees, 25.8% were secondary school graduates, 9.5% had post-graduate qualifications, and 0.6% had lower academic levels than the other respondents. The employment status of majority of the respondents (54.8% and 34.8%) were students and full-time employees. A total of 5.2% of respondents were self-employed, and 2.4% were retired. Unemployed or part-time employees were 1.5% and 1.2%, respectively (Table 1).

The demographic data indicate that 70% of the respondents have bachelor's degrees or higher educational qualifications and consist of younger participants (47%). Hence, we assumed that the respondents were aware and knowledgeable about the current COVID-19 situation and plastic waste management. As such, obtained data from the participants were considered more reliable.

According to the census data obtained from the most recent "Population and Housing data-2020" [26], the population density of Sri Lanka and the questionnaire respondents' distribution were plotted as shown in Fig. 1. Each district was considered as a stratum and randomly selected a representative sample according to the district's population. A cross-sectional analysis of the data indicated that the sample population distribution characteristics were considerably similar to the population density data.

3. Results and discussion

Here, we discuss how behavioural patterns are affected by gender, educational levels, monthly income levels, and employment status in the community. We also identify the community levels that should be prioritised to manage COVID-19-related plastic waste.

Table 1
Sociodemographic characteristics of the participants (n = 1033).

Variable	Group/Item	Frequency	% of the respondents
Gender	Male	444	43
	Female	589	57
Age	18–24	487	47
	25–30	272	26
	31–75	274	27
Education level	Uneducated	4	0.6
	Elementary	2	0.4
	Secondary	267	26
	Bachelor Degree	662	64
	Post Graduate	98	9
Area	Urban	395	38
	Sub-urban	512	50
	Rural	126	12
level of income ([a]per Anum)	Below 1200$	214	21
	1200$ −3600$	210	20
	3600$ - 6000$	221	21
	Above 6000$	130	13
	Prefer not to say	258	25
Employment status	Employed –Full time	360	35
	Employed –Part-Time	16	2
	Self-employed	54	5
	Unemployed	12	1
	Student	566	55
	Retired	25	2

[a] The level of income was calculated in LKR during the study period and converted into USD for better understanding.

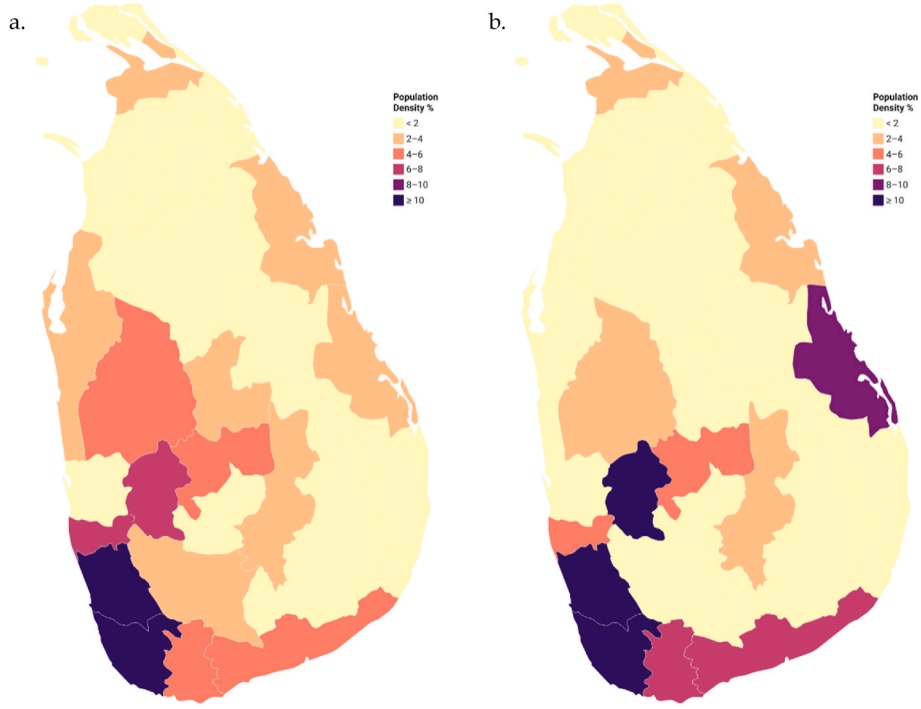

Fig. 1. (a) Sri Lankan population distribution and (b) the respondents' distribution.

3.1. Pre-COVID and post-COVID plastic consumption

Several main SUPs were identified before and after the COVID-19 pandemic. Pre-pandemic grocery bags (35.2%), food packaging containers (23.8%), and plastic bottles (21.5%) were found to be the most prominent SUPs used. While coffee cups & lids, plastic straws and plastic cotton buds' usage were identified as 8.2%, 6.3% and 5.1%, respectively. According to the analysis, most respondents, irrespective of their age, income level, or education, consume plastic products daily. A total of 18%–20% of urban, suburban, and rural respondents use plastic, grocery bags, and food packaging containers significantly. When cross-tabulating the SUP products and age groups, nearly 22% of respondents from the 31–75 age group use plastic bottles, and 19.5% use coffee cups and lids daily. Among the COVID-19-related plastic waste, disposable face masks (39.9%), hand sanitiser products (33.0%), gloves (14.5%), and face shields (12.5%) were identified as the products which were used as preventive measures against COVID-19.

Cross-analysis was carried out for COVID-related plastic products and employment status. Full-time employees, retired people, and students tend to use disposable face masks and hand sanitiser products. However, the retired respondents (usually age 60+) use face shields (20.4%) as protective equipment with face masks and hand sanitiser products. COVID-19 is often more severe among people above 60 or with health conditions [27]. Thus, using face shields with other protective products was common among the older community as an extra protective step.

3.2. Hypothesis analysis

The Cronbach's alpha test has been conducted for the data used in hypotheses to test the validity of the responses collected. Hypothesis 01 = 0.76, Hypothesis 02 = 0.85, Hypothesis 03 = 0.80 and Hypothesis 04 = 0.92.

3.2.1. Pre-COVID-19 and post-COVID-19 plastic disposal

The main waste disposal methods in Sri Lanka are open dumping, burning, burying, recycling, and handing over to waste collectors [28]. A ranked question was asked from respondents to receive the most accurate disposing methods they followed before COVID-19 and after COVID-19 situations. Figs. 2 and 3 show the respondents' plastic waste disposal methods before COVID-19 and the disposal methods according to their area.

Analysis indicated that the respondents' first preferred waste disposal method is handing over to collection irrespective of the pandemic. However, a slight reduction (32.1%–31.4%) in handing over the waste post-COVID-19 was observed. The second most-followed method has changed post-pandemic; respondents tend to burn the waste rather than hand it over to recycling centres. A possible reason for this finding is that recycling during the COVID-19 outbreak was a massive challenge because recycling programs and facilities were shut down [29], and people preferred to destroy their plastic waste rather than get exposed. According to the guidelines prepared by the World Health Organization [30], burning CPW would be effective at eliminating COVID-19, although burning plastic waste would be a huge problem considering its environmental impacts.

Few hypotheses were created to analyse a few rationales to test whether consumers' opinions or behaviour patterns changed due to the pandemic.

Hypothesis 01.
- H_0 = There is no significant association between disposal patterns before the pandemic and the educational levels of the respondents.
- H_1 = There is a significant association between disposal patterns before the pandemic and the educational levels of the respondents.

Hypothesis 02.
- H_0 = There is no significant association between disposal patterns after the pandemic and the educational levels of the respondents.
- H_1 = There is a significant association between disposal patterns after the pandemic and the educational levels of the respondents.

The association between the disposal patterns of pre-and post-COVID pandemic and the educational levels of the respondents was tested using the chi-square test. The results show no significant association between

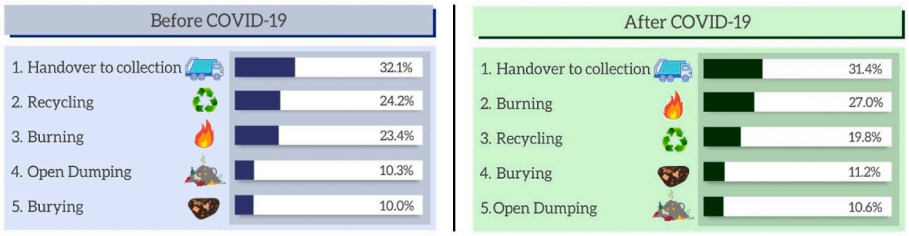

Fig. 2. Respondents' plastic waste disposal methods prior to the COVID-19.

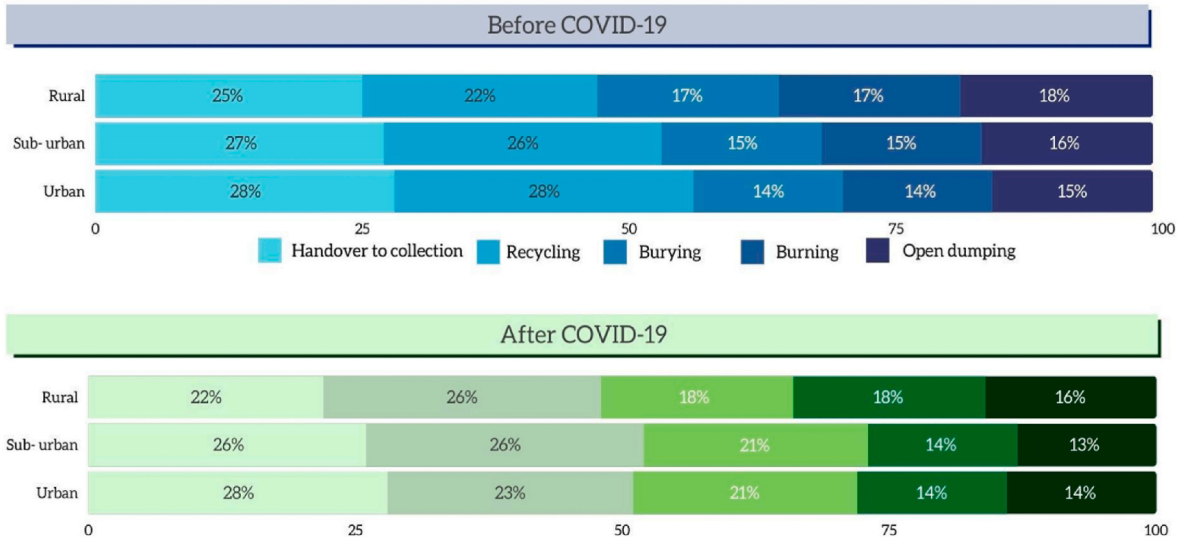

Fig. 3. Respondents' plastic waste disposal methods vs area where they live.

the disposal method before COVID and the academic level of a person ($p = 0.185$), where the H_0 of hypothesis 01 is accepted. The analysis proved that there is a significant association between the disposal method after COVID and a person's education level ($p = 0.025$); H_0 of hypothesis 02 was rejected. A possible reason for this finding is the increased ability of an educated person to grasp the knowledge from the sources compared with an uneducated person [31].

The information flow to the public about COVID waste management is crucial during the pandemic. The awareness of handling COVID plastic waste is essential, and many institutions, including the Central Environmental Authority (CEA), local authorities, and public media, took the initiative to shoulder this responsibility.

Questions were asked to obtain the general perception of respondents about whether they had received information about how to

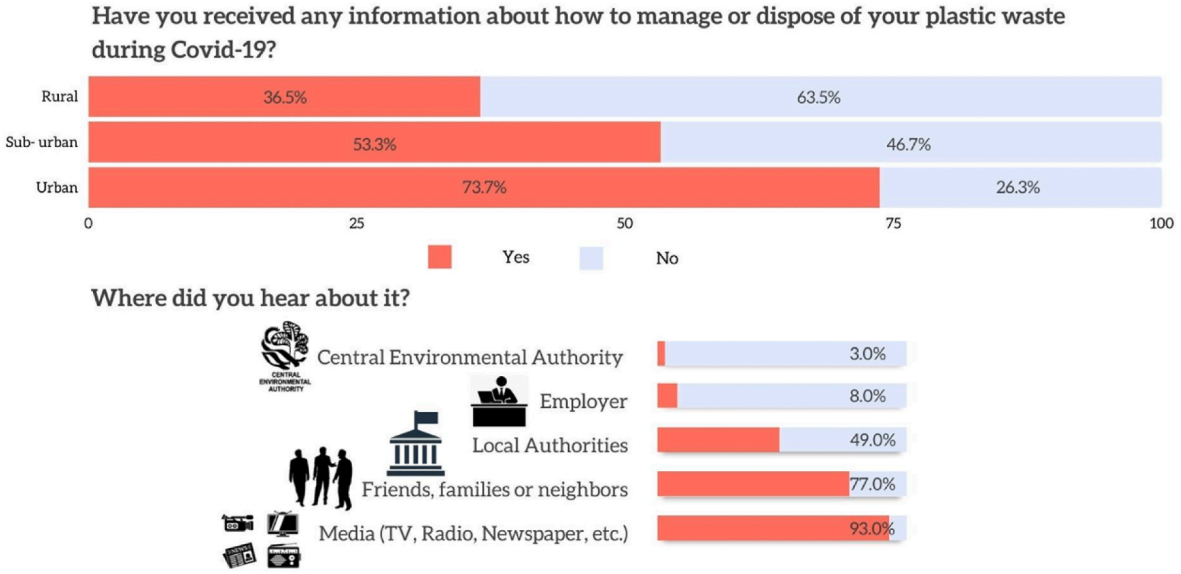

Fig. 4. The sources of information of the COVID related plastic waste management.

manage or dispose of plastic waste during the pandemic. 73% of respondents in urban and 53% in sub-urban regions have received the information. However, only 36% of respondents from rural areas have received the data (Fig. 4).

The most effective medium for spreading the information is media (93%) and communication (77%). Respondents stated that CEA (3%) and employers (8%) receive less information. In Sri Lanka, the CEA is the main body responsible for issuing policies and guidelines according to government requirements. However, people are unaware whether the information comes from the CEA. Therefore, the respondents considered the media the primary source of information, especially in rural and suburban areas.

The Centres for Disease Control and Prevention has developed interim COVID-19 guidelines for businesses and employers intending to help prevent workplace contamination from COVID-19. It stated that the employers should take necessary actions to educate employees about steps that can be taken to protect themselves and dispose of plastic or any other waste during COVID-19. Most developed countries practice specific COVID-19 health and safety guidelines and know how to dispose of their PPE waste properly. However, the results indicate a lack of information transfer from employers to employees and workers.

3.2.2. Sensitivity, awareness, and impact of plastic waste

A total of 66.3% of respondents agreed (Strongly agreed and agreed) that COVID-19 affects the usage of SUP products in households, and 33.7% of respondents disagreed (Strongly disagreed and disagreed) that COVID-19 affects the usage of SUP products in households. Furthermore, 68.7% of people strongly agreed that they had noticed a change in the amount of plastic waste in the environment where they live since COVID-19, whereas 20.6% disagreed. The results also show that most respondents are aware of the change in plastic waste in the surrounding environment after COVID-19.

Hypothesis 03.

- H_0 = There is no significant association between the number of members in the house and the awareness of change in plastic waste in the surrounding environment.
- H_1 = There is a significant association between the number of members in the house and the awareness of change in plastic waste in the surrounding environment.

A chi-square test was conducted ($\alpha = 0.05$) to identify the association between the number of members in the house and the awareness of change in plastic waste in the surrounding environment. A significant association was found between the number of household members and the understanding of change in plastic waste ($p = 0.002$); Ho rejected. This finding revealed that people are more sensitive to the increase in plastic waste when households have more members.

Likert-scale questions were used to identify the scale of understanding and the opinion on the impact of plastic pollution on the natural environment, human health, and several key industries. The primary sectors were tourism, fishery, and agriculture [28]. For natural environments such as waterways and land, urban environment, and human health, most respondents (more than 50%) considered the impact of plastic pollution to be extremely high. As for the agricultural, fishery, and tourism industries, 44.3%, 49%, and 39.5% of respondents considered the impact extremely high.

Respondents' perception of the enforced law on banning polythene before and after the COVID-19 situation was assessed by the below-listed statement question. Before COVID-19, most respondents agreed to ban plastic bags in Sri Lanka. The results were further analysed using the Wilcoxon Sign-Rank Test (Table 2).

Hypothesis 04.

- H_0 = There is no significant difference between the perception of banning polythene before and after the COVID-19 pandemic

Table 2
Wilcoxon signed-rank test to identify the difference in ranks between the perception of banning polythene before and after the COVID-19 pandemic.

Ranks				
		N	Mean Rank	Sum of Ranks
Opinion about regulation after COVID-19? – Opinion about regulation before COVID-19?	Negative Ranks	129[a]	87.62	11302.50
	Positive Ranks	38[b]	71.72	2725.50
	Ties	866[c]		
	Total	1033		

a. Opinion about regulation after COVID-19? < Opinion about regulation before COVID-19?.
b. Opinion about regulation after COVID-19?> Opinion about regulation before COVID-19?.
c. Opinion about regulation after COVID-19 = Opinion about regulation before COVID-19?.

- H_1 = There is a significant difference between the perception of banning polythene before and after the COVID-19 pandemic.

A two-tailed *t*-test has been conducted to compare the mean difference between the perception of banning polythene before and after the COVID-19 pandemic. A significant difference is found between the perception of banning polythene before and after the COVID-19 pandemic ($p = 0.000$); H_0 was rejected.

The analysis indicates that 129 respondents disagreed with the polythene banning regulations before COVID-19 than after COVID-19. A total of 38 respondents disagreed with the polythene banning regulations after COVID-19, and 866 respondents had no opinion change towards the policies according to the COVID-19 situation.

3.3. Perception of enforcing the plastic waste management

Question series was asked to obtain respondents' perceptions regarding whether a plastic collection centre was located in their community and the mode they would be willing to travel if the authorities could not collect garbage from the household. The options included walking, car, motorbike, three-wheeler, and household waste collection. A total of 47% of the respondents preferred to hand over the waste to household collectors. The modes of travel selected were to hand over the waste by walking (18%) and using motorbikes (17%) to the recycle centre. These results indicate that the respondents wanted a recycling centre within walking distance or nearby their households. The least preferred mode was handing the waste over to the centre by a three-wheeler (5%).

The time duration respondents were willing to commit to travelling to hand over waste was analysed. Most respondents were willing to spend approximately 5–10 minutes of their time travelling to a recycling centre and handing over the waste (Fig. 5).

4. Conclusions

This study provides an insight into SUP usage and disposal methods in the pre-and post-COVID-19 pandemic in Sri Lanka. Sri Lanka's waste management systems were inadequate to deal with plastic waste before the pandemic. Thus, the added CPW from households will be a considerable concern for the existing waste management system. The ripple effect of COVID-19 on plastic pollution will be severe shortly and may result in the collapse of the current waste management system if not appropriately addressed. Significant behavioural changes in disposal methods due to COVID-19 were identified. The pandemic has decreased the recycling of plastics and increased household plastic burning to minimise contamination. However, burning plastic without proper treatment will impact the environment and the health of the

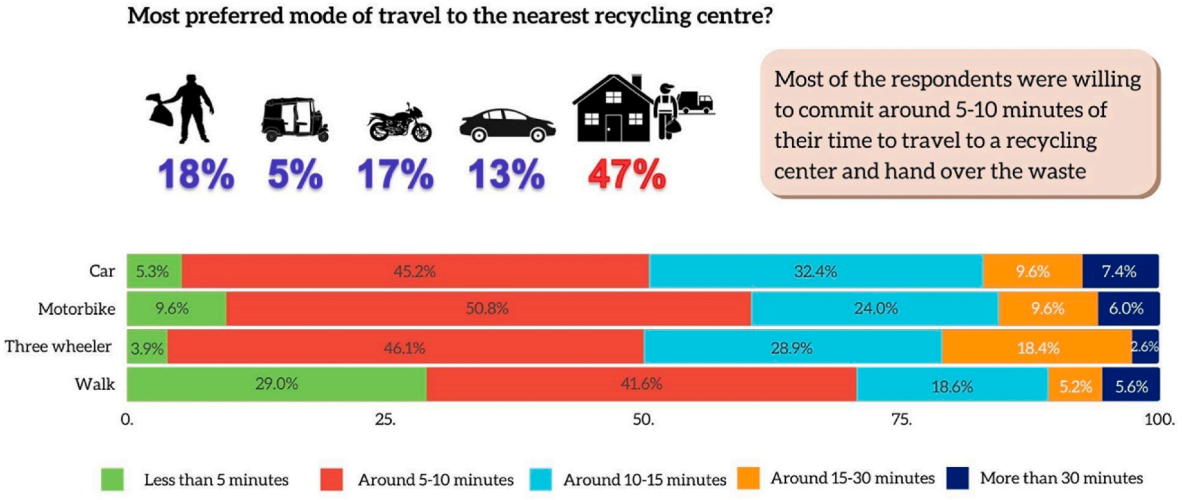

Fig. 5. Most preferred mode of travel to the nearest recycling centre.

surrounding organisms. Furthermore, recycling would either not be an ideal disposal method because the plastic waste may be contaminated and spread to the local community or even waste recycling personnel. Thus, the government should consider these disposal methods with the current capacity of the waste management system without jeopardising the health of the waste collectors or workers. A significant association was found between the disposal method pre-COVID-19 and a person's educational level. Therefore, we recommend launching awareness programs targeting the uneducated population using simplified methods to grasp the ideas quickly. The results show that the information reached to the rural community is comparatively low. Therefore, authorities should consider this situation seriously and take necessary actions to educate the rural community, as the lack of awareness can be a reason for changes in COVID-19-related plastic disposal. People were found to prefer handing over plastic waste to collectors even if recycling centres were introduced into their communities. Since recycling plastics during COVID-19 is not ideal, implementing mobile incineration units in recycling or waste collecting centres as a waste management strategy would be perfect. This practice could reduce CPW from landfills and provide a more sustainable and eco-friendly solution.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Rohantha Rukshan reports financial support was provided by University of Moratuwa Department of Civil Engineering. Prof.Champika Liyanage reports a relationship with University of Central Lancashire that includes: funding grants.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.cscee.2022.100246.

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