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ORIGINAL RESEARCH ARTICLE

Environmental awareness and plastic use behavior during the Covid-19 pandemic

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ABSTRACT

BACKGROUND AND OBJECTIVES: Plastic waste in Indonesia increased significantly during the Covid-19 pandemic. With this surge in plastic consumption and waste, awareness of environmental sanitation becomes essential, especially regarding the use of plastic. Society must consider the impact of single-use plastics and implement good plastic waste management. This study aimed to determine the environmental awareness of a community and what factors contributed to its plastic waste utilization activities during the Covid-19 pandemic.

METHODS: The data collection in this study was conducted using a questionnaire with a cross-sectional analytical approach. The study was conducted in Makassar City, South Sulawesi, the largest city in Eastern Indonesia, and purposive sampling was used to determine selected respondents. Data analysis was carried out using chi-square to identify partial relationships and logistic regression to distinguish relationships simultaneously.

FINDINGS: This study found that 53.2 percent of respondents frequently used plastic during the Covid-19 pandemic. Partial relationship analysis showed that general knowledge about waste and its impact was not significantly related to plastic use activities during the pandemic. Meanwhile, knowledge about plastic use during the pandemic, knowledge of protecting the environment, attitudes toward plastic use, attitudes toward waste management, behavior toward plastic use, and behavior regarding processing plastic waste were significantly related to plastic use activities during the Covid-19 pandemic, with respective test values of 0.000 each. Willingness to pay was also significantly related to plastic use activities during the pandemic, with a test value of 0.007. Simultaneous analysis showed that knowledge about plastic use during the pandemic was related to plastic use activities during the same time frame, with an odds ratio value of 0.398 and a negative relationship direction. Plastic waste-processing behavior was the most dominant factor influencing plastic use activities during the Covid-19 pandemic, with a test value of 0.000 and a positive relationship direction. Respondents who did not have good waste management behavior were 3.963 times more likely to use plastic frequently in their daily activities during the pandemic.

CONCLUSION: The study results show the importance of increasing knowledge regarding plastic use and waste management. Good knowledge will intervene in attitudes that encourage good behavior. This study focuses on the relationship between plastic processing behavior and the intensity of plastic use during the Covid-19 pandemic. It emphasizes the need for intervention in the form of education about the importance of protecting the environment and providing facilities that enable people to implement good waste-processing behavior.

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INTRODUCTION

The emergence of coronavirus disease 2019 (Covid-19) disrupted the usual course of human life and significantly changed people's lifestyles (Alzghoul *et al.,* 2022). Owing to this global health crisis, individuals were required to work from home (Igalavithana *et al*., 2020), which, in turn, led to an increase in online orders for food and beverages. This situation occurred because people avoided gatherings with large crowds to avoid the Covid-19 virus. During the pandemic Covid-19, the use of single-use plastic (SUP) rose because of the assumption that plastic offers users protection against exposure to the Covid-19 virus, even though this virus can survive on plastic surfaces for up to 72 hours (Shekoohiyan *et al*., 2022). Accordingly, one of the impacts of the Covid-19 pandemic is the increase in the consumption of plastic waste (Rai *et al*., 2022). Similarly, plastic use in Indonesia increased during the Covid-19 pandemic. In 2019, plastic waste was the third largest category of waste in Indonesia, accounting for 16.05 percent (%) of the country's total waste and totaling 4,739,684 tons. In 2020, amid the Covid-19 pandemic, this figure increased to 5,041,117 tons, pushing plastic waste (16.31%) to the second largest category at 16.31%, just behind food waste. Then, in 2021 and 2022, the use of plastic waste in Indonesia continued to increase, reaching 17.86% (5,280,702 tons) and 18.08% (6,500,458 tons), respectively, of the total waste generated in the country (SIPSN, 2023). Plastic is a versatile lightweight material that can be processed using various manufacturing techniques and has significant market potential. Plastics are polymer chains of monomers combined in repeating patterns. Fossil sources are converted into these macromolecules through various methods, such as polymerization, polycondensation, and polyaddition (Choudhury *et al*., 2022). Around 50% of the plastic produced is single-use plastic (Jahani *et al*., 2019). The increasing use of plastic has an impact on human life throughout the world (Abhilash and Inamdar, 2022). Previous research found that the increase in purchasing intensity is not linear with the level of waste recycling. Plastic products that are used only once before being thrown away, such as plastic bags, coffee cups, soda bottles, and water bottles, have meager recycling rates (12%) (Shams *et al*., 2021). Steps taken to control the Covid-19 pandemic have encouraged increased takeout food consumption, resulting in the use of SUP cutlery (Ho *et al*., 2023). The pandemic has caused a 5% to 10% increase in global plastic production, impacting soil quality through increasing microplastic (MPs) content. The increasing use of plastic waste contributes to land pollution and damage to marine ecosystems. Plastic pollution poses an environmental challenge because of the complexity of waste management and recycling, resulting in the accumulation of plastic waste. This situation will worsen environmental pollution (Rai *et al*., 2022). The global increase in plastic use during the Covid-19 pandemic contributed to heightened emissions of pollutants and greenhouse gases. It also fueled plastic pollution on both land and in the sea, endangering biodiversity and human health. Increasing plastic pollution is exacerbating future plastic problems, both on a small and large scale (Winton *et al.,* 2022). The main reasons for this environmental crisis are population density, high consumption of plastic products, and the inappropriate disposal of plastic waste (Van *et al*., 2020). Waste recycling is considered to reduce the amount of plastic waste pollution (Igalavithana *et al*., 2020). If recycling is carried out incorrectly, it will impact human health and the environment (Salhofer *et al*., 2021). Prior studies reported a minor decline in the frequency of trash disposal to collectors and recycling centers during the Covid-19 pandemic. Specifically, the percentage of individuals handing over waste to collectors decreased from 32.1% to 31.4%, while the percentage of individuals utilizing recycling facilities decreased from 24.2% to 19.8%. By contrast, after the occurrence of the pandemic, there was an observed increase in respondents' inclination toward the incineration of plastic garbage from 23.4% to 27.0% (Jayasinghe *et al*., 2022). Recycling plastic waste can be carried out using the Smart Waste application, which is used in the Philippines. This innovative application can detect how much plastic waste is collected in one waste container. After a large amount of waste has been collected in a trash can, the waste officer will dispose of the plastic waste through recycling (Sidhu *et al*., 2021). Another method for recycling SUP waste is via the reduce, reuse, recycle, and recover (4R) scheme (Mahmoudnia *et al*., 2022). Another waste management alternative is innovative waste technology, which utilizes near-field communication (NFC) from the user's smartphone. This technology

can identify users through their user registration, and then the trash bin will sort the type of waste thrown away by the user. Collected and filled waste will be exchanged for compensation (Roche *et al*., 2021). Personal norms, which are shaped by environmental values and beliefs, are the main predictor of behavioral willingness. In campaign strategies, personal norms can be considered to change people's behavior in using reusable goods and products with plastic-free packaging alternatives (Shah *et al.,* 2023). A person's behavior will change if three elements are present, namely, ability, motivation, and opportunity (Allison *et al*., 2022). Moreover, the dominant factors influencing an individual's desire to process waste are the type of waste bin used, knowledge about how to manage waste and the dangers of poor waste management (Ssemugabo *et al*., 2020), location of residence, respondent's age, and knowledge on how to sort waste (Nsimbe *et al*., 2018). Previous research generally focused on the influence of demographic determinants (Choi *et al*., 2022), environmental impact analysis (Magni *et al.,* 2022), impact on marine animals (Eisfeld-Pierantonio *et al*., 2022), differences in waste quantity before and during the Covid-19 pandemic (Alazaiza *et al*., 2022), waste disposal behavior (Mejjad *et al*., 2021), technology for mitigating the impact of MPs (Zhao *et al.,* 2023), and production and management strategies (Liang *et al*., 2021). Behavioral influencing factors that are the source of the waste problem need to be researched and paid special attention. Therefore, the present study aims to determine the dominant factors that influence the use of plastic waste during the Covid-19 pandemic based on the aspects of knowledge, attitudes, and behavior. The main objective of this study is to explain how plastic utilization activities occurred during the Covid-19 pandemic. This study was conducted in Makassar, Indonesia in 2022.

MATERIALS AND METHODS

This cross-sectional analytical study aimed to identify the most dominant factors influencing plastic use activities during the Covid-19 pandemic based on the aspects of knowledge, attitudes, and behavior. The study was carried out in the urban area of Makassar City, Indonesia, in 2022. Makassar is a municipal entity that functions as the administrative center of South Sulawesi Province. It is regarded as one of the prominent urban centers in the nation of Indonesia. Makassar City is ranked as the fourth most populous city in Indonesia, and it holds the distinction of being the largest city within the Eastern Indonesia Region. Accordingly, the city holds the potential to produce large amounts of waste. Makassar consists of 15 sub-districts, namely, the districts of Biringkanaya, Tamalanrea, Manggala, Panakukang, Rappocini, Tallo, Wajo, Makassar, Ujung Pandang, Sangkarang, Mamajang, Ujung Tanah, Bontoala, Mariso, and Tamalate (Fig. 1).

Site and study sample

In this study, the sub-districts were categorized based on three groups: 1) groups with significant and developing populations, 2) groups categorized as saturated areas and business/shopping centers, and 3) coastal area groups. Group 1 consists of the Biringkanaya, Tamalanrea, Manggala, Panakukang, Rappocini, and Tallo district. Group 2 consists of the districts of Wajo, Makassar, and Ujung Pandang. Group 3 includes the Sangkarang, Mamajang, Ujung Tanah, Bontoala, Mariso, and Tamalate. Purposive sampling was conducted in these three groups. Biringkanaya District and Manggala District represent group 1. Wajo District represents the saturated sub-district group 2. The coastal area group 3 is represented by Ujung Tanah District and Mariso District. Except for the Manggala sub-districts, five sub-districts with the largest population were selected from the 15 sub-districts. Manggala District, which has the largest population in Makassar City, is represented by six sub-districts. Random sampling was used to determine the sample for this study. Specifically, the first sample was the first residence located to the right of the village head's office, the second sample used an interval of five households from the previous sample, and so on. Selected respondents were adults living in the selected households.

Data collection and survey

This study used a questionnaire instrument to collect data from respondents. The questionnaire consists of 1) respondent identity, 2) knowledge aspects, 3) attitude aspects, 4) behavior aspects, and 5) activity aspects of plastic use during the Covid-19 pandemic (Table 1). The knowledge aspect consists of four sub-aspects. (1) General knowledge about plastic, with the example statement "Plastic can be used for food packaging." (2) Knowledge of

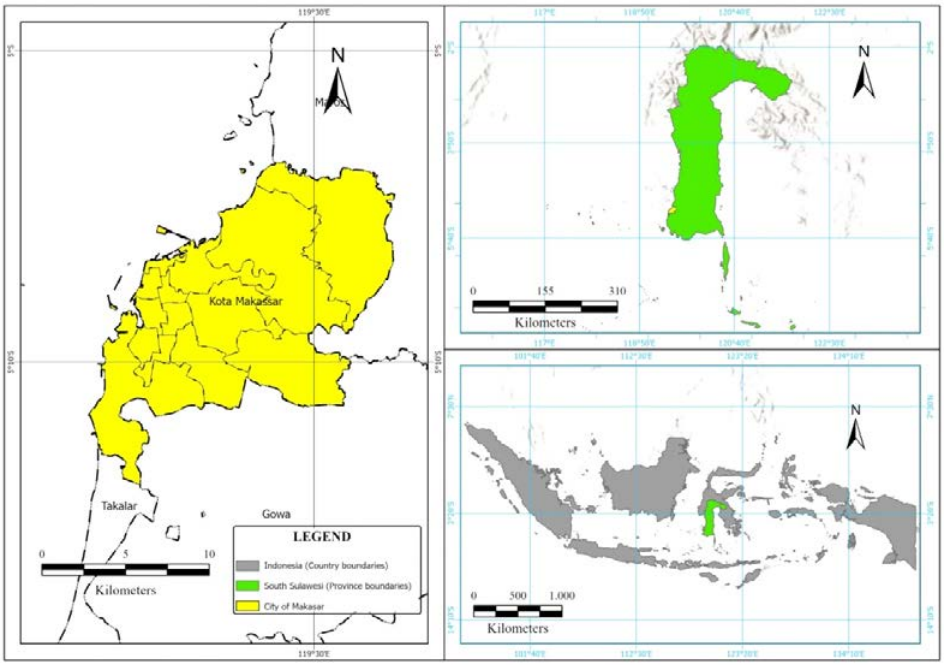

Fig. 1: Geographic location of the study area in Makassar City, South Sulawesi Province, Indonesia

Table 1: The study questionnaire

Questions	Answer	Measurement results
Respondent identity		
Education level	Graduated from college, graduated from college, graduated from high school, graduated from junior high school, graduated from elementary school, did not graduate from elementary school, or never went to school	-
Marital status	Single, married, divorced, or widow	
Frequency of drinks ordered online in a week	More than one time, only once, never	-
Plastic use activities during the Covid-19 pandemic	Always, almost always, sometimes, rarely, or never	Seldom or often
Knowledge		
General knowledge about waste	False or true	Poor or good
Knowledge of the impact of waste	False or true	Poor or good
Knowledge of protecting the environment	False or true	Poor or good
Knowledge about plastic during Covid-19	False or true	Poor or good
Attitude		
Waste management attitude	Strongly agree, agree, neutral, disagree, strongly disagree	Poor or good
Willingness to pay	Strongly agree, agree, neutral, disagree, strongly disagree	Willing or unwilling
Attitudes toward plastic use	Strongly agree, agree, neutral, disagree, strongly disagree	Poor or good
Behavior		
Plastic waste-processing behavior	Always, almost always, sometimes, rarely, or never	Poor or good
Plastic use behavior	Always, almost always, sometimes, rarely, or never	Poor or good

the impact of plastic on the environment, with the example statement "Plastic is a substance that is difficult to decompose/degrade in the environment." (3) Knowledge about plastic during the Covid-19 pandemic, with the example statement "The more often you change the plastic you use, the more you will reduce the risk of exposure to Covid-19." (4) Knowledge of protecting the environment, with the example statement "Plastic cups can be recycled to make crafts." Respondents' opinions regarding their general knowledge about plastic, knowledge of the impact of waste, knowledge of protecting the environment, and knowledge of plastic use during the Covid-19 pandemic received a value of 1 for "correct" answers and 0 for "wrong" ones. Meanwhile, in the attitude aspect, there are three sub-aspects. (1) The attitude toward plastic, with the example statement "For me, using shopping bags provides more comfort than using plastic." (2) Willingness to pay, with the example statement "I am willing to pay more for food packaging that is more environmentally friendly than using plastic." (3) The attitude toward waste management, with the example statement "In my opinion, plastic waste should not be thrown into the organic waste bin." Respondents' opinions regarding attitudes toward managing waste, willingness to pay, and attitudes toward using plastic received a score of 5 for "strongly agree," 4 for "agree," 3 for "neutral," 2 for "disagree," and 1 for "strongly disagree." In the behavioral aspect, there are two sub-aspects. (1) Plastic use behavior, with the example statement "I choose options with less plastic when shopping online." (2) Plastic waste management behavior, with the example statement "I recycle the plastic waste that I produce." Respondents' opinions regarding plastic waste-processing behavior and plastic use behavior received a score of 5 for "always," 4 for "almost always," 3 for "sometimes," 2 for "rarely," and 1 for "never." An example statement regarding the aspect of plastic use during the pandemic is "During the pandemic, I bought food with plastic packaging online." Respondents' opinions regarding plastic use activities during the Covid-19 pandemic received a score of 5 for "never," 4 for "rarely," 3 for "sometimes," 2 for "almost always," and 1 for "always."

Analysis procedures

Data analysis began with the editing, coding, and data entry stages. After the initial three stages were completed, the next stage was transforming or modifying the data. The dependent variable, namely, plastic use activities during the Covid-19 pandemic, was often or rarely measured. Meanwhile, the knowledge, attitude, and behavior variables have good or poor measurement results (Table 1). The measurement results of this study were categorized based on the skewness value. If the skewness value was in the range of minus (-) 2 to 2, the data were declared normally distributed so that the cut-off point was the mean value. On the other hand, if the skewness value was less than (<) -2 or more than (>) 2, then the data on that variable were not normally distributed, so the cut-off point used was the median value.

Statistical analysis

When data modification was completed, the data underwent univariate, bivariate, and multivariate analyses. The objective of univariate analysis is to ascertain the distribution of variables, which is typically given in the form of a frequency distribution table. In the context of statistical analysis, bivariate analysis employs the chi-square test to examine the partial association between dependent and independent variables. In this study, the chi-square test was also used to select candidate variables for inclusion in multivariate modeling with the condition that the p-value is less than or equal to (≤) 0.25. Binary logistic regression was also performed multivariate analysis. Model selection was carried out by entering all independent variables that met the p-value requirements for bivariate selection and then re-selecting variables that were not significant with a test value (p-value) > 0.05 (Samimi *et al.,* 2023). The final model included significant variables (p-value ≤ 0.05) to identify the independent variables with the most strongest relationship to the dependent variable (Samimi and Nouri, 2023). The entire data processing process used the Statistical Program for Social Science (SPSS).

RESULTS AND DISCUSSION

Table 2 shows that 228 (82%) respondents were married, and 129 (46.4%) had graduated from high school. A total of 142 (51.1%) respondents never ordered drinks online regularly during the week, while 95 (34.2%) respondents said they ordered drinks online more than once every week.

Table 2: Respondent characteristics

Respondent characteristics	Categories	Number (person)	Percentage (%)
Marital status	Single	38	13.7
	Married	228	82.0
	Divorced	4	1.4
	Widow	8	2.9
Education level	Never went to school	3	1.1
	Did not graduate from elementary school	3	1.1
	Graduated from elementary school	47	16.9
	Graduated from junior high school	47	16.9
	Graduated from high school	129	46.4
	Graduated from college	15	5.4
	Graduated from college	34	12.2
Frequency of drinks ordered online in a week	Never	142	51.1
	Only once	41	14.7
	More than one time	95	34.2

Table 3: Knowledge, attitudes, and behavior in using waste

Variables	Categories	Number (person)	Percentage (%)
Plastic use activities during the Covid-19 pandemic	Often	148	53.2
	Seldom	130	46.8
General knowledge about waste	Poor	147	52.9
	Good	131	47.1
Knowledge of the impact of waste	Poor	183	65.8
	Good	95	34.2
Knowledge of protecting the environment	Poor	134	48.2
	Good	144	51.8
Knowledge about plastic during Covid-19 pandemic	Poor	79	28.4
	Good	199	71.6
Waste management attitude	Poor	137	49.3
	Good	141	50.7
Willingness to pay	Unwilling	113	40.6
	Willing	165	59.4
Attitudes toward plastic use	Poor	122	43.9
	Good	156	56.1
Plastic waste-processing behavior	Poor	118	42.4
	Good	160	57.6
Plastic use behavior	Poor	148	53.2
	Good	130	46.8

Table 3 shows that 130 (46.8%) respondents said they seldom used plastic in their daily activities during the Covid-19 pandemic while 148 (53.2%) said they often used plastic. The majority of respondents (147, 52.9%) had poor general knowledge regarding waste, but 183 (65.8%) respondents had good knowledge about the impacts of waste. Meanwhile, 199 (71.6%) and 144 (51.8%) respondents had good knowledge regarding the use of plastic during the Covid-19 pandemic and protecting the environment, respectively. The majority of respondents' attitudes regarding waste processing were also predominantly good (141, 50.7%). Likewise, the willingness to pay additional expenses to use non-plastic containers was also dominant at 165 (59.4%) respondents. Attitudes toward plastic use were also predominantly good at 156 (56.1%) respondents. During the pandemic, many people thought leaving the house is the same as contracting the virus. Accordingly, the adoption of large-scale social restrictions (PSBB) led to a surge

in online retail activities. This circumstance resulted in a notable escalation in the level of demand and utilization of SUP (Abhilash and Inamdar, 2022). The behavioral aspect of the current study shows that the majority of respondents (53.2%) did not have good plastic use behavior. Plastic use continued to increase during the Covid-19 pandemic because of its light weight, durability, and low production costs. These advantages make plastic, especially SUP, the ideal choice for everyday use, including for drinking water bottles and coffee cups (Mohana *et al*., 2023). Thus, people must be able to process waste, at least what they produce themselves. In this study, as many as 160 (57.6%) respondents had good behavior regarding waste processing during the pandemic.

Table 4 shows that general knowledge variables related to waste and its impact were not partially significantly related to plastic use activities during the Covid-19 pandemic. Most respondents (84, 57.1%) had poor general knowledge regarding waste and often used plastic during the pandemic. In addition, 95 (51.9%) respondents generally had poor knowledge of the impacts of waste and often used plastic. Seven other variables in this study were significantly related to plastic use activities during the pandemic. Knowledge of using plastic during the Covid-19 pandemic, knowledge of protecting the environment, and attitudes toward plastic use were significantly related to plastic use activities during the pandemic, each with p-value=0.000. The odds ratio (OR) value for knowledge of protecting the environment is 2.370, which means that respondents with poor knowledge had 2.370 times higher potential of using plastic frequently during the pandemic than the comparison group, namely, the respondents with good knowledge. This study aligns with previous research that states environmental awareness will either encourage or hinder community involvement in using plastic (Pocas and Selbourne, 2023). Public awareness can be increased through media channels, seminars, and workshops that involve and inspire communities to adopt zero-waste or sustainable packaging practices (Trubetskaya *et al*., 2022). Controlling plastic pollution is closely related to increasing the public's awareness to protect the environment and suppressing their desire to use plastic in their daily activities. Sun et al. (2023) stated that public attitudes are predominantly positive regarding the reuse of plastic but negative regarding waste collection and sorting activities. The community is also worried about the impact of indiscriminate burning and rubbish dumping, which will trigger air, water, and land pollution. The current research also found that the OR value of the relationship between knowledge of plastic use and plastic use activities during the Covid-19 pandemic was 3.345. This result means that respondents who had poor knowledge about plastic use were 3.345 times more likely to

Table 4: Results of Chi-Square analysis

Variables		Plastic use activities during the Covid-19 pandemic						p-value	OR
		Often		Seldom		Total			
		n	%	n	%	n	%		
General knowledge about waste	Poor	84	57.1	63	42.9	147	100	0.186	1.396
	Good	64	48.9	67	51.1	131	100		
Knowledge of the impact of waste	Poor	95	51.9	88	48.1	183	100	0.612	0.855
	Good	53	55.8	42	44.2	95	100		
Knowledge of protecting the environment	Poor	86	64.2	48	35.8	134	100	0.000	2.370
	Good	62	43.1	82	56.9	144	100		
Knowledge about plastic during the Covid-19 pandemic	Poor	58	73.4	21	26.6	79	100	0.000	3.345
	Good	90	45.2	109	54.8	199	100		
Waste management attitude	Poor	54	39.4	83	60.6	137	100	0.000	0.325
	Good	94	66.7	47	33.3	141	100		
Willingness to pay	Unwilling	49	43.4	64	56.6	113	100	0.007	0.510
	Willing	99	60	66	40	165	100		
Attitudes toward plastic use	Poor	48	39,3	74	60,7	122	100	0.000	0.363
	Good	100	64.1	56	35.9	156	100		
Plastic waste-processing behavior	Poor	38	32.3	80	67.8	118	100	0.000	0.216
	Good	110	68.8	50	31.3	160	100		
Plastic use behavior	Poor	59	39.9	89	60.1	148	100	0.000	0.305
	Good	89	68.5	41	31.5	130	100		

have frequent plastic use activities during the pandemic compared to those who had good knowledge. The results of this study are in line with those if previous research, which found that there was poor knowledge about various types of plastic materials and their impact on health (Pocas and Selbourne, 2023). This study also significantly related waste processing attitudes (p-value=0.000) to plastic use activities during the Covid-19 pandemic, with an OR value of 0.325. Most respondents (94, 66.7%) had good waste processing attitudes and frequent plastic use activities during the Covid-19 pandemic. Respondents with a poor attitude toward waste processing were 0.325 times more likely to use plastic in their activities during the pandemic compared to those who had a good attitude. The variable willingness to pay for plastic use activities during the pandemic was significantly but partially related (p-value=0.007), with OR=0.510. This result means that respondents unwilling to incur additional costs to avoid using plastic were 0.510 times more likely to use plastic during the Covid-19 pandemic than the comparison group. The majority (60%) of respondents often used plastic and were willing to pay additional costs to avoid using plastic. This finding contrasts with previous research by SSemugabo *et al*. (2020), who found that 67.1% of their respondents were unwilling to spend money to protect the environment related to waste issues. Abhilash and Inamdar (2022) also found that most respondents (58.4%) were unwilling to pay to avoid plastic use. Another attitude related to plastic use activities during the Covid-19 pandemic is attitudes toward plastic use. This study found that respondents who had a poor attitude toward the use of plastic were 0.363 times more likely (OR=0.363) to use plastic in their daily activities than the comparison group. This figure shows that respondents' knowledge regarding plastic utilization activities during the pandemic tended to be poor. However, most respondents had a good attitude. Individual knowledge and attitudes were found to be closely related. Previous research explained that individual attitudes can also be influenced by factors other than knowledge (Nsimbe *et al*., 2018). The present study found that the behavioral variables of plastic use and plastic waste processing were significantly related to plastic use activities during the Covid-19 pandemic, each with a p-value=0.000. The OR value for plastic use behavior is 0.305, and the OR value for plastic waste-processing behavior is 0.216. Respondents with poor use of plastic had the potential to frequently use plastic during the Covid-19 pandemic 0.305 times more compared to respondents with good behavior. Based on the results of this study, respondents continued to frequently use SUPs in their households during the pandemic. These findings are strengthened by previous research, which stated that 78.7% of respondents used plastic bags as waste containers (Ssemugabo *et al*., 2020). Other research also confirmed that most respondents, regardless of age, income level, or education, consume plastic products every day. As many as 18%–20% of urban, suburban, and rural respondents use plastic, grocery, and food bags in significant quantities. Before the Covid-19 pandemic, the most used SUP products were plastic shopping bags (35.2%), plastic food packaging (23.8%), and plastic bottles (21.5%) (Jayasinghe *et al*., 2022). The continuous increase in plastic waste indicates the importance of processing plastic waste. This study found that individuals with poor plastic waste-processing behavior were 0.216 times more likely to use plastic frequently during the Covid-19 pandemic than those with good knowledge (Table 3). Thus, a reorientation toward internal production is necessary because most plastics are not biodegradable. It is also important to note that plastic waste from the pandemic must be sterilized before being recycled (Abhilash and Inamdar, 2022). Regarding municipal waste management services, even though people's knowledge and attitudes regarding waste sorting are increasing, their motivation to sort waste is still relatively lower (Wang *et al*., 2022). There is no difference in waste management between SUP and other plastic packaging at the household level. Both types of plastic are regarded as waste made from the same polymers (Schmidt and Laner, 2021). The availability of alternatives to plastic is also an important focus. Previous research found that 83.33% of respondents chose to use plastic daily due to the lack of plastic alternatives (Bandara *et al*., 2023). The conditions that trigger the continuous use of plastic are then considered in developing strategies to change people's behavior. The plastic use behavior of the community can be positively influenced by increasing their knowledge and boosting public confidence to practice responsible plastic use, which, in the case of this study, is avoiding the use of SUP. Interventions

can take the form of enhancing education, providing technical equipment that supports waste collection and sorting activities, and providing or facilitating access to plastic alternatives. Plastic waste can be minimized by recycling, although during the Covid-19 pandemic, recycling activities were difficult to carry out due to movement restrictions and other safety issues (Mohana *et al*., 2023). Recycling processes can be classified into four types: primary (a mechanical process is used to recycle plastic waste into products with the same properties as bare plastic), secondary (a mechanical process is used to recycle plastic waste into products with lower properties than the base plastic polymer), tertiary (a chemical process if used to reduce polymers into monomers/oligomers so they can be re-polymerized into new plastic products or used to make other types of materials), and quaternary (energy recovery in some forms of plastic processing) (Abhilash and Inamdar, 2022). The utilization of plastic trash as an energy source and the repurposing of used plastic objects into value synthetic products are effective solutions for the management of plastic waste. A waste management infrastructure must be established in order to effectively implement the 4R principles and ensure the appropriate exploitation of resources (Mahmoudnia *et al*., 2022). One way to reduce SUP is to reuse plastic bags (Gomes *et al*., 2022) or use reusable shopping bags (Amenábar *et al*., 2020). The use of reusable plastic will reduce the potential for health problems that arise due to plastic waste. Previous research found that reusable plastic should be used an average of 30 times to reduce the climate-change-based health impacts of SUP (Deeney *et al*., 2023). Plastic waste can also be reused in the construction industry. Using plastic waste can not only reduce the impact of plastic pollution but also limit excessive dredging of sand and other materials. Using 10% plastic mixture to replace cement can yield more robust construction results than not using any plastic waste in the mixture (Kamal *et al.,* 2023). Plastic waste from plastic bottles can also be used as road-paving material (Russo *et al.,* 2022). The use of plastic for asphalting has been around since the 1980s. From 2000 to 2022, asphalting as a form of processing plastic waste was a research topic in 412 studies (Ma *et al.,* 2023). Previous research found that using plastic waste as a paving material can help increase the durability and service life of asphalt for five years. Processing plastic as asphalt material is also considered to have minor consequences for human health and the ecosystem (Russo *et al.,* 2022). Other studies proposed the use of composting methods for processing plastic waste, but in practice, such methods cannot be applied to all types of plastic waste. This method can only be used on biodegradable plastics. The public is also required to participate in the sorting process, although previous research found that people's attitudes tend to be pessimistic regarding the sorting process (Sun *et al.,* 2023). Choosing a composting method also requires government synergy to stimulate the public to sort waste that can go through the composting process, including by pressuring the industry to put recycling labels on plastics that can be recycled (Pocas and Selbourne, 2023).

This study also simultaneously analyzes the relationship between the dependent and independent variables through logistic regression (Table 5). It selects independent variables for logistic regression modeling using a p-value<0.25. The regression model does not include the knowledge variable regarding the impact of waste because it has a p-value>0.25. By contrast, the other eight variables are included in the regression model because they meet the p-value requirement of <0.25.

Table 5: Bivariate selection results

Independent variables	p-value
General knowledge about waste	0.186
Knowledge of the impact of waste	0.612
Knowledge of protecting the environment	0.000
Knowledge about using plastic during the Covid-19 pandemic	0.000
Waste management attitude	0.000
Willingness to pay	0.007
Attitudes toward plastic use	0.000
Plastic waste-processing behavior	0.000
Plastic use behavior	0.000

Table 6: The first model analysis results of logistic regression

Variables	Plastic use activities during the Covid-19 pandemic				
	B	SE	Wald	p-value	OR
General knowledge about waste	-0.137	0.274	0.251	0.617	0.872
Knowledge of protecting the environment	-0.417	0.285	2.141	0.143	0.659
Knowledge about using plastic during the Covid-19 pandemic	-0.663	0.338	3.853	0.05	0.515
Waste management attitude	0.211	0.327	0.417	0.518	1.235
Willingness to pay	-0.87	0.303	0.083	0.773	0.916
Attitudes toward plastic use	4.000	0.307	1.694	0.193	1.492
Plastic waste-processing behavior	0.968	0.346	7.817	0.005	2.634
Plastic use behavior	0.432	0.324	1.773	0.183	1.540
Constant	-0.586	0.332	3.110	0.078	0.557

Table 7: Final model analysis results of logistic regression

Variables	Plastic use activities during the Covid-19 pandemic				
	B	SE	Wald	p-value	OR
Knowledge about using plastic during the Covid-19 pandemic	-0.920	0.308	8.930	0.003	0.398
Plastic waste-processing behavior	1.377	0.267	26.573	0.000	3.963
Constant	-0.477	0.196	5.936	0.015	0.621

The results of the logistic regression in the initial modeling are shown in Table 6. The variable general knowledge about waste has a p-value=0.617. It does not meet the p-value<0.05, so it is declared not significantly related to plastic use activities during the Covid-19 pandemic. The variable knowledge of plastic use was simultaneously related to plastic use activities during the Covid-19 pandemic (p-value=0.05), with an OR=0.515. This result means that with other variables, respondents with poor knowledge regarding plastic use had the potential to use plastic 0.515 times in their daily activities during the Covid-19 pandemic. Three variables related to attitude, namely, attitude toward processing waste (p-value=0.518), willingness to pay (p-value=0.773), and attitude toward plastic use (p-value=0.193), did not have a significant influence on plastic. Waste-processing behavior was stated to be simultaneously related to plastic use activities during the Covid-19 pandemic, with a value of p=0.005. The modeling results show that respondents who misbehaved in managing waste were 2.634 times more likely to use plastic daily during the pandemic. The behavioral factor variable using waste was also not simultaneously significantly related to plastic use activities during the Covid-19 pandemic with p-value = 0.183 (Table 6).

Table 6 shows two variables significant to plastic use activities during the Covid-19 pandemic in the model. The next step is to look at the most dominant determinants influencing plastic use activities during the Covid-19 pandemic through final modeling, which contains the significant variables in the first modeling. The final modeling results are presented in Table 7.

Based on Table 7, the association between plastic use during the Covid-19 pandemic and the level of knowledge regarding plastic use was statistically significant (p=0.003). The OR of 0.398 suggests a negative relationship between plastic use activities during the pandemic and knowledge. This is further supported by the negative beta coefficient (B) of -0.920. Concurrently, there existed a correlation between behavioral aspects in plastic waste processing and the most recent modeling of plastic use patterns amid the Covid-19 pandemic, as indicated by a statistically significant p-value of 0.000. The plastic waste management behavior variable exhibits a strong positive connection (B=1.377) and OR=3.968, making it the primary determinant of plastic use behaviors during the pandemic. This implies that individuals who exhibited inadequate waste management practices were 3.968 times more likely to engage in regular plastic usage in their daily routines during the pandemic compared to individuals who demonstrated effective waste management practices. The consideration of recycling both

medicinal and non-medical waste is imperative to uphold public health and mitigate potential environmental hazards within the ongoing Covid-19 pandemic (Shekoohiyan *et al*., 2022). In the "new normal" era, efforts to find solutions to excessive consumption and production of plastic waste, unsustainable use, and management of plastic are becoming increasingly urgent (Winton *et al*., 2022). Continuous use of plastic without proper processing and management will trigger plastic pollution (Mukhtar *et al*., 2023). Before the Covid-19 pandemic, SUP waste was considered a major environmental problem in land and marine ecosystems. The global impact of plastic pollution has a detrimental impact on flora and fauna, social welfare, and public health. Plastic waste is known to cause environmental stress, adding micropollutants to world ecosystems that are vulnerable and stressed by change (Jayasinghe *et al.,* 2022). Previous research explains that most plastics are burned, resulting in more significant pollution (Sun *et al.,* 2023). Poor waste management can be the root of many health and environmental problems, from the spread of disease to the increased release of new pollutants (such as MPs) into the environment (Mahmoudnia *et al.,* 2022). Plastic generally ends up in landfills and is difficult to biodegrade, leading to dirty environmental conditions. Plastic waste has the potential to block sewer lines and drainage systems, which facilitates the breeding of disease agents such as mosquitoes. This condition can also be a means for the growth of other pathogens that cause malaria, cholera, typhus, diarrhea, and other diseases (Mukhtar *et al*., 2023). Therefore, drastic measures are needed to reduce the amount of plastic pollution (Van Rensburg *et al.,* 2020). The ineffectiveness and inadequacy of current waste management systems and the lack of proper enforcement of environmental regulations, post-pandemic mishandling of plastic waste have escalated rapidly, causing severe environmental impacts (Raja *et al.,* 2020). Climate change and the emergence of particulate matter are the most influential impact categories in all waste processing scenarios considered, amounting to 74%–76% of the total environmental impact. Environmental pollution, including plastic pollution in land, air, and water environments, is also the cause of toxicity in humans, amounting to 20%–22% of the total toxicity cases (Bracquené *et al*., 2021). Facility closures during the pandemic also had a significant impact on plastic recycling facilities around the world. This condition resulted in the inappropriate and illegal dumping of plastic waste into the sea and land (Shams *et al*., 2021). The dominance of online plastic packaging sales likewise causes plastic waste accumulation. The increase in the amount of waste contradicts the public's desire to recycle waste (Abhilash and Inamdar, 2022). One solution can be offered by increasing public knowledge regarding efficient waste management. Public knowledge about efficient waste management will encourage the community to participate in waste management. Besides encouraging positive societal decisions, efficient waste management will reduce waste pollution and save costs (Fadhullah *et al*., 2022). During the Covid-19 outbreak, there has been a notable surge in the utilization of personal protective equipment (PPE) and disposable plastic items. The condition bears consequences for plastic garbage, as the improper handling of such items poses a growing risk of environmental harm. Bio-based or biodegradable plastics have the potential to serve as a feasible substitute for synthetic polymer plastics. The global rental production capacity for biodegradable or bio-based plastic is presently limited to a mere 4 million tons. Developing biodegradable plastic materials, such as face masks, has become essential and has achieved significant development progress. The substitution of these commodities with synthetic plastics constitutes a crucial measure in mitigating the environmental repercussions of the pandemic (Mahmoudnia *et al*., 2022). Individual motivation can encourage individuals to take the initiative to carry out behavior, but external motivation will encourage them to improve behavior for external rewards and pressure. Self-motivation can continue to improve and maintain waste-sorting behavior to a certain level (Wang *et al*., 2022). Recycling SUP waste is a difficult task because the composition of plastic itself is complex (Bracquené *et al*., 2021). Therefore, people need to be aware of the use of SUP and switch to shopping bags that can be used many times. Based on previous research, the composition of plastic waste produced by households in one region in Malaysia reached 19%. The study also explains that locality is a significant factor related to perceptions of waste management, with a p-value of 0.04 (p-value<0.05). Most respondents (80.2%) believe that plastic recycling is a way to increase economic

development (improving economic and social welfare), and 79.3% believe that increasing plastic recycling will create new jobs (Roche *et al*., 2021). The results of this study and the scientific debate with previous research show the importance of increasing public knowledge regarding waste in general to include knowledge regarding waste during the Covid-19 pandemic. Basic knowledge regarding waste and knowledge that focuses on the reality faced by society, namely, the Covid-19 pandemic conditions, will encourage positive attitudes and behavior in protecting the environment through controlling decisions in using plastic waste. Continuous training can increase knowledge so that the entire community can manage waste well. If this training can be carried out in the household environment, it can motivate people to control the accumulation of household waste (Fadhullah *et al*., 2022). The community must also be motivated to protect the surrounding environment from plastic pollution (Shekoohiyan *et al*., 2022). Attitudes and knowledge can change if they get motivation from the social environment. Therefore, if the community can behave well toward the use of plastic, then a person's attitude will also be good toward the perception of the use of SUP (Wang *et al*., 2022). A person's behavior will change if there are three elements present within them, namely, ability, motivation, and opportunity (Allison *et al*., 2022). Meanwhile, some motivation itself comes from within the individual, and some from outside the environment (Wang *et al*., 2022). This finding is reinforced by other research showing that a combination of skills, opportunities, and motivation is required to implement behavior, indicating the need for a holistic approach to intervention design (Winton *et al*., 2022). The government is an essential actor in stimulating people's desire to be able to process and manage plastic. According to Pocas and Selbourne (2023), the government is the actor most responsible for information regarding the benefits of plastic for society as consumers. The government can formulate regulations that pressure business actors to use plastic that can be recycled or reused, as is done in European countries (Pocas and Selbourne, 2023). In 2020, China introduced policies to reduce plastic consumption and encourage a more environmentally friendly lifestyle by gradually banning or limiting the production, sale, and use of several actively promoted plastic products (Sun *et al*., 2023). The Indonesian government has emphasized that the implementation of waste management can be carried out by district/city governments by establishing waste management policies and strategies based on provincial and national policies. In Law Number 18 of 2008, district/city governments have the authority to develop and supervise the performance of waste management carried out by other parties. Regional governments also have the authority to determine the location of temporary storage areas, integrated waste processing sites, and/or final waste processing sites. Law Number 18 of 2008 also explains the community's obligation to manage household waste, including reducing and handling waste in an environmentally sound manner. Manufacturers are also encouraged to include labels on packaging, with the aim of making it easier to sort and handle waste, including plastic. This law emphasizes that producers must manage the packaging and/or goods they produce that cannot or are difficult to decompose by natural processes. The Republic of Indonesia Government Regulation Number 81 of 2012 concerning the Management of Household Waste and Similar Household Waste reaffirms the role of producers in managing plastic. Producers must develop plans or programs to limit waste generation and use packaging that is easily decomposed in nature and produces as little waste as possible (Pemerintah Indonesia, 2012). Republic of Indonesia Government Regulation Number 27 of 2020 concerning Special Waste Management, including Plastic, also states that waste management is done through reduction and handling. This reduction limits the generation of specific waste, recycles specific waste, and reuses plastic waste. Meanwhile, the handling referred to in government regulations is sorting, collecting, transporting, processing, and final waste processing (Pemerintah Indonesia, 2020). Indonesian government regulations cover various waste issues, from processing, management, and use to emphasizing different responsibilities for each element of society. Good regulations then require appropriate implementation accompanied by monitoring and evaluation, as also contained in the regulations. Previous research states that the supervision, monitoring, and evaluation process carried out by the government can be influenced by systemic challenges, such as ineffective

communication and top-down policies (Trubetskaya *et al*., 2022). The government can also start increasing monitoring and evaluation of programs that have been designed as permitted by regulations in Indonesia. Furthermore, it can use the results of this research as a consideration in designing programs by focusing on increasing knowledge about the use of plastic and plastic waste management behavior.

CONCLUSION

This study explains plastic utilization activities during the Covid-19 pandemic. Plastic use during the pandemic was largely prevalent (53.2%) among the general population. A significant proportion of individuals lacked enough understanding of waste in a broader context, with 52.9% exhibiting limited knowledge. A considerable majority (65.8%) likewise possessed insufficient awareness regarding the ramifications associated with the utilization of plastic materials. By contrast, a significant proportion of the general population possessed a commendable level of understanding pertaining to the use of plastic materials amid the pandemic, with 71.6% demonstrating awareness in this regard. Additionally, a noteworthy percentage of individuals (51.8%) exhibited a commendable level of knowledge concerning the safeguarding of the environment during the pandemic. Community attitudes tend to be good in using plastic waste (56.1%), willingness to pay (59.4%), and waste management (50.7%). The majority of waste usage behavior was poor at 53.2%, whereas waste management behavior tended to be good at 57.6%. General knowledge about waste (p-value=0186) and the impact of waste (p-value=0.612) were not significant on plastic use activities during the Covid-19 pandemic. Partially, knowledge about plastic during the Covid-19 pandemic (OR=3.345), knowledge of maintaining the environment (OR=2.370), plastic use attitudes (OR=0.363), waste management attitudes (OR=0.325), plastic use behavior (OR=0.305), and plastic waste management behavior (OR=0.216) were significantly related to plastic use activities during the pandemic, with each having a p-value=0.000. Willingness to pay was also partially related to plastic use activities during the pandemic, with p-value=0.007 and OR=0.510. Simultaneously, knowledge about plastic was significantly related to plastic use activities during the Covid-19 pandemic (p-value=0.003), with OR=0.398, and the direction of the relationship was negative (B=-0.920). Plastic waste management behavior was the dominant factor influencing plastic use activities during the pandemic (p-value=0.000). Individuals with poor plastic waste management behavior had 3.963 times more significant potential to frequently use plastic in their daily activities than those with good behavior in managing plastic waste. Plastic consumption has increased since the Covid-19 pandemic. This situation happened because of changes in human lifestyle during the pandemic, cheap prices, and easy access. Plastic pollution has various impacts, both on environmental health and human health. Several actions can be taken to address potential adverse impacts, starting with selective delivery of materials to recycling sites and improvements to the sorting stage. This research recognizes the need to deepen the community's barriers to good plastic use and management behavior. However, this research is limited to behavioral determinant factors, namely, attitudes, knowledge, and actions. It is hoped that future research can further explore the determinants of individual behavior by using different perspectives, such as the health belief model. This model can dissect individual perceptions from various aspects, including perceived barriers and perceived benefits, which are not the focus of the current research. Future research can also collect information through a qualitative approach to find in-depth information.

AUTHOR CONTRIBUTIONS

H. Herdiansyah, the corresponding author, was responsible for supervising the study, obtaining funding, conceptualizing the research, developing the methodology, and preparing the resources. Nuraeni participated in writing the original draft, reviewing and editing, preparing pictures, analyzing the data, interpreting the results, preparing the tables of study results, and drawing conclusions.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely observed by the authors.

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ABBREVIATIONS

>	More than
≤	Less than or equal to
<	Less than
%	Percent
-	Minus
–	Until
4R	Reduce, reuse, recycle, and recover
B	Beta coefficient
Covid-19	Coronavirus disease 2019
MP	Microplastic
NFC	Near-field communication
OR	Odd ratio
p-value	The probability under the assumption of no effect or no difference
PPE	Personal protective equipment
PSBB	Pembatasan Sosial Berskala Besar (Large-Scale Social Restrictions)
SE	Standard Error
SIPSN	Sistem Informasi Pengelolaan Sampah Nasional (National Waste Management Information System)
SPSS	Statistical Program for Social Science
SUP	Single-use plastic

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