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Unmasking emerging issues in solid waste management: Knowledge and self-reported practices on the discarded disposable masks during the COVID-19 pandemic in the Philippines

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**ABSTRACT**

The COVID-19 global health crisis has resulted in the emergence of a new type of solid waste—inaappropriately discarded disposable masks (DMs)—posing serious risks to the public health and to the environment. This study assessed the knowledge (“K”) and self-reported practices (“P”) of the general public in DM waste management. A researcher-developed instrument was utilized to gather data with a reliability coefficient index of 0.94. The survey was participated in by 13,116 online users. Pearson r and multiple linear regression were performed to test the relationship between the participants’ demographic characteristics and their K and P. Results revealed that the participants obtained a weighted mean and standard deviation of 1.15±0.10, which shows that 11,597 or 88.41% are knowledgeable on solid waste disposal and management. The self-reported practices of the participants obtained weighted mean and standard deviation rating of 2.16±0.10, which is interpreted as “Always Practiced”. This signifies that the participants adequately practiced the essentials in disposing DMs. Furthermore, there is a significant relationship between K and P with their demographic characteristics on disposing DMs like age, sex, level of education, annual income, and type of residence. The obtained Pearson r=−0.178 (p<.01) indicates that the level of knowledge of the participants is significantly related to the practices they apply in disposing used DMs. As a recommendation, campaigns and interventions on the proper disposal of DMs should be put forward and implemented, utilizing various social media resources and platforms that are conveniently accessible to the general public.

1. Introduction

With the emergence and detection of the Corona Virus Disease in 2019 (COVID-19) and the World Health Organization’s (WHO) official declaration of a global pandemic resulting from this disease, restrictions implemented in varying extents have been put in place throughout the world to mitigate its ramifications in people’s health and lives (Abbasi et al., 2020; Adhikari et al., 2020; Almulhim et al., 2021; Centers for Disease Control and Prevention 2020a; Shang et al., 2020; Sohrabi, Alsaifi, O’Neill; World Health Organization 2020a). A number of systems and plans have been initiated and conducted in affected countries to contain the spread of the virus, and to consequently lessen the negative social and economic impacts brought about by the disease. In the Philippines, people are required to conform to specific health protocols and to apply certain safety practices, as a way of minimizing public health risks from COVID-19.

The Philippine national government, together with the local government units (LGUs), have recommended a number of mitigating measures, which include placing certain areas identified as high-risk zones into lockdown (staying or isolation at home), determined as the most effective preventive measure (Fadare and Okoffo, 2020; Kulkarni and Anantharama, 2020; Parashar and Hait, 2021; Saadat et al., 2020; Urban and Nakada, 2021). Other means of controlling the effects of the disease include physical and social distancing, and restricting travel and mobility (Chintalapudi et al., 2020; Lin et al., 2020; Fadare and Okoffo, 2020; Imdad et al., 2020; Parashar and Hait, 2021; Rubio-Romero et al., 2020; Selvarajan et al., 2021; Sun et al., 2020). Apart from these measures, performing proper hand washing and hygiene, as

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well as wearing of disposable masks (DMs) and face shields in public spaces in the country have been additionally ordered.

In fact, the present Philippine national government mandated the use of face masks or DMs all over the country to avoid getting infected with the virus, resulting in the issuance and implementation of local ordinances on the mandated use of face masks or DMs from different LGUs (Mendez and Tupas, 2020). Face masks are generally homemade cloth masks or non-medical fabric masks that can be crafted at home from different kinds of textiles and that can be washed after every use. On the contrary, DMs are disposable, loose-fitting masks that are initially reserved for healthcare workers and first responders, as recommended by the Center for Disease Control and Prevention (CDC, 2020b). However, due to the global pandemic, even non-medical individuals are now required to wear DMs on a daily basis for protection and safety purposes (Almulhin et al., 2021; CDC 2020c; Kahlert and Bening, 2020; Parashar and Hait, 2021; Rowan and Laffey, 2021; Saadat et al., 2020; World Health Organization, 2020b). Consequently, sellers have seen this as an opportunity to engage in physical and online trading of DMs, which people would then buy in bulk and use daily for protection against the disease. For this reason, this study focuses on the use and disposal of DMs in the Philippines.

The use of DMs as a preventive response to the increasing number of COVID-19 infections among people has eventually resulted in doubling the production of DMs to address public demand for consumption. The demand for DMs grows in a consistent rate and increases to 1.2 billion per month, assuming that 20 million households in the country necessitate the use of two face masks every day (Crismundo, 2020). Such a large sum of DMs does not yet take into account DM donations from international governments and non-government organizations to be distributed and utilized in hospitals, isolation centers, and quarantine areas in the country. In effect, the COVID-19 health crisis has surface a new waste item that poses added burden to the environment—improperly discarded DMs.

Discarded DMs are inappropriately littered in different environmental areas where plastic and plastic particle wastes should not be thrown, such as in water bodies, in public roads and highways, and in mountainous areas. This waste item poses negative impact in the marine ecosystem as it becomes marine debris (Almulhin et al., 2021; Arduso et al., 2020; Chakraborty and Maity 2020; De la Torre et al., 2020; Kutralam-Muniasamy et al., 2020; Mallick et al., 2021; Martinez Silva and Nanny, 2020; Mol and Caldas, 2020; Parashar and Hait, 2021; Rume and Islam, 2020; Vilagran et al., 2020), and it threatens people whose livelihoods primarily depend on aquatic resources (Department for Environment, Food and Rural Affairs (2020); Kasam, 2020). Discarded DMs could also be spotted in public roads and highways (Bamber, 2020) – posing a potential source of viral transmission to people, most especially to garbage collectors (CDC, 2020d; Das et al., 2021). The World Health Organization (World Health Organization 2020c) reported that incorrect disposal of these masks may actually increase the rate of viral transmission. Certainly, COVID-19 has not only given rise to a global pandemic, but has also led to the increased production and consumption of DMs, resulting in the emergence of a new environmental challenge (Das et al., 2021; Mallick et al., 2021; Parashar and Hait, 2021). This environmental challenge arises from the fact that other wastes that should be managed properly should not be ignored. Biomedical waste management is an equally important matter as the world grapples with the pandemic. In a cross-sectional study, Jalal et al. (2021) found that 41% of the respondents had excellent knowledge of biomedical waste management. In communities that are put under lockdown, the household waste should also be given attention. Filho et al. (2021) report that 45–48% of the respondents observed an increased consumption of packed food, fresh food, and food delivery during the lockdown. These potentially increased waste generation during the lockdown.

Figure 1 shows the unacceptable disposal of DMs in oceans, highways, mountains, and other places in the country during the pandemic. The figure implies that Filipinos apply improper waste management practices in discarding DMs. The emergence of discarded DMs as environmental litter both in the terrestrial and aquatic environments clearly testifies to the environmental aftereffects of inappropriate waste management practices among the people. There is sufficient evidence from studies conducted that people demonstrate inadequate knowledge and unacceptable practices in terms of the use and disposal of DMs (Ahmed et al., 2020; Kelkar et al., 2013; Kumar et al., 2020; Parashar and Hait, 2021). Thus, this study was conducted to assess the knowledge and self-reported practices of the general public in the Philippines when it comes to disposing DMs to limit the spread of COVID-19, and to determine if there are significant correlations to their personal characteristics. Realizing these aims will make the study to be the first in the country to problematize the environmental ramifications of the improper disposal of DMs, and to explore Filipinos’ waste management behavior in relation to discarding DMs. This study is then significant to other contexts as the problems that it addressed could be prevalent in other places in the globe, and could also be replicated or redesigned for further studies. By inquiring into the waste management practices of Filipinos, disposal problems could be minimized, if not eradicated through evidence-based policies that could be crafted and implemented. While the application may be local in context, the information obtained from this empirical study would have far-reaching impacts to countries and governments desiring to solve similar problem.

2. Methods

2.1. Study area

Philippines, which is a country composed of 7640 islands, is located at the western Pacific Ocean (see Fig. 2). The islands are grouped together to form the three main geographical categories from north to south— Luzon, Visayas, and Mindanao. The country is surrounded by the South China Sea at the western part, the Philippine Sea at the east, and the Celebes Sea at the southwest section. Manila is the country’s capital city, while its largest metropolis is Quezon City; both of which are situated at the urban zone of Metro Manila. Philippines is considered to be the twelfth most populous country in the world, containing a population of approximately 109 million Filipinos in its area that covers 300,000 km² (120,000 sq mi). Since the country is home to peoples of diverse ethnicities and varied cultures, it is identified as a multinational state.

In terms of waste management, there are legislative measures to ensure safe and clean environment. The disposal of used DMs, even prior to the COVID-19 pandemic, is covered by an issuance of the Philippine Department of Environment and Natural Resources (DENR). The administrative order (AO 22–2013) was issued to mandate the legally acceptable management of used face masks and other infectious wastes generated by hospitals, clinics, and health centers across the country.

2.2. Sampling technique

Through an online survey questionnaire facilitated and administered through the use of Google Forms, online users were requested to share their knowledge and practices in using and disposing DMs. The link for the survey was kept open for five months—from January until May 2021—to allow for the maximum participation of interested online users and to provide sufficient time for responding to and retrieval of the questionnaire. In this case, involvement in this study was voluntary. There were 16,497 online users who completed the online survey questionnaire. However, only 13,116 were qualified as participants, which means that the remaining 3381 people were excluded in the study because they did not meet the set criteria. In order to be included as participants in this study, an individual must be: 1) a Filipino citizen; 2) 18 to 70 years old; 3) permitted by the authorities to acquire essential needs from outside their residences; and 4) using at least three DMs per week.
2.3. Participants

Two groups served as participants in this study – the first group is composed of experts who validated the questionnaire, and the second group is comprised of the general public who answered the questionnaire. The experts were 21 healthcare professionals who were purposively selected because of their experience and expertise in the medical field. They are doctors, nurses, public health and biology professionals invited to validate the research instrument. For the chosen health care professionals, the following selection criteria were used: (1) currently serving as a health care provider in a clinic or hospital; (2) obtained at least a Bachelor’s degree in medicine or any of the allied health sciences; (3) at least ten years of experience as a health care professional; and (4) residing in the country. For the chosen biology professionals, the following selection criteria were adopted: (1) currently holding a teaching or research position in an academic institution; (2) obtained at least a Master’s degree in biology and its allied disciplines; (3) actively engaged in research activities in biology; (4) employed as biology professor or researcher for at least ten years; (5) residing in the country. On the other hand, the general public is represented by online users.
coming from the 17 regions of the Philippines, each with representatives, as shown in Fig. 3. The electronic administration of the questionnaire paved the way for large-scale implementation of this study.

2.4. Study tool

The researcher-made instrument used in this study was composed of four parts: Part 1 includes the informed consent form; Part 2 asked for the participants’ personal characteristics; Part 3 is composed of the 37 items that examine the knowledge and practices of the participants in disposing DMs; and Part 4 is composed of five open-ended questions. Nineteen items in the questionnaire specifically look at the participants’ knowledge of DM disposal, whereas the remaining 18 items particularly assess their practices in DM disposal. Responses to knowledge items were “True” or “False”, while responses to practice items were “Always”, “Sometimes”, or “Never”. The researchers used Pearson r and Multiple Linear Regression to determine the significant relationship between demographic profile and knowledge and practices of the respondents. The researcher-made instrument underwent through two stages to test its validity and reliability; it was validated and pilot tested before it was deployed for actual gathering of data. The first stage is the conduct of content and face validations. The instrument was sent to different healthcare professionals to obtain their comments and suggestions for the improvement of the data gathering tool. All the suggestions and recommendations were considered and incorporated in the revised version of the instrument. The second stage was the test of the instrument’s reliability. The questionnaire was pilot tested to 50 adults to compute for its reliability coefficient through the Cronbach Alpha statistical treatment. The test examines how reliable large-scale survey instruments are. The computed value tells how closely related a set of items are as a group. These 50 adults were composed of students, professionals, and urban and rural residents, hence, they were selected based on their demographic profile. A reliability coefficient index of 0.94 was yielded, which means that the questionnaire is excellent (George and Mallery, 2003).

After testing the validity and reliability of the researcher-made instrument through the two-stage process of expert validation and pilot testing, the instrument was then converted to its electronic version via Google Forms Application. The link of the survey questionnaire was then posted to the social networking sites of various government agencies and non-government organizations. It was also disseminated through the researchers’ social media platforms to gather maximum participation from online users. Such a mechanism of administering the survey instrument was made due to travel and mobility restrictions that were in place in public areas, and more importantly, in order to collect data from the different regions in the country. With the expanding internet connectivity across the country and predominant ownership of a mobile phone among Filipinos, there was a relatively wide reach of the invitation to participate in the survey.

2.5. Data analysis

Descriptive statistics was used for summarizing the demographic characteristics of the participants. The data collected were analyzed using the SPSS software for Windows, version 26.0. Pearson r and Multiple
Linear Regression were performed to test the relationship of the participants’ demographic characteristics and knowledge and practices in the use and disposal of SMs.

Pearson’s r correlation coefficient formula is as follows: 
\[ r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}} \]  
(2)

The multiple linear regression formula is presented below where: 
\[ y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_p x_{ip} + \epsilon \]  
(3)

3. Results and discussion

Figure 4 presents the demographics of the 13,116 participants in this study. The majority of the participants are classified under the 18–25 age bracket (58%). It can also be observed from the figure that 8172 or 62.4% are females, more than half are college graduates (51.2%), most of them (69.3%) are receiving <200,000 pesos ($4000) as an annual income and reside in rural areas (63.5%). 99.9% of them are using disposable masks.

3.1. Knowledge on the disposal of DMs

Table 1 shows the results of the self-reported practices of the respondents in disposing the utilized DMs. The majority of the participants got all the correct answers, ranging from 63.03% (8268) to 99.17% (13,008), which implies that they are knowledgeable in disposing DMs. 13,008 or 99.17% (1.01±0.09) of the respondents acknowledged that disposing correctly the utilized DMs is their responsibility. In reality, however, this finding is inconsistent with the reports made by Abatayo (2020); Chua (2020), and the Department Environment and Natural Resources (2020) that DMs are disposed in the Philippine roads, mountains, beaches, rivers, and oceans. Some urban cities in the country, like Cebu and Valenzuela, have issued and have been implementing ordinances to penalize the improper disposal of masks (dela Cruz, 2020). These legal interventions prohibit people from throwing and dumping DMs in public places. If people are aware of the acceptable ways on how to dispose SMs, as demonstrated in the findings of this study, then local authorities would not have resorted to legal actions, reinforced by directives from the national government, particularly from Department of Interior and Local Government (DILG).

The reports on improper disposal of DMs in public areas is also supported by a number of other studies concluding that people are not responsible enough in discarding their used masks (Fadare and Okoffo, 2020; Kalina and Tilley, 2020; Prata et al., 2020). Colina (2020) and Health (2020) pointed out that disposable DMs should not be flushed in the toilet and must not be thrown into canals,
Fig. 4. Demographics of the samples.

streams, rivers, beaches, or any bodies of water, as these may become potential health hazards. Certainly, there is mismatch between the self-reported knowledge of the participants and the actual practices of people in terms of disposing their DMs, as verified by news reports and findings from studies (Collina, 2020; Health, 2020).

The researchers argue that the actual practices of the participants may yield substantially different findings. The study by Olaifa et al., (2018) supports this argument. It was revealed in their study that in order to increase awareness on the proper disposal of DMs among people, then there is a need to continue educating them in whatever platforms (Das et al., 2021; Mallick et al., 2021; Parashar and Hait, 2021) and regardless of their demographics. The information to be shared to continuously educate people on proper DM disposal should include the composition of DMs, hazards associated with improper disposal, and proper and safe ways to dispose these. In doing so, the information will be inculcated and will become part of the good habits of people. The lowest score in the self-reported knowledge of the participants pertains to the item, putting other’s lives at risk if improper segre-
Table 1
Self-reported knowledge of the general public in disposing SMs.

| Knowledge | Correct Answer n (%) | Score (mean ± SD) |
|-----------|----------------------|-------------------|
| Disposable masks cannot be recycled. | 11,899 (90.71) | 1.15±0.35 |
| Disposable masks can be reused. | 10,560 (80.51) | 1.80±0.40 |
| The discarded mask has secretions, which can be dispersed and transmitted through air. | 10,968 (83.62) | 1.16±0.37 |
| There are proper trash bins where utilized disposable masks are to be disposed. | 12,120 (92.40) | 1.08±0.27 |
| The right way to discard surgical masks is folding it half inwards. | 10,867 (82.85) | 1.17±0.38 |
| I will get infected if I touch the discarded mask. | 10,512 (80.14) | 1.20±0.40 |
| I can get sick if I touch a discarded mask in the bin without washing my hands. | 12,084 (92.12) | 1.08±0.27 |
| Disposal of face mask must be within a 4-meter distance from people’s activities or sleeping area. | 11,844 (90.30) | 1.10±0.30 |
| Bins must not be within children’s reach. | 12,780 (97.43) | 1.03±0.16 |
| It is my responsibility to dispose the surgical masks correctly and responsibly. | 13,008 (99.17) | 1.01±0.09 |
| Surgical masks are considered medical wastes. | 12,336 (94.05) | 1.06±0.24 |
| Used disposable masks should be disinfected so these will not become second source of Covid-19. | 11,988 (91.39) | 1.09±0.28 |
| Mixture of disposable masks and recyclable waste may cause a potential danger to garbage collectors when they put their hands in the waste bins. | 12,776 (97.40) | 1.04±0.20 |
| Special trash cans/bins for disposed masks should be set up in communities as disposal points. | 12,408 (94.59) | 1.05±0.23 |
| I should not randomly discard a disposable mask as this may carry Covid-19. | 11,796 (89.93) | 1.10±0.30 |
| Contaminated masks should not be mixed with household wastes. | 12,468 (95.05) | 1.05±0.22 |
| I believe that proper and correct disposal of disposable masks may stop the spread of Covid-19. | 12,480 (95.14) | 1.05±0.21 |
| I might be putting the others’ lives at risk without proper segregation of face masks. | 8268 (63.03) | 1.37±0.48 |
| Keeping the disposable mask in a paper bag for a minimum of 72 h prior to its disposal is recommended. | 9180 (69.99) | 1.30±0.46 |
| 11,597 (88.41) | 1.15±0.10 |

Note: 0.01–1.99 True; 2.00–2.99 False; n-sample; %-percentage; SD-Standard Deviation.

3.2. Self-reported practices on the disposal of DMs

The descriptive computation of the self-reported practices of the general public in disposing DMs is presented in Table 2. The table shows that all of the participants in this study (100% or 13,116) do not practice burying the discarded DMs ten feet below the ground to prevent infection – a statement which does not conform to the recommendations by Bandela (2020), who put forward the idea that DMs must have to be incinerated or buried at a depth of, at least, ten feet from the Earth’s surface to kill the virus. Studies from Rowan and Laffey (2021), Ghodrat et al. (2017), and Wang et al. (2020) corroborated with the idea that incineration is deemed to be safe, simple and effective. Pouring hot water on the used DM is not also practiced by the participants (8160 or 62.2%); whereas 1272 (9.7%) reported that they perform the method of decontaminating the DMs before throwing it. However, it should be noted that pouring hot water alone without observing 56 °C temperature for the liquid and without soaking the SMs in it for 30 min would not kill the viruses (Wang et al., 2020).

More than half (52.6% or 6900) of the respondents practice discarding the used DMs in an open bin while 8100 (61.8%) in closed bins. The knowledge in discarding DMs in an open or closed bin is a favorable attitude as far as waste management is concerned, however, discarding it in a closed bin is more preferable. 28.1% (3684) of the respondents reported that they do not discard their DMs after using them, while 71.9% or 4933 discard them after use. Rowan & Laffey (2021) and World Health Organization 2020e urged that DMs are for one-time use only and cannot be reused. Another incorrect practice the respondents reported was the non-folding into half of the DMs (5760 or43.9%) and non-cutting them into small parts (6996 or 53.3%). Abronsum (2020) asserted that DMs must be folded in half inwards before throwing it away in a closed bin to avoid viral transmission or infection and potential reuse by other individuals—a statement which was supported by a number of researches conducted (Cudauya, 2020; D’Costa, 2020; Ong, 2020). Cutting used DMs into pieces is a practice to ensure that these are not washed and reused by garbage scavengers.
Moreover, washing hands after removing DMs were done only by 10,369 of the participants (79.1%), which implies that 20.9% of the participants are not washing their hands after removing the used DMs, an incorrect practice among them. The CDC (2020) and Medical University of South Carolina (2020) advocates for washing hands before and after removing SMs so that infections are avoided. Hand washing is always the last step after removing and disposing DMs (CDC, 2020), as hand hygiene is one of the most important measures to prevent the spread of the virus. Disinfecting the bins before using it again was not practiced by 53% of the participants, although it should be emphasized that thorough cleaning and disinfection is important for infection prevention and control (Victoria State Government, 2020).

It is worthy to note that, 63.3% of the participants admitted to throwing their discarded DMs in recycle bins. This finding is consistent with the report of The Brussels Times (2020), where it was revealed that residents throw their DMs in recycle bags, although these waste items are not supposed to be recycled. Studies would also maintain that DMs must not be disposed of in recycling bags (Coach, 2020; Fuller and Gibson, 2020). It was found that the participants in this study throw away their used DMs in recycle bins because at present there are no designated garbage bags where the DMs could be properly discarded. This may be attributed to the lack of expert consultation and planning among LGUs when it comes to proper waste management, which could have resulted in a more comprehensive and strategic policy-making. Vanapalli et al., (2021) suggested that a specific colored bags must be provided by the LGUs to households to dispose their used DMs in sealed bags—this way can make easy separation and treatment.

More than half of the respondents disposed their DMs when it has tear/s (8580 or 65.4%), and fell to the ground (7620 or 58.1%), which indicates that the remaining half of the participants do not discard them immediately when it has tear/s and has fallen to the ground, instead the participants would reuse them as much as they want. (Centers for Disease Control and Prevention 2020g), and The Washington post (2020) advised that, when the DM was soiled, damaged and torn, then it must be thrown away immediately since it may have been contaminated by bacteria or other organisms—the participants, however, do not heed to this advice. The immediate disposal of DMs if it fell on the floor were performed by more than half of the participants (7620 or 58.1%), while the remaining percentage were undecided and/or reused the mask. Washing the used DMs before discarding them is not a practice among the participants (8065 or 61.5%). This may be attributed to the recommendation from the aforementioned studies that SMs are not reusable, and therefore, must be discarded at once after use.

### Table 2

| Practices | Always n(%) | Sometimes n(%) | Never n(%) | Score (mean±SD) |
|-----------|-------------|---------------|-----------|-----------------|
| I do not reuse disposable masks. | 6637 (50.6) | 3768 (27.8) | 2711 (20.7) | 2.30±0.79 |
| I discard disposable masks after each use. | 9433 (71.9) | 3348 (25.5) | 335 (2.6) | 2.69±0.51 |
| I dispose it immediately upon removal in open bins. | 6900 (52.6) | 4453 (33.4) | 1763 (13.4) | 2.79±0.71 |
| I dispose it immediately upon removal in closed bins. | 8100 (61.8) | 4512 (34.4) | 504 (3.8) | 2.58±0.57 |
| I dispose it in a plastic bag or zip-lock bag before throwing it in the garbage bag. | 4729 (36.1) | 5711 (43.5) | 2676 (20.4) | 2.16±0.73 |
| I cut the used disposable masks into half before I discard it. | 3552 (27.1) | 4004 (30.5) | 5760 (43.9) | 1.83±0.83 |
| I cut the used disposable masks into small parts to prevent re-using them. | 2748 (21.0) | 3372(25.7) | 6996 (53.3) | 1.66±0.80 |
| I wash my hands before taking off the mask. | 7260 (55.4) | 4560 (34.8) | 1296 (9.9) | 2.45±0.67 |
| I wash my hands after taking off the mask. | 10369 (79.1) | 2494 (19.0) | 253 (1.9) | 2.77±0.46 |
| I burn it to avoid infection. | 1777 (13.5) | 4474 (34.1) | 6865 (52.3) | 1.61±0.71 |
| I bury it at a depth of at least 10 feet from the surface in order to prevent infection. | 0 (0.0) | 0 (0.0) | 13177 (100) | 1.59±0.71 |
| I disinfect the bins before using it again as a bin. | 6169 (47.0) | 4931 (37.6) | 2016 (15.4) | 2.32±0.72 |
| I do not put the surgical masks in a recycle bin. | 4152 (31.7) | 4631 (35.3) | 4333 (33.0) | 1.99±0.80 |
| I place disposable masks in rubbish bags, tied and kept separate from other wastes. | 6096 (46.5) | 5820(44.4) | 1200 (9.1) | 2.37±0.65 |
| I pour boiling water on the disposable masks before disposing them. | 1272 (9.7) | 3684(28.1) | 8160 (62.2) | 1.47±0.67 |
| I dispose my disposable masks immediately it has torn. | 8580 (65.4) | 3695(28.2) | 841 (6.4) | 2.59±0.61 |
| I dispose my disposable masks immediately if it fell to the floor. | 7620 (58.1) | 4835 (36.9) | 661 (5.0) | 2.53±0.59 |
| I wash the used disposable masks before discarding. | 1765 (13.5) | 3286 (25.1) | 8065 (61.5) | 1.52±0.77 |

Note: 0.01–1.00-Never; 1.01–2.00-Sometimes; 2.01–3.00-Always; n-sample%; percentage; SD-Standard Deviation.

### Table 3

| Variables | Knowledge | Practices |
|-----------|-----------|-----------|
| | Sig. r | Sig. r | Sig. r | Sig. r |
| | | | | |
| Age | -0.079** | .000 | -0.178** | .000 | -0.028** | .002 | -0.178** | .000 |
| Sex | -0.056** | .000 | -0.085** | .000 | -0.056** | .000 | -0.056** | .000 |
| Education | .031** | .000 | -.044** | .000 | -0.031** | .000 | -0.044** | .000 |
| Annual income | .045** | .000 | -0.019* | .029 | .045** | .000 | -.019* | .029 |
| Residence | .049** | .000 | -.006** | .000 | .049** | .000 | -.006** | .000 |

Note: *p<0.01; **p<0.05

The self-reported practices of the participants obtained a weighted mean rating of 2.16±0.15, which is interpreted as "Always Practiced". This data manifests that the participants adequately perform the essentials in disposing DMs, particularly during this time of the COVID-19 pandemic. Adequate practice score of the participants was 41.2% (5398), which is fairly higher than the recorded 31.5% in a study conducted in Ethiopia (Azage et al., 2013). Nevertheless, higher percentages were found in Pakistan, South Africa, and Sri Lanka. In these countries, the following quantitative results were yielded—70.7%, 77.4%, 53.9% and 74.8%, which denotes that the participants in these studies apply acceptable practices in waste management of used DMs (Ajmal and Ajmal, 2017; Deres et al., 2018; Olaifa et al., 2018; Samarakoon and Gunawardena, 2011). The relatively low score of the participants in this study could result from the lack of waste management trainings, information dissemination campaigns, and/or negative attitudes of the participants in practicing appropriate measures in the disposal of DMs—a recommendation supported by Vanapalli et al., (2021).

### 3.3. Correlation between the demographic characteristics and the knowledge and self-reported practices in disposing DMs

Results of the correlation between the self-reported knowledge and practices and demographic characteristics is presented in Table 3. The obtained coefficients of correlation between knowledge on disposing DMs and the demographic characteristics of the participants are statistically significant like age (r=0.79, p<.01); sex (r=-0.056, p<.01); level of education (r = 0.031, p<.01); annual income (r=0.045, p<.01); and type of residence (r = 0.049, p<.01). The findings indicated that these demographic characteristics of the participants affect their knowledge in disposing DMs; the younger the age, the better the knowledge than...
those older in age. Age can then influence knowledge (Beier and Ackerman, 2003; Laor et al., 2017) on the proper disposal of DMs.

The high level of knowledge on the waste management of used DMs among participants belonging to the younger age bracket could be closely associated to their exposure to various social media platforms where information on proper waste management is conspicuously disseminated. Being immersed in online information on the appropriate ways of discarding DMs consequently increased the knowledge of the participants in the said matter. In contrast, studies by (Al-Mohrej et al., 2016) and Bawazir et al., (2018) reported that the older an individual is in terms of age, the more that he/she is knowledgeable on certain topics or subjects.

Furthermore, it was also revealed in this study that males tend to be more knowledgeable than females, indicating that sex can also influence the participants’ knowledge in discarding the DMs. However, such a result is negated by the studies of (Al-Mohrej et al., 2016) and Bawazir et al., (2018), which argued that women are more knowledgeable than men. In this case, the context where the data for this study were gathered may have resulted in this finding that does not align with previous studies conducted that established the correlation between sex and an individual’s knowledge of the proper waste management of used DMs.

The results of the correlation analysis also reveal that the educational level attained by the participants has a significant influence on their level of knowledge; the higher the educational level obtained by the participant, the higher his or her knowledge in the proper disposal of DMs. Studies conducted by Beier and Ackerman (2003), Kumar et al. (2013), Laor et al., (2017), Ranu et al., (2019) support this finding because they concluded that the higher the educational attainment of an individual, the higher the level of knowledge in managing DM wastes.

Apart from educational attainment, this study also found that income becomes a contributory factor in the acceptable waste management of used DMs; the lower the income, the higher the level of knowledge in disposing the used DM. Similarly, in studies conducted by Al-Hanawi et al., (2020) and Beier and Ackerman (2003), it was discussed that income is closely linked to the knowledge of participants. This finding could be attributed to the personal belief of most Filipinos that getting sick is costly. Because of this common notion, knowledge of proper handling and disposal of used DMs would be imperative to keep the family safe from possible infections. Moreover, this study revealed that those who are residing in urban areas are more knowledgeable in DM disposal, rather than those who are living in the rural areas. The findings also suggest that mass media should be used as a strategic tool for raising awareness on the standards and protocols in managing wastes generated from used DMs, in order to target old-aged, low-income, low-educated, female and rural-residing people.

Moreover, the practices on the disposal of DMs were also statistically significant related to the demographic characteristics of the participants, as yielded by the obtained coefficients of correlation. As can be gleaned in Table 3, the practices of the participants in disposing DMs are significantly related to age (r = 0.228, p < .01); sex (r = 0.085, p<01); level of education (r=−0.044, p<01); annual income (r=−0.019, p>05); and type of residence (r=0.069, p<01). These findings imply that the older participants tend to be better in disposing DMs than the younger ones – a clear indication that age influences an individual’s practice. This finding is supported by the study conducted by Laor et al., (2017) who found out that age can affect the level of participant’s practice.

Sex is also a factor that has effects on one’s practice, since this study disclosed that females are better at managing wastes, like used DMs, than males. This result is consistent with the findings from the studies made by Aldowayan et al., (2017); Al-Hanawi et al., (2020); Moran and Del Valle (2016) who reported that men are less likely to show preventive and protective measures than women. As regards education, it is also a factor that could influence the practice in throwing away DMs, but results would indicate that those who have attained lower level of education tend to have better practice in disposing utilized DMs. On the con-

Table 4

| Variable          | Knowledge                  | Practices                  |
|-------------------|----------------------------|----------------------------|
|                   | B  | β  | t   | p    | B  | β  | t   | p    |
| Constant          | 1.164 | 0.000 | 2.220 | 0.000 | 100.92 | 0.000 |
| Sex               | -0.012 | -0.061 | 6.950 | 0.000 | -0.040 | 6.468 | 0.004 |
| Age               | -0.001 | -0.070 | 7.422 | 0.000 | -0.027 | 8.055 | 0.004 |
| Education         | 0.001 | 0.031 | 3.500 | 0.000 | -0.004 | 0.034 | 3.754 | 0.000 |
| Annual Income     | -4.6810 | 0.014 | 1.433 | 0.152 | -1.5189 | 0.012 | 1.298 | 0.198 |
| Type of residence | 0.007 | 0.038 | 3.413 | 0.000 | -0.046 | 0.065 | 7.431 | 0.000 |

Note. Adjusted R² for knowledge is 0.012 and for practice is 0.016; F-value for ANOVA for knowledge is 32.791 and for practices is 26.405; p < .01.

Table 4 Regression analysis for knowledge and practices in disposing DMs on the demographic variables.
have attained a higher level of education, and who are residing in urban places. On the other hand, annual income has no significant effect on the participants’ level of knowledge on disposing DMs. However, it should be noted that the significant predictors merely explain 1.2% of the total variation of knowledge, which denotes that there are more critical variables that could provide rationale to the variation of knowledge in disposing SMs other than the factors that this study took into consideration.

It could also be derived from the table that the participants’ practices in disposing DMs is also significantly influenced by the same set of demographic variables (F-value = 26.405, p < .01) like sex (B = 0.040, p < .01), age (B = 0.001, p < .01), education (B = -0.004, p < .01) and type of residence (B = -0.046, p < .01). Categorically, the effect of these demographic variables on practices were reversed. Thus, results imply that females (coded 1) tend to be more observant on the proper practices in disposing DMs than males. Also, participants who are younger in age, who have attained higher level of education and who are residing in urban areas are less observant in performing proper practices in disposing DMs. Like in knowledge, participants’ practices are not affected by their monthly incomes.

Even though sex, age, education and type of residence are identified as significant predictors of practices, they only explain 1% of the total variation of practices. This means that, similar to knowledge, there are other factors, apart from the demographic variables considered in this study that could better explain the variation of practices in the disposal of wastes resulting from used DMs.

3.4. Ways forward in waste management of used disposable masks in the Philippines

To date, many parts of the world, including the Philippines, lack strategic and sustainable regulations in the efficient management of microplastic pollution, such as used DMs (Abbasi et al., 2020). During the prevailing pandemic, the mismanagement of these plastic wastes serve as threat that negatively impacts the environment (Parashar and Haiti, 2021). Without effective planning and necessary policy intervention, the surge of single-use plastic wastes would eventually cause leakage into the environment, thus prompting a new public health crisis (Vanapali et al., 2021). With these emerging issues in waste management, careful attention must be taken in planning and designing mechanisms in order to avoid the potential alarming environmental impacts of mismanaging the discarding of used DMs. The existing waste management flow of discarded DMs in the Philippines is presented in Fig. 5.

DMs used by individuals with low knowledge and poor waste management practices may discard them in inappropriate ways and in the wrong places, such as waterways, streets, rivers or any bodies of water, highways, and even in vegetative zones. At the offset of this COVID-19 pandemic, a number of movements have already been initiated and operated by public and private individuals in the country to address the increasing volume of plastic wastes, such as used DMs, which were generated from households, medical facilities, isolation and quarantine areas, and local government units. Commonly, these used DMs have been littered in different land and aquatic areas as the majority of the population in the country lacks appropriate knowledge, hence acceptable practices in managing the discarding of used DMs. The amassed used DMs are then disposed in unlabeled waste bags or trash bins where they are mixed with other plastic wastes. These would then be transported and incinerated before disposing them to landfills.

Certainly, such a faulty mechanism in discarding used DMs in the country aggravates the repercussions of mismanaged COVID-19 wastes. In order to resolve this emerging issue on the constantly increasing waste generation from used DMs, the researchers propose a strategic and sustainable waste management mechanism that includes a tripartite system of recommended interventions for the efficient treatment of discarded used DMs. Fig. 6 presents these three feasible actions that may be implemented in order to redirect the present plastic waste management paradigm: a) information dissemination through multimedia platforms; b) proper waste management of used disposable masks using color-coded waste bags or bins; and c) employing sustainable waste management approaches, such as reusing and recycling.

As the COVID-19 pandemic continues to pose serious health risks with its new and emerging variants, people are pressed to use DMs on a daily basis, especially those who are classified as authorized persons outside of residence that include essential workers. This constantly growing demand on DMs will eventually result in large scale plastic wastes that could go beyond control if not urgently managed. Therefore, it is imperative that the prevailing faulty mechanism on managing used DMs in the country be amended and reinforced by the suggested paradigm.

- Available and accessible multimedia platforms, such as social networking sites and radio broadcasts, are of paramount importance in attaining social accountability when it comes to waste management in the country. Information, education, and communication (IEC) campaigns must be launched via these platforms in order to improve the social awareness and consumer behaviors of people when it comes to the using and discarding DMs. At the micro-level, health-
care professionals and other medical-related organizations should raise awareness on proper disposal of DMs through public health interventions and health education. Toward a sustainable approach in improving the knowledge and practices of Filipinos in the proper disposal of plastic wastes, such as used DMs, the education sector should plan and design curriculum spaces for the inclusion of environmental education. Empowering people in order to reinforce and sustain a certain environmental operation is a necessary action to bring about successful participatory implementation (Das et al., 2021; Limon and Villarino, 2020; Limon et al., 2020; Mallick et al., 2021; Parashar and Hait, 2021).

- The use of color-coded or labelled waste bags or bins in households, medical and health facilities, isolation and quarantine areas, and in local government units must be practiced in order to avoid littering and mismanagement of used DMs. Furthermore, packaging wastes with uniform compositions rather than mixed or multilayered materials should also be encouraged (Parashar and Hait, 2021). These measures would facilitate the efficient collection and transportation of wastes in recycling facilities or for incineration and landfill disposal.

- Strategic and sustainable approaches in the treatment of discarded DMs should also be considered, such as reduce and reuse. Reducing the usage of DMs by offering the public alternatives, such as the use of reusable cloth masks and face shields, would cut down the consumption and generation of DMs. Chemical or mechanical recycling of used DMs following decontamination and/or sterilization should also be encouraged, and even incentivized to urge research and product innovation among government and non-government agencies and private industries (Parashar and Hait, 2021; Vanapali et al., 2021).

4. Study strengths and limitations

This is the first study to assess the knowledge and practices on the disposal of DMs during the COVID-19 pandemic in the Philippines. The practical implication of this study would be significant to environmental managers and local leaders as the country is still dependent on the use of DMs as protection from the virus. The empirical findings provide an impetus among local leaders to take a proactive stance against improper disposal of used DMs. Policies and legislative measures could be crafted, implemented, and monitored to ensure an environmentally safe community. On the scientific aspect, the study provided significant information to the growing corpus of literature on knowledge and practices related to COVID-19. In particular, an initial data about knowledge and practices of DM disposal among the populace would provide scientific researchers a basis for technological interventions to increase knowledge and reduce poor practices. Manufacturers of DM could potentially use the information from this study to ensure that responsible consumption and production be observed. The findings could motivate the manufacturers to trace the pathway of consumption and eventual disposal of used DMs so that more environmentally-friendly raw materials be used during the mass production of the DM. Data collection took place for 5 months. The questionnaire used was translated into Ilokano and Filipino in order to represent the multilingual communities where the participants are situated; through this translation, the participants are expected to easily understand the content of the questionnaire. The data gathered from the participants were self-reported, which may taint their responses with bias. To address this limitation in future studies, the researchers may employ administrative data. One potential way is triangulating data through other data collection methods such as interview, focus group discussions, or journal writing. Individuals, like workplace supervisors, may be involved in the study, to corroborate or refute the practices claimed through the self-reported instrument. Moreover, community-based national sampling surveys are not considered feasible, especially during this period of pandemic. As such, data were collected online, depending on the participants’ strong wireless fidelity networks. Therefore, people in far flung areas where internet connection is not possible did not participate. Since the study did not reach the 20% total samples of the country’s population, it could not be generalized at a national level. Most of the participants involved in this study belong to ages 18–25 years old, since individuals classified under this bracket are generally active in using social media platforms. Further research should attempt to cover at least 20% of the country’s total population. Additionally, since this study did not address causation and some variables may be endogenous, a regression analysis should be performed in future studies.

One significant methodological novelty that this present study has achieved is the maximum utilization of the potentials of technology in data collection. Distance among the islands and island groups in the Philippines during the time of pandemic and lockdown did not hamper the timely collection of data from the respondents. It is worth noting that the participation of a significant number of participants across the country proves that technology facilitated the identification and subsequent collection of data through the questionnaire. The fidelity and stability
of internet connection may pose a problem in packets of areas in the country. However, the predominant use and dependence on technology has moved service providers to beef up their internet service connection in various areas of the country. The methodology of collecting data from various groups through technology is an innovative way of instituting changes in research approaches that appear to be hampered by the COVID-19 pandemic. In the end, the ultimate goal is to arrive at a better understanding of how the populace discard their used DMs and propose measures to curb DM pollution.

Conclusion

The findings in this study show that the participants are adequately knowledgeable but have unsatisfactory practices when it comes to the acceptable disposal of wastes generated from used DMs. The findings suggest that the participants who are classified as young males, having high level of educational attainment, having lower income, and residents of urban areas have high knowledge level, while participants categorized as old females, having lower level of educational attainment, having low income, and residents in rural areas demonstrate good practices toward disposing DMs. The results of this study recommends that everyone should be educated about environment-friendly and sustainable ways on how to discard used DMs, regardless of age, sex, level of education, level of income, or place of residence. Campaigns on the appropriate disposal of DMs utilizing multimedia platforms, such as social networking sites and radio broadcasts, which are both available and accessible to the general public, should be one of the priorities during this pandemic. Furthermore, the Philippine national government should also empower the local government units (LGUs) to implement strategic and sustainable approaches in the treatment of discarded DMs so that the people and the environment are both safe from the threats of the COVID-19 pandemic. The findings of the study add to the general population’s knowledge of the serious problems of improper DM disposal. As the pandemic grips the global community, it is imperative that management of waste be given urgent attention side by side by the handling and management of the disease itself. States around the world could craft national legislative measures to curb the increasing DM improper disposal. Strategic interventions such as intensified education campaign in highly urbanized communities where transmission of the virus is faster and more serious, curriculum-based advocacy for the young people who could potentially have a multiplier effect in their respective households, and strict and consistent implementation of policies at the local level.

CRediT authorship contribution statement

Mark R. Limon: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. John Paul C. Vallente: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. Aris Reynold V. Cajigal: Data curation, Formal analysis, Methodology, Project administration, Writing – review & editing. Marlowe U. Aquino: Formal analysis, Methodology, Project administration, Writing – review & editing. Jovenita A. Aragon: Formal analysis, Methodology, Writing – review & editing. Rosabel L. Acosta: Formal analysis, Methodology, Writing – review & editing.

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Supplementary materials

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