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The Evaluation of E-Waste Management During the COVID-19 Pandemic in the Philippines

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Abstract: E-waste management is an emerging challenge both globally and in the Philippines due to its hazardous impacts on human health and the environment. The COVID-19 pandemic and physical distancing protocols have induced heavier reliance and increased usage of electronic gadgets and appliances for home learning, work from home, and healthcare work. Hence, this study seeks to explore how the pandemic has affected e-waste generation and management systems in the Philippines using online surveys and over-the-phone interviews involving various stakeholders such as Filipino electronics consumers, electronics manufacturers, junk shop owners, environmentalists, and policy makers. In line with studies reported from other countries, results show that the nine investigated electronics experienced a general decrease of 30.2% from 2018-2019 (pre-pandemic) to 2020-2021 (mid-pandemic). Notably, mobile phones garnered the largest volume of both sales and disposal from 2018-2021. Lockdown restrictions, lack of recyclers, and insufficient awareness are the key factors faced by common Filipinos in e-waste recycling during the pandemic. Local junk shop owners experienced a decrease in incoming e-waste volumes from local households and private companies. Mobile phones were reported to be the most difficult electronic gadget to recycle, and batteries were reported to be the most harmful component for both human health and the environment. Overall, the environmentalists and professionals identified lack of public awareness as the largest problem in the e-waste management system and recommended that public and private bodies engage in joint efforts to create comprehensive guidelines regarding the manufacture, consumption, and disposal of electronics.

Keywords: WEEEs; e-waste management; Philippines; COVID-19 pandemic; environment

1. INTRODUCTION

Waste Electrical and Electronic Equipment (WEEE), or e-waste, is steadily becoming an increasing concern in the Philippine waste management system. The Philippines' Department of Health statistics showed that there was a significant increase in imports of electronics, from $26.642B in 2020 to $31.736B in 2021 (DOH, 2021). Most of these imported electronics will enter the local e-waste management system in due time, increasing the volume of e-waste present. With the Philippines experiencing an increase in the dependence and usage of electronic gadgets during the pandemic under remote work and online learning set-ups, the quantity of e-waste generated is further expected

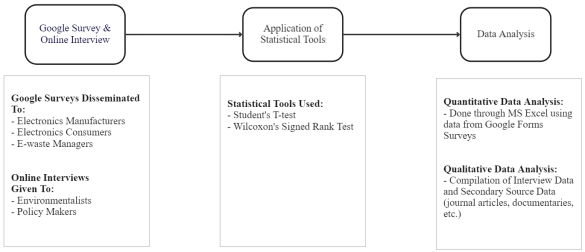
to rise in the future, as supported by other studies (Choi et al., 2021; Forti et al., 2020). Both remote working and distance learning have necessitated the use of air conditioners, laptops, desktops, and mobile devices, which led to the escalating consumption of these gadgets (Gerding et al., 2021; Miklyaeva & Bezgodova, 2020). Furthermore, numerous households have bought refrigerators due to the demand for more food storage resulting from the increased frequency of home cooking (Bender et al., 2021). Microwaves, air purifiers, oxygen concentrators, and ventilators have also been utilized in order to reduce health risks induced by COVID-19. Many have resorted to sterilizing ordered food, as well as face masks, using microwaves (Rubio-Romero et al., 2020), whereas several establishments, especially those in the healthcare sector, have installed air-cleaning devices to combat the spread of the virus (Gupta et al., 2020). However, despite the findings of these studies, there are several studies proposing that e-waste will decrease in coming years instead. A global study conducted by the UN detailed that due to the pandemic negatively affecting electronic sales, the future e-waste to be handled is to decrease by a significant 4.9 million metric tonnes (Balde & Kuehr, 2021); these findings are also supported by research which outlined a similar forecast (Althaf et al., 2020).

The main objective of this paper is to explore and analyze the impact of the COVID-19 pandemic on the e-waste generation and management systems in the Philippines. After evaluating the trends from various studies in the e-waste field, the present study focused primarily on nine electronics: air conditioners, refrigerators, microwaves, air purifiers, oxygen concentrators, ventilators, laptops, desktops, and mobile phones. These electronics were evaluated to improve the e-waste recycling and disposal procedures in the Philippines. Furthermore, data collection will be done through conducting online surveys and interviews with various stakeholders such as Filipino electronics manufacturers, electronics consumers, e-waste managers, environmentalists, and policy makers.

2. METHODOLOGY

The study utilized both surveys and interviews to gather quantitative and qualitative data. Figure 1 illustrates how the study was conducted. All relevant documents such as the Research Ethics Clearance Form, Research Information Sheet, Parental and Informed Consent Form, were processed prior to data collection. Questionnaires were administered to a large population of electronics users (n=422, 383 household consumers, thirty-two (32) business consumers, and seven (7) healthcare consumers) from three specific sectors. Moreover, e-waste managers, specifically junk shops, environmentalists, and two Department of Energy and National Resources (DENR) representatives, were surveyed and interviewed. All questionnaire content was phrased to only include data from the time window of 2018-2021. As the pandemic was at its peak in the Philippines from 2020-2021, a two-year timespan, a similar two-year period was also applied to the pre-pandemic period, focusing on the years 2018-2019. The acquired quantitative data was analyzed using the Student's T-test ($p<0.05$) to determine if there was a significant change in e-waste generated before (2018-2019) and during the pandemic (2020-2021). Likewise, the Wilcoxon signed-rank test ($p<0.05$) was used to verify the findings from the Student's T-test.

Figure 1.
Data Collection and Analysis Methods



3. RESULTS AND DISCUSSION

3.1. TRENDS IN CONSUMPTION OF ELECTRONICS

The study's acquired data in the Philippine context correlated with the findings gathered by other countries, which also suggested a general decrease in the volume of e-waste generated during the pandemic (Balde & Kuehr, 2021). To determine whether the changes in e-waste produced before (2018-2019) and during the pandemic (2020-2021) were significant or not, the Student's T-test and Wilcoxon signed-rank test were utilized. Employing the p-values from the two tests' analyses, the researchers determined the significance of the value changes, and determined whether the consumption of these electronics increased or decreased over the given period. Values at $p<0.05$ are labeled as significant in these two-tailed tests. It must be noted that all ventilator data collected were from

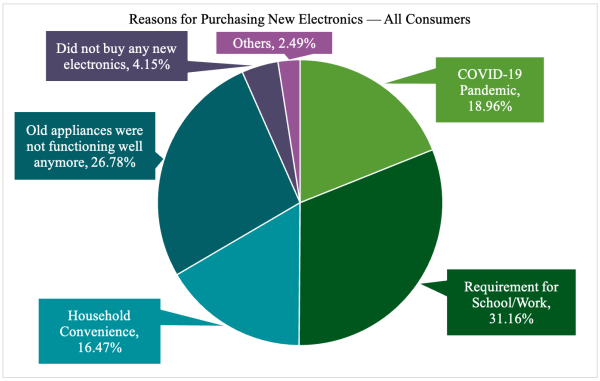
business offices and medical facilities only, excluding households due to their lack of access to this electronic. Overall, electronics experienced a 30.2% decrease in consumption over the investigated time period (2018-2021). For specific electronics, air conditioners, refrigerators, microwaves, ventilators (business and healthcare only), laptops, desktops, and mobile phones experienced a decrease in consumption, whereas air purifiers and oxygen concentrators experienced an increase in consumption. Correspondingly, consumers from general households portrayed an overall decrease in new electronics purchased, while consumers in the business and healthcare sectors proved to have undergone an increase in such (Table 1). Increased consumption of digital electronics such as laptops, desktops, and mobile phones was caused by their necessity for online school and work, as 31.16% of respondents have stated (Figure 2). Moreover, higher consumption of air purifiers, oxygen concentrators, and ventilators was caused by the COVID-19 pandemic (18.96%). Increased consumption of air conditioners, refrigerators, and microwaves was attributed to improving consumers' household or workspace convenience (16.47%). These findings correlate to the reasons found in other studies for the reasons of purchases for these electronics during the pandemic (Gerding et al., 2021; Bender et al., 2021).

Table 1
Comparison Between Average Number of Electronics Purchased by Consumers between 2018-2019 (Pre-pandemic) and 2020- 2021 (During Pandemic)

Electronics	P-Values		Value Changes	
	T-test	Wilcoxon's	Significance	Percentage
All Electronics	0*	0.00001*	Significant	Decrease
Air Conditioners	0*	0.00001*	Significant	Decrease
Refrigerators	0.00001*	0.00014*	Significant	Decrease
Microwaves	0*	0.00001*	Significant	Decrease
Air Purifiers	0.00092*	0.00988*	Significant	Increase
Oxygen Concentrators	0.06124	0.1556	Not Significant	Increase
Ventilators	0.01881*	0.00001*	Significant	Decrease
Laptops	0.11573*	0.00001*	Significant	Decrease
Desktops	0.14265	0.267	Not Significant	Decrease
Mobile Phones	0	0.00001	Significant	Decrease
Consumer Sector	P-Values		Value Changes	
	T-test	Wilcoxon's	Significance	Percentage
Household Consumption	0*	0.00001*	Significant	Decrease
Business Consumption	0.95367	0.9442	Not Significant	Increase
Healthcare Consumption	0.90673	sample too small	Not Significant	Increase

$p < 0.05$

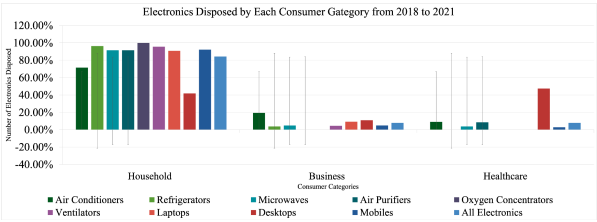
Figure 2
Consumers' Reasons for Purchasing New Electronics



3.2. E-WASTE DISPOSAL AND RECYCLING

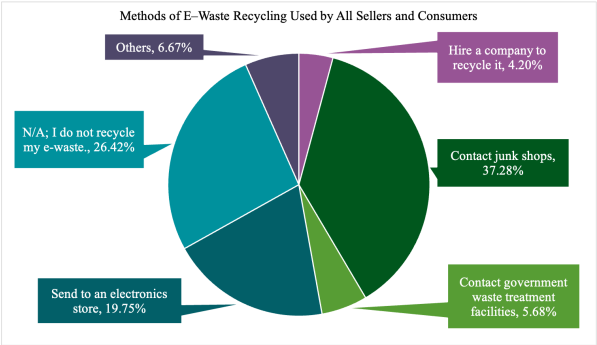
From 2018 to 2021, 84.32% of disposed electronics came from general household consumers, 7.84% from business office consumers, and 7.84% from healthcare unit consumers (Figure 3). Notably, mobile phones were the electronic that experienced the most drastic decrease in purchases during the pandemic and also the gadget that was most disposed of.

Figure 3
Electronics Disposed by Each Consumer Category from 2018 to 2021



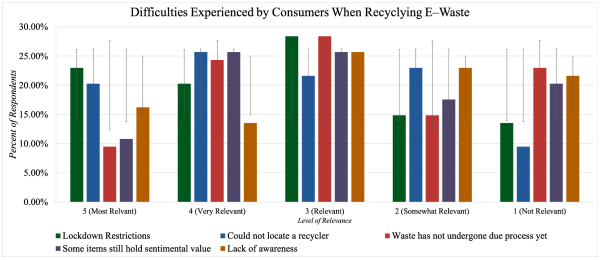
In line with initial hypotheses, none of the surveyed electronics sellers discarded or recycled any of the electronics they sold, and instead had defective units primarily sold to maximize profit. Moreover, 37.28% of consumers typically contact junk shops to recycle their e-waste, 19.75% send their e-waste back to the electronic stores they first purchased them from, 5.68% contact government waste treatment facilities, and 4.20% hire a company or somebody else to recycle it for them (Figure 4). The remaining 6.67% specified other methods of recycling, which mostly involved dismantling electronics for themselves. Notably, consumers who do not recycle their e-waste specified that they were waiting for the launch of formal e-waste recycling programs near them. With electronics consumers being essential proponents in the e-waste management system, the 26.42% of respondents who stated that they do not recycle their e-waste through the appropriate channels may prove to be crucial in contributing to a backlog of poorly managed e-waste, giving rise to a risk of environmental hazard.

Figure 4
Methods of E–Waste Recycling Used by Filipino Consumers



The online survey was able to identify a number of factors (as reported and experienced by the respondents) affecting the e-waste disposal and recycling during the pandemic (Figure 5). Lockdown restrictions caused by the COVID-19 pandemic was identified as the biggest factor affecting consumers' e-waste recycling (22.97%). 20.27% of the respondents cited "could not locate a recycler," 16.22% reported "lack of awareness", and 10.81% noted "sentimental attachment" as factors affecting e-waste recycling during the pandemic.

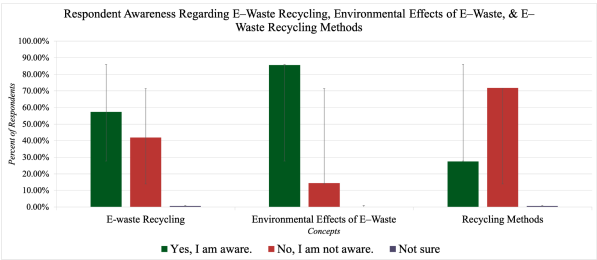
Figure 5
Factors Affecting Consumers' Recycling of E–Waste



3.3. E-WASTE AWARENESS AND PRODUCER RESPONSIBILITY

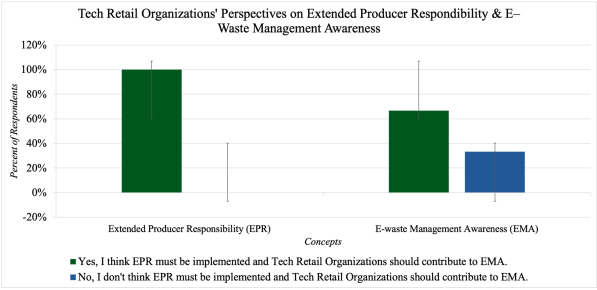
When asked about their awareness on e-waste recycling, recycling methods, and environmental effects, 85.60% of respondents noted that they were aware of the environmental effects of e-waste. 57.40% of respondents were aware of e-waste recycling and only 27.50% were aware of e-waste recycling methods (Figure 6). These results show that 72.5% of respondents were poorly informed about e-waste recycling methods. This may pose difficulties for future e-waste handlers, as the lack of public awareness about their recycling methods may hinder the effectiveness of their e-waste management processes and negotiations.

Figure 6
Levels of Awareness Regarding E–Waste Recycling Methods and Environmental Impacts



Among tech retail companies, knowledge of extended producer responsibility and e-waste management awareness of general public masses had been thoroughly demonstrated. 100% of tech retail companies have indicated full agreement with the implementation of extended producer responsibility, but only 66.70% indicated a willingness to contribute to spreading e-waste management awareness among general masses (Figure 7).

Figure 7
E-waste Retailers' Perspectives on Extended Producer Responsibility and E-waste Management Awareness



3.4. QUALITATIVE DATA ANALYSIS

Since the interviewed junk shop owners and recyclers were not familiar with usage of online messaging platforms, over-the-phone interviews were conducted to understand the e-waste management practices in the Philippines. The junk shop owners reported a general decrease in incoming e-waste volumes since the beginning of the pandemic, which is consistent with the findings of this study's consumer surveys. Further investigation revealed that the public's lack of awareness and junk shops' lessened manpower over the pandemic are the main factors responsible for the decrease in the e-waste volumes. Furthermore, in terms of the waste handling process, the junk shop owners reported that mobile devices generally posed to be the most difficult electronics to recycle because of their many small parts; batteries had also proven to be unanimously voted as the most harmful component for both human health and the environment. Interestingly, earlier e-waste handlers deemed "refrigerators" to be the most difficult electronics to recycle due to their bulk and size, and the cathode ray tube to be the most harmful as mentioned in the Philippine e-waste documentary entitled "Baklas," (GMA Public Affairs, 2021). Although these findings could be attributed to the small sample size and varying demographics of the respondents, it is important to emphasize that proper training and knowledge still needs to be given to the e-waste recyclers to enable proper e-waste recycling of different electronic gadgets. With reported high purchases of mobile phones and increased use of gadgets with batteries, their proper disposal should be a priority to safeguard human health and the environment.

The junk shop owners and recyclers also mentioned other difficulties that they faced during the pandemic such as lack of government support, employee training, and physical space to transport processed e-waste. The respondents agreed that the country's overall e-waste generation is going to increase in the future, with citizens becoming more reliant on technology and more regularly buying newer models of electronics. The reported decrease in the e-waste volumes during the pandemic was perceived as a temporary trend and most respondents expected that with the sales and ever-growing market of appliances and devices, there will be a backlog of e-waste to be handled in the future.

With Philippine junk shops, treatment facilities, and storage and disposal facilities (TSDs) cutting down on manpower, there is still a dangerous backlog of e-waste to be managed from both domestic and international waste sources (Ella, D. M.-L. et al., 2022). During the writing period of this study, only four enacted policies specifically regulate e-waste management, namely RA Nos. 6969 and 9003, and DAOs 94-28 and 2013-22, which are very few to fully encompass the totality of e-waste management in the Philippines (Celestial et al., 2018). Due to weak enactment of these policies, especially on informal waste managers like junk shops, a large volume of e-waste ends up in Philippine landfills, dumped in bodies of water, acid baths, or burned openly (Manegdeg et al., 2021).

3.5. RECOMMENDATIONS

Practical and continuous research on estimating the volumes of e-waste generation can help in developing sustainable solutions for e-waste management. As such, e-waste managers must be given proper training in recycling of electronics such as mobile phones, air purifiers, and oxygen concentrators, since a large portion of future e-waste will consist of these gadgets. Philippine government bodies, particularly the DENR and DOH, must also mandate and design instructional programs that focus on effectively recycling these devices. Additionally, due to the toxicity and danger risked by batteries and cathode ray tubes, appropriate disposal methods must be applied. Establishing more e-waste recycling channels can help encourage the general public to dispose of e-waste conveniently and appropriately, while spreading awareness about the topic.

4. CONCLUSIONS

Overall, the nine electronics covered in this study experienced a decrease of 30.2% in purchases and disposal from the pre-pandemic (2018-2019) to the mid-pandemic (2020-2021) periods. Based on the conducted Student's T-test and Wilcoxon signed rank tests, purchases and disposal of air conditioners, refrigerators, microwaves, ventilators, laptops, desktops, and mobile phones experienced a decrease, while air purifiers and oxygen concentrators experienced an increase. These results are in line with results found in other studies. Based on conducted interviews with e-waste professionals, it was noted that since studies are showing that the pandemic may continue, it is imminent that all parties related to e-waste management must improve their knowledge on e-waste disposal and recycling processes to handle the increasing volume of incoming e-waste such as mobile phones, air purifiers, and oxygen concentrators, while still properly managing their current volume of incoming e-waste. Establishing more e-waste recycling channels across the country can also further propagate awareness regarding e-waste to the general public.

5. ACKNOWLEDGMENTS

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