



A Life Cycle Assessment of Disposable Medical Masks and its Impacts Towards the Environment in the Context of the COVID-19 Pandemic

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Abstract: This study is about the Life Cycle Assessment of Disposable Medical Masks and its Environmental Impacts in the context of the COVID-19 pandemic in the Philippines. Prior to the study, the researchers have noticed that there was an increase in demand for disposable medical masks as a response to the COVID-19 pandemic. The overall objective of the study was to assess the environmental impacts of the life cycle of disposable medical masks in the context of three variables which are energy consumption, waste production, and pollution. The impacts were assessed using related literature and gathered data from respective respondents through the dissemination of online questionnaires among 5 different focus groups. The results from the surveys have shown that the production of healthcare waste has doubled in the past year and is mainly composed of disposable medical masks. In addition, answers from the surveys have shown that the majority of households improperly dispose of their masks by not complying with the set guidelines of the Department of Health. After data collection and discussion, the researchers have observed the connections between the increase in demand for masks and the damaging of the environment in relation to the three variables. To conclude, the researchers have disproved the initial null hypothesis.

Key Words: life cycle assessment; disposable medical mask; environmental sustainability; Personal Protective Equipment; COVID-19

1. INTRODUCTION

1.1 Rationale

At the beginning of the pandemic, the world turned its focus to prioritizing safety and health that the state of the environment was neglected. With this, many environmental advocates and organizations have been bringing attention to the rise in energy consumption from the production and disposal of medical masks. In addition, a more pressing environmental concern was brought up due to the improper disposal of medical masks. After use, the mask cannot be recycled due to the risk of contamination therefore, it is needed to be disposed of (Parkinson, 2020). Without proper disposal, masks end up in landfills and even in the ocean causing damage to marine life and worsening the issue of general pollution (Kassam, 2020). The several issues brought up by these articles show the overall severity of the environmental situation caused by disposable medical masks.

1.2. Statement of the Problem

The study assessed the Life Cycle of Disposable Medical Masks and its Impacts towards the environment in the context of the COVID-19 pandemic.

Specifically, the research answered the following questions:

1. What is the Life Cycle of Disposable Medical Masks?
2. What are the proper and improper methods/processes in the disposal of medical masks?
3. What are the impacts of the production processes of disposable medical masks towards the environment?
 - a. Energy consumption
 - b. Production waste
4. What are the impacts of the disposal of disposable medical masks towards the environment?
 - a. Energy consumption
 - b. Waste production
 - c. Pollution

1.3. Hypothesis

The increasing rate of utilization of disposable medical masks has no significant impact towards the environment in the context of the COVID-19 pandemic.



2. METHODOLOGY

2.1. *Type of Research and Research Design*

A descriptive research design was chosen to show the analysis of the life cycle of the masks in determining its effects towards the environment. It was used to justify the presented realities which were obtained through the answered survey forms of the chosen respondents in relation to the LCA of disposable medical masks.

2.2. *Samples and Sampling Technique*

To select respondents for data collection in the LCI phase, the researchers have utilized a convenience sampling technique. This was used because of the lack of availability of the respective respondents given the ongoing COVID-19 pandemic. Each focus group consisted of a certain number of respondents, again, depending on the availability of respondents in the ongoing pandemic disregarding the factors of age and sex. The five focus groups were based on their profession and expertise in the main focus of this research: environmentalists, medical practitioners, waste management officers, mask consumers and mask distributors.

The first focus group consists of environmentalists required to have knowledge about key environmental issues such as waste pollution and overconsumption of energy. The second focus group consists of medical practitioners with a minimum of 5 years of experience serving in their medical field and knowledge about the coronavirus. The third focus group is composed of waste management officers with respective expertise on the presence of waste pollution and waste production, specifically in terms of PPE, perspectives, and data regarding PPE pollution and the environmental effects of the disposal process. The fourth focus group is composed of mask distributors willing to disclose information regarding their rates of supply and demand of sales with respect to the ongoing COVID-19 pandemic. Lastly, the fifth focus group was mask consumers utilizing disposable medical masks as a preventive measure from getting the virus; their questions were focused on their rate of consumption on a monthly basis and their disposal process after usage.

2.3. *Research Instrumentations*

The researchers utilized five different surveys wherein one was adapted from past studies to gather and collect data. The first survey was a five-item questionnaire given to environmentalists created by the researchers to gather information about effects caused by the life cycle of disposable medical masks from an environmental perspective. The second instrument given to medical practitioners

was a seven-item survey to understand the purpose and effectiveness of a mask in hindering the spread of the COVID-19 virus. The third instrument is a seven-item survey disseminated among mask sellers which focuses on the rate of sales of different types of masks in Metro Manila during the COVID-19 pandemic. The fourth instrument was a five-item survey focused on the consumption rate of masks and means of their disposal which is administered to mask consumers in Metro Manila. This survey was focused on their consumption rate of their preferred types of masks and their means of disposal after usage.

The last survey that was given to HCWM officers was an adapted and shortened version of the Health-Care Waste Management Rapid Assessment Tool. This was developed by the WHO, and its goal is to promote safe and appropriate practices in the field of HCWM ("Health-care waste management rapid assessment tool", 2016). Its purpose is to understand the processes and the overall situation regarding the HCWM system.

2.4. *Procedures*

Preparation of Adapted Survey Questionnaire
The researchers designed a survey fit to the specifications of the study which highlighted the given variables, and this was done specifically for the respondents under the category of medical practitioners and environmentalists. Aside from the designed surveys which have been disseminated to medical practitioners, environmentalists, mask distributors, and mask consumers, an adapted Health Care Waste Management (HCWM) assessment was utilized for the chosen Waste Management Officers. Afterward, a confidentiality conforme has been made for respondents to be assured of the compliance towards the Data Privacy Act of 2012, to be signed prior to answering the designed survey.

Administration of the test to the respondents

Firstly for the chosen available medical practitioners, environmentalists, mask distributors, mask consumers, and waste management officers, all were given a confidentiality conforme to answer prior the survey. Afterwards, questionnaires were administered to the respondents.

2.5 *Statistical Treatment*

The researchers made use of Descriptive Statistics as its statistical treatment in this study. It was used to thoroughly describe and indicate the manners on how the life cycle of disposable medical masks impact the environment, specifically in the context of the COVID-19 pandemic. Through the obtained data, the statistical analysis of this was focused on the evaluation of the answers of the respondents and used as one of the basis of the

conducted study.

3. RESULTS AND DISCUSSION

3.1 Problem 1

What is the life cycle of a disposable medical mask?

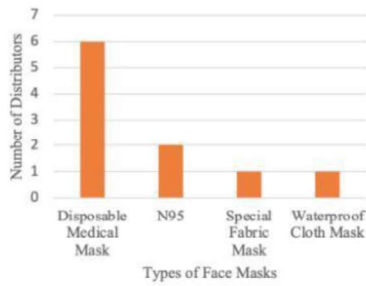


Figure 1. Types of Face Masks Sold

There are three main phases of the life cycle of disposable medical masks: production, usage, and disposal. The researchers decided to give focus to only the production and disposal phases. Within the production phase, there are four sub-processes that occur accordingly: (1) Acquisition of raw materials, (2) Transportation of materials, (3) Production line, (4) Distribution to the sellers. The generic type of surgical face masks that 85.7% of all respondents from the distributors' focus group sell are commonly made up of 3 non-woven layers (see figures 1 and 2) which all serve a purpose in providing the mask's filtration efficiency. These layers are produced in one of two procedures: spun bond or melt-blown (Chua et al, 2020).

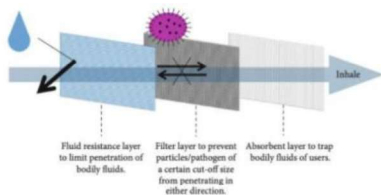


Figure 2. Layers of a Disposable Medical Mask (Chua et al., 2020)

In the disposal phase of the cycle, 6 sub-processes occur accordingly: (1) Initial segregation, (2) Storage, (3) Collection, (4) Transportation, (5) Treatment, (6) Final Disposal (DENR-EMB, 2020). The first process is the most crucial since it decides whether the HCW will undergo proper disposal or not. As seen in figure 3, results from the surveys showed that 71.4% of HCW are disposed of in the wrong waste container. The other 29.6% get stored and transported

by DENR certified transportation companies to treatment facilities.

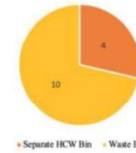


Figure 3. Disposable Methods of Medical Practitioners and Consumer

All the results and discussions done under this research problem can be consolidated into figure 4.1 and 4.2.

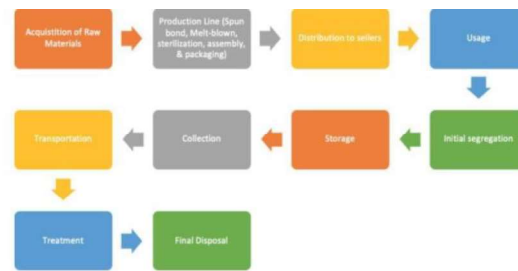


Figure 4.1. Life Cycle of Disposable Medical Masks

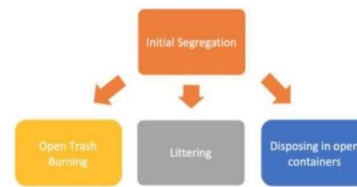


Figure 4.2 Improper Disposal Method of Disposable Medical Masks

3.2. Problem 2

What are the proper and improper methods/processes in the disposal of medical masks?

One respondent observed that the most common yet improper means of disposal include open trash burning, littering, and disposal in open-containers (figure 4.2). Each method creates their own negative effect on the state of the environment. Out of these three, the one that was frequently admitted by the survey respondents was the disposal in open-containers as seen in table 1. The waste coming from this process often ends up in open and unsecured dumping grounds which have become a commonplace for households to recover and recycle the objects found (Ferronato & Torretta, 2019). The continuation of these practices causes infections and viruses to be spread more rapidly.

3.3. Problem 3

What are the impacts of the production processes of disposable medical masks towards the environment?

Table 1. Improper Disposal Methods of Consumers and Medical Practitioners

Consumer/Medical Practitioner	Disposal Methods of Medical Masks
Consumer 1	"Put it in a bin filled with used masks"
Consumer 2	"I just throw it in the trashcan"
Consumer 3	"we just throw it in the trash can"
Consumer 4	"Usually, they are placed in our non-biodegradable waste basket after the straps/elastic has been cut off"
Consumer 5	"I throw them in my trash bin just like normal trash."
Consumer 6	"We cut it in the middle and roll it up before tossing it in the trash"
Consumer 7	"Honestly, I just throw it in the nearest trash bin."
Consumer 8	"By throwing it in the garbage."
Medical Practitioner 1	"Tear and throw in wastebasket"
Medical Practitioner 2	"for surgical mask put it in a garbage can but for special mask like Philips Fresh air mask with N95 clean it with alcohol and the n95 component can be replace after more than 5 usage"

As presented in figure 4, 92.9% of masks in the distributor's inventory is sold and this leads to the increase of product demand from consumers and suppliers.

To further discuss, two t-test: Two-Sample Assessing Unequal Variances was utilized to analyze the relationship between mask distributors and consumers. First, it computed a value of $P(t \leq t) = 0.697503595$ which shows there is no significant difference between the two variables; this indicates the increase of sales of masks because of the demand and need of the product in the context of the pandemic. Second, a value of $P(t \leq t) = 0.500136489$ indicates the significant difference between the targeted amount of sales and supplies. This implies the gap between the masks being supplied to distributors and consumed by the general public; there is a possible overproduction of masks which can create waste. As said by a mask distributor, the shelf life of a mask lasts from 3-5 years before considered "expired" or ineffective of use. The excess in inventory can lead to the expiration of product and ineffective usage.

3.4. Problem 4

What are the impacts of the disposal of disposable medical masks towards the environment?

The usage of disposable medical masks is the most effective type to be used as a preventive measure

for the virus because of the filtration from the exposure of aerosol spray with proper usage. Although according to figure 5, the usage also required proper disposal after usage as a health precaution, yet PPE is not classified under waste disposed of using proper methods of disposal.

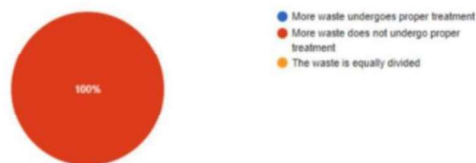


Figure 5. The Division of Waste Undergoing Proper and Improper Treatment according to Environmentalists

The improper disposal of these disposable medical masks results in certain aspects in energy consumption, waste production, and pollution which lead to severe repercussions that negatively affect the environment.

Energy Consumption

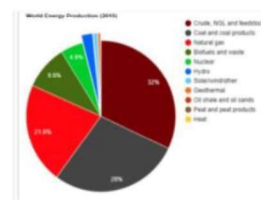


Figure 6. Energy Production and Usage as of 2015 (Hanania et al., 2020)

Based on figure 6, the second most utilized is non-renewable energy such as coal/coal products which are used to generate electricity that runs the technology to properly dispose of clinical waste, and with the increase of usage, the required energy is bound to have a direct relationship as well.

Waste Production

The improper disposal has led to the increase of waste in relation with the rate of demand and supply of PPE, and the added criteria of usage and disposal of this mask. The 3-ply masks are only effective up to six hours of usage then a replacement is needed. With the given condition, each individual consuming these masks must comply for maximum protection.

Especially for frontliners and the general public who are constantly exposed to the possibility of being infected. This circumstance has led to the doubling of healthcare waste wherein most do not undergo proper disposal.



Pollution

With the increase of the rate of waste production, 100% of these wastes are categorized to undergo the improper disposal (refer to figure 5). Under the category of improper waste, one specific process evident amidst the pandemic is discarding of masks in landfills which is shown to be borderline sustainable (refer to figure 7).

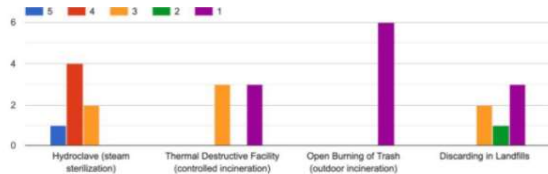


Figure 7. Level of Sustainability of Various Disposal Processes according to Environmentalists

Referring to figure 8, the disposal process of these medical masks greatly impact the environment in terms of pollution and this is highly evident in the present context of the improper disposal of masks.

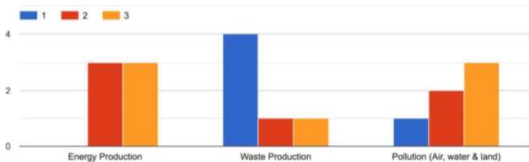


Figure 8. Casualties of Environmental Issues regarding the Life Cycle of Disposable Masks (1 - highest impact and 3 equivalents to the latter)

As seen in figure 9, the disposal process of the medical masks is the least sustainable portion of the life cycle and this is because of the three factors which are energy consumption, waste production and pollution as explained respectively.

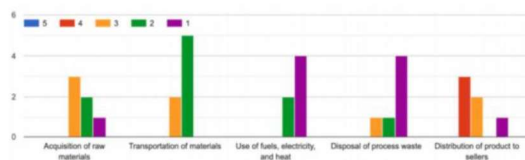


Figure 9. Sustainability of each Process in the Life Cycle of Medical Masks (5 equivalents to being the most Sustainable and 1 equivalent to the latter)

4. CONCLUSIONS

4.1. Summary of Findings

The following are the summary of the results that the researchers gathered from the surveys of the

study:

Disposable medical masks are the most utilized type of mask for the prevention of COVID-19 to spread. Therefore, 85.7% of mask distributors focus their attention on selling disposable medical masks as compared to cotton masks, N95's, and etc.

The production rate of disposable medical masks is higher than the consumption rate of the general public of this product. Therefore, the likeliness of product expiration is higher.

Among the mask consumers and medical practitioners, 71.4% of respondents improperly dispose of their medical face masks by placing them in regular waste bins rather than special color-coded waste bins specifically meant for healthcare waste.

A total of 100% in the HCWM officer focus group agree that open burning, littering, and disposal in open landfills are common improper means of disposal. The most sustainable process, yet still improper out of the three is littering.

In terms of waste production, the usage of disposable medical masks in the ongoing pandemic has been a factor leading to the increase of medical waste by 100%.

A total of 66.7% of environmentalists agree that the overall life cycle of disposable medical masks has the most impact on waste production, while 16.7% mentioned pollution received the highest impact.

4.2. Conclusions

The following conclusions are drawn based on the summary of findings:

While there is no significant difference between the number of masks sold and consumed, there is a significant difference between the number of masks supplied to these distributors and their sales. The overall life cycle gravely impacts environmental issues such as waste production, pollution, and energy consumption (arranged from most impacted to least impacted)

Most processes involved in the life cycle of disposable medical masks compromise the environmental sustainability of the product.

4.3. Recommendations

Having considered the summary of findings and conclusions in this chapter, the following recommendations are forwarded:

Future researchers are advised to look into and compare disposable medical masks to other variants to assess the suitability for prevention in the COVID-19 pandemic. In addition, to give medical disposable masks a point of comparison in terms of environmental sustainability.

To have a stronger foundation of data and information, the researchers suggest making use of a wider range of participants particularly in the HCWM



officers and mask manufacturers.

As brought up by one mask distributor, it is recommended to focus on the different levels of mask quality with regards to their respective price ranges to have an understanding of the value of materials involved in the life cycle assessment and to make an informative decision upon purchase.

Due to the lack of time and resources under the circumstance of the ongoing COVID-19 pandemic, the researchers advise to conduct an experiment in order to obtain empirical data and make use of this research paper as preliminary paper to further back up future results and findings.

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To the mask consumers and distributors for sharing their expertise regarding the consumption and the rate of demand and supply of PPE.

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