FACEMASK USAGE AND DISPOSAL PRACTICES FROM SAFETY AND WASTE PERSPECTIVE

ABIRAMI V. VEERAMANI

FACULTY OF ENGINEERING
UNIVERSITI MALAYA
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ABIRAMI V. VEERAMANI

DISSERTATION SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE MASTER OF SAFETY, HEALTH AND ENVIRONMENT ENGINEERING

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Name of Candidate: Abirami V Veeramani

Matric No: 17219524

Name of Degree: Master of Safety, Health and Environment Engineering

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Designation: Senior Lecturer
Dept. of Chemical Engineering
Faculty of Engineering
University of Malaya

FACEMASK USAGE AND DISPOSAL PRACTICES FROM SAFETY AND WASTE PERSPECTIVE

COVID-19 has sparked a worldwide emergency and prompted concerns about waste management due to the excessive face mask waste generated globally. Malaysia records over 10 million face masks binned daily and in average a person spends RM180/year on face masks since the pandemic outbreak. Therefore, this study aims to explore the current issues arising from face mask waste from safety and waste dimension in Malaysia. The main objectives of this study are to identify the face mask usage among Malaysian and provide the best safety and waste practices of face mask. Questionnaire and case study analysis have been conducted to collect the data in this study. The questionnaires were distributed to a random population to understand their current practices in wearing face masks, selection preferences and face mask waste management and knowledge level. The data was analyzed using SPSS analytical tool. The result shows that majority (73.3 %) of the respondent agreed choosing face mask that is comfort and fit to their face. Besides, 77.2% of responded agreed that the level of bacterial filtration efficiency (BFE) is important in mask selection. And, around 90 respondents agreed wearing double mask in public spaces. According to 52.8% respondents, N95 masks are most effective in providing protection against COVID-19. 65% respondents are not satisfied with available information of disposal of face masks. Finally, based on the results obtained through the analysis, a guidance was developed to assist users on end-to-end process to improve their management of face mask. Since many nations considering COVID-19 as an endemic phase and thus existence of face mask may prolong longer in usage, this research will assist in developing enhanced public knowledge on safe use and effective face mask waste management for all level of stakeholders.

Keywords: COVID-19, pandemic, waste management, facemask usage

PRAKTIK PENGGUNAAN DAN PELUPUSAN PELITUP MUKA DARI PERSPEKTIF KESELAMATAN DAN PEMBUANGAN SISA

COVID-19 telah mencetuskan kecemasan di seluruh dunia dan kebimbangan mengenai amalan pengurusan sisa yang terhasil di seluruh dunia. Pemakaian pelitup muka menjadi amat penting. Malaysia mencatatkan lebih dari 10 juta pelitup muka dibuang tiap hari dan seseorang menghabiskan RM180 setahun dengan pembelian pelitup muka. Tujuan penyelidikan ini adalah untuk memahami isu-isu semasa yang timbul dari sisa pelitup muka dari perspektif keselamatan dan pengurusan sisa di Malaysia. Objektif utama kajian ini adalah untuk mengenal pasti penggunaan pelitup muka di kalangan rakyat Malaysia dan memberikan amalan keselamatan dan pembuangan topeng muka yang terbaik. Soal selidik dan analisis kajian kes telah dilakukan untuk mengumpulkan data dalam kajian ini. Ianya diedarkan secara rawak untuk memahami amalan semasa memakai topeng muka, pilihan pelitip muka dan pengurusan sisa pengetahuan. Data dianalisis menggunakan alat analisis SPSS. Hasil kajian nyatakan, 73.3% respon keselesaan dan kesesuaian pelitup muka adalah penting dan 77.2% respon tahap BFE penting. Separuh daripada responden memakai pelitup muka berganda di tempat awam. 52.8% berpendapat bahawa topeng N95 paling berkesan dalam memberikan perlindungan terhadap COVID-19. 65% respon rasa tidak puas hati dengan maklumat yang ada mengenai pembuangan pelitup muka. Penyelidikan ini juga memberi panduan untuk membantu pengguna pelitup muka mengurusan topeng muka dan Seperti yang dibincangkan baru-baru ini, banyak negara menganggap COVID-19 sebagai fasa endemic dan berharap kajian ini dapat membantu mengembangkan pengetahuan masyarakat mengenai penggunaan selamat dan pengurusan sisa pelitup muka yang berkesan.

Kata kunci: COVID-19, pandemik, pengurusan sisa, pelitup muka

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LIST OF SYMBOLS AND ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
CDC	Centre of Disease Control
DOE	Department of Environment Malaysia
DV	Dependent Variable
FDA	Food and Drug Administration
FM	Face Mask
HEPA	High Efficiency Particulate Air filter
IV	Independent Variable
MCO	Movement Control Order
MOH	Ministry of Health Malaysia
PM	Particulate Matter
PPE	Personal Protective Equipment
RM	Ringgit Malaysia
SSPS	Statistical Package for the Social Sciences
SW	Scheduled Waste code
USD	US Dollars
WHO	World Health Organization

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CHAPTER 1: INTRODUCTON

1.1. Introduction

A cluster of pneumonia cases caused by a newly found coronavirus occurred in Wuhan, China, in December 2019. World Health Organization (WHO) this virus was given the designation 2019-novel coronavirus (2019-nCoV). Malaysia. It is said to have originated in China's province in late December 2019. Initial studies states that a huge number of SRAS related coronavirus has been identified in bat's natural reservoir (Peng Zhou, 2020)

Many countries has been badly impacted with the pandemic situation in terms of economically, socially and politically where their efforts the eradicated this pandemic resulted in national lockdowns, suspension of travels and increased stress to medical departments("Mapping the Coronavirus," 2021). For example, India who is experiencing an acute surge in COVID-19 cases (Gettleman, 2021) and with more than 3,226,719 active cases (Ministry of Health and Family Welfare, 2021) is fighting to curb further spread of the virus by implementing 21-days lockdown

As of now, the number cases is 164,343,282 and with 3,407,159 deaths worldwide ("Mapping the Coronavirus," 2021) affecting almost all the countries in the world to battle the virus whilst managing the wellbeing of entire population (Fig.1). There has been a significant increase in the number of confirmed cases and deaths on globally (9 May 2021) with more than 5.5 million cases and more than 90,000 (Fig,2) deceased due this virus outbreak and infection (W. H. O. WHO, 2020).

Due to high surge of cases and challenges faced to perform contact tracing, Malaysia implemented Movement Control Order (MCO) nationwide(Malaysia, 2020). The nation

witnessed a huge economical downfall during the first ever movement control order (MCO) as well as change of new government thus enabling Ministry of Health (MOH) as the main trustee to manage COVID-19 in the country.

Even though many nations have restricted their travels that isn't necessary. Because of enhanced testing ability and community transmission, confirmed cases and deaths are projected to rise. By emphasizing stricter movement control controls and public health measures such as practices of social distancing, hygiene practices, avoidance of massive gatherings as well as wearing personal protective equipment (PPE) like facemasks.

As there was need of PPEs rose with level of usage from wide range of community for self-protection, it directly contributes stress and impact to waste management process. Used PPE need to be disposed as clinical waste because it contains human or animal tissues, bodily fluids etc. in accordance to Environmental Quality (Scheduled Wastes) Regulations 2005("TheStar," 2020).

There is rising issue with improper disposal of facemasks amongst common population who has limited access or knowledge to perform proper waste disposal of used PPEs. Excessive usage of facemask during pandemic season leads to serious waste management issue and this is due to lack of a proper guidance on facemask usage and disposal leads to issue in scheduled waste management flow. Procurement of PPEs for wider crowd usage e.g., companies, offices, medical facilities on bulk storage of facemask waste put extra pressure on regular waste management practices leading to inconsistent management strategies.

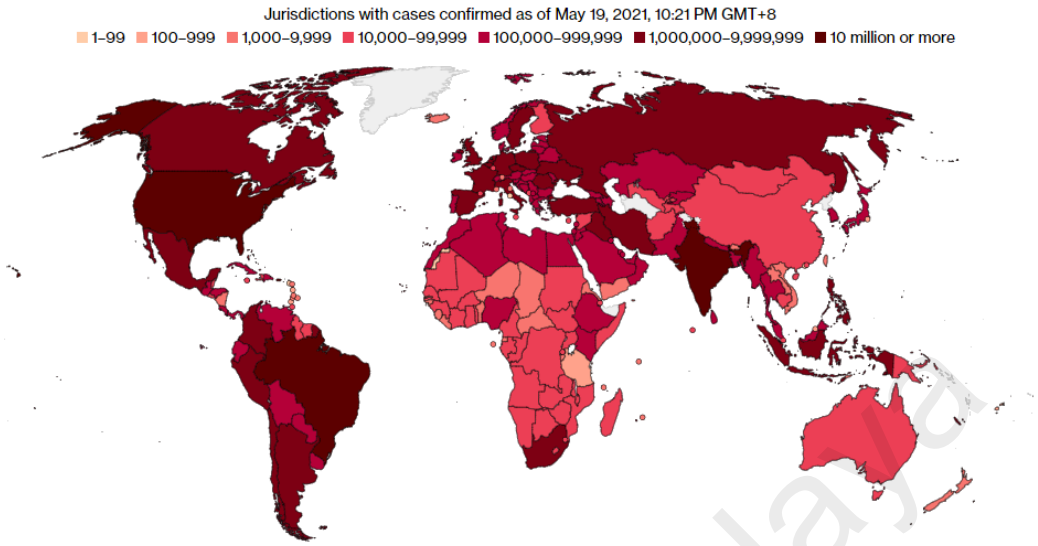

Figure 1.1: Show global distribution of COVID-19 pandemic cases.

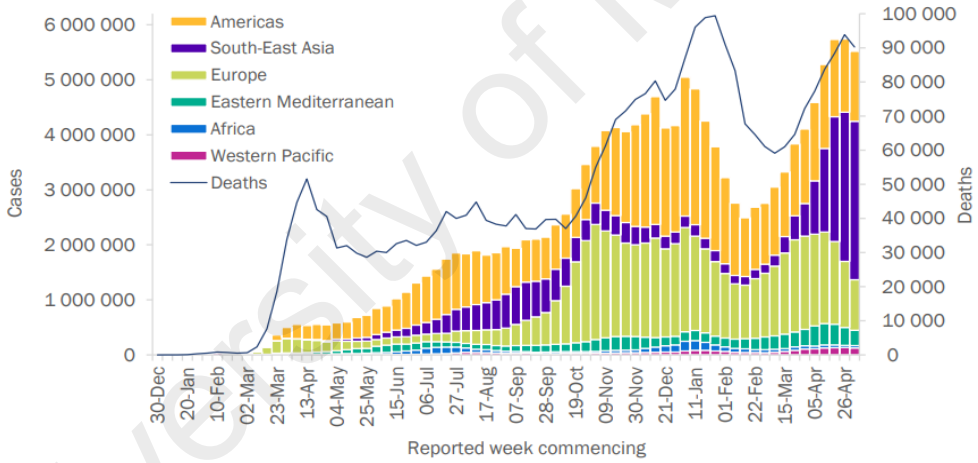

Figure 1.2 Distribution of COVID-19 cases on weekly basis by WHO region

1.2. Problem statement

The COVID-19 virus caused pandemic and its greater risk of injury has increased face masks and medical waste in the environment. Thus, as a result, the pandemic must be prevented and controlled as soon as possible. (Sarawut Sangkham, 2020).

According to UN data, over 75% of COVID-19-related plastic PPE trash will wind up in landfills or the sea. Every month, billions of face masks and gloves could be utilised over the world and generating waste. According to the article, in total of 2,228,170,832 pieces of face mask used by people in Asia countries with confirmed COVID-19 case.

As for Malaysia - Solid Waste Management and Public Cleansing Corporation (SWCorp) Federal Territories director Mohd Zahir Shari advised people to dispose of their used facemasks in a sanitary manner rather than throwing them away with other trash. Amidst this pandemic, WHO has advised nations to increase at least 40% rise in disposable personal protective equipment (PPE) manufacturing to cater for all level of community as a protective layer.

During the pandemic, personal protective equipment (PPE) has driven increased pollution. This is mainly due to the improper disposal of used facemask during COVID-19 pandemic globally. The rise in used face mask waste is due to increased usage of facemask during COVID-19 pandemic as many nations mandate and sanction laws for people to wear face masks when they are in public spaces where there is higher possibility for disease spread to occur. Also, it has been understood that the lack of a proper guidance on facemask usage and disposal among major users and stakeholders leads to issue in scheduled waste management flow.

1.3. Research Questions

Since this research developed to better understand and identify the waste management process of facemasks (PPEs) during COVID-19 pandemic period, the research questions of this research are:

1. What are the current issues related safety and waste dimensions of used face mask?
2. What the current waste management process (disposal methodologies) implemented in Malaysia on managing facemask wastes generation? Are there any differences in waste management process based on different settings e.g., healthcare settings, home / general settings?
3. What are the criteria's that need to be weighed by stakeholder to ensure clearer understanding, effective handling and prevent wastage of face masks?

1.4. Research Aim

This research aims to identify best practices in disposing used facemask during COVID19.

The aim is achieved by looking at the environmental effects from waste management perspective on facemask waste during this COVID-19 pandemic in Malaysia. Subsequently to find and propose a long-term implementation practices for users and stakeholders to minimize facemask waste generation.

1.5. Research Objectives

The general purpose of this research is to identify the relationship between COVID-19 pandemic impacts on waste management in Malaysia.

1. To identify issues related to safety and waste dimensions of face mask
2. To determine best practices in managing disposal aspects of face mask.
3. To provide stakeholders a basic standardization guideline on procurement, usage, and management of facemasks during global crisis in Malaysia.

1.6. Scope of study

This research conducted to look at disposal methodologies of used face mask and the environmental effects of facemask waste during this COVID-19 pandemic in Malaysia. The data obtained in this research based on journals, articles, research conducted on COVID-19 from the year 2019 – 2021. A list of questionnaires distributed to community in Malaysia to understand user's preferences in selecting, managing, and disposing used face masks during COVID-19 pandemic. The scope of this research is within safety and waste management from used face mask generated because of COVID19 from a disposal point of view.

1.7. Significant of study

This research outlines the current issues on used facemask waste littering around the world that affects the environment's ecosystem. It is contaminated, non-reusable adding this PPE into list of affecting the environment in non-reversible, infectious, and hazardous way.

The World Health Organization (WHO) release an interim guidance to manage infection prevention and control management based on WASH (water, sanitation, hygiene) and waste management perspective. The guidance specifies the type of practices that could be adopted in a healthcare facility as well as homes and communities. Thus, this research also describes the face mask disposal process in Malaysia on used facemasks at a different setting based on current practice

As the perspective of face coverings varies in a large community depending on background, nature of tasks and community, this research also aims to obtain feedbacks based on a structured questionnaire on their views and practices in using facemasks during this pandemic period.

This research is based on compliance, governments and international organizations have advocated for handwashing, social distance, and the use of personal protective equipment (PPE) by healthcare professionals and, later, for the community. Upon making face coverings as a legal requirement, this raises the need to procure facemasks to ensure self-protection measures are being taken accordingly. Specifically, this research develops and proposes a unified framework of checklist for stakeholders to assist them with procurement of facemasks amidst managing pandemic.

Ever since the pandemic outbreak, there had been increase in number of single used facemasks been littering our sidewalks, malls, community spaces (Nsikak U. Benson, 2021). This research also discusses the effectiveness of reusable facemasks as a personal protective equipment as well as its impact to the environment based on waste management views.

CHAPTER 2: LITERITURE REVIEW

2.1 Introduction

This chapter begins with review of literature of history of face masks from golden era to recent development by addressing the chronological timeline of the evolution. Then important role played by face mask during COVID-19 pandemic briefly discussed with additional information the available type of face masks in the market for all level of population's usage. Evolution of face masks from economical and market perspective in during COVID-19 analysed in this chapter. Then the level of effectiveness of different types of face mask during COVID-19 based on its filtration efficiency from safety perspective and limitations and challenges with usage and disposal of face mask from waste perspective are discussed as well. Lastly this chapter discusses current issues with waste management process due to improper disposal of face masks during COVID-19 and conclude the chapter with a summary.

2.2 History of Facemasks and adaptations

Mankind has fought through many notable powers of pandemics. Many theories resolves around the idea of spread of infectious disease from cultural to scientific perspectives and this doesn't stop humans to fight with innovations that saves from further life losses and embracing safety in work culture (Walleser, 2020). Face masks as they are utilized in health care and the general public today, can be traced back a long way in history

to recent times where knowledge of infection is developed based on germ theory. (Strasser & Schlich, 2020).

The word 'mask' derives from the Medieval Latin word 'masca,' which means 'spectre or nightmare, and later, it came to be used to describe facial coverings in mid-16th century England. (Ike, Bayerle, Logan, & Parker, 2020). Masks have been used for a multiple use throughout history, including as costume elements or funeral instruments and now to achieve goals in medicine and public health (Ike et al., 2020).

According to Global Times China, face mask similar look artifacts have been found dating back to the 6th century BC where at the entrances of Persian tombs, there were several depictions of people wearing cloth over their mouths (Times, 2020).

From the 14th to the 17th centuries, in only the 14th century, the plague swept Europe and Asia, killing an estimated 200 million people. (Pan, Goel, Akin, & Patel, 2020). Face masks has been in existence to humans since the early modern middle age (Matuschek et al., 2020) for treating sick people impacted from bubonic plaque. As shown in Figure 2.1, the mask looks like a bird’s beak and filled in with medical herbals as a natural protection and many suggests that even though the mask portrays deep and grim imaging, its matches with the modern day version of protective suits and facial coverings (Walleser, 2020).

Adapting face mask into medical practice symbolizes an infection-prevention methodology by keeping all the microorganisms at bay rather than kill them with chemicals. (Strasser & Schlich, 2020). The same mindset adapted by recent timers to protect and prevent human population from exposure of micron particles and usage of face mask diverse depending on the wearer's acceptance of the circumstance. In accordance to WHO, wearing of a mask alone is insufficient to provide adequate protection and appropriate protection

against COVID-19; it must be used as part of a comprehensive approach to prevent transmission and save lives. (Organization, 2020)

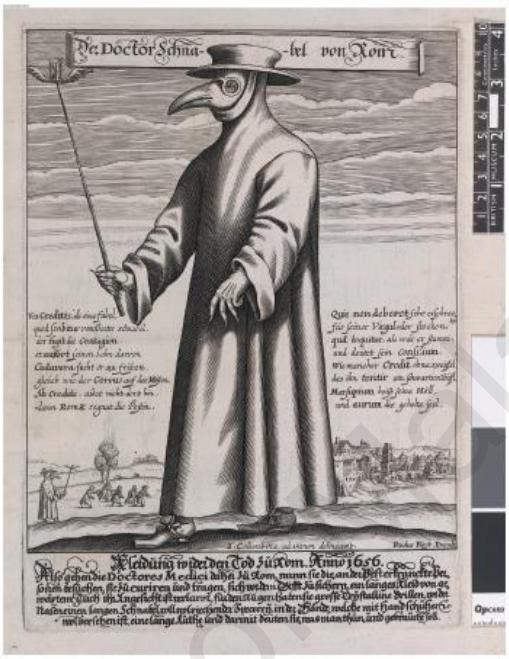

Figure 2.1: Doctor Schnabel von Rom, Kleidung wider den Tod zu Rom with beak like face mask at Nuremberg, 1656, The British Museum, London, UK.

The result resembled a modern cotton face mask in appearance, but the covering around the mouth and nose area was thicker than it is now and provides the much-needed protection for the medical practitioners as well as community users (Pan et al., 2020). Yet the layered mask has very low level of comfortability and ability to breath due to its layered construction (Walleser, 2020).

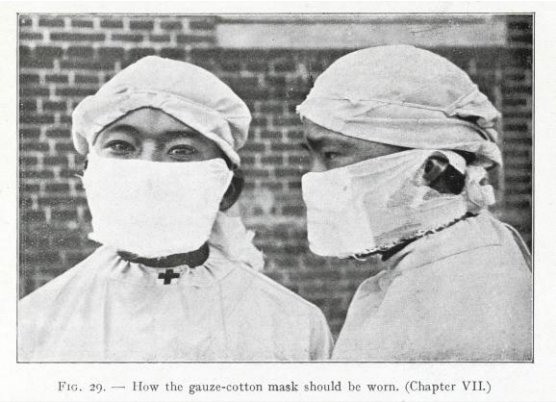

Fig. 29. — How the gauze-cotton mask should be worn. (Chapter VII.)

Figure 2.2: The masks we use today evolved from this prototype.

During the first decades of the twentieth century, Wu Lien-teh, a specialist in public health from Malaysia, was examining the outbreak of the pneumonic plague in northern China. He made a mask out of layers of gauze encased in cotton, as shown in Figure 2.2 with ties for hanging on the ears and securing at the rear of the head/neck

Medical face mask undergone tremendous transformation over the years with additional layers cotton and materials like metal frames inserted in to ensure there is cross transmission takes place from or to the person wearing the face mask. To ensure long term usage of the face mask, it is made in a way that it is washable and sterilized (Strasser & Schlich, 2020).

Disposable paper masks were improved to synthetic non-woven fibers during the 1930s and 1960s, which eliminated the need for washing and sterilizable masks. (Walleser, 2020). Evolution of masks has been extensive in conditions to protect occupational or military health personals and it differs from the masks that dedicated for wider population to protect them from infectious outbreaks and the level of protectiveness majorly defers accordingly for different individuals. (van der Sande, Teunis, & Sabel, 2008).

2.3 COVID-19 and Face Masks

To combat the spread of the COVID-19 virus, most governments issued lockdown regulations as well as social and physical distancing measures. (Benson, Bassey, & Palanisami, 2021). Being in aligned with need, organizations like Food and Drug Administration (FDA) taking additional measures to help the government and public health to have continued access to medical devices and relevant equipment to have continuity with medical emergency support and based on the assessment, personal protective equipment like gloves & gowns (examination purposes), surgical masks & respirators are facing limited supply issue worldwide (FDA, 2021).

Back in 2019, Malaysia sent half a million of face mask to Sarawak to combat with haze issue that raised due to forest fires from neighboring country (Daily, 2019). High number of face masks mainly medical mask type (surgical and N95) has been seen worn by Malaysian during haze period while they were out in public spaces. The dry weather also leads to respiratory illnesses amongst Malaysian and some organization initiated work from home mode to safeguard employee's safety and health. As the level of air quality reading referred with Air Pollution Index (API) it reached very unhealthy level and raised national disaster management's concern over the time to mitigate this issue.

Facemasks appeared to be an acceptable method worldwide during the COVID-19 epidemic although up until today, there has been a scientific debate that has its base in the medical and scientific history. Future research on long-term mask efficiency and effectiveness used in non - hospital settings is needed, as it will provide more precise information. (Matuschek et al., 2020). People from all community level are now in need to wear a face mask in a protective measure to safeguard from COVID-19 infection.

And to as a preventive measure, WHO and CDC had release guidance documentation outlining methodologies and importance of practicing social distancing, hand hygiene and coughing techniques (Nzediegwu & Chang, 2020). Similarly, Ministry of Health Malaysia (MOH) been actively releasing posters and infographics to educate and alert public on COVID-19 impacts and ways to stay protected as shown in Figure 2.3. Personal protective equipment (PPE) became a mandated lifeline for medical front-liners who manages COVID-19 patient cases as a priority.

Figure 2.3: Poster released by MOH on staying safe during COVID-19.

During the 1930s, single use paper masks began to supplant medical masks. and by 1960s, were replaced with materials made of synthetic. Later, there were displays for various types of filtering masks constructed of non-woven synthetic fibers for use in the medical

field. The proposed face masks are where all disposable and the key highlight or rather selling point is its performance, ease of use, and comfort. In contrast to typical medical masks, these cup-shaped respirator masks were meant to sit securely on the face and filter incoming air also standard masks to prevent the spread of droplets. (Strasser & Schlich, 2020). In recent times, the face mask has evolved to a range of different level of bacteria filtration efficiency and that is now critical for pandemic situations.

Even use of cloth masks shows prove of efficiency in curbing disease spread, taking in consideration of immense spread of disease via droplets – other preventive measures such as hand hygiene provide a combined effectiveness overall. (Lima et al., 2020). In developing countries, low-cost face masks constructed of various fabric materials are fairly common. (Neupane, Mainali, Sharma, & Giri, 2019). During COVID-19 pandemic, many companies regardless of their backgrounds immersed themselves in personal protective equipment (PPE) selling business and the mask produced were at low cost and lower quality. Lack of quality control standards in face mask making causes irreversible damages to health and environment due to poor quality of raw material and its infectiveness in disease spread prevention.

The common conception of "risk compensation" is based on the belief that people have a level of risk with which they feel satisfied and adjust their behavior to maintain it, but the evidence is more consistent with that people who adopt a behavior care are actually more permeable, and not less, to incorporate other similar measures that increase their safety (Richly & Cardona Maya, 2020). As much of a safe feel that a face mask could offer, without additional protective measures like hygiene and sanitization, it not effective in curbing the disease from further spread. A century later, WHO also warned about the dangers of wearing masks by warning about “the false sense of security that they can confer, which could lead

to non-compliance measure proposed such as such distancing and proper hand hygiene (Richly & Cardona Maya, 2020). Also, depends on type of face mask, to stop disease from spreading to healthy people to stop disease from spreading to others.

Therefore, there is a wide trust that these protective tools made based on suggestions made by the authorities in charge of health of respective nations can help to curb of coronavirus transmission in the community as many 2nd and 3rd world countries have discovered. (Lima et al., 2020).

In the evolution of face mask during COVID-19 and increasing demand and need for all level of population depending on risk exposure and risk group categorization, face mask needs to fit the user to provide maximum level of protection to prevent further spread of the virus. Thus, different types of face mask made available in market in various types and protection levels for general population to specific-task workers like healthcare workers.

2.4 Types of Face Masks

WHO says that it is very crucial to have facemasks that fits to users face because any gap allows the virus to escape regardless the rate of BFE. (Organization, 2020). Plus the Ministry of Health (MOH) Malaysia has release guidelines on the case of the COVID-19 pandemic, masks should be worn and which describes general ways of proper use of medical and non-medical masks (MOH, 2020). Depending on type of masks and reusable features, it shows a major difference on how they filter microorganisms yet also shows positive reinforcement when being used in a right manner (Strasser & Schlich, 2020). Different types of face masks undergo various production process with different kind of raw materials used, thus this leads to massive of amount of waste if not being managed properly.

By understanding the type of masks as shown on Figure 2.4 for example, clear distinction between respirator which mainly utilized to be user-friendly and well-designed personally to avoid gaps and air leaks, make sure to suit user's facial features. Whereas surgical masks are designed to protect the user's working environment by preventing the emission of air droplets (van der Sande et al., 2008). Wearing non-fit or suitable masks can also lead to extreme wastage as the user might procure for another different set of masks upon identifying the non-fit situation. In this case – it leads to unnecessary pile up of face masks and in a long run it is a waste.

Figure 2.4: Shows different types of face masks available in the market

Not everyone could wear any type of face mask, many considerations need to be taken in terms of profession, age, medical conditions. In this case, limitations on face masks to be worn by children younger than 2 years old, person with difficulty in breathing, and someone who is not capable to remove their face masks without any external help in case of unconsciousness or differently abled person (MOH, 2020) need to be adhered to in order to avoid risks of suffocations. Regardless, as contrasted with adults, children were far less

protected from exposure, which could have been connected to the masks' poor fit on child's face (van der Sande et al., 2008). Also, active nature of a child might further complicate the face mask fitting and wearing process that includes crucial steps of wearing timing and hygiene matters.

To guarantee that any mask is as effective as feasible and to avoid an increased transmission risk, proper use, storage, cleaning, and disposal are required. The face masks are quite important to test on the sort of fabric chosen, way they're put on, and the manner they are treated has an impact on whether they are effective in reducing the chance of transmission or harmful to the person. (Sunjaya & Morawska, 2020).

When a mask is being produced, it has moderate level of absorption rate and it must fit to local nation's health authority guidelines which supposedly reduce the cross transmission within the population (Lima et al., 2020). Yet as discussed above, many of personalized and individual sellers has begun selling non-medical mask or fabric masks to wider population which does not made in accordance local health authority guidelines. The selling point of this type of masks is either to fit fashionably to their clothing's as well as comfort and fit.

2.4.1 Medical masks

The MOH Malaysia recommends N95 and 3 ply surgical masks for healthcare providers. Also, person who is not feeling well and exhibiting symptoms of COVID-19 are recommended to wear medical masks (Ministry of Health, 2020). People of age 60 and over or person with underlying medical condition are advised to wear medical mask as well. WHO describes medical masks as below:

1. made up of three layers of synthetic nonwoven fabrics

2. layers of filtration stacked in the middle
3. various thicknesses are available for option
4. have varying fluid-resistance and filtration levels

Figure 2.5: Shows different types of medical masks

As discussed in many health forums, medical masks are highly effective when its being worn by infected person or a medical professional who was prior trained to use different types of medical masks shown in Figure 2.5.

2.4.2 Non-medical masks

Non-medical masks are any type of masks that not to be used professionally and adaptable for general community. Non-medical masks are also the type of reusables as well as disposal type. While choosing a non-medical mask, one should check for filtration, breathability and fit. Elastic bands or ties should be used to keep it in place comfortably with little adjustment. Ensure it fits closely over your nose, cheeks, and chin. When the mask's

edges aren't as close to the face as they should be and moves, rather of being filtered by the fabric, air enters the mask through the edges. Vents or exhalation valves on masks are not recommended since they enable unfiltered air to escape. As shown in Figure 2.6, fabric face masks must provide maximum protection to the user with proper fit, comfort and secures either with ties or ear loops. Three layers of cloth should be used to make fabric masks:

- An inner layer of cotton serves as an absorbent substance.
- A non-woven, non-absorbent middle layer, such as polypropylene.
- Non-absorbent outer layer, such as polyester or a polyester blend.

Figure 2.6: Shows the recommended way to wear a fabric mask

Reusable masks could offer different level of protection to different user. Earlier this year, France banned certain homemade fabric COVID-19 masks from public use as they deemed not to offer the required protection for recently developing and highly risky virus variants. (BMJ, 2021). This is not the case in many countries that do mandate face masks but allow flexibility for the user to select their own type of mask to wear in public settings. Yet, WHO still maintains its stand on standard reusable mask produced must be at least 3 layered with sufficient filtration and suitable absorbent material.

These findings bolstered the notion that reusable masks could be dangerous, preventing further study into well-designed and industrially manufactured reusable masks.

(Strasser & Schlich, 2020). Yet due to the current urge faced by medical governance by implying the importance of face mask to curb further spread of COVID-19 disease, many types of face masks required to be assessed on its effectiveness whilst it is being adapted as a common practice and fashion sensing.

Disposable masks and respirators will undoubtedly continue to play an important role to health care's PPE in the future, because some of them have specialized filtration properties for use in medical settings (Strasser & Schlich, 2020). Disposables deemed as easy to go, which was a clear advantage. to anyone "who has seen staff disentangling the tapes and reassembling autoclaved linen masks", as said by a British medical researcher back in 1980.

The economic growth observed in face mask market shows the increasing level of awareness about the on-going pandemic season and adherence to local health governance and it is in particular forecasts increase in Asia Pacific market. (Wood, 2020). Thus, with the soaring demand in the market and globally the cap pricing for different types of face masks in not being set as standardization.

2.5 Costing and Market for Face Masks

The Malaysia government has set the ceiling limit for face mask in 2020 after the country faces shortage face mask with soaring high price. It was previously set at RM2.00 per piece and later reduced to RM1.50 in March 2020. Following government's mandate for people to wear face masks in public, in August 2020 the price of per piece of face mask reduced to RM1.00 and later in October 2020, the final price by government gazette was RM0.70 cents.

According to global market projection, the face mask market is expected to hike up from USD 737 million in 2019 to USD 22,143 million in 2021 and then By 2025, the budget will be reduced to USD 3,021 million.(Wood, 2020). The use of surgical masks in the healthcare business is the key reason for their popularity. Furthermore, from 2019 to 2021, the continuing COVID-19 pandemic is likely to push the surgical mask market.(Wood, 2020). The economic growth observed in face mask market shows the increasing level of awareness about the on-going pandemic season and adherence to local health governance and it is in particular forecasts increase in Asia Pacific market (Wood, 2020).

As the price reduction of face masks implemented by government, it helps families from lower income families to purchase face masks as well as mostly encourages stock-ups (panic buying) of face masks. Surgical, respirator, dust, and pitta masks are all part of the disposable face masks category. During the projection period, the rising use of respirators in hospitals will fuel demand for disposable face masks. (Wood, 2020).

A point of consideration and discussion, where in recent times pricing of face mask is determined by level of protection the face mask offers to the user overall during the period they wear. This could potentially lead to a diverse perception considering Malaysia has population from 3 different level of income range and the affordable category would purchase most effective face mask and the other categories don’t.

2.6 Effectiveness of face mask during COVID-19 Pandemic

Level of protectiveness of a face mask is rated via combination of results of microorganism stifling potential, mask fitting and potential air leaks as well as proper use by the wearer (van der Sande et al., 2008). A mask's particulate matter (PM) filtering efficacy is

determined by a number of factors, including pore size, shape, clearance, and pore number density. (Neupane et al., 2019). As shown in Figure 2.7, a study conducted to analyze the effectiveness of different types of face coverings used by all level of population during COVID-19 pandemic as a layer of protection to prevent spread of the virus (Khalik, 2020).

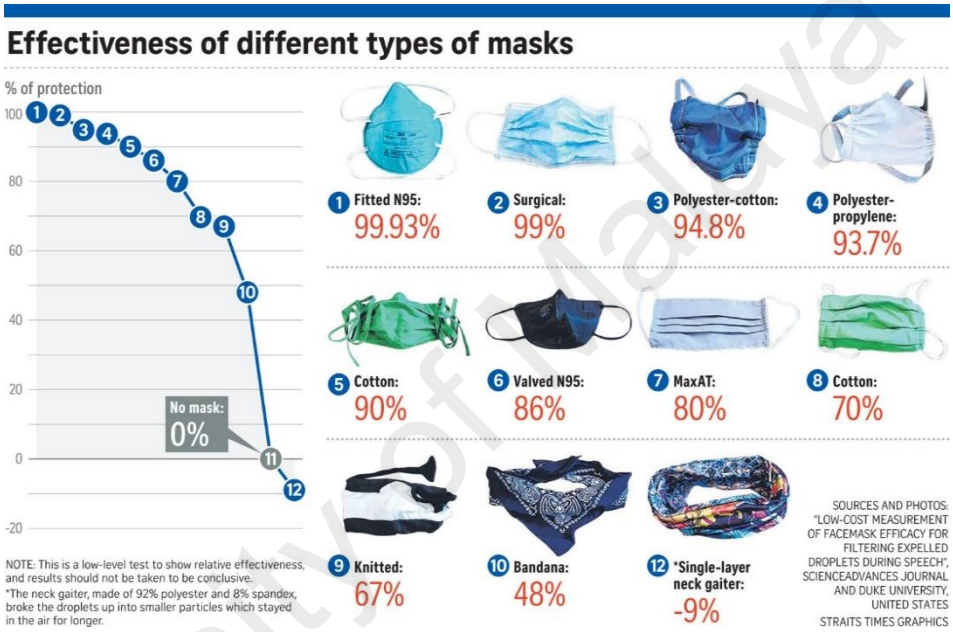

Figure 2.7: Shows effectiveness of different types of face masks

Based on a study conducted by a group of researchers from China of knowledge and practices during spike in COVID-19 cases, almost 98% of participants acknowledge that they wore face masks when leaving their home in recent days (Zhong et al., 2020). This corelates with study conducted by group of researchers to compare the effectiveness of different types of masks mostly used by public in China which is the medical masks, homemade masks (non-medical masks) and N95 and the results show 99.98%, 97.14% and 95.15 respectively for each type of masks (Ma et al., 2020). This study shows that medical mask has higher efficiency in comparison non-medical and N95 masks.

There is a study showed that N95 masks prevents entry of almost all viruses are prevented by wearing medical masks in about 97 percent of cases. Whilst a self-made mask prevents around 95% of virus. In another study, it is discovered that self-made masks example like teacloths might still provide a level of protection but lesser in comparison to medical masks (van der Sande et al., 2008). As per the current trends in the market, people find it a fashion trend to match their face mask with their clothing and most of the face masks are non-industrial made. According to recent research, masks with high-density synthetic layers outperform handcrafted and homemade masks. (Strasser & Schlich, 2020). Whilst this trend raises a question between fashion and prevention, face masks are undeniably becoming a common attire of a human just like other cloth fittings.

Fabric face masks poses as a moderately effective preventive measure in at a medium level in prevention of spread of viral infections like COVID-19. The effectiveness of the droplet barrier is influenced by the type of fabric used, the quantity of layers, and the frequency of washings. (Lima et al., 2020) In a study conducted by researchers says that if local authorities require it, user shall wear a mask and the reported likelihood is highly influenced by age and mask efficacy. (Edward S. Knotek II, 2020). As per the current situation in Malaysia, wearing a face mask has been mandated by local authorities when people are going out to public spaces. Yet, the requirement differs depending on the national recovery phases that the country was in now. A hefty compound is being imposed to those who violate the COVID-19 rules such as not wearing a face mask which was set by local government.

User's preferences differ based on many components and consideration when they choose to purchase a mask. Ranging from type of mask if it is a disposable or reusable, comfort and fit, pricing and last the efficiency of the mask to filter particulate matters. WHO

recommends a checklist to ensure the perfect mask that fits user's face – there should not be any gaps at sides, at the nose and around the chin. The protection level of face mask is not achieved when it not being worn in a right way. As discussed previously, personal respirators proven to provide higher level of protection in comparison to surgical masks also highly influenced by discomfort experienced by the wearer which directly impact level of compliance and protectiveness in curbing the pandemic (van der Sande et al., 2008).

Many methodologies are used to test effectiveness of face masks for example for cloth masks. In a study conducted to test filtration efficient of a cloth mask, the samples of different types of cloth masks have been exposed to a natural working environment in an open area for about 30 minutes where most sources of particulate matters (PM) observed in the area. Later the samples taken back to lab and after that, assess the mask's effectiveness after washing and drying as usual using common detergent and air-dried. The study proves there is a reduction in filtration efficiency after each washing and drying process.

The filtering efficiency was calculated as, FE = (%) = (a -b)100/a (1)

By using the same methodology, many other studies suggest discarding and after the fourth washing cycle, replace the masks. (Lima et al., 2020). We can deduce that the filtering efficacy observed in these trials will be similar to viral particles generating COVID-19 because most cloth masks showed modest absorption of micrometric and nanometric particles.

Adaptation of face mask amidst this COVID-19 pandemic is local health's strategic measure to contain further spread of the virus thus increasing number of people wearing face mask shall interfere in spread of virus in general community and flats the infection rate curve in the country. Multiple studies have been ongoing clinically and demographically to

understand user's perspective toward effectiveness of a face mask amidst this pandemic and it differs if they are wearing it for a protection or prevention purposes (Brainard, Jones, Lake, Hooper, & Hunter, 2020).

Areas on mask ventilation is also another chapter that is crucial to be addressed and relevant it may be possible to lessen the level of mask ventilation problems by being aware of them and to ensure a safe patient care, it is critical to educate the proper setup and maintenance of mask ventilation. (Baker, 2018).

2.7 Limitations and challenges

During the COVID-19 epidemic, the scarcity of face masks became a symbol of modern medicine's and public health's frailty. (Strasser & Schlich, 2020). A list fulfills a statutory obligation under Food and Drug administration (FDA) and reflects the device types that the FDA has identified as being in short supply at the moment, and will be kept and updated as the COVID-19 public health emergency develops. (FDA, 2021). As discussed above, the list shows, personal protective equipment like gloves & gowns (examination purposes), surgical masks & respirators are facing limited supply issue worldwide (FDA, 2021).

Lack of studies for procurement of suitable face masks for users limits the knowledge dissemination to wider community as well leads majority group of people to select lower cost mask which also provides the similar type of protection in absorbing particles during COVID-19 outbreak (Lima et al., 2020). The mandated regulations to wear a face mask during pandemic could influence a person's selection on choosing a face mask, lower-level income person may opt to purchase a cheaper face mask just to follow the local requirement.

Due to frequent use of face masks in recent days, users tend to use the same mask over a period of time with multiple cleanings. As mentioned in a study, if a fabric mask is being repeatedly used for a certain period of time, its ear loops shall be stretched, which could cause the face mask to be loose and unfit to be worn again. (Neupane et al., 2019). A popular medical researcher in 1918 was also quoted as saying that a mask could be washed and used endlessly. (Strasser & Schlich, 2020). Echoing that, to avoid a mask scarcity during the next pandemic, consider the risks of the throwaway culture in addition to building vast stocks of disposable face masks where this can have a negative impact on the environment and lead to poor waste management.

2.8 Waste Management of Facemasks

2.8.1 Waste Generation of Used Face Masks

Based on a local research conducted recently, 87% of Malaysian acknowledged that they wear face mask when they go out in the public in comparison of 55% from the year 2020. Most of these masks are disposable masks with one-time usage. Ever after the COVID-19 outbreak, the quantity of discarded disposable surgical and face masks has increased dramatically in global level and which can be found strewn throughout the streets and highways (Benson et al., 2021). Malaysia records over 10million face masks binned on a daily basis and in China, there has been an accumulation of 142,000 tonnes of medical wastes with the capability to treat medical waste in the country has increased from 4902.8 tonnes/day from before the COVID-19 outbreak until now is at 6022 tonnes/day (Benson et al., 2021).

Disposal face masks in general made of polypropylene and categorized as non-biodegradable. WHO says that 15% of waste release from healthcare settings are at least

hazardous and dangerous to human and environment is not being properly disposed (WHO, 2018). During COVID-19 among many types of generated and face masks are classified under infectious waste as it has higher possibility to be contaminated with blood and other bodily fluids. With rising cases daily, and being not able to control public movement due to economic and financial reasons, countries has recommended in some has mandated the wearing of face masks (Nzediegwu & Chang, 2020).

Tons of contaminated PPEs mainly face masks find its way into general wastes meaning it an improper waste management and poses heavy risks to human health and environment as a whole (Nzediegwu & Chang, 2020). The waste management handling councils faces immense stress and overloading due to generation of different type of biomedical wastes generated during COVID-19 pandemic period apart from face masks alone.

Addressing local council's protection plan, it recommends front-liners not to reuse their face masks or any other PPEs they use during their course of work to curb further spread of the COVID-19 disease (Benson et al., 2021). Unless it is N-95 types of respirator type mask, it can be still reused provided that it is still intact, not damaged, or soiled.

As the number of face mask production is on rise, the generation of used face mask also increases in alignment of mandated policy for people to wear face masks when there are in public spaces. Used face masks in healthcare settings finds its way to be properly disposed as contaminated or clinical waste properly, yet it is not the same case for face masks used by general population at public or non-healthcare work settings.

2.8.2 Facemask waste management during COVID-19

As many Asian countries are still struggling to set up a proper infectious waste management process and do not have an enhanced solid waste management as a baseline will bring risk of infectious contamination to wider population (Sangkham, 2020). Countries with poor waste management strategies and poorly maintained landfills could pose dangerous risk to human health as the landfills could be a potential food bank for livestock that again

In some countries, due to the global infectious disease outbreak they are suffering from a shortage of returns and proper operation of recycling (Tripathi, Tyagi, Vivekanand, Bose, & Suthar, 2020).

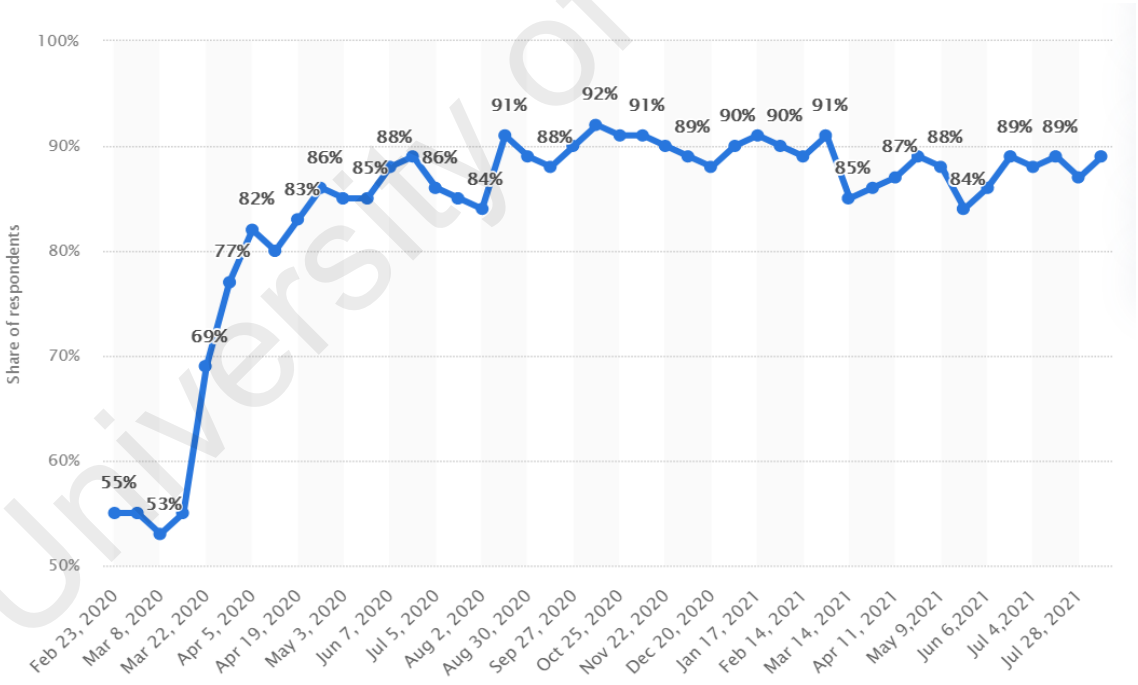

Figure 2.8: Shows trend of face mask wearing in Malaysia's public spaces during COVID-19 outbreak

Based on Figure 2.8, it shows a trend released by Statista proves an increasing trend in wearing face mask at public spaces in Malaysia during COVID-19 outbreak (Statista, 2021). In Malaysia, according to Minister of Environment and Water, Datuk Tuan Ibrahim Tuan Man says the current face masks used by public (non-healthcare settings) can be disposed at sites managed under respective local councils (Star, 2020). Whilst, in Johor Bharu, Malaysia around 321 metric tonnes of medical waste inclusive of PPE were sent out for scheduled waste disposal site to be properly incinerated from hospitals and medical clinics combined (Musa, 2020). According to state Department of Environment (DOE) director, the necessary requirement for infectious waste management is defined under Environmental Quality (Scheduled Wastes) Regulations 2005 and respective organizations required follow the criteria set by DOE to handle proper handling, as well as waste collection and disposal (Musa, 2020).

Due to this mismanagement of infectious waste, subsequently many serious diseases, as well as environmental issues will be arising within the general community. (Sangkham, 2020). As per the current COVID-19 situation in Malaysia, patients are overcrowding isolation facilities and hospitals, resulting in a substantial amount of healthcare infectious waste. Countries have implemented severe and adaptable waste disposal laws to limit the spread of viruses through solid waste produced by households, self-isolated COVID patients, and hospitals as the prevailing conditions have influenced waste collection and disposal. (Tripathi et al., 2020).

Back in 1969, a total disposal system introduced in healthcare settings that not only impact evolution of face masks but syringes, needles, trays, and surgical equipment were among the items on display as well. Part of the point of disposability was to decrease the risk of jeopardizing the fragile state of sterility. Yet, this has put a strain to develop a proper waste

management flow to manage infectious waste disposal as well as boosting the plastics manufacturing.

Human and animal anatomical waste, contaminated blood, swabs, expired pharmaceuticals, syringes, glassware, abandoned mattresses, and other biomedical wastes may include numerous diseases, viruses, and toxic compounds.(Tripathi et al., 2020). In the waste collecting system, the main route for virus transmission is from the generator to the collector. Thus, if the directions for preserving the trash untouched for at least 72 hours are not followed before disposing of it, because the virus can survive for several days on a solid surface. If household waste is collected from the homes of home isolated patients, waste collection systems with a compaction system may also emit viral aerosols.

Lacking personalized waste management system for households in general amongst many countries leads to the main issue – mismanagement of infectious and biomedical wastes like face masks. In buildings (residential, government, and hospitals) and public locations, special waste collection buckets for disposable PPEs could be supplied. Trained staff might empty such waste collection buckets at least once a day, then disinfect or dispose of the PPE. (Nzediegwu & Chang, 2020)

2.9 Summary of Literature Review

Overall, this literature review provides a brief overview of development of face mask from a beak-like mask and its evolvement to be a primary protection level for people globally amidst pandemics in every era. We could see many contributing factors politically and economically plays important role on either mandating or relaxing wearing face mask for general population to curb further spread of the viruses.

Face mask's market (pricing) at a point of time soared high and deemed as critical stock that running outreach for many people globally which heavily impacts the healthcare industry. In this time, it influenced the rise of reusable face masks in various versions by many business stakeholders. This has its pro and cons as the population have access to facial coverings and in other hand, question raised on sufficiency of level of protection offered by reusable face masks. Also, the knowledge on safely wearing a mask and disposing it after usage during pandemic were not well established among common population.

As the face masks continue to run out and being in hot demand, many users took opportunity to bulk purchase and stock up masks in larger quantity either for personal or business use. This provides further niche for face masks globally and increases production level. All the topics discussed in literature review contributes to excessive waste generation of used face mask due to improper disposal.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter discusses the research methodology applied in this study. It deals with the description of research design, research population, data collection techniques and data analysis as well as the tool used to analyses the data.

3.2 Research Design

Research design in this study proposed to show the method and technique of study used to generate accurate and reliable data that met the study objectives and provided answers to the research questions. (Juma, 2021). This study employed a quantitative survey design and administered it to a group of people in Malaysia on face mask usage and disposal practices from a safety and waste management perspective.

Group of participants in the study were routinely asked to fill out an anonymous questionnaire, after receiving their informed consent for the study and data gathering, as well as disclaimers about privacy. Individuals in the survey are anonymized to ensure confidentiality.

The survey involves the management of a series of questionnaire in a Google Form format which aimed to gather information on current practises and public opinion on the face mask usages with the common population. Respondents' background factors enable researchers to answer study questions about variances in practice and thoughts on the future

of advertising in the hotel sector based on age, gender, and experience with COVID-19 pandemic.

3.3 Conceptual Framework

This research is based on 2 different variables relevant to the study, namely independent variable (IV), and dependent variable (DV). Independent variable of this research is ‘improper disposal of used face masks during COVID-19’ and dependent variable identified will be the ‘impact to waste management process’. Both these variables indicate a causal relationship where DV is dependent on IV to achieve our objective of research study.

This research also uses the mediator variable to link the IV and ID to explain how both variables affects each other. Figure 3.2 show visualization of conceptual framework which is based on cause-effect relationship between the main variables and mediator variables. Mediator variables identified are improper usage of face masks, excessive use of disposal or non-reusable face masks, lack of proper usage and maintenance of face masks and lastly lack of knowledge on proper disposal of face masks.

Thus, using a questionnaire, a list of questions developed to understand respondent’s response on procurement of face masks, attitudes, and practices on face mask usage as well the level of knowledge and understanding on local policies and requirement for waste management. Based on the outcome of the questionnaire and response rate, we will discuss based on the identified objectives of this research.

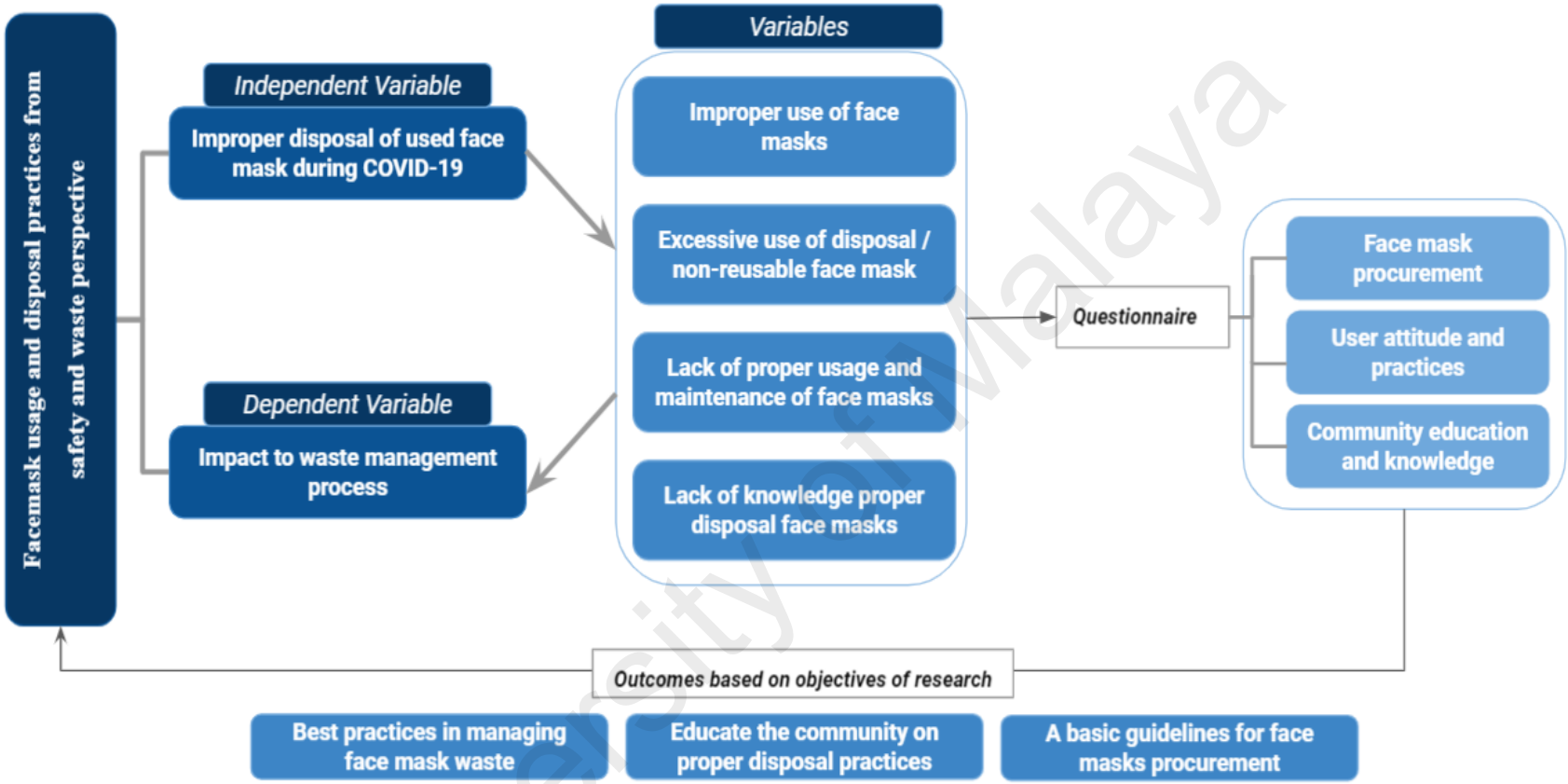

Figure 3.2: Shows the research design framework developed for this study

3.4 Data Collection Technique

The sum of the items under consideration is referred to as a population this study. It is a collection of all situations of openness, sharing and interest. The study's target population was a group of people who were interested to share information, experience, and information regarding face mask usage from safety and disposal dimension. The targeted population is general mixed population in Malaysia with minimum of 150 respondents. The final response collected for questionnaire were total of 182 respondents.

In conducting the study, both primary and secondary data collection techniques applied. These techniques were employed to further understand the current trends and perspective in face mask usage during COVID-19 pandemic.

3.4.1 Primary Data Collection

A series of questionnaire shared to respondent groups via a e-link accompanied by an introduction detail. Disclaimer and personal protection data of respondents were acknowledged as well. The questionnaire takes approximately less than 10 minutes to be completed with several sections to be fulfilled. In total of 38 questions were aligned with 4 different sections. Sample questionnaire attached in Appendix A. Questions of the survey was referenced with previously done study conducted in University of Naples, Spain.

Firstly, in Section A demographic details of respondents such as gender, age range, household income and employment status were collected. Section B of the questionnaire require respondents to answer questions of their face mask selection (disposable or reusable mask) and rate of usage. Likert scale used in these questions. Questions on current trends of double masking and average expenditure spent for face masks were also asked. Section C

lists questions on user's way of maintaining their face masks in terms of hygiene, cleanliness, storage, and practiced method of disposal. Section D of the questionnaire asks opinion-based question from respondents on types of masks that is effective in preventing COVID-19, current fashioned face mask trends and preference to wear face mask if not mandated by Malaysian local councils. Lastly, the questionnaire wraps up with understanding the level of knowledge that respondents possessed on face mask disposal and their rate of satisfaction with the available information about used face mask management in Malaysia.

For the next step, the questionnaires were collected and analysed. In the next step, the data were analysed, and the data were reported statistically in numbers and percentages. In paragraphs, the findings were also reported and discussed. The results from researcher's observation were also in every discussion described as supplementary information. Lastly, conclusions are based on analysis of the questionnaire.

3.4.2 Secondary Data Collection

Data on rate of usage and disposal face mask worldwide were gathered via statical records provided by health authorities bodies, NGOs survey and public records on population data and census. WHO, CDC and MOH released position papers and interim guidance on COVID-19 evolvement in recent times and topics around face masks has been reviewed and discussed. Other relevant reference materials were discussed in depth in Chapter 2.

Other researchers who have conducted survey on similar field is used as a reference to build the list questionnaire. For example, there was a survey conducted in Poland to understand the use of face masks during COVID-19 by Lukasz Matusiak and team. Some of outcome of that survey is studied to integrate in this research study.

3.5 Data Analysis

Once all the respondents had completed submitting their response, the answers provided were gathered and populated. Pre-checking involved in making sure the response provided is relevant to the question asked and fit to use as material to run data analysis. In total of 2 responses were invalid and unable to be used for analysis.

3.5.1 SPSS Analytical Tool

The data from the questionnaires were calculated and analysed by using Statistical Package for Social Sciences (SPSS) programmer. Prior uploading the data into SPPS tool, pre-analysis needs to be done to recode the responses into the format that SPPS could read and analyse. Thus the 180 responses need to be transferred into Google Excel to recode for each question in the questionnaire.

SPSS tool provides the flexibility to run different type of test to analyse the data yet depending on the type of expected outcome. Thus, it is important to refer to research question and objective to set the goal and outcome from the analysis.

3.5.2 Demographic Analysis

Firstly, demographic analysis was conducted to categorize the responses accordingly. By this, it gives a better perspective of mean age group of respondents, educational level as well as economical categorization. Using this demographic analysis, it was later used to conduct cross tabulations and other relevant test to analyse correlations between variables.

3.5.3 Pearson's chi-square test

Using the responses from questionnaire, the data used to run crosstabulation and Pearson's chi-square test via the SPSS tool. Then Pearson's chi-square test conducted to test the existence of relationship between 2 variables and potentially influencing the distribution of data. All the data analysis were aligned with research objectives and outcome of the findings discussed from safety and waste management perspective. The findings later were identified and presented in table and bar chart format for display the response rate with a summary of findings.

3.5.4 Development of face mask usage checklist

Considering the user's response via questionnaire in each section – information was gathered on types of issues faced by community from safety and waste management perspective and current practices by users on face mask management in general. These information were later used to develop the facemask management guidelines for all stakeholders.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. Introduction

This chapter represent the research findings of the data collected from study conducted on collected samples. The main sources of data for analysis are via questionnaire and followed by SPSS tool for analysis. Based on the research questions of the study, the findings will be presented accordingly.

4.2. Waste Management Practices by Region

As of 2020, referring to Table 2.1 the estimated face mask disposed in the mentioned regions are 3,378,451,702. The face mask acceptance rate of each region refers to the adoption rate by population as well as mandatory practice local councils respectively. Each region averages 1 mask usage per day in average.

$$\textit{Total daily face masks generated} = \frac{(T_p \times U_p \times A_r \times A_c)}{10{,}000} \quad (2)$$

T_p = estimated population of each country; U_p = % urban population; A_r = % FM acceptance rate; A_c = daily average usage of face mask

Oceania region with smallest population generates 21 million of used face masks daily with an average of 1 mask / per person in a day. Whilst Asia ranks the highest in generation of face mask on daily basis 1.8 billion. Asia records 80% acceptance rate to wear face mask as a part of preventive measure to curb COVID-19 outbreak and mostly it is

mandated when people are out in the public spaces. Moreover, China is the main source of production and supplier for face masks for majority of countries. Thus, consumer juvenescence the COVID-19 epidemic has compounded the plastic pollution problem for single-use products and materials due to health and safety concerns. (Benson et al., 2021).

Table 4.1: Reports on face mask waste globally by regions in 2020

Region	Population	Face masks acceptance rate (%)	Average Facemask /capita/day	Estimated daily facemask disposed
Africa	1,340,598,147	70	1	411,814,854
Asia	4,641,054,775	80	1	1,875,181,681
Europe	747,636,026	80	1	445,022,934
South America	653,952,454	75	1	380,414,703
North America	368,869,647	80	1	244,335,150
Oceania	42,677,813	75	1	21,682,379
Total				3,378,451,702

4.3. Respondent's Demographic Analysis

Total of 180 respondents answered the provided questionnaire. Out of 180 respondents, 103 were female (57.2%) and 77 were male (42.8%). Age of respondents ranging from 18 – 60 and above and the mean age for female respondent is 38 years old while for male is 39 years old. Table 4.1 provides detailed summary on respondent's demographic profile.

Based on our responses, 92.2% of the respondents are Malaysian whilst 7.8% of them are international citizens residing in Malaysia. The respondents vary from 5 different

categories of employment statuses and more than half which is 56.1% of them are non-government employees and minority respondents from government employment.

87.8% of the respondent has attended college or university to complete their education and the rest has completed primary school level and professional trainings respectively.

Respondents in this study ranging from income from less than RM2000 to more than RM10000. An equal distribution of all level of income can be seen in this group of respondents Mean household income of this group of respondents is between RM 2001 to RM 4000. For ease of SPSS tool analysis these group regrouped and classified as B40, M40 and T20 household group as well. Majority of respondents have a household member from 1 – 6 number of people in general. A saturated representation from our general community is collected via this survey.

Table 4.2 shows summary of respondent's profile based on demographic

Gender	**Frequency**	**Percentage (%)**
Male	77	42.8
Female	103	57.2
Age	**Frequency**	**Percentage (%)**
20 - 29	75	41.7%
30 - 39	50	27.8
40 - 49	25	13.9
50 - 59	22	12.2
60 and above	8	4.4
Nationality	**Frequency**	**Percentage (%)**
Malaysian	166	92.2
International	14	7.8
Education Level	**Frequency**	**Percentage (%)**
Primary / High School	11	6.1
Professional Training	10	5.6

College/University	158	87.8
Other:	1	0.6

Employment Status	**Frequency**	**Percentage (%)**
Government employee	10	5.6
Non-government employee	101	56.1
Freelancer / Self-employee	20	11.1
Full time Student	37	20.6
I'm not working	12	6.7

Income	**Frequency**	**Percentage (%)**
Less than RM2000	58	29.4
RM2001 - RM 4000	32	17.8
RM4001 - RM6000	33	18.3
RM6001 - RM8000	24	13.3
RM8001 - RM10,000	15	8.3
RM 10,001 and more	23	12.8

Household Members	**Frequency**	**Percentage (%)**
1 to 3 person	87	48.3
4 to 6 person	85	47.2
7 to 9 person	7	3.9
More than 10 person	1	0.6

4.4. Face mask usage issues safety and waste perspective

4.4.1. Face mask purchase and vendor selection

For the question asked on ‘Where do you purchase face mask from?”, 61.7% of responders prefers to purchase their mask from pharmacy, 51.1% purchases from general store / convenience store or supermarkets, 17.2% and 6.7% respondents prefer independent / personalized seller and bulk sales vendors respectively. Figure 4.1 reflects the percentage of response on types of sources for face mask purchase by respondents. Based on the response,

face masks sourced and sold by pharmacies deemed by the public as a better quality, safe and medically approved face masks.

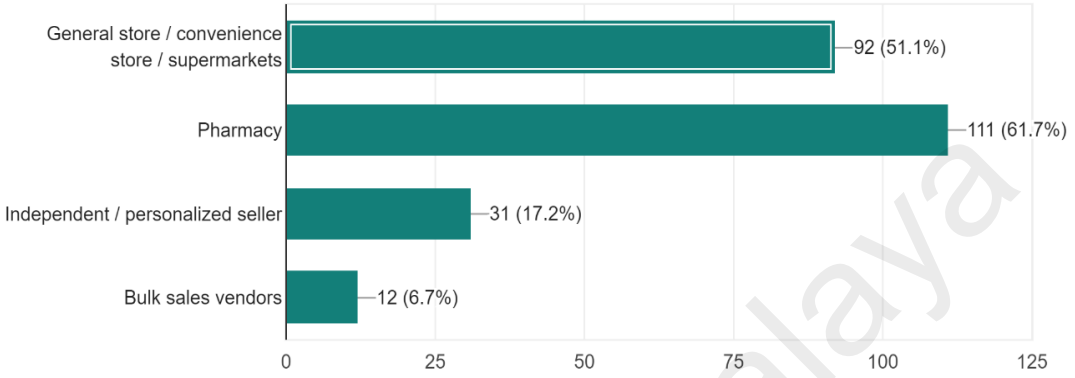

Figure 4.1 shows the rate of response on purchase source of face mask by respondents

Figure 4.1 reflects the percentage of response on types of sources for face mask purchase by respondents. Based on the response, face masks sourced and sold by pharmacies deemed by the public as a better quality, safe and medically approved face masks. This defines the importance of procuring face masks from legit and licensed stores to ensure product quality and safety is guaranteed. Also enable users to have access to different variety of face mask brands, types and models that offers different level of protection for users.

4.4.2. Duration of wearing face mask and its effectiveness

In the questionnaire, the respondents were questioned on span of time they use their face masks either reusable or disposable before they are changing it. This is to understand if the user is aware of limitations of a face mask to protect the user before it needs to be either disposed or disinfected.

Table 4.3 show the timespan of users wearing their face mask before they decide to continue to use or changing it

Mask Type	User preference							
	4–8 hours	**10–12 hours**	**1 day**	**2–5 days**	**1 week**	**More than 1 week**	**I don't use disposable mask**	**I don't use reusable mask**
Disposal face mask	**47.2%**		40.0%	10.0%	0.6%	0.6%	1.7%	
Reusable face mask		16.7%	**33.3%**	17.8%	5.0%	6.1%		21.1%

As per Table 4.3, we can observe that users do consider to either dispose their disposable face mask or replace / disinfect their reusable face mask after maximum of 1 day usage. This explains user's attitude, knowledge, and practice towards wearing and dispose a face mask after using it. For disposable type of mask, the majority user says they would dispose it within 4 -8 hours of usage, followed by maximum of a day. According to WHO, any type of mask that is damaged or soiled needs to be immediately changed or else can be worn for one shift or throughout the day with proper hygiene being followed. As for reusable mask, users can use the mask for a longer term yet depending on environment setting they are

in. If they are in high risk setting like public spaces and frequent in close contact with people, they need to frequently change and wash their reusable masks to ensure higher protection.

4.4.3. Importance of wearing double mask

Whilst wearing double mask is highly recommended and proven to reduce wearer exposure to COVID-19 according to CDC study, respondents were asked a question if they wear double mask when they are going out in the public (CDC, 2021). 58.3% around 105 of them responded with 'Yes' and 41.7% around 75 responded with 'No'. This interprets the need to educate the community on importance of educating and raising awareness on precautionary measure to reduce user's exposure the COVID-19

As a follow up question, respondents also asked on their double mask combination that they apply if they wear double mask. Based on Table 4.4, 39.4% of respondents wear the recommended combination of face mask in accordance with CDC and MOH Malaysia which is disposable mask (surgical type) and reusable mask (fabric mask). This method of mask combination does not reduce the oxygen supply to user and double masking provides 85.4% of protection as well.

Table 4.4 shows response rate for different combination of double mask

Combination of double mask	**Response rate (%)**
Disposable mask + disposable mask	20
Reusable mask + reusable mask	2.2
Disposable mask + reusable mask	39.4
I don't wear double masks	38.3

Also, another discussion points to be considered during education of double masking and its effectiveness, users need to be made aware of proper used face mask disposal methods as well to heighten their level of knowledge on current waste management process and rising issue with regards to improper waste disposals.

4.4.4. Face mask pricing and bulk purchases

As Malaysian government capped the pricing of face mask and set a ceiling price to enable all level communities to have capacity to purchase face mask, yet it is based on the type (medical or non-medical) and mask specification (ply specifications) does influence the pricing range of a particular face mask. 35.6% of respondents to this questionnaire typically spend RM10 – RM20 per month for per box of face mask and on yearly average they spend RM180 for face masks.

Also, 119 respondents (66.1%) do agree to have purchase face masks in bulk (more than 3 boxes of disposable / 2 pieces of reusable mask) in one purchase recently. This phenomenon is due to the recent rise in COVID-19 cases as well to cater the need of users who are still required to travel and work on-site. The requirement to wear a face mask is still being mandated by local government especially when going out to public spaces.

The need and attitude to unnecessarily piling and stocking up face masks not just impact the market but also contributes to excessive waste because every medical face mask has its expiry date. It is valid for 3 years from the date of manufacturing provided they had been stored properly and the expiration of the mask is influenced by the capability of the mask to provide a good fit. Elastic bands, straps and built of the mask tend to degrade over a period, thus the mask loses its effectiveness to protect the wearer.

4.4.5. Environment impact due to improper disposal of face masks

Based on respondent's response as populated in Figure 4.2, 82.8% (149 respondents) selected environmental contamination as the main selection for question on "In your opinion, how does improper disposal of face masks affect the environment or the community?".

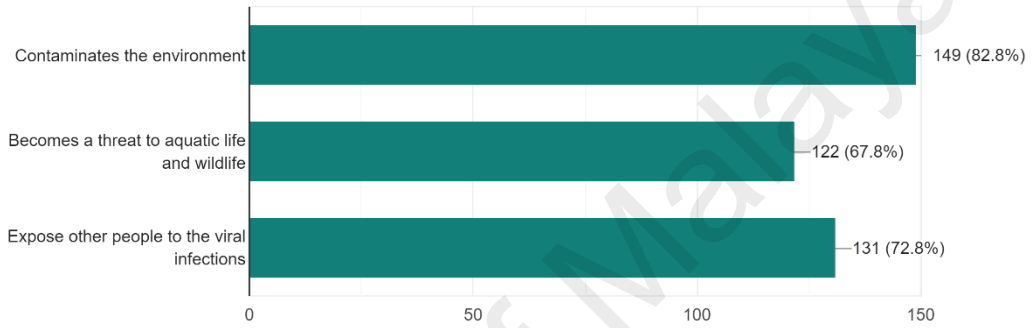

Figure 4.2 shows the rate of response on impact of improper disposal of face mask on environment and community

This question is designed to understand the level of awareness that the users possess with regards to the environmental impacts that used face masks and improper disposal of those face masks imposes. All the given options are impacted due to improper disposal of used face masks during COVID-19 pandemic.

Based on the analysis, majority of the respondents understand the current issues faced by the environment due to improperly discarded used face mask and the subsequent impacts such as threat to aquatic and wildlife as well potential exposure to other people due to cross contamination.

The current local councils in Malaysia does provide a framework for waste management in general but there a vague gap identified in terms of covering the current issues happening in Malaysia with regards to rising face mask wastes inclusive of all type of medical

waste during COVID-19 recently. This shows there need to be an urge to enhance local policies and procedures with regards to used face mask management and greener ways to manage these types of waste instead of ending up in landfills.

4.4.6. Lack of satisfaction level face mask disposal information

To understand the level of satisfaction the users (representing general community) on the current available public information on used face mask disposal methodology and the ease of accessing the information. Based on Table 4.5, its show there is a significant relationship of 70% respondents between age range of 31 – 40 years old answered that they are not satisfied with the current available information or knowledge sources for the disposal of discarded face masks and similarly respondents from other age group also records 'No' as their response. The users in the age range of 31 -40 years old are majority representing the working community and this show that they either not aware of the available information or there is not much information available for their perusal.

Table 4.5 shows age range and level of satisfaction with availability of information on face mask waste disposal

			Are you satisfied with current local information / knowledge sources for the disposal of discarded face masks		
			Yes	No	Not Sure / Maybe
Age	Below 30	% within Age	17.3%	65.3%	17.3%
	31-40	% within Age	16.0%	70.0%	14.0%
	Above 40	% within Age	27.3%	60.0%	12.7%

Table 4.6 shows employment status and level of satisfaction with availability of information on face mask waste disposal

			Are you satisfied with current local information / knowledge sources for the disposal of discarded face masks		
			Yes	No	Not Sure / Maybe
Employment Status	Working	% within Employment Status	22.9%	63.4%	13.7%
	Not working	% within Employment Status	12.2%	69.4%	18.4%

In another crosstabulation, between working users and level of satisfaction on available information on face mask disposals, respondents from 2 different categories of employment status (working and not working) responded that they are not satisfied with the current available information or knowledge sources for the disposal of discarded face masks respectively. The significant results can be view in Table 4.6 accordingly.

Each of the analysis shows that the information on waste management process – mainly on used face masks disposal methodology need to be improvised and made available publicly to all level of general population for their information and practice. Infographics, e-posters, advertisement, government portals, or user-friendly website would be a good resource medium to share the information to public to enhance their knowledge to improve satisfaction level.

4.4.7. Diverse income range impact face mask selections

In this chi-square test results as presented in Table 4.7, the income range of respondents have signification association with their selection on type of face mask either disposable or reusable mask. 68.1% respondents categorized under M40 in which their salary income ranging between RM4001 – RM1000 indicate that which purchasing a face mask, the type of face mask offered in the market is important to them.

Table 4.7 shows income range and importance of type of face mask crosstabulation

			When choosing a mask, how important is type of face masks (disposable / reusable) for you	
			Less important	**Important**
Income	Less than RM4000	% within Income	50.6%	49.4%
	RM4001 - RM10,000	% within Income	31.9%	68.1%
	RM 10,001 and more	% within Income	52.2%	47.8%

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	6.357	2	0.042
Likelihood Ratio	6.450	2	0.040
Linear-by-Linear Association	0.799	1	0.372
N of Valid Cases	180		

As discussed above, the face mask market on economical level in Malaysia has evolved from the start of pandemic and now users are exposed to many different types of face mask for their selection and perusal depending on their daily exposure. Different type of face mask either disposable or reusable has its own market price depending on its specification, thus the M40 group highly evaluates their mask selection based on the type prior purchasing their mask.

Furthermore, respondents also analyse the long-term impact in terms of cost for face mask by comparing the price range between purchasing disposable masks and reusable masks. As discussed above, in yearly average a person could spend RM180 for face mask purchase and this is depending on number person in the household. Thus, the respondents would compare the cost impact of purchasing different type of mask either disposable mask that could be only used one time or a reusable mask that could be used multiple times.

4.5. Practices in managing face mask usage & disposal

The Pearson chi-square test is used to identify two categorical variables have a connection and cross tabulation would allow the researcher to analyse indication between the 2 variables (Schumacker & Tomek, 2013). All the questions in the questionnaires tabulated into SPPS tool to compute the analysis.

Cross tabulation analysis was used to test significance between 2 variables based on their responses. Several hypotheses based on objective of the research were analysed and decision either to reject or retain the null hypothesis is based on the value outcome for $p<.0.05$. Researchers can analyse each chi-square cell value for relevant significance to calculate the overall value (Schumacker & Tomek, 2013).

4.5.1. Important selection criteria for face masks

The effectiveness of a face mask varies to individual based on their perspective and description about safety and comfort while selecting a face mask. When a person wears a face mask, it must provide the required safety level as well as comfort to the user. Yet, in recent times there Thus the questionnaire constructed in a way to understand the level of importance of each component in which a person considers while selecting a suitable and preferred face mask.

All 180 respondents have responded to these 5 questions regarding the importance of each component during their selection of face mask. Section B of the questionnaire collects response on face mask selection criteria and usage, and it were based on 5-point Likert Scale, (1= Not so important, 2= Slightly Important, 3= Moderately Important, 4= Important, 5= Very Important).

Table 4.8: Facemask selection criteria response rate

No.	Statement	1 Not so important	2 Slightly Important	3 Moderately Important	4 Important	5 Very Important
1	When choosing a mask, how important is comfort and fit for you?	0 0%	0 0%	10 5.6%	38 21.1%	132 73.3%
2	When choosing a mask, how important is type of face masks (disposable / reusable) for you?	4 2.2%	7 3.9%	28 15.6%	39 21.7%	102 56.7%

3	When choosing a mask, how important is face mask pricing range for you?	10 5.6%	12 6.7%	39 21.7%	43 23.9%	76 42.2%
4	When choosing a mask, how important is bacterial filtration range (BFE) for you?	1 1%	3 1.7%	13 7.2%	24 13.3%	139 77.2%
5	When choosing a mask, how important is mask branding for you?	35 19.4%	26 14.4%	48 26.7%	38 21.1%	33 18.3%

Based on the response rate from all 180 respondents as reflected in Table 4.2, all 5 criteria listed scored as 'Very Important' by majority of them. Yet, highest score is for level of importance for comfort and fit at 73.3% and bacterial filtration range at 77.2% respectively. This response shows the heighten awareness among community of importance of selecting and wearing a suitable (comfortable and fit) face mask and as well a face covering with a protective level of bacterial filtration range. Based on the findings, it provides a brief overview of user's preference in selecting their face masks and this can provide a baseline to develop a guidance checklist for users to manage their face masks accordingly.

4.5.2. Different age range and mask type

The test analysis on significant relationship shown in Table 4.8 reflects respondent's age range do influence the selection of types of face mask while purchasing. For ease of analysis the age range of respondents split into narrower 3 different category of below 30 years old, between 31 – 40 years old and above 40 years old.

A strong significance can be observed where 69.1% of respondents between the age range between 31 – 40 years old says when choosing a face mask, the type of face mask either disposable or reusable is very important to them. This significance shows the relevance of respondents in the age group of 31 – 40 years old to be in working category, thus choosing a suitable type of face mask for work relatedness is important for them. Moreover over, users in this age group of has higher chances of exposure to COVID-19 at from workplace as they might be working onsite.

Table 4.9: Shows the age range and importance of face mask type crosstabulation

			When choosing a mask, how important is type of face masks (disposable / reusable) for you	
			Less important	Important
Age range	Below 30	% within Age range	54.7%	45.3%
	31- 40	% within Age range	40.0%	60.0%
	Above 40	% within Age range	30.9%	69.1%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.607	2	0.022
Likelihood Ratio	7.684	2	0.021
Linear-by-Linear Association	7.452	1	0.006
N of Valid Cases	180		

This significance also translating that respondents from this age group of 31- 40 years old has well-built understanding on the need and importance to select a suitable type of face mask depending on their exposure environment.

Yet, in other analysis computed to cross tabulate the relationship between age and pricing of face mask, there were no significant association found between the two variables.

4.5.3. Face mask selection based on bacterial filtration efficiency (BFE).

Bacterial filtration efficiency (BFE) for a face mask relates to efficiency of the material that is used to build the layer that will act as a barrier to protect the user from aqueous viral moistures (Forouzandeh, O'Dowd, & Pillai, 2021)

For chi-square significance test as reflected in Table 4.9, respondent's employment statuses were split into 2 categories of 'Working' and 'Not working' for ease of crosstabulation and results interpretation. Working category comprises respondents classified under government employee, non-government employee as well as freelancer / self-employee. Not working category comprises respondents from group of full-time student and not working.

Table 4.10 shows the employment status and importance of face mask BFE crosstabulation

			When choosing a mask, how important is bacterial filtration efficiency range (BFE) for you	
			Less important	Important
Employment Status	Working	% within Employment Status	18.3%	81.7%
	Not working	% within Employment Status	34.7%	65.3%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.435	1	0.020
Likelihood Ratio	5.136	1	0.023
Linear-by-Linear Association	5.405	1	0.020
N of Valid Cases	180		

The test shows significant association between working respondents and their preferences for BFE when purchasing face mask. Respondents tend to prefer to analyse and

provide importance to the level of safety and protection a face mask could offer to the user while being exposed to public spaces during pandemic.

Also, working respondents tend to be in a higher risk group as depending on their work nature, they might require supporting their job from physical site or office and this is where the level of protection a face mask could offer is crucial for the wearer.

4.5.4. Face mask selection based on branding.

Face mask branding is seemed to be crucial for certain type of users where in their perception, the making of a face mask under certain well-known brand shall be produced in a better quality in compared to common brands. Expansion of face mask economy and market in recent pandemic times influence many brand owners mainly apparel business settings to develop face masks for general population.

Table 4.11 shows the employment status and importance of face mask branding crosstabulation

			When choosing a mask, how important is mask branding for you	
			Less important	**Important**
Employment Status	Working	% within Employment Status	77.9%	22.1%
	Not working	% within Employment Status	91.8%	8.2%

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	4.651	1	0.031
Likelihood Ratio	5.295	1	0.021
Linear-by-Linear Association	4.625	1	0.032
N of Valid Cases	180		

Based on Table 4.10, we can observe there is a significant association 91.8% of respondents from non-working category (full-time student and not working) said that the branding of a face mask not important when selecting or purchasing a face mask. Similarly, 77.9% respondents from working category also said that the mask branding is not important when selecting a mask.

Thus, there is other specifications in face mask that could be taken into consideration when purchasing a face mask such as BFE level, type of face mask, comfort and fit and branding could be the last specification to look into as a key consideration. Also, as branded face masks costs higher than common branded face mask, the cost factor is deliberately been considered by the non-working group of respondents.

This baseline information can be used a guide for stakeholders to procure face masks for their focus group of population (students, workers, elderly etc.) to consider importance of brands versus cost versus masks specifications.

4.5.5. Importance of double masking

Based on chi-square significant analysis as presented in Table 4.11 on age range and its significance on response on wearing mask when going out to public spaces. 100% of respondents of age 60 and above says they wear double mask when they are out in public spaces and it is highly significant for this age group.

Similarly, the next highest significance of 72.7% were observed with respondents within age range of 50 – 59 years old. As discussed in above, double masking is highly encouraged by MOH Malaysia to ensure higher protection level when exposed to COVID-19 virus and proven to be effective protection of highly contagious Delta variant.

Table 4.12 shows the age range and trend of wearing double mask in public spaces crosstabulation

			Do you wear double mask when you are going out to the public spaces	
			Yes	**No**
Age	20 - 29	% within Age	57.3%	42.7%
	30 - 39	% within Age	48.0%	52.0%
	40 - 49	% within Age	56.0%	44.0%
	50 - 59	% within Age	72.7%	27.3%
	60 and above	% within Age	100.0%	0.0%

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	9.873	4	.043
Likelihood Ratio	12.844	4	.012
Linear-by-Linear Association	4.314	1	.038
N of Valid Cases	180		

Wearing double masks and with increased level of protection is crucial for these age group of people because they are often classified as group of people with increased risk of serious illness from COVID-19. Also, these group of older adults more likely to get seriously ill due to existing underlying medical condition and may require hospitalization and intensive care for them to recover from illness.

Based on Table 4.12, 66% of female respondents shows significance association to wear double mask when they are out in public space in comparison to male respondents. And as discussed above, the proper double masking method in accordance with CDC and MOH Malaysia is to combine disposable mask & reusable mask to ensure sufficient protection and oxygen supply to the users.

Based on Table 4.13, female respondents show higher significant of 50.5% on the right double masking method when they are out in the public spaces.

Table 4.13 shows the gender and trend of wearing double mask in public spaces crosstabulation

			Do you wear double mask when you are going out to the public spaces	
			Yes	**No**
Gender	Male	% within Gender	48.1%	51.9%
	Female	% within Gender	66.0%	34.0%

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	5.852	1	0.016
Likelihood Ratio	5.855	1	0.016
Linear-by-Linear Association	5.820	1	0.016
N of Valid Cases	180		

Table 4.14 shows the gender and double masking combination crosstabulation

			What is your combination of double mask?			
			Disposable mask + disposable mask	**Reusable mask + reusable mask**	**Disposable mask + reusable mask**	**I don't wear double masks**
Gender	Male	% within Gender	23.4%	3.9%	24.7%	48.1%
	Female	% within Gender	17.5%	1.0%	50.5%	31.1%

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	13.221	3	0.004
Likelihood Ratio	13.585	3	0.004
Linear-by-Linear Association	.019	1	0.892
N of Valid Cases	180		

Thought this demographic analysis and double masking trend shows significant association, it is equally important to education everyone on the importance to stay safe and protected against COVID-19 during pandemic. Anyone with underlying medical condition is at high risk of developing severe symptoms and classified under category 3 -5 and in need of immediate medical attention.

Thus, staying protected with adequate and suitable face masks (single or double masks) is as crucial of being vaccinated.

4.5.6.Enhance level of awareness on face mask disposal issue

Based on Table 4.14, the analysis shows significant association of 77.8% respondents with university or college education background agrees that there is a rising issue on improper facemask disposal method in recent times. Also, group of respondents that are 'not sure' with the rising issue from both group of respondent's ranges between 20.3% - 22.7%.

Table 4.15 shows the education and level of awareness on rising face mask waste disposal issue crosstabulation

			Do you think there is rising issue with improper disposal of face masks globally?		
			Yes	No	Not Sure / Maybe
Education	Non-University/College	% within Education	63.6%	13.6%	22.7%
	University/College	% within Education	77.8%	1.9%	20.3%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	8.552	2	0.014
Likelihood Ratio	5.671	2	0.059
Linear-by-Linear Association	.813	1	0.367
N of Valid Cases	180		

This response influenced by the level of exposure and accessibility to information that this group of respondents may have with the recent issues on COVID-19 waste management. The level of awareness on the rising issues due to improper disposal if used face masks shows a positive turn to availability of information of recent environmental issues to be concerned about by the public. Also, group of respondents with educational background majority resides within working category as well as active student which provides them a platform either workplace or college / university for them to further discuss the current issues with used face mask disposal within their community and offers unique solutions. Many non-governmental organizations have taken up voluntary role to provide newer solutions to manage and reduce face mask in a greener way and reduce negative impact to the environment.

For example, Queensland University of Technology Australia developed a face mask made out of plant waste and enhance biodegradable way of disposing used face masks (Layt, 2020). Many countries have developed drop off bins that enable people to safely dispose used face masks in a dedicated bin that will be soon recycled into a sustainable form of material ranging from usable plastic ware to building raw materials.

4.6. Face mask management

Based on the analysis and identified findings, it is clearly understood that face mask will be deemed as important layer of protection for all populations across the globe if the pandemic continues to extend for a longer term. It is important now to view the face mask management from safety and waste dimension from a proactive approach rather than then addressing its adverse outcome.

To review the research question no.3 on they criteria's that need to be considered by stakeholder to ensure clearer understanding, effective handling and prevent unwanted waste of face masks, it needs to be tackled from a waste management strategy. Based on waste management hierarchy, highest level addresses prevention as an ideal strategy to prevent waste at the initial stage.

Furthermore, to address the responses from questionnaire as well as case studies, the gap identified is lack of an outlined process or guide for users to manage the face masks from end-to-end process. With a proper guideline in place, the stakeholders able to properly manage the face mask from initial procurement level which addresses the waste prevention at the beginning level itself.

4.6.1. A checklist for face mask management

In this research, to assist multiple level of stakeholders on an end-to-end process of face mask usage and disposal and using the references from valid sources - a checklist with a comprehensive framework developed as attached in Appendix A. The components of the checklist are based on case studies and responses from the questionnaire conducted with

general community in Malaysia to understand their current practices in face mask management.

The checklist of face mask management guidance is split into 3 different sections, namely as face mask procurement, usage, and management. Each of this section describes the step-by-step process needs to uptake by stakeholder to ensure a smooth end to end process to manage face mask usage in their community or organization.

In Section 1 (green) under face mask procurement, stakeholders clearly go through the process of selecting a suitable face protection based on the need and focus group of people. As per research findings, the users are spilt into using different types of face mask either medical masks or non-medical masks. By identify the population's need, this will bring to a drop-down on items such as target group's size, pricing criteria and pre-set regulatory standards. Mask manufacturing standards is depending on the country that stakeholders are procuring from as in Malaysia we have a fixed standard on legal mask procurement. Some organizations have a fixed budget allocated for employee's welfare and some may not. Yet, the pricing of face mask should not be a primary concern as the prioritization for safety of working environment must always supersedes costing. Furthermore, certain face mask design specifications need to follow to ensure sufficient level of protection is achieved by user while wearing the mask.

In section 2 (blue), the process stream down to individuals and their usage attitude and knowledge. This section is applicable upon completion of face mask procurement. Prior using the face mask, users need to be trained with basic knowledge as mentioned in the checklist. Based on the listed questions in the guidance checklist, users shall learn in detail about using a face mask from start of wearing until the removal process. Comprising standard

and best practices around the world, the user can understand how to properly use a face mask to achieve required protection level to curb spread of COVID-19 as well protecting others.

In section 3 (yellow) which is the management, users provided with information of how to properly store new stocks of face mask properly masks for reusable purposes. This practice is emphasised to ensure there is no wastage occurs from user's end with damaged or improperly used masks. In addition, there is available information on how to properly clean a reusable face mask to prevent damage to the mask and ensure prolonged use of a face mask. Cleaning of face mask might differ to type of face mask the user owns. Lastly, users can refer to proper disposal methodology that can be easily practiced by discarding via general or household waste itself until there is a specific guideline releases by local authority.

This checklist can be used by an individual as a one-stop reference point to understand process flow in face mask usage when it comes to selection of suitable face mask and how to usage it in a right manner to ensure safe level of protection being achieved. Also, it can give a clear description to properly dispose used face masks and best practices in managing a clean reusable face mask.

4.6.2. Face mask management guidance

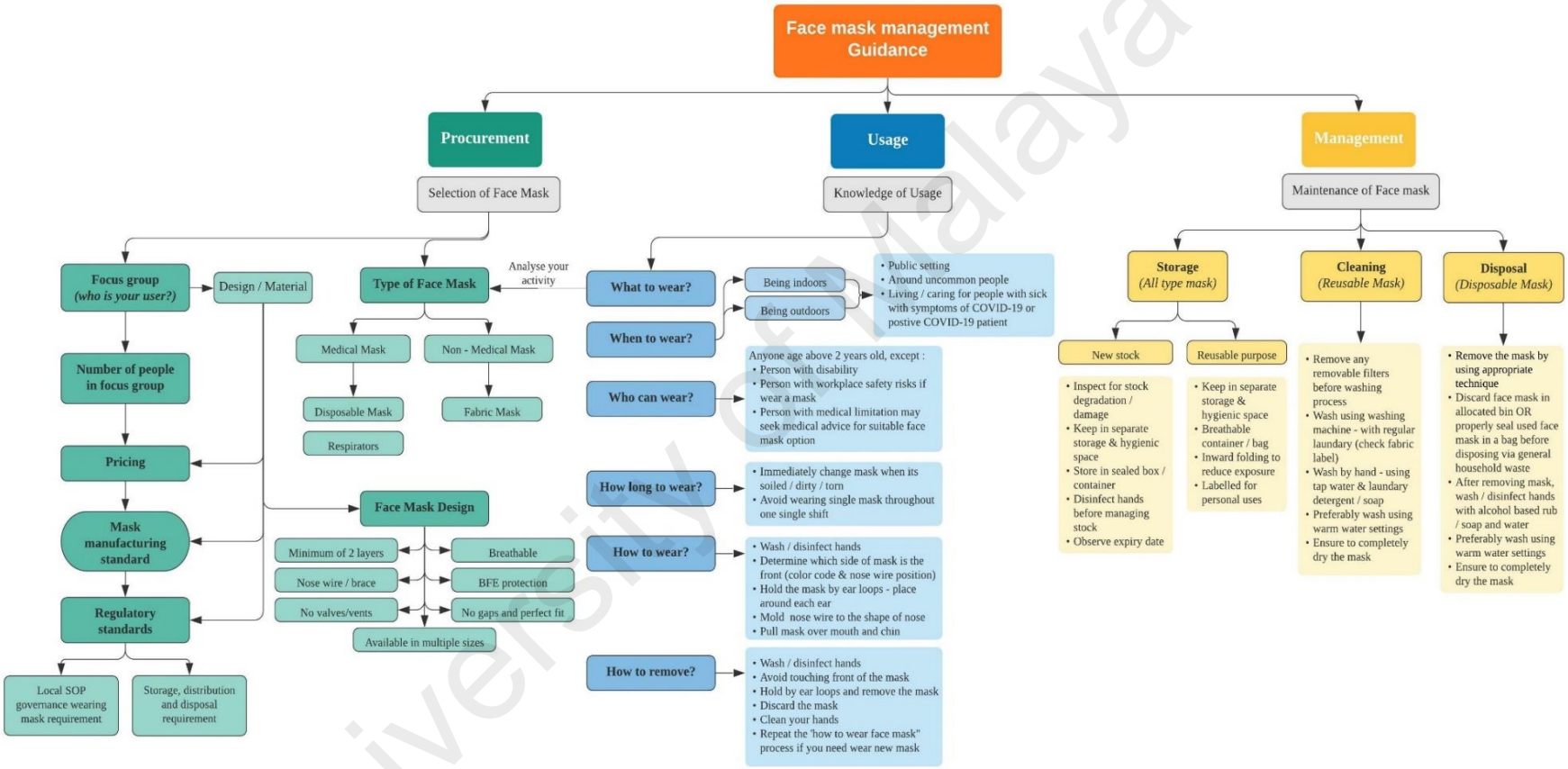

Figure 4.3: Shows 3 sections of facemask management guidance

4.7. Summary of findings

As a conclusion, based on the findings of the analysis it is understood that the face mask users in Malaysia have diverse perspective and preferences on face mask management and usage from safety and waste dimension. The unique diversity is common in all nations and it is also seen as challenge to implement a standard or common approach to address rising topics like waste management of used face masks during critical times like COVID-19 pandemic.

Local councils and policy makers are always on spotlight to address waste management issues, yet the collaboration and efforts is required from all stakeholder to ensure effectiveness of applied approach.

Regardless, it is important to take a pro-active approach in managing waste arising from any source point and it will be effective with the support of a properly outlined guidance or procedure governed by local councils to ensure compliance and adherence.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

Thus, in this chapter, a discussion based on the results obtained in Chapter 4 presented. All 3 research questions revisited with a brief overview. Final part of this chapter discussed the contribution of the study with recommendations and suggestion for upcoming studies.

5.1. Conclusion

This section reports the summary of findings and discusses 3 research questions.

Research question 1: *What are the current issues related safety and waste dimensions of used face mask?*

From research analysis conducted, the current issues with used face mask during COVID-19 pandemic is due to its improper management of waste generated from different settings in the community. In terms of safety aspects, users need to be equipped with basic knowledge on ways to properly use a face mask, ability to differentiate the types of masks available as well as the level of protection a face mask could offer in different work or environment settings. A face mask used by a person suspected with COVID-19 symptoms or a positive COVID-19 patient, is a highly contaminated material and with improper disposal management, this could jeopardize another person's wellbeing and impacting the public health. Thus, when a user lacks knowledge to properly utilize and dispose this will impose a safety risk.

From waste dimension, many disposable and single use face masks are made from polypropylene plastic and once it's being disposed, it takes years to decompose and provides

adverse effect to the wider environment in long term. Also, users also need to be educated on to be a responsible buyer as now everyone has ability to purchase face masks provided is it in a manageable market demand level for masks in Malaysia. Users tend to get into the trend of panic purchases and stock up face masks beyond their need. And those mask upon expiry dates, might end up in landfills. This will put our already strained waste management system into further pressure to manage excessive waste generated from discarded face masks. It is clear from the analysis that there is a lot work and effort need to be by multiple stakeholders ranging individual to government policy makers to prevent rising issues on used face masks in Malaysia.

Research question 2: *What the current waste management process (disposal methodologies) implemented in Malaysia on managing facemask wastes generation? Are there any differences in waste management process based on different settings e.g., healthcare settings, home / general settings?*

Based on study conducted, the waste management process for discarded facemask differs in different settings based on the standard operating procedures set by as well as the local Malaysian compliance guidelines. Used face mask waste generated in a healthcare setting required to follow Environmental Quality (Scheduled Wastes) Regulation 2005. Any type of disposable plastic wastes generated from healthcare facilities or COVID-19 relatedness areas such quarantine centres or vaccination centres needs to be classified as scheduled wastes under code SW 404 falls in First Schedule of the Act. Waste generators need to make sure that these wastes are properly being disposed at prescribed premises that licensed by Department of Environment (DOE). One of the methodologies used is

incineration process and if any parties found to be at incompliance by disposing waste at unlicensed premises, hefty fine shall be placed on the organization.

In contrast, for any type of waste generated from household or public shall be solely managed under local council of relevant jurisdiction. Based on Environment and Water Ministry, there is no plans to review law on used face masks from general settings like the markets, conveniences store, offices and malls as these wastes are not classified as clinical waste. Thus, currently there is no clear guideline for public on proper final disposal channel to discard used face masks.

Research question 3: *What are the criteria's that need to be weighed by stakeholder to ensure clearer understanding, effective handling and prevent wastage of face masks?*

Based on analysis conducted, there is a gap identified with level of knowledge, awareness satisfaction rate among respondents on the information perceived with regards to disposal of used face masks. Identifying the profound reason for this gap, there is a multiple layer of topics needs to be addressed to identify a solution such as basic awareness, user training, smart procurement, stocks management etc.

Many international health governance platforms like World Health Organization (WHO) and Centre of Disease Control (CDC) as well as local health authorities like Ministry of Health Malaysia (MOH) had been release multiple references materials to assist individuals to enhance knowledge and assists their decision making for COVID-19 relatedness topics e.g., face masks preferences, physical distancing measures etc. These materials and reference documents released to the public after much research and

understanding the changing trends happening aligning to COVID-19 pandemic. Yet, it is a challenge to develop a standardized guideline for a diverse group of communities and stakeholders. As discussed in Chapter 4, a guidance document on facemask management is developed with this research to assist all level of stakeholders to review their face mask process prior and after purchase. This document will guide the stakeholder from procurement, usage, and management perspective as an overall approach.

In summary, the key takes from this research is to understand face mask usage and disposal knowledge and attitudes that attributes to waste and safety constituents in general. Specifically, this study intended to provide a clear view and guidance to multiple stakeholder who have faced challenges and questions in term of managing face mask from the beginning of the pandemic. Safety dimension of a product must be always be a priority when developing from scratch and thus the quality of the product shall be guarded. Similarly, face masks that offers primary level of protection to users need to be under governance of local authorities for its product specifications (material, BFE) and compliance to environment protection (biodegradable and harmless to environment). Health councils of respective countries must enhance public knowledge and promote practices that users could adopt to ensure a smooth waste management process is being followed to dispose used face masks to prevent it end up in wild or ocean contributing to pollution. The world is facing enough environmental changes and challenges to have this to added to the list. Also, government can look into supporting small profit NGOs or researchers who works on recycling used face masks waste into a sustainable products or sponsor development of biodegradable face masks to reduce production of disposable face masks amidst pandemics.

With sufficient knowledge and guidance, the users could improvise the ways they manage their face masks from right procurement, selection, utilization, and finally proper disposal. This could ensure the face mask lifecycle is environmentally sounds thus lesser waste would be release the landfill and less or no impact our environment. It is a long-term roadmap and goal to achieve but it is definably achievable with strong collaboration, supportive stakeholders, proper guidance, education, heighten awareness level and robust compliance process.

5.2. Implication of the Study

From the study and analysis undertaken to answer the research question and achieve the goals the topic discussed in the intention to address the strain faced by waste management system in Malaysia during this COVID-19 pandemic period. Additionally, this study has examined most of the journals within the span of two (2) years from the relevant fields to ensure consistency of information.

The analysis and write-up conducted in this study aims to assist as an underlying basis to future researchers to further study of the impacts and solutions for used face masks regardless of pandemic period as face masks also seen as a new norm in the current era.

This study of face mask usage and disposal practices from waste and safety perspective is important to stakeholders who aims to have a standard practice in managing their in-house face mask management from the start of the cycle of procurement until the disposal process. It will be providing an underlying flow of circular economy by not just

managing the waste but to emphasis on waste prevention, green purchasing and recycling and reuse attitudes.

The face mask management guidance developed for stakeholders can be further enhanced by future researcher to incorporate newly developed local and international policies and procedures for better guidance for relevant stakeholder to follow and understand the end-to-end process flow of managing face mask usage in any settings.

5.3. Recommendations for Future Studies

As discussed in previous chapter, this study analysis and response from questionnaire is obtained from a general population in Malaysia not limited to any geographical locations. It is modest as the sample size is smaller than any targeted community and there are certain limits to the generalization been made in this study. Thus, in future, the sample size from a specific location or community can be obtained to ensure preciseness and ability to have larger samples to analyse.

The motivation of this study to understand the underlying issue with face mask usage and disposal in Malaysia during COVID-19 pandemic. For further study based on the current research, it is suggested to supplement causes of the issues from different perspectives such as economic point of view. This could provide more insights on face mask market at global level and how the market thrives during pandemic and non-pandemic season.

As this study is conducted during the niche period of pandemic, as time goes by there might be a more robust process on local level to manage face mask usage and disposal from a safety and waste perspective in Malaysia. Thus, the research objective of this study could

deep dive into more safety, environment, and engineering solutions to address waste management issues in Malaysia.

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