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ORIGINAL ARTICLE

The Unseen Threat: Microplastic Emissions from Face Masks and Limited Public Awareness

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Abstract

Masks are typically made of plastic materials, which can contribute to plastic pollution if not properly disposed. A survey should be conducted to assess the public awareness of microplastics (MP) emissions and mask disposal, which could inform targeted educational campaigns to promote sustainable practices. This study used an online survey to gather data from a sample of the general public aged 20 years or older who had used masks. The survey included questions on mask usage, disposal, and awareness of the presence of MP in masks. The survey found that, although awareness of the risks of MP was high, the respondents' understanding of them was low, particularly among younger individuals. The survey also revealed that more than half of the respondents did not know whether their masks contained plastic materials and that there was a lack of awareness regarding the potential environmental and health impacts of improper mask disposal. These results revealed that it is crucial to raise public awareness of the environmental and health impacts of improper mask disposal and the presence of MP in masks.

Keywords Face-mask · Disposal · Microplastic · Awareness · Survey

Introduction

During the past 3 years of the pandemic, the use of masks for personal health care has increased rapidly, but recently, as transition to an endemic phase, mask usage has sharply declined. Vaccination rates may be sufficiently high to provide significant protection against viruses, and public health authorities may decide to lift mask mandates or make them optional for fully vaccinated individuals [1]. Although mask mandates are lifted, some people may choose to continue wearing masks for various reasons [2]. Some individuals may feel safer and more comfortable wearing masks in public settings, particularly if there are concerns about the spread of new variants. In addition, airborne fine dust is a serious problem in Korea, particularly during spring, when Asian dust can cause health problems. Thus, masks can protect against the inhalation of fine dust particles and prevent the spread of respiratory illnesses [3].

In general, surgical masks and N95 respirators should be disposed of after each use and not be reused. Single-use disposable masks should be discarded in a closed bin, such as a trash can with a lid, to prevent the spread of any infectious diseases that may be on the mask [4]. Additionally, masks should not be littered or left in public spaces as they can contribute to environmental pollution. However, during the pandemic it is common to discard masks on the streets [5, 6]. When masks are thrown away from the trash at home or in the office, they can potentially contaminate other wastes and pose a risk to the sanitation workers who handle the waste. To address this problem, it is important to raise awareness about the proper disposal of masks and provide adequate waste management infrastructure to support safe disposal [7].

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The main material used in masks is typically a nonwoven fabric made from synthetic fibers [8]. This material is designed to filter out particles and droplets that may contain viruses and is often referred to as a melt-blown fabric. Some masks may contain high-molecular-weight plastic ingredients, such as polypropylene (PP) or polyester. PP is one of the most commonly used polymers in medical mask production, because it is lightweight, flexible, and exhibits excellent filtering properties. Polyethylene, polyester, and polystyrene have also been used in surgical masks [9]. Therefore, plastic masks can negatively impact the environment if improperly discarded.

Plastic pollution is a major environmental issue, and steps must be taken to reduce the amount of plastic waste in the environment [10]. This includes the proper disposal of masks and other plastic products, as well as reducing the use of single-use plastic items whenever possible [11, 12]. Recycling masks requires separating the different components of the mask, including the PP and any metal components, and reprocessing them into new products. However, recycling masks also raises potential concerns regarding hygiene and contamination, particularly given the risk of transmitting infectious agents through the masks [13]. Additionally, the recycling process can generate microplastics (MP) and other pollutants, which can have negative environmental and health impacts.

It is possible for MP to be released during the use and disposal of masks made of plastic materials. When masks are improperly used or littered, they can break down into smaller pieces over time, eventually becoming MP. When masks are worn, they can shed small plastic fibers, especially when handled or adjusted frequently and become airborne, posing a risk of exposure to MP [14]. These fibers can be released into the air or onto surfaces, potentially contributing to MP pollution [15]. While more research is needed to fully understand the extent of MP release from masks, it is important to properly dispose of masks made of plastic materials to minimize the risk of releasing MP into the environment. However, the mechanism by which MP are released from masks during respiration is not fully understood. Some studies have suggested that MP released into the air can be inhaled or ingested by humans and other organisms [15–17]. Therefore, it is important to continue researching the potential health and environmental impacts of MP and to take steps to reduce their release into the environment.

However, it is unclear whether the public is aware that MP can be emitted from masks. Although there has been some media coverage of the potential environmental impacts of disposable masks and the release of MP, this information may not have reached everyone [18]. Surveys can be an effective way to assess public awareness of mask disposal and MP emissions. Several awareness surveys have been conducted regarding mask use and disposal [19–22]. However, there have been no awareness surveys on the potential emissions of MP during mask use and disposal. The emergence of MP from masks is a relatively recent discovery, and the scientific community is still investigating the extent and impact of this phenomenon [11]. In other words, there seems to be a gap in the research on public awareness of MP emissions and mask disposal. Conducting an awareness survey on this topic could be useful for identifying potential areas where education and outreach efforts are needed to help individuals understand the potential environmental impacts of mask use and disposal. Therefore, this study aimed to conduct a survey to assess the public awareness of MP emissions and mask disposal.

The survey included questions about people's current practices and attitudes towards mask disposal, as well as their knowledge and understanding of the potential risks of MP emissions originating from masks. The questionnaire was divided into four parts: (1) current status of mask usage according to age and occupation; (2) current status of mask usage among children; (3) type of mask disposal method; and (4) potential exposure to MP from masks. In the endemic era, this information could be used to develop targeted educational materials and campaigns to promote more sustainable mask use and disposal practices, leading to reduced exposure of humans and the environment to masks.

Methods

Participants for Online Survey

We aimed to investigate the general public's perception by investigating the behavior of face mask litter and awareness of the possibility of exposure to humans and the environment through an online survey. To confirm the representativeness of the population of interest, the target of the survey was the general public aged 20 years or older who used masks. Participants were recruited through social media platforms and online forums (October 2022). Demographic variables (sex, age, marital status, parental status, occupation, and mandatory mask-wearing) were used in the surveys to describe the characteristics of the study population and to investigate potential associations with the study outcomes [22]. It is important to include these variables to ensure that the study results are generalizable to the population of interest and to identify potential confounding factors that may influence the study outcomes [1].

Participants were required to complete a self-administered questionnaire that assessed their perceptions of and attitudes towards MP in masks. All the participants provided informed consent before participating in the study. All 1000 responses were complete and met the study's inclusion criteria: 510 were from men and 490 from women, suggesting

that the study had a roughly equal representation of men and women in the sample. To ensure that the sample composition by age was representative of the population distribution, the sample was divided into five age groups from 20 to 60 s, with proportions of 17.6%, 17.6%, 21.8%, 23.4%, and 19.6%.

Questionnaire Development

The questionnaire was developed based on a literature review on the potential exposure of humans and the environment through mask disposal [9, 15]. The questionnaire comprised four main parts: (1) overall use of masks, (2) use of masks by children living with adults, (3) mask disposal, and (4) general awareness of exposure to MP. The first part addressed overall mask use, which is important for understanding the prevalence and frequency of mask usage in the study population. The second part specifically focuses on mask use by children living with adults, which is important because children may have different mask usage patterns than adults and may be at a higher risk of exposure to MP. The third part addresses mask disposal, which is important for understanding the potential environmental impact of mask use and the potential for MP to enter the environment. Finally, the fourth part focused on the general awareness of exposure to MP originating from mask usage, which is important for understanding the level of knowledge and understanding of this issue among the study population. This study was limited by its reliance on self-reported data, which may have been subject to bias. The study will also be limited to participants who have access to, and are comfortable using, online survey platforms.

Results and Discussion

Current Status of Mask Usage with Ages and Occupations

As part of the survey, the participants were asked several basic demographic questions to gather information about the study population. The questions were about marital status, parental status, number of household members, occupation, and obligation to wear masks. According to the survey results, 63.7% of the participants were married, and 59.4% had children living in their households. This information may help understand how marital and parental status affect mask usage and disposal habits. As for the age of the children living together, 19% were under the age of 7; 52.3% were in elementary (27.7%), middle (11.8%), and high (12.8%) schools; and 28.7% were college students. This indicates that approximately 3/4 of the children were at the age at which they can use and discard masks by themselves. Households with four members accounted for 31.3% of the respondents, whereas households with three members accounted for 26.2%.

Occupational groups were classified into 13 categories: manager, 7.4%; professional, 10.9%; business, 31.8%; service, 8.0%; sales, 4.7%; agriculture and fisheries, 0.5%; craftsman, 3.6%; mechanic, 1.9%; simple labor, 4.2%; soldier, 0.4%; college student, 3.7%; homemaker, 15.5%; and unemployed, 7.4%. In addition, the survey data indicated that approximately one-third (33.6%) of the respondents reported that wearing a mask was mandatory in their occupations, such as public transportation drivers, salespeople, station workers, couriers, security guards, and hospital workers. This suggests that a significant portion of the population is required to wear masks as part of their jobs and highlights the importance of proper mask usage and disposal practices in the workplace to prevent potential exposure to MP or other contaminants.

The daily average mask-wearing time was investigated for adult men and women and analyzed according to age group. As shown in Fig. 1a, during weekdays, men wore masks slightly longer than women, but on holidays, both sexes wore masks for a similar duration of 3.8 h. By age group, Individuals in their 20s had the longest mask-wearing duration (7.2 h), and the wearing time decreased as age increased. Younger adults in their 20s may engage in more outdoor activities than older adults, which could potentially contribute to longer durations of mask wearing. This trend was also observed during the holidays. The observation that the average daily mask-wearing time for all age groups was longer on weekdays than on weekend (6.1 h versus 3.9 h, respectively) suggests that people may feel a greater need to wear masks during their daily activities. On weekends, when people spend more time indoors with their families or close friends, they may feel less of a need to wear masks.

The average daily mask-wearing time was also investigated for occupations where wearing a mask was mandatory, as shown in Fig. 1b. The order of mask-wearing time was the highest for station employees (12.0 h) and health/medical occupations (8.7 h), followed by customer service (8.3 h), restaurant businesses (8.2 h), and salesmen (7.8 h). Bus drivers worked on holidays; therefore, the wearing time of masks was constant, regardless of weekdays (6.5 h) and weekends (7.0 h). Subway engineers work in three shifts for 12 h; therefore, they wear masks for a long time. The occupations recommended to wear masks had an average daily mask-wearing time of 7.7 h, whereas occupations not recommended to wear masks had a lower average daily mask-wearing time of 5.3 h. Occupations that are recommended to wear masks may involve higher levels of contact with others or exposure to the virus, which may lead to a higher level of compliance with mask-wearing guidelines. The habit of wearing masks even appeared on holidays, and occupations

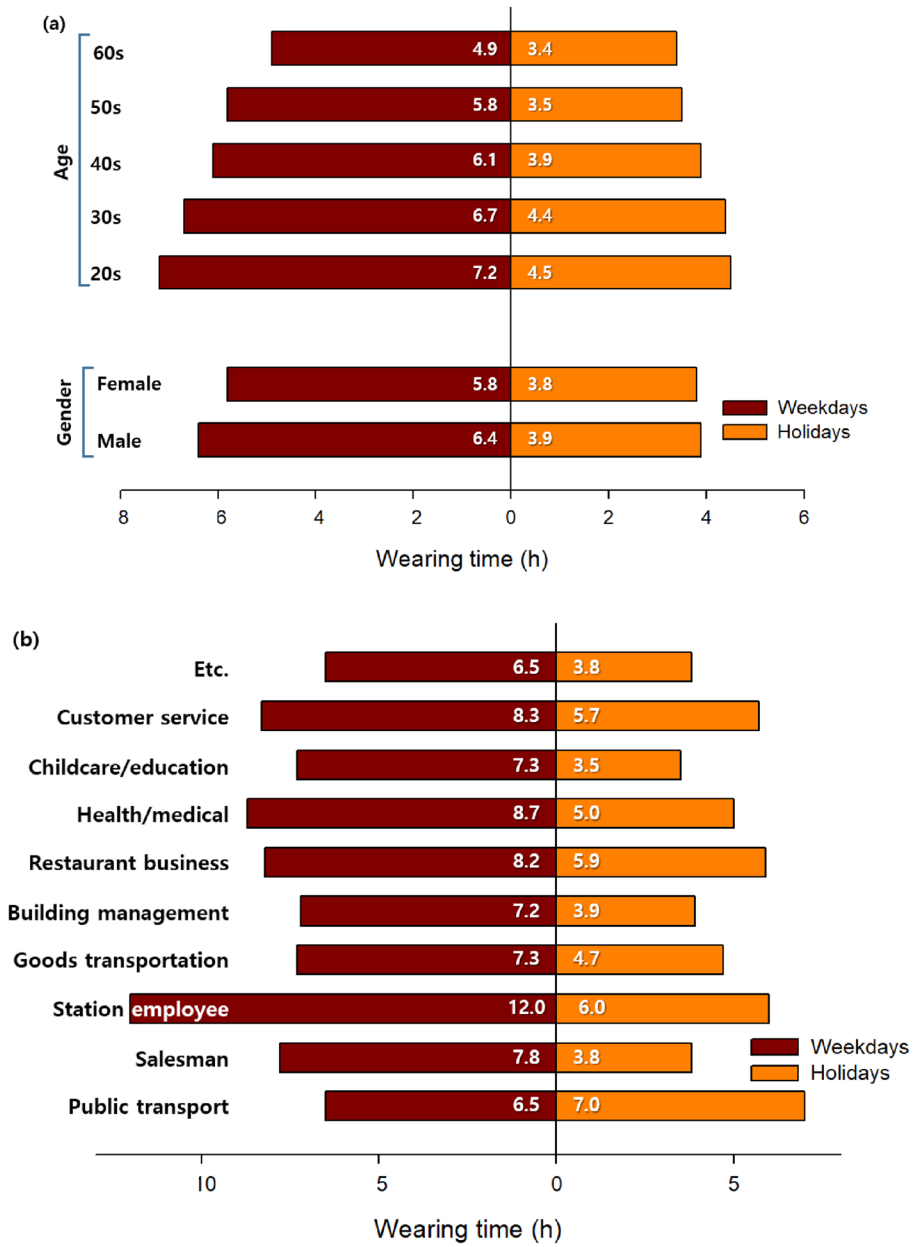

Fig. 1 Daily average mask-wearing time by **a** gender and age, and **b** type of occupations where wearing masks is mandatory

recommended wearing masks for an average of 4.5 h even on holidays.

The annual average number of masks used varies by age, with people in their 20s (521.7 masks per year) using the most and those in their 60s (341 (521.7 masks per year) using the least, that is, 464.6, 419.5, and 422.0 masks/year for people in their 30s, 40s, and 50s, respectively. Older individuals may spend more time indoors or engage in fewer social interactions, resulting in lower frequency of mask usage. The average number of masks used per year for men and women was 433.6 and 427.5 masks/year, respectively. In addition, occupations where wearing masks is mandatory used an average of 82 more masks per year than jobs where mask wearing is only recommended. Masks were replaced daily, regardless of occupation. In Korean culture, it is common for individuals to wear masks as a preventive measure against air pollution or during the cold and flu season, even before the pandemic [2]. The habit of wearing masks regularly may have contributed to the trend of daily mask replacement. The habit of frequently changing masks can be beneficial for personal hygiene, as it helps maintain a clean and effective mask to prevent the spread of infections. However, this can cause additional environmental problems, particularly if large numbers of single-use masks are discarded. Therefore, the proper disposal of masks is important to minimize their environmental impact and prevent the spread of infections.

The occupations with the highest average number of masks used per year were goods transportation (834.1), salesmen (631.0), restaurant business (581.3), health/medicine (537.1), childcare/education (437.9), station employees (416.0), and public transportation (404.0). Because mandatory mask-wearing requires individuals to wear masks for longer periods of time, it is likely that they will need to replace their masks more frequently than those in jobs where wearing a mask is only recommended: for occupations with mandatory and recommended mask-wearing, the mask-wearing time was 6.1 h versus 3.9 h, and the number of masks used was 485.3 masks/year versus 403 masks/year, respectively. This could explain why the average number of masks used was higher in occupations where wearing masks was mandatory.

Masks were divided into three main types based on their design: dome type (type 1: KF-94 and N95 masks), bird's beak type (type 2: KF-94, KF-AD, N95, and fashion masks), and pleated type (type 3: dental and surgical masks). The dome type has a more rounded shape that may provide greater comfort and ease of breathing for the wearer. The beak-type bird is designed to fit tightly over the nose and mouth, providing a high level of filtration and protection against airborne particles. The pleated type is designed to be lightweight and easy to wear. On average, 25.9% of the respondents said that they used masks depending on the season. In particular, the replacement rate was high among women (32.7% and 19.4% for female and male, respectively) and among those in their 60s (34.7%).

As shown in Fig. 2, the preferred mask type varied according to the season. Regarding the percentage of use by type of mask, the bird's beak type accounted for 42.1%, dome type accounted for 35.5%, and pleated type accounted for 22.4%. Type-1 and type-2 masks may provide better filtration than type-3 masks, as they often have multiple layers and a more complex structure. In contrast, type-3 masks, also known as surgical or medical masks, are simple and affordable options that provide basic protection against droplets and airborne particles. Additionally, type-3 masks are relatively easy to breathe through, making them comfortable to wear for extended periods of time [20]. This is particularly important for healthcare workers or other individuals who need to wear masks for several hours at a time [1]. In addition, type-3 mask usage tended to increase rapidly in summer (66.4%) and then rapidly decreased in winter (4.2%). Hot and humid weather during summer can make it uncomfortable to wear a mask for extended periods, especially if the mask (type-1 and type-2 masks) is thick or difficult to breathe through. Type-3 masks, on the contrary, are designed to be lightweight and breathable, which makes them more comfortable to wear during hot weather.

Current Status of Mask Usage of Accompanying Family Members (Children)

In Korea, it was common for many people, especially children, to wear masks, even before the corona crisis [23]. Children's use of masks is highly dependent on parents and

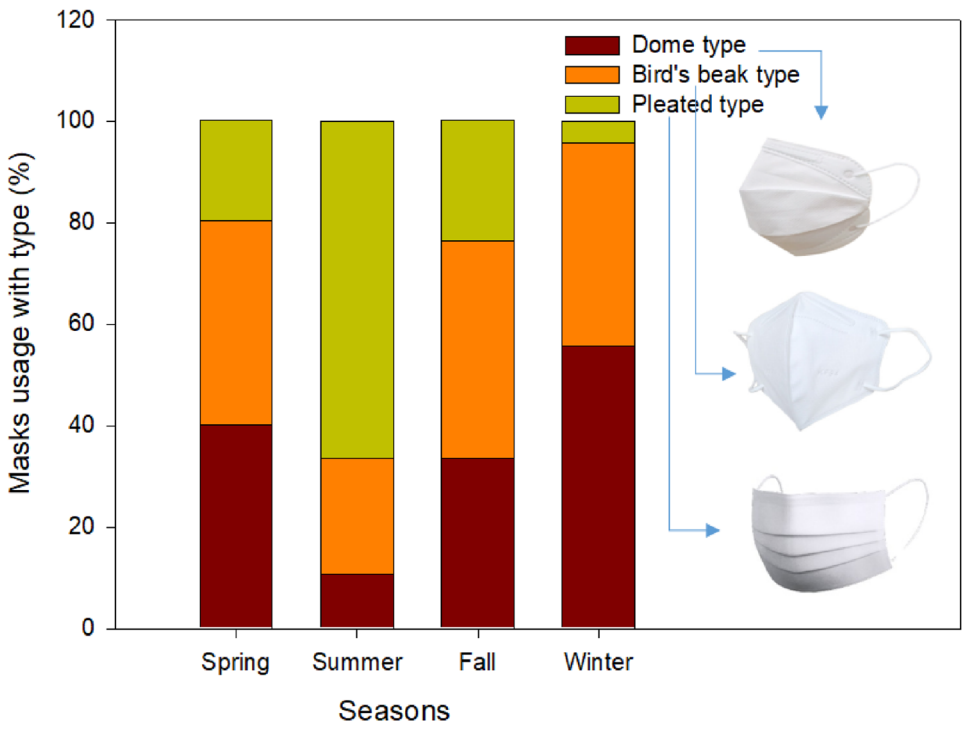

Fig. 2 Type of mask preferred varied with the season

caregivers. Parents play a crucial role in helping children understand why wearing a mask is important and in making masks part of their daily routines. As shown in Fig. 3, the mask usage status of accompanying family members is represented by the daily wearing time of masks, number of masks used per year, and usage rate according to mask type. Children spend an average of 4.5 h wearing masks per day, which is less than the average of 6.1 h for adults. Interestingly, the average number of masks used per year by children was 468.2, which was slightly higher than the average for adults (430.6 masks/year). Children may be more prone to losing or misplacing masks, leading to more frequent replacements. As children are more active and spend more time outdoors, they may be exposed to more pollutants and allergens, which may require the use of masks. This could have led to more frequent mask usage and replacements.

Based on the data in Fig. 3a, b, the mask-wearing time was generally proportional to the number of mask usages per year. As individuals spend more time in educational settings, such as schools or universities, they may be required to wear masks for longer periods of time to prevent the spread of infectious diseases. This can contribute to longer overall usage times and more frequent replacements. Additionally, kindergarteners wore masks for a short period (6.4 h), but with a large average number of masks used per year (502.8 masks/year).

As shown in Fig. 3c, children used type-1 and type-2 masks, both of which were effective in blocking droplets, at a higher rate than adults. Among children under elementary school age, less than 13% wore type-3 masks and more than 87% wore type-1 and type-2 masks. This suggests that parents or caregivers may prefer to use type-1 and type-2 masks for younger children, perhaps because of their perceived effectiveness or availability. However, among middle school students and older adults, the choice for type-3 is increasing. This may be due to several factors such as increased awareness of the importance of wearing masks as individuals get older, the need for more durable and longer lasting masks, and the availability of different types of masks in different settings.

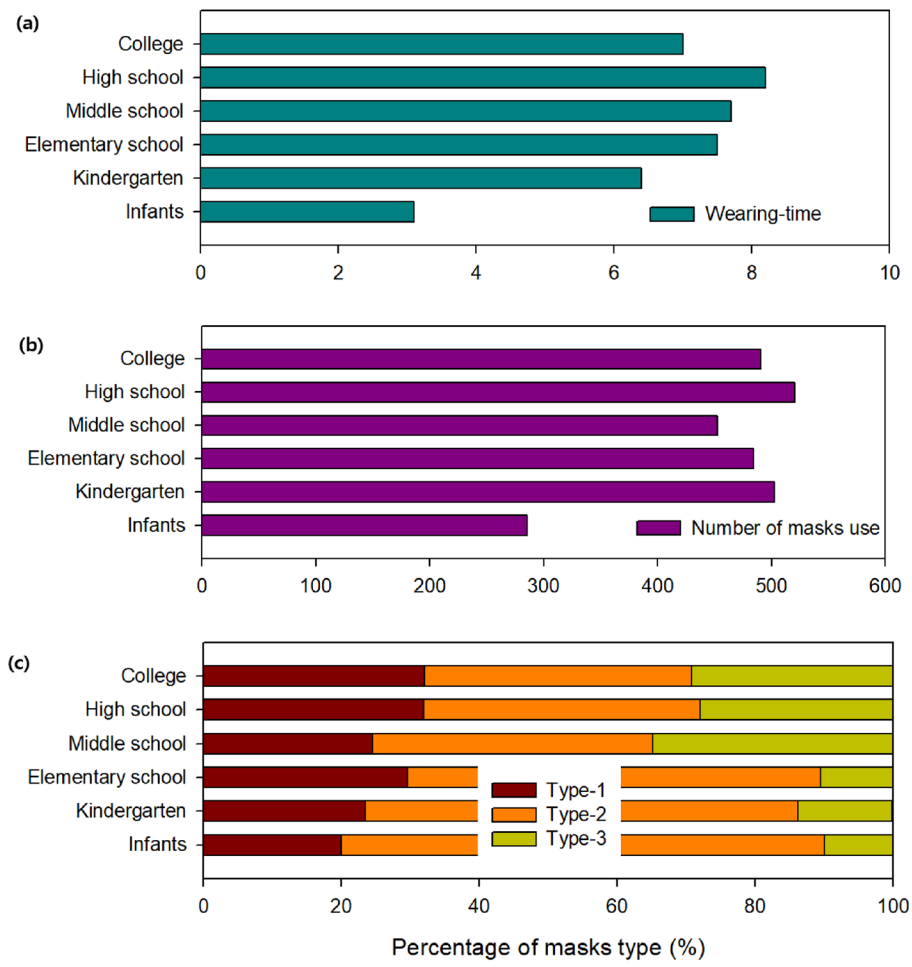

Fig. 3 Mask usage status of accompanying family members: **a** daily wearing time of masks, **b** number of masks used per year, and **c** usage rate according to mask type

Type of Mask Disposal Method

The increase in mask usage time and usage can lead to an increase in the number of discarded masks, and if masks are not properly disposed of, they can adversely affect the environment. Disposable masks are made of materials such as PP, which can take hundreds of years to break down in the environment. When discarded masks end up in landfills or as litter in the environment, they release MP and harmful chemicals into the soil and water, which can negatively impact wildlife and human health [12]. Furthermore, improper disposal of masks can contribute to plastic pollution in oceans, which is a growing environmental crisis that threatens marine life and ecosystems. Therefore, it is important to check how the general public disposes of masks and review whether they are properly disposed. This can help identify any issues or gaps in waste management and raise awareness about proper ways to dispose of masks. When masks are lost or littered in the environment, they can release microplastics and harmful chemicals into soil and water, which can have negative impacts on wildlife and human health. Furthermore, lost masks pose a risk to sanitation workers who may come into contact with them during waste collection and disposal.

A survey was conducted on the disposal of used masks, and it was found that there are several methods for mask disposal, including general waste, designated waste, and recycling. Figure 4 shows the percentage of waste masks according to the mask disposal method by age. The majority of the cases were handled as general waste (97.4%), whereas only 2.1% were handled as designated waste. Approximately 0.5% of them recycle waste masks, although mask recycling was rare. There was no significant difference in mask disposal by age (96%, 99.4%, 97.7%, 97.9%, and 95.9% for people in 20–60 s, respectively). A single-use mask should be disposed of in a designated waste bin after use and should not be reused. Therefore, most single-use masks are disposed of as general trash. Recycling masks is possible for certain types of masks made from recyclable materials, such as cloth masks. Most participants seemed to wear disposable or N95 masks, because the recycling rate was low. Because discarded masks are difficult to recycle, an increase in trash unavoidably results in an environmental burden. The materials used in the production of N95 masks may vary but typically include various components: the outer layer (nonwoven PP), middle layer (melt-blown PP), inner layer (soft, non-woven PP), nose clip (metal), and ear loops (polyester, nylon, and polyurethane) [8]. The diversity of chemicals in masks is one of the reasons why their recycling is challenging [13].

There were also differences in the methods of disposing of masks according to occupational group. Masks were discarded as general garbage by 96.4% of those required to wear them, whereas only 3.6% were discarded as designated waste. Healthcare workers may have specific guidelines and protocols for the disposal of masks as designated waste because of their higher risk of exposure to infectious materials. However, only 7.2% of the masks used were classified as designated garbage, whereas 92.8% were disposed of as general waste. Some occupational groups such as

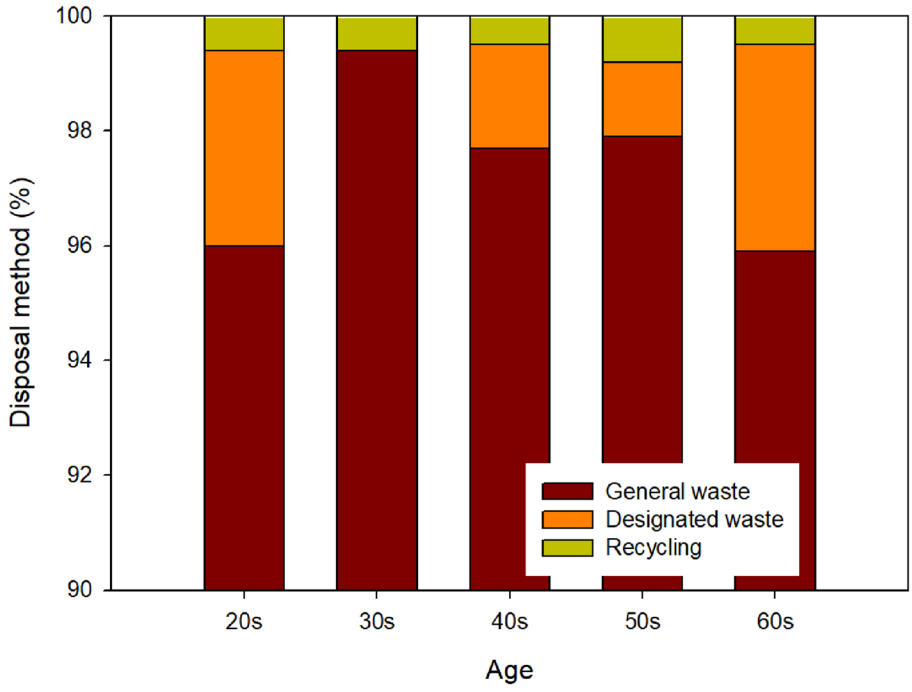

Fig. 4 Percentage according to mask disposal method of waste masks by age

public transportation, station employees, goods transportation, restaurants, and customer services treat used masks as 100% general waste. As described above, masks are generally treated as general waste. In most places, general garbage is collected by waste management companies or local government agencies and transported to a designated landfill or incineration facility for disposal [21].

If masks are not properly disposed of, they can spread infectious diseases and negatively affect the environment. One example is the loss of a mask. Therefore, a questionnaire survey was conducted to determine the demographic characteristics of the experience of losing a mask. According to the investigation, 38.1% of the respondents reported having lost a mask, which means that over one-third of the participants had experienced mask loss. Furthermore, on average, these respondents lost 33.3 masks/year, indicating that mask loss is relatively common [5]. A higher percentage of men (43.3%) reported losing their masks than women (32.7%). The average number of masks lost per year was approximately 33, regardless of sex. As shown in Fig. 5, the experience of losing a mask was generally higher among younger individuals. 43.3% and 29.6% among those in their 20 and 60 s, respectively. In the case of people who experienced loss, the highest number of losses was reported by those in their 40s (43.7 masks/year). Those in their 20s lost an average of 40.3 masks/year, whereas those in their 60s lost an average of 15.0 masks/year. Younger generations and active workers are more likely to report losing their masks. This finding suggests that more active individuals may be more susceptible to mask loss because of forgetfulness. Therefore, there is a need for increased awareness and education regarding proper mask usage and storage to reduce the frequency of mask loss.

General Awareness of MP Exposure Originated from Masks

The increased use and improper disposal of masks can have adverse effects on the environment. In addition, because the masks are composed of PP fibers, there is a possibility of exposure to MP during use [9]. The improper disposal of masks can lead to plastic waste pollution, which can harm ecosystems. Photooxidation causes the rapid fragmentation of plastic waste, leading to the formation of nanoplastics and MP [11]. Especially, the formation of nanoplastics through photooxidation exacerbates the challenges of plastic pollution, as these tiny particles may have more widespread and long-lasting impacts on ecosystems and aquatic life. In addition, during the use of masks, there is a possibility of exposure to MP, because the PP fibers in the masks can shed and become airborne. The inhalation of MP poses potential health risks, as the particles can accumulate in the lungs and potentially cause respiratory problems [9, 15]. Therefore, the overall awareness of MP and the possibility of human exposure to MP in masks were surveyed.

Awareness of the risk of MP to humans and the environment was found to be high regardless of sex: 90.4% and 92.4% for males and females, respectively. The awareness of

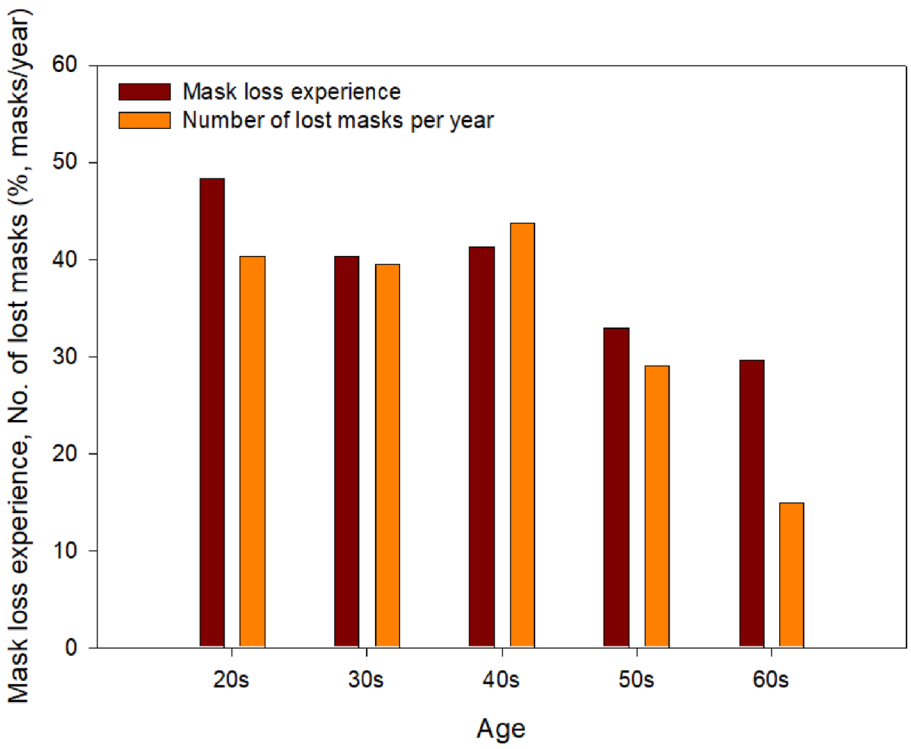

Fig. 5 Percentage of mask loss experience and number of lost masks per year

MP hazards was slightly lower for single individuals (86.6%) than for married individuals (94.0%). Awareness of the dangers of MP was high among parents and caregivers, suggesting that they may take steps to protect their children from potential exposure to MP. People in their 20s had the lowest awareness of MP: 85.0%, 94.5%, and 94.0% for those in their 20s, 40s, and 60s, respectively. This suggests that this age group may be less informed about the potential environmental hazards associated with MP.

Even if the awareness of MP is high, the level of understanding may differ. Therefore, the understanding of MP and the risk perception of MP were surveyed. The survey used a six-point Likert scale, with 6 being the highest level of understanding. The average values for risk perception and understanding of MP were 5.29 and 3.95, respectively. Although people are aware of the dangers associated with MP, they are not well informed about them. This may be due to a lack of education and awareness programmes, limited access to information, or misinformation. As shown in Fig. 6a, there was a positive correlation between risk perception and understanding of MP. People who are more informed and knowledgeable about MP may perceive a higher level of risk, because they are aware of the potential environmental and health impacts of MP pollution. In addition, it was observed that both indicators–risk perception and understanding of MP–increase with age. This suggests that older individuals tend to perceive higher levels of risk associated with MP and have a better understanding of the issue than younger individuals do. Therefore, educational programs and awareness campaigns targeted at younger demographics could enhance understanding, focusing on the specific environmental and health impacts of microplastics, thereby fostering more responsible behaviors.

In a subsequent question, the respondents were asked whether their masks contained MP. It was found that 55.6% of the respondents were unaware of this. Additionally, 48.2% of married people and 37.3% of single people recognized the presence of microplastics on their masks. It is possible that some individuals do not realize that masks can contain plastic materials because they are made of non-woven fabric that feels like a traditional fabric. Although awareness of the risk of MP is high, more than half of the respondents did not know whether the masks contained plastic materials. This suggests a lack of understanding or knowledge regarding the composition of masks and their potential environmental impact. It is important to raise awareness about this issue as improper disposal of masks can lead to the release of MP into the environment, contributing to plastic pollution.

A low-quality mask can be easily damaged, thus easily emitting MP. When wearing a mask for a long time, one can be exposed to a high amount of MP through respiration [15]. Although masks are designed to block bacteria and MP in

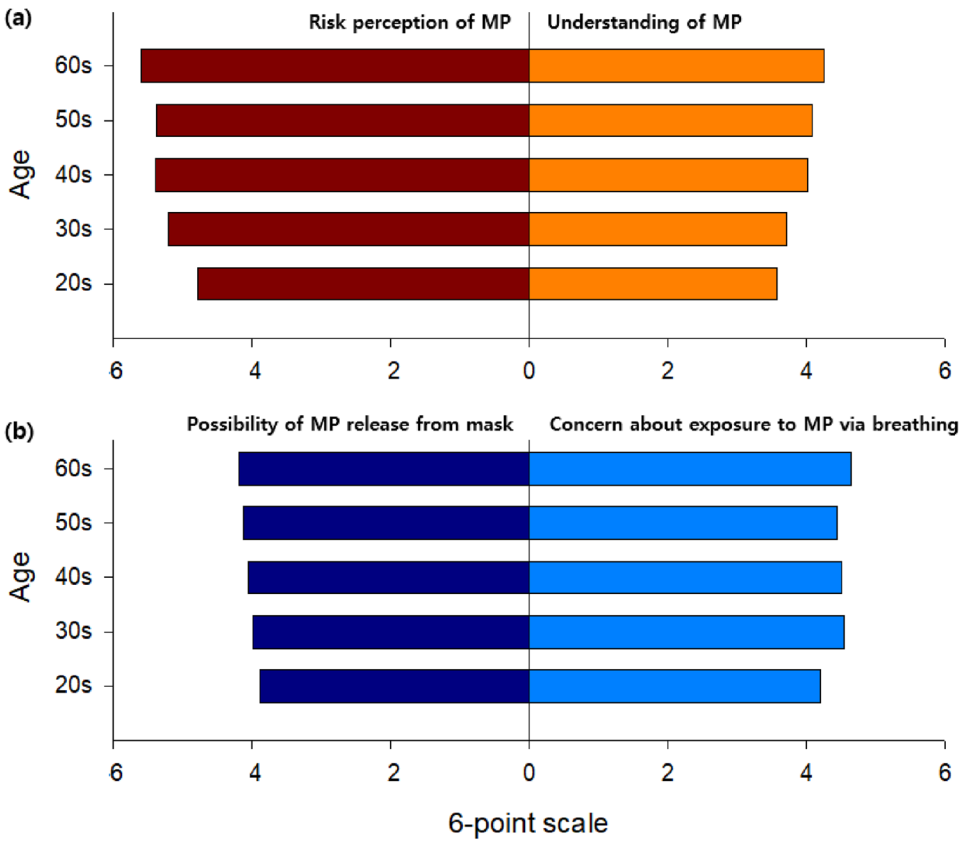

Fig. 6 Survey results about **a** understanding and risk perception of MP and **b** possibility of MP release from masks and concern about exposure to MP through breathing

the air, it is ironic that breathing can cause exposure to MP from within the mask itself [16]. Therefore, in addition to asking about the presence of MP in masks, two questions were asked about whether MP would fall out of the mask and whether there was a possibility that the released MP might be inhaled into the human body through breathing. The average scores for the two questions were 4.06 and 4.47, respectively. Respondents had an average level of awareness regarding the potential for MP to fall off their masks. However, once informed of this possibility, respondents expressed greater concern about the potential health risks associated with the inhalation of MP released from masks. As shown in Fig. 6b, there was no significant difference in the perception of the potential for MP to fall off masks or be inhaled across all age groups. However, as age increased, there was a slight improvement in overall awareness of the issue.

In September 2022, the status of wearing masks outdoors in Korea was switched from mandatory to recommended. On January 30, 2023, the requirement for wearing masks indoors was lifted. On March 20, 2023, the recommendation to wear masks on public transportation and in open pharmacies became less strict, indicating that it was no longer mandatory. Although the transition to the endemic era, many individuals continue to wear masks both indoors and outdoors as a preventive measure. In the survey, respondents were asked whether they planned to continue wearing masks in the future and, if so, for how long. As shown in Fig. 7, even after lifting the mask mandate, many individuals expressed their intention to continue wearing masks. Approximately 80% of the respondents indicated that they would continue wearing masks at schools, daycare centers, public transportation, and large marts, even after the lifting of the mask mandate. Moreover, they planned to continue wearing masks for at least 13 months. In the office, only 54.5% said they would wear a mask continuously for approximately 12 months. This suggests that despite the transition to the endemic era, many individuals remain cautious and concerned about the potential for continued transmission of viruses in certain settings and are taking steps to protect themselves and others through ongoing mask use. In terms of personal health, many people plan to continue wearing masks, even after the mandatory requirements are lifted. However, mask usage is expected to decrease by only approximately 20% over the next 12 months or more, indicating that mask disposal remains a significant issue. Therefore, it is crucial to develop an appropriate strategy for mask disposal, even in endemic situations. This will eventually reduce human and environmental exposure to MP.

Conclusions

Masks are mainly disposed of as general household waste, which means they end up in landfills or incinerators. This can lead to potential environmental and health hazards owing to the release of MP and other harmful substances into the environment. It is important to properly dispose of masks to minimize their negative impact on the environment and public health, and to prevent MP pollution. The use of masks remains high, and there is a high incidence of unintentional exposure to masks in the environment due to mask loss, accounting for 38% of cases. There was a gap in awareness among the respondents regarding the presence of MP in masks and their potential exposure to them. In

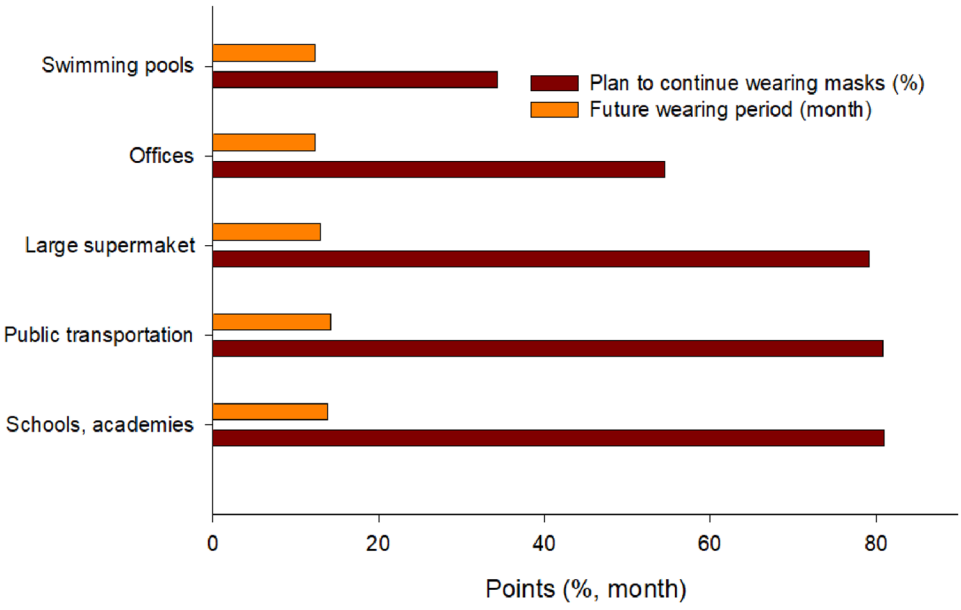

Fig. 7 Survey result for plan to continue wearing masks and wearing period even after the obligation to wear masks is lifted

addition, there was also a problem that recycling was not easy because a mask is composed of a variety of materials.

Therefore, it is important to develop strategies for appropriate use and disposal of masks in the endemic era as well as potential future respiratory diseases. First, it is necessary to raise public awareness about the environmental and health impacts of improper mask disposal and the presence of MP in masks. This can be achieved through public education campaigns and the dissemination of information through various channels such as media outlets, social media, and government websites. Second, it is important to promote the use of reusable masks made of eco-friendly materials such as cotton instead of disposable masks. This will not only reduce the amount of waste generated, but also minimize the release of MP and other harmful substances into the environment. Third, it is necessary to establish a system for proper collection, sorting, and recycling of used masks. This can be achieved through collaboration between the government, the private sector, and civil society organizations. Collection bins specifically designated for used masks can be installed in public places, and guidelines can be developed for the proper sorting and recycling of masks. Finally, it is important to promote the development and use of eco-friendly materials for the production of masks to minimize the environmental impact of their production and disposal. This can be achieved through R&D initiatives and government incentives for companies adopting eco-friendly production processes and materials. Overall, a comprehensive and collaborative approach is required to address the challenges posed by the use and disposal of masks during the endemic era.

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