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RESEARCH PAPER

Determination of the Estimated Amounts of Discarded Face Masks due to COVID 19 in Turkey

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ABSTRACT
In this study, the estimated amounts of discarded face masks due to COVID 19 were investigated. In this context, the amount of waste face masks was determined separately according to the mask types used (nonwoven, meltblown, and 3-ply, pleated) and the importance of waste face masks was revealed. According to obtained data, the estimated total daily face mask use in Turkey is 72,351,638. The highest amounts of nonwoven, meltblown, and 3-ply face mask waste were determined as 26.88, 36.29, and 43.68 tonnes/day for İstanbul city, respectively. Total amounts of nonwoven, meltblown and 3-ply face mask waste in Turkey were calculated as 144.7, 195.35, and 235.14 tonnes/day, respectively. The top 5 provinces with the highest amount of waste masks are listed as follows; İstanbul (nonwoven=26.88, meltblown=36.29, 3ply=43.68 tonnes/day), Ankara (nonwoven=9.91, meltblown=13.38, 3ply=16.11 tonnes/day), İzmir (nonwoven=7.76, meltblown=10.47, 3ply=12.61 tonnes/day), Bursa (nonwoven=5.40, meltblown=7.29, 3ply=8.78 tonnes/day), and Antalya (nonwoven=4.45, meltblown=6.01, 3ply=7.23 tonnes/day), respectively. In Turkey, 91.3% of medical waste collected in health institutions in 2019 (90,920 tonnes) was sterilized and disposed of in storage areas (83,010 tonnes). 8.7% of medical waste was sent to incineration facilities and disposed (7,910 tonnes). Considering these values, 132, 178.35, and 214.7 tonnes/day of nonwoven, meltblown, and 3-ply face mask wastes can be disposed by sterilization and the remaining 12.7, 17, and 20.44 tonnes/day by incineration, respectively.

KEYWORDS: Health, pandemic, pollution, SARS-CoV-2, waste.

INTRODUCTION

The human coronavirus that has club-shaped glycoprotein spikes on its envelope giving it the crown appearance is a common pathogen of the respiratory system. The majority of coronavirus strains induce mild upper respiratory infections (Hadid et al., 2020). Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a positive-sense single-stranded RNA virus is a novel coronavirus causing an infectious disease named COVID-19 (Çolak et al., 2021; Okunlola, 2021). The first outbreak of coronavirus was reported in Wuhan (China) in December 2019 (Hui et al., 2020; Tsang et al., 2021). Then, the novel coronavirus has quickly become a global concern. The World Health Organization declared the virus outbreak a pandemic on March 11, 2020 (WHO, 2021). The global pandemic has caused worldwide suffering and death of unimaginable

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magnitude from COVID-19 (Hosoki et al., 2020). COVID-19, as of 8 February 2020, has infected 106,752,707 and 2,539,559 individuals worldwide and in Turkey, respectively. COVID-19 has caused 2,328,807 and 26,900 deaths worldwide and in Turkey, respectively. Furthermore, the pandemic has caused the world to undergo unprecedented change in a short space of time. It has infringed personal freedom, has taken a toll on healthcare systems worldwide, and has disrupted economies of nations (Herron et al., 2020; Silva et al., 2020; Viswanath & Monga, 2020; Vanapalli et al., 2021; Benson et al., 2021a; Benson et al., 2021b).

The world health organization has recommended regulations because of the exponential spread of COVID-19 around the globe, and its fatal effects. The countries have imposed their own regulations with the same aim to stop the transmission of COVID-19 among their citizens (Atangana & Atangana, 2020). Public health officials have called for the widespread adoption of preventative behaviors that can curb the spread of COVID-19 (Howard, 2021). Face masks are physical barriers to respiratory droplets that may enter the nose and mouth and to the expulsion of mucosalivary droplets from infections individuals (Chua et al., 2020; Rowan & Moral, 2021). Wearing of face mask is among the most effective preventative behaviors (Howard, 2021). Because, the airborne transmission represents the dominant route for the spread of COVID-19 disease, the main human-to-human diffusion mechanism (Zhang et al., 2020; Morawska et al., 2020; Bontempi, 2020; Bontempi, 2021). The spread of SARS-CoV-2 is predominantly via aerosol (droplets from the patient's mouth or nose) (Viswanath & Monga, 2020). An aerosol is defined as a suspension system of liquid or solid particles in a gas (Hinds, 1999; Eliades & Koletsi, 2020). Airborne transmission is described by World Health Organization as the propagation of an infectious agent caused by spreading these droplets that remain infectious during their air suspension (Schiobuola & Tambai, 2021). Droplet and airborne spread occur through the air through sneezing, coughing, singing, talking and exhaling (Chua et al., 2020; Rowan & Moral, 2021). The spread of aerosol from a patient to the person via a direct droplet assault can vary in quantum from low level contamination – from encounters such as talking – to high level contamination – via coughing or sneezing. Such aerosol entry may be via the mouth, nose or eyes of the recipient. The virus is detectable in droplets for up to 3 hours (Viswanath & Monga, 2020). Therefore, wearing of face mask has been extensively supported to reduce airborne transmission of viruses (Leung et al., 2020; O'Dowd et al., 2020; Howard, 2021). Moreover, the use of face masks as a means of source control in public places is strongly supported because of the large proportion of asymptomatic patients (Esposito et al., 2020). The without a mask, the risk of transmitting COVID-19 is 17.4%, while with an N95 respirator or face mask, the number drops to 3.1% (Long et al., 2020). A wide variety of face masks are available (Viswanath and Monga, 2020). Non-medical face masks are made from a variety of woven and non-woven materials such as cotton, cellulose, polypropylene, polyester, silk and gauze (Vainshelboim, 2021).

More or less, each and every country is facing the COVID 19 effects posed by the virus and making an attempt to eliminate it at their own levels (Chaudhary et al., 2021). Turkey's government has firstly been made compulsory the wearing of face mask in supermarkets, shopping centers, public transport, taxis, barber shops and hairdressers. Later, in May 2020, it was made mandatory to use face masks in some cities when going out. Then, in September 2020, it was made mandatory to use them in all cities when going out. This legal obligation still continues. Because of the legal obligation about wearing face masks, numbers of face masks used daily in Turkey cause a huge amount of waste face masks during the COVID 19 pandemic.

This study aims to determine the amount of waste face masks generated by discarded of masks used by humans due to COVID 19 pandemic. In this context, the amount of waste face masks was determined separately according to the mask types used (nonwoven, meltblown, and 3-ply, pleated) and the importance of waste face masks was revealed. The innovation of this research is the absence of any studies on the amount of waste mask in Turkey. Therefore, in this perspective, it is quite new and original research and it is the first study in Turkey.

MATERIAL & METHODS

In this study, population values obtained from Turkish Statistical Institution (TSI) were used to calculate the estimated amounts of discarded face masks due to COVID 19. Turkey's population is 83,614,362 people as of December 31, 2020 (TSI, 2021). Depending on the population, the amounts of face mask wastes were calculated on a daily, monthly, and annually. Three different mask types that are commonly used in calculations were selected. These mask types are as follows; 1) mask made of nonwoven fabric, 2) mask made of meltblown fabric and 3) 3-ply, platted (wire). Nonwoven, meltblown, and 3-ply masks were weighted as 2 g, 2.7 g, and 3.25 g, respectively. The mask acceptance rate in Turkey is 95% (as of October 19, 2020). It is stated by World Health Organization that "children aged 5 years and under should not be required to wear masks” (WHO, 2021). There are 7,454,754 people between the ages of 0-5 in Turkey. Therefore, in our study, children aged 0-5 years were not taken into account in the estimated amount of face mask waste.

Estimated amount of face mask waste is calculated as follows:

$$A_{WFM} = (NW\ x\ P) x 10^{-6} \tag{1}$$

$$A_{WFM} = (MB\ x\ P) x 10^{-6} \tag{2}$$

$$A_{WFM} = (PLY\ x\ P) x 10^{-6} \tag{3}$$

$$W_{WFM} = (A_{WFM}\ x\ R) \tag{4}$$

A_{WFM} is amount of waste face mask (tonnes/day) (If face mask acceptance rate =100%), NW is amount of nonwoven mask used (g), P is population (person), MB is amount of meltblown mask used (g), PLY is amount of 3-ply, pleated mask used (g), R is acceptance rate of face mask (95%), W_{WFM} is waste face mask (tonnes/day).

The following equations are used in the calculation of amount of waste face masks disposed by storage and incineration methods.

$$SD_{WFM} = (W_{WFM}\ x\ D) \tag{5}$$

$$ID_{WFM} = (W_{WFM}\ x\ I) \tag{6}$$

SD_{WFM} is amount to be disposal of by storage of waste face mask (tonnes/day), D is percentage of storage (%), $ID_{WFM,}$ is amount to be disposal of by incineration of waste face mask (tonnes/day), I is percentage of incineration (%).

RESULTS AND DISCUSSION

Due to COVID 19, the use of face masks has been made mandatory in Turkey and therefore each facemask used is considered waste in this study. Waste face masks can cause environmental pollution as well as adversely affect human health. In this context, it is very important to determine the amount of waste face mask that may occur as a result of the use of face masks.

Fig. 1. The photographs of the detected masks

We detected many waste masks in the waste face mask scan we conducted. The photographs of the detected masks are shown in Figure 1. In Figure 1, the places where waste face masks are mostly thrown can be expressed as follows. It is possible to encounter waste face masks on the streets and avenues, in front of markets and shopping areas, in areas such as parks and gardens, and on roads that people frequently use. It should also be noted that the contaminated face masks by the virus are a significant threat for human to health. Kampf et al. (2020) have reviewed the persistence of coronaviruses on different surfaces and have reported viruses' survival on plastic for up to 5 days. van Doremalen et al. (2020) have reported viable SARS-CoV-2 virus on plastic for up to 72 h (Urban & Nakada, 2021). The virus was found to be more stable and viable for 2–3 days on plastics than on cardboard, copper, banknotes, and wood (Chin et al., 2020; Doremalen et al., 2020; Benson et al., 2021b).

The estimated total daily face mask use in Turkey is 72,351,638. In the literature, there is only three studies that reported total daily face mask use (103,168,104; 51,278,153 and 26,066,112 pieces) in Turkey (Hantoko et al., 2021; Benson et al., 2021b; Sangkham, 2020). The difference between the results is from the assumptions done by them. The reported value by Hantoko et al. (2021) was calculated based on the assumptions as to the population of 84,842,191, average daily face masks per capita as 2, the acceptance rate of face masks as 80%. The reported value by Benson et al. (2021b) was calculated based on the assumptions as to the population of 84,339,067, average daily face masks per capita as 1, the acceptance rate of face masks as 80%. The reported value by Sangkham (2020) was calculated according to the urban population based on the assumptions as to the population of 84,410,067, average daily face masks per capita as 1, the acceptance rate of face masks as 80%. Lower and higher values were reported by Nzediegwu & Chang (2020). They calculated total daily masks in Nigeria and Egypt as 171,508,138 and 70,406,070, respectively while 37,796,413 and 10,368,023 in Burkina Faso and in Morocco, respectively. Benson et al. (2021b) reported that China, India, United States, Brazil, and United Kingdom, is estimated to generate nearly 702, 386, 219, 140, and 45 million discarded face masks daily.

Estimated amounts of face mask wastes (nonwoven) due to Covid 19 in Turkey are given in Figure 2.

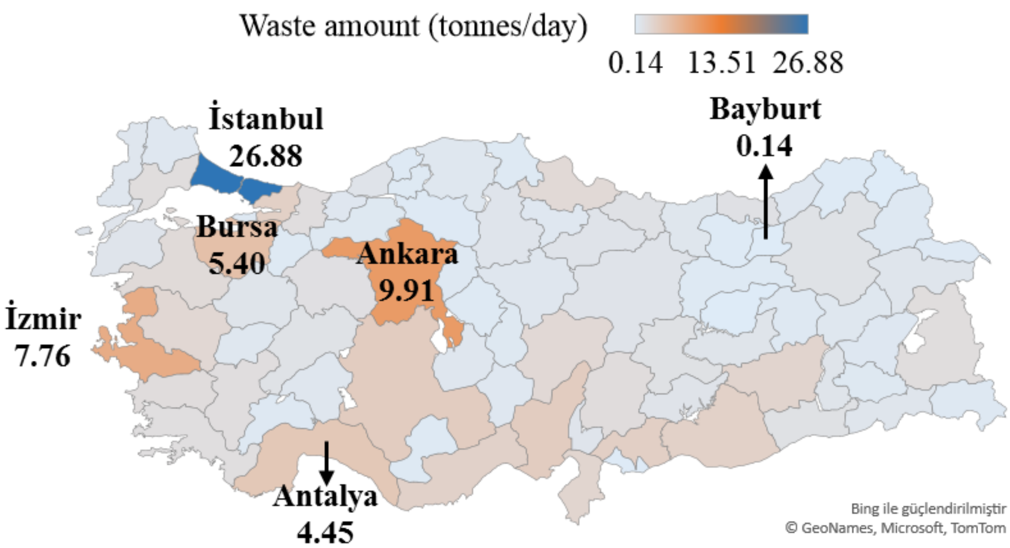

Fig. 2. Estimated amounts of face mask wastes (nonwoven) due to Covid 19

When Figure 2 was examined, the highest amount of face mask (nonwoven) waste was determined as 26.88 tonnes/day for İstanbul city. The reason for the high amount of waste face mask is the high population. The population of Istanbul is 14,147,445. The lowest amount of face mask waste was determined as 0.14 tonnes/day for Bayburt city. The population of Bayburt is 75402. The total amount of face mask waste in Turkey was calculated as 144.7 tonnes/day. In the literature, there is only one study that reported the mass of discarded face mask (310 tons/day) in Turkey (Hantoko et al., 2021). The difference between our results and their results is from the assumptions done by them. The reported value by Hantoko et al. (2021) was calculated based on the assumptions as the population of 84,842,191, average daily face masks per capita as 2, the acceptance rate of face masks as 80%, and 3 gram/face mask. However, Turkey's population is 83,614,362 people as of December 31, 2020 (TSI, 2021). The face mask acceptance rate in Turkey is 95% as of October 19, 2020. In our study, the weights of face masks are taken for 3 different face masks (nonwoven, meltblown, and 3-ply mask as 2 g, 2.7 g, and 3.25 g, respectively). Moreover, we did not take into account the age group (0-5) that do not use face masks.

The number of provinces where more than 20 tonnes/day of face mask waste will be generated was determined as 1 while there was not any province where 10-20 tonnes/day of face mask waste will be generated. Furthermore, there are 80 provinces where 0-10 tonnes/day of face mask waste will be generated. The top 5 provinces with the highest amount of waste masks are listed as follows; İstanbul, Ankara, İzmir, Bursa, and Antalya, respectively. The amount of waste masks in these cities was calculated as 26.88, 9.91, 7.76, 5.40, and 4.45 tonnes/day, respectively. The monthly and annual amount of face mask waste in Turkey were 4341 and 52,817 tonnes, respectively. In Turkey, 91.3% of medical waste collected in health institutions in 2019 was sterilized and disposed of in storage areas. 8.7% of medical waste was sent to incineration facilities and disposed (TSI, 2021). Considering these values, 132 tonnes/day of face mask wastes can be disposed by sterilization and the remaining 12.7 tonnes/day by incineration. In the literature, Hantoko et al. (2021) reported preferred technological approaches for the treatment of COVID-19 contaminated face mask waste as autoclave/steam sterilization and microwave while secondary preferred technologies as twin-chamber incineration, brick-built demontfort incinerators and barrel incinerators with air induction. Furthermore, the emergency solution was reported as an onsite pit burial. It is worth noting that, infection risk of SARS-CoV-2 for workers of that treatment facilities is high.

Estimated amounts of face mask wastes (meltblown) due to Covid 19 in Turkey are given in Figure 3.

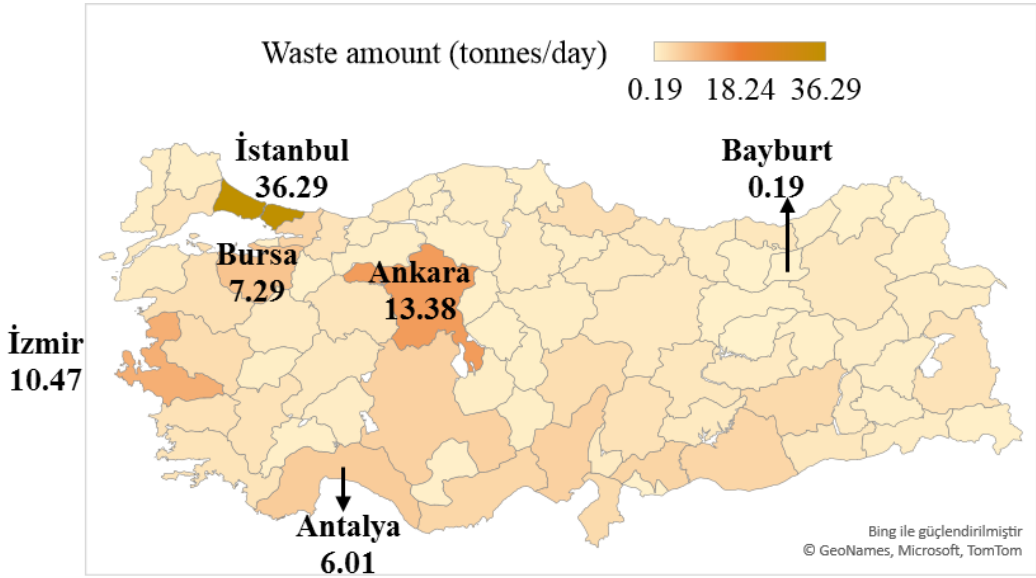

Fig. 3. Estimated amounts of face mask wastes (meltblown) due to Covid 19

When Figure 3 was examined, the highest amount of face mask (meltblown) waste was determined as 36.29 tonnes/day for İstanbul, the lowest amount of face mask waste was determined as 0.19 tonnes/day for Bayburt. The total amount of face mask waste in Turkey was calculated as 195.35 tonnes/day. The number of the province where more than 20 tonnes/day of face mask waste will be generated was determined as 1 while there were 2 provinces where 10-20 tonnes/day of face mask waste will be generated. Furthermore, the number of provinces where 0-10 tonnes/day of face mask waste will be generated was determined as 78. The top 5 provinces with the highest amount of waste masks are listed as follows; İstanbul, Ankara, İzmir, Bursa, and Antalya, respectively. The amounts of waste masks in these cities were calculated as 36.29, 13.38, 10.47, 7.29, and 6.01 tonnes/day, respectively. Monthly and annual amounts of face mask waste in Turkey were 5860 and 71303 tonnes, respectively. Considering these values, 178.35 tonnes/day of face mask wastes can be disposed by sterilization and the remaining 17 tonnes/day by incineration.

Estimated amounts of face mask wastes (3-ply, pleated) due to Covid 19 in Turkey are given in Figure 4.

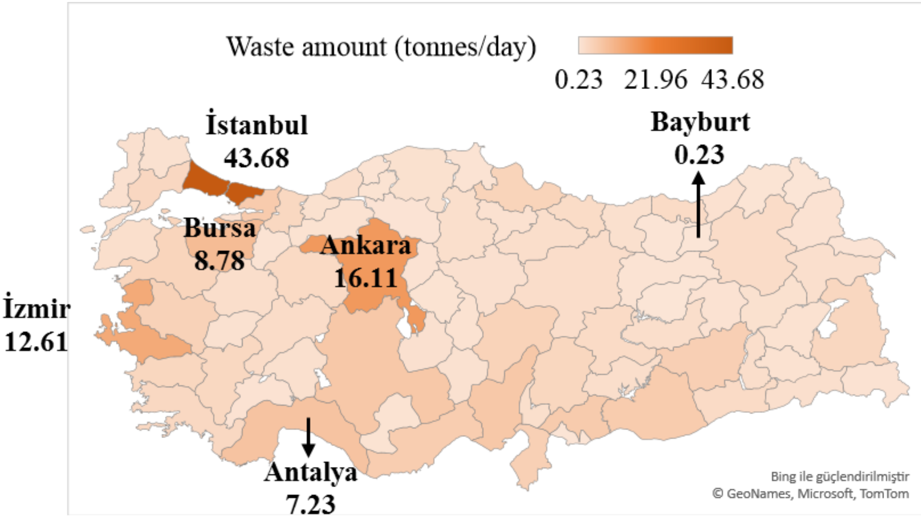

Fig. 4. Estimated amounts of face mask wastes (3-ply, pleated) due to Covid 19

According to Figure 4, the highest amount of face mask waste (3-ply, pleated) was determined as 43.68 tonnes/day for İstanbul, the lowest amount of face mask waste was determined as 0.23 tonnes/day for Bayburt. The total amount of face mask waste in Turkey was calculated as 235.14 tonnes/day. The number of the province where more than 20 tonnes/day of face mask waste will be generated was determined as 1 while there were 2 provinces where 10-20 tonnes/day of face mask waste will be generated. Furthermore, the number of provinces where 0-10 tonnes/day of face mask waste will be generated was determined as 78. The top 5 provinces with the highest amount of waste masks are listed as follows; İstanbul, Ankara, İzmir, Bursa, and Antalya, respectively. The amounts of waste masks in these cities were calculated as 43.68, 16.11, 12.61, 8.78, and 7.23 tonnes/day, respectively. Monthly and annual amounts of face mask waste in Turkey were 7054 and 85827 tonnes, respectively. Considering these values, 214.7 tonnes/day of face mask wastes can be disposed by sterilization and the remaining 20.44 tonnes/day by incineration.

In the literature, there is not any study about the discarded amounts of face masks in the cities of Turkey. Therefore the discussion is made by the results given for various countries. Benson et al. (2021b) reported high amounts of discarded face masks for countries that have high populations (e.g. China at 1.4 billion, India at 1.3 billion, United States at 331 million, Brazil at 212 million, Nigeria at 206 million population). Benson et al. (2021b) reported that approximately 3.4 billion single-use face masks are discarded daily due to the pandemic. Regional estimates indicate that Asia with the highest population is projected to generate the highest quantity (1.8 billion) of discarded face masks/day, followed by Europe, Africa, Latin America and the Caribbean, North America, and Oceania at 445, 411, 380, 244, and 22 million face masks/day, respectively. Sangkham (2021) reported that China has the highest daily use of face masks (989,103,299 pieces). China is followed by India, Indonesia, Bangladesh, Japan, Pakistan, Iran, Philippines and Vietnam with 381,179,657, 159,214,791, 99,155,739, 92,758,754, 61,762,860, 50,648,022, 48,967,769 and 46,288,632 pieces, respectively. Hantoko et al. (2021) reported that Asia has the 54% of the total daily face masks consumption globally. Because, Asia has the biggest population in the world and more countries in Asia have assigned compulsory face mask use for their citizens (Hantoko et al., 2021). Hantoko et al. (2021) reported that according to the total population and the percentage of urban population, the number of face masks used daily in the world is estimated to reach over 7 billion.

According to the ages, estimated amounts of face mask wastes due to Covid 19 in Turkey are given in Figure 5.

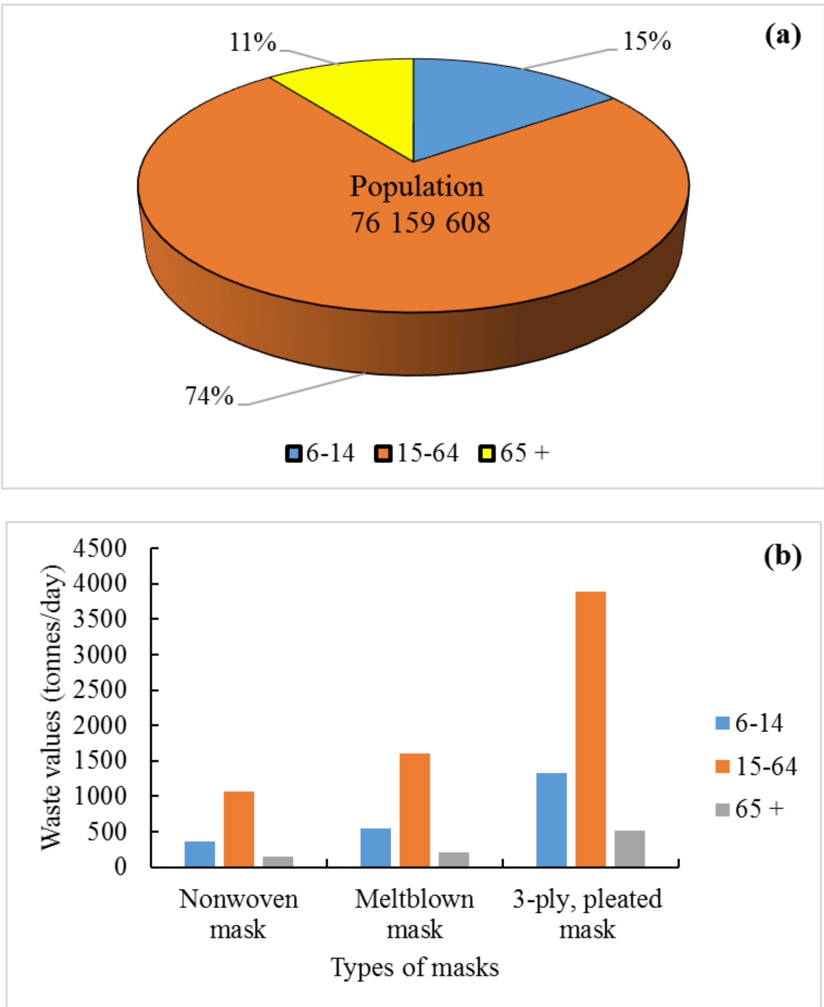

Fig. 5. Estimated amounts of face mask wastes due to Covid 19 (according to ages)

According to Figure 5 (a), 74% of the population was between the ages of 15-64 in Turkey. There are 56,592,570 people between the ages of 15-64. 15% of the population was between the ages of 6-14 in Turkey. There are 11,613,483 people between the ages of 6-14. 11% of the population was between the ages of 65+ in Turkey. There are 7,953,555 people at the ages of 65+. When Figure 5 (b) was examined, in the case of using the nonwoven mask in Turkey, the amount of face mask waste was calculated as 22.07 tonnes/day for 6-14 age group. In the case of using the meltblown and 3-ply, platted masks, the amounts of face mask wastes were calculated as 29.79 tonnes/day and 35.86 tonnes/day, respectively (for 6-14 age group). In the case of using the nonwoven mask in Turkey, the amount of face mask waste was calculated as 107.53 tonnes/day for 15-64 age group. In the case of using the meltblown and 3-ply, platted masks, the amounts of face mask wastes were calculated as 145.16 tonnes/day and 174.73 tonnes/day, respectively (for 15-64 age group). In the case of using the nonwoven mask in Turkey, the amount of face mask waste was calculated as 15.11 tonnes/day for 65+ age group. In the case of using the meltblown and 3-ply, platted masks, the amounts of face mask wastes were calculated as 20.40 tonnes/day and 24.56 tonnes/day, respectively (for 65+ age group). Depending on the population, the highest amount of face mask waste is quite high in the 15-64 age group. According to these calculations, face mask waste amounts have followed the order of 15-64 age > 0-14 age > 65+ age.

CONCLUSION

Unfortunately, most of the face masks used are discarded directly into the environment and cause environmental pollution. The global environmental impacts of waste face masks can be summarized as follows. Face masks discarded on the streets and avenues visually create an ugly image and cause visual pollution. As a result of the discarded masks on the streets by people infected by SARS-CoV-2 virus, it may be possible that the SARS-CoV-2 are transported to receiving environments by wind and rainwater. This can dramatically increase the rate of spread of the virus. The discarded face masks can reach sewage systems with rain water and then to rivers, seas, and lakes, which are the receiving environments. Within this context, measures should be taken urgently to prevent waste face masks from being thrown into the streets and to increase awareness activities.

The management of mask use needs strict operations such as segregation, sorting, storage, collection, transport and final disposal (Sangkham, 2020). The management of wastes of face masks is a troubling upshot of COVID-19 pandemic (Herron et al., 2020; Silva et al., 2020; Vanapalli et al., 2021; Benson et al., 2021a; Benson et al., 2021b). Essential municipal services (e.g. waste collection and treatment) have been threatened while there is an unprecedented rise in the amount of medical and domestic wastes generated (Jambeck et al., 2015; Benson et al., 2021b). Countries are aware that waste management and proper disposal of face masks play a critical role in preventing the spread of COVID-19 in the neighbouring communities (Sangkham, 2020). There is a need to adequately revise existing waste collection and management procedures to foreclose potential threat of COVID-19 pandemic (Jambeck et al., 2015; Benson et al., 2021b). The untreated terrestrially derived biomedical and domestic wastes can be redistributed into the environment (Benson et al., 2021b). Furthermore, improper management of SARS-CoV-2 generated wastes (e.g. disposal in uncontained landfills, littering, and open dumping) could compound the existing marine litter's pollution (Jambeck et al., 2015; Benson et al., 2021b). The fate and distribution of biomedical wastes during and post-SARS-CoV-2 outbreak would require effective waste management strategies including proper identification, collection, segregation, storage, treatment, and disposal. The waste treatment options for biomedical and domestic plastic wastes generated during SARS-CoV-2 pandemic are non incineration treatments (thermal, irradiative, chemical disinfection, biological) and incineration treatment (for pharmaceutical waste) (Benson et al., 2021b). Furthermore, waste minimization should also be considered. The waste minimization that reduce the production of these wastes supports sustainable future. The use of reusable face masks by soap washing can be encouraged to reduce the amount of discarded face masks.

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The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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