



Face Mask Consumption and Medical Waste Generation During the COVID-19 Pandemic in Iran: Challenges and Problems

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Abstract

Background: The outbreak of COVID-19 has caused a devastating pandemic scenario in the world. The mortality rate has increased and new socio-economic challenges are emerging. Millions of gloves, gowns, face masks, and face shields are used daily to prevent airborne transmission and facilitate the treatment of COVID-19. Mismanagement of these wastes can lead to increased concerns due to their contamination potential. A comprehensive plan to improve the management of medical wastes in every country requires awareness of the current status of solid waste.

Objectives: The study aimed to calculate and estimate the consumption rate of face masks and medical waste generation rate during the COVID-19 pandemic in Iran. Also, the performance of different departments of medical waste management and future challenges are discussed.

Methods: The daily consumption of face masks and medical waste generation were calculated based on the population data, the percentage of the urban population, face mask acceptance rate, the number of face masks needed per person per day, total COVID-19 confirmed cases, and medical waste generation rate (kg/bed/day).

Results: The consumption of face masks in Iran is estimated at 46576000 pieces per day. Also, the three provinces of Tehran (9,560,000 pieces), Khorasan Razavi (3,825,600 pieces), and Isfahan (3,523,200 pieces) have the highest consumption rate of masks, respectively. Increasing the number of confirmed COVID-19 cases has increased the medical waste generation rate. Until April 3, 2021, more than 1,920,394 cases of COVID-19 have been confirmed in Iran, and calculations show that the medical waste generation rate in Iran is about 7,585.56 tons per day.

Conclusions: COVID-19 is a highly infectious and problematic disease. The continuous increase in the number of confirmed COVID-19 cases has increased face mask consumption rate and medical waste generation rate, and as a result, new challenges have emerged in the field of solid waste management. These emerging challenges in managing solid waste during the COVID-19 pandemic necessitate the development of appropriate waste management policies and strategies.

Keywords: Medical Waste, COVID-19, Infectious Waste, Face Mask, SARS-CoV-2

1. Background

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the most important global health crisis of the 21st century and the greatest challenge that humans have faced since World War II (1). The COVID-19 outbreak began on December 31, 2019, in Wuhan, the largest metropolitan region in Hubei Province, China (2). The disease was initially classified as pneumonia of unknown etiology since the cause of the infection was unknown. The Chinese Center for Disease Control and Prevention (CDC) developed an intensive program to investigate the cause of the disease. The disease was attributed to a novel

virus belonging to the coronavirus (CoV) family, and on January 12, 2020, the World Health Organization (WHO) announced that the coronavirus was the cause of the infection in Wuhan (3). Coronavirus contains single-stranded RNA as nuclear material and is 65 to 125 nm in diameter (4). SARS-CoV-2 has high infectivity and a long incubation period and has spread rapidly around the world. Global transmission, a significant number of deaths, recurrent mutations, infections, death among care providers, and adverse effects on vulnerable or susceptible groups are major causes of COVID-19 concern (5, 6).

Due to the worldwide spread of SARS-CoV-2, the WHO declared the coronavirus outbreak a global pandemic on

March 11, 2020 (7). Since then, the disease has been spreading rapidly around the world, disrupting the global economy, and posing enormous health, environmental, and social challenges to the human population (1). WHO has recommended various guidelines, including social distancing, frequent hand washing, use of personal protective equipment (PPE) such as face masks, medical gloves, and aprons for healthcare providers and others who are in contact with COVID-19-infected patients (e.g., physicians, nurses, caregivers). Also, with the increase in the number of COVID-19 confirmed cases, healthcare centers in every country have made mandatory the use of face masks in public places because COVID-19 may spread through asymptomatic carriers, respiratory droplets, and close contact (8, 9). These recommendations have resulted in using millions of PPEs every day during the pandemic.

The Solid Waste Association of North America (SWANA) has reported changes in the source and volume of solid waste generated due to quarantine and health measures to control the outbreak of COVID-19 (10). China's Joint Prevention and Control Mechanism of the State Council reported that the amount of municipal solid waste (MSW) in large and medium-sized cities has decreased by 30%. However, medical waste generation (infectious and non-infectious) has increased sharply (37%) in Hubei Province, China (11). It was also reported that the average amount of medical waste generated in Wuhan hospitals in China was 240 tons per day, in comparison to 50 tons generated per day before the pandemic (12).

Millions of contaminated plastic-based PPEs (e.g., face masks and gloves), are now in use around the world, and mismanagement of waste poses a growing environmental and health threat (7, 13, 14), and may spread the SARS-CoV-2 more quickly. For example, studies have shown that the coronavirus can survive in plastic objects for 2 to 3 days (9). These threats can be controlled in developed countries through sustainable and green waste management strategies. However, in developing countries such as Iran, with weaker waste management strategies, the threats will be more serious, and careful planning and monitoring of the collection, transportation, and disposal of these materials are felt more than ever.

2. Objectives

Municipal waste management measures have raised further concerns during the COVID-19 pandemic. Appropriate strategies should be implemented at all levels to plan waste management and inform the international community and waste management stakeholders. Evidently, any neglect of waste management will have a devastating impact on health and society. Therefore, this study

aimed to estimate face mask consumption in Iran during COVID-19, estimate the amount of medical waste generated, and express the problems and challenges ahead.

3. Methods

3.1. Estimation of Daily Face Mask Use

The amount of D_{FMU} [daily face mask use (pieces)] is estimated using Equation 1, which is derived from the study of Nzediegwu and Chang (8).

$$D_{FMU} = P \times U_{pp} \times F_{MAR} \times \left(\frac{FM_{RPD}}{10000} \right) \quad (1)$$

P: population (persons): 79 million people; U_{pp} : percentage of urban population = $100 \times (\text{urban population} / \text{total population})$.

Population and percentage of urban population data were extracted from the official site of the Statistical Centre of Iran, which is based on the latest census conducted in 2016. F_{MAR} : face masks acceptance rate = 80% (8); FM_{RPD} : number of face masks required per person per day = based on the assumption that each person in the general population uses one face mask each day (15).

3.2. Estimation of Daily Medical Waste Generation

To estimate the amount of D_{MWG} [daily medical waste generation (tons/day)], we use Equation 2 which was previously presented in Sangkham's study (16).

$$D_{MWG} = \frac{M_{WGR} \times N_{CCS}}{1000} \quad (2)$$

M_{WGR} : medical waste generation rate, that is 3.95 kg/bed/day (17); N_{CCS} : number of COVID-19 confirmed cases (infected persons). The number of COVID-19 confirmed cases was collected from <https://www.worldometers.info/coronavirus/country/iran/>. Worldometer is one of the best free reference websites managed by an international team of developers, researchers, and volunteers intending to make accurate and up-to-date global statistics available to a wide audience around the world (18).

4. Results and Discussion

Iran, with geographical coordinates of 3200 N and 5300 E, is generally a mountainous and semi-arid country located in southwestern Asia. COVID-19 is a sensitive issue in many countries. The total number of confirmed, recovered, and death cases are the only information that the Iranian Ministry of Health publishes about COVID-19. These data are important for estimating the face mask consumption rate and medical waste generation rate during the COVID-19 pandemic in Iran.

4.1. Daily Face Mask Use (Pieces)

The number of face masks used daily in 31 provinces of Iran was estimated using Equation 1. A total of 46,576,000 face masks are used each day. The provinces with the higher consumption rate of face masks are Tehran with 9,560,000 face masks, and then Khorasan Razavi, Isfahan, Khuzestan, and Fars with 3,825,600, 3,523,200, 2,841,600 and 2,734,400 face masks respectively (Table 1).

The Ministry of Interior of the Islamic Republic of Iran has recently divided the provinces into 5 regions based on proximity factors, geographical location, and commonalities (Figure 1). Accordingly, the highest daily consumption rate of face masks by the population belonged to region one (Tehran, Qazvin, Mazandaran, Semnan, Golestan, Alborz, and Qom provinces) with 15,894,400, followed by region two, region five, region three, and region four which were equal to 8,392,000, 8,041,600, 7,272,800 and 6,975,200, respectively (Figure 1). The study conducted by Nzediegwu and Chang (8) revealed that the total number of face masks used per day increased during the outbreak of COVID-19. The authors used a mathematical equation to calculate the number of face masks used in Asian countries. The results revealed that the daily use of face masks depends on population (persons), urban population (percentage), face masks acceptance rate (percentage), and the number of face masks required per person per day. Therefore, Equation 1 can be used to estimate face mask scenarios during the COVID-19 pandemic.

4.2. Daily Medical Waste Generation

The amount of medical waste generated during the COVID-19 pandemic has been increasing at an unprecedented rate and. One of the major sources of medical waste generation is healthcare providers, especially in hospitals (7). Until April 3, 2021, more than 1,920,394 people in Iran have been infected with the SARS-CoV-2, which is ranked 15th in the world (19). Equation 2 revealed that the total medical waste generated in Iran is about 7,585.56 tons per day (Table 1).

The amount of medical waste generated is directly related to the number of confirmed cases and the medical waste generation rate (kg/bed/day) (16). The study conducted by Sangkham (16) revealed that the countries with the highest rate of medical waste generation were India (6,491.49 tons/day), Iran (1,191.04 tons/day), Pakistan (1,099.30 tons/day), Saudi Arabia (1,083.17 tons/day), Bangladesh (927.81 tons/day), and Turkey (908.07 tons/day).

The rapid increase in the number of COVID-19 confirmed cases has significantly increased the amount of medical waste generation and face mask usage. Using

medical gloves, face masks, and surgical aprons is recommended for healthcare professionals such as doctors, nurses, medical technicians, and nursing assistants. Wearing face masks is also mandatory for citizens (8, 9).

4.3. Management of Infectious Waste for Final Disposal During the COVID-19 Pandemic

The COVID-19 pandemic has caused a global emergency and, in addition to increasing medical waste, has raised social and economic concerns. The number of confirmed cases is increasing rapidly due to the high prevalence of the virus. As the results of the study show (Figure 1 and Table 1), the daily generation of COVID-19-related medical waste has increased with the increase in the number of COVID-19 confirmed cases (9, 10). Now, personal protective equipment including face masks, gloves, gowns, and face shields are used to prevent, diagnose, and treat this disease. As a result, a significant increase in the use of face masks and medical waste generation has been observed.

SARS-CoV-2 is very infectious and health officials should pay close attention to its prevention and control. To reduce the risk of spreading COVID-19 in hospitals, residential areas, communities, and public places, careful planning, standardization, and development of detailed medical waste management guidelines must be considered. Improper management of medical waste during its various stages (pre-treatment, separation, storage, delivery, collection, transport, and disposal) is another way of spreading the SARS-CoV-2, mainly through contact with contaminated surfaces and objects. Therefore, to prevent the spread of SARS-CoV-2, all necessary precautions should be taken and practical guidelines should be provided. Economic and social conditions must also be taken into account in these guidelines (20).

4.3.1. Separation, Collection, Storage, Transfer, and Disposal

The inorganic component of municipal solid waste in developed and developing countries is mainly composed of plastic, metal, and glass (21). The generated waste may contain traces of COVID-19 and may be a source of SARS-CoV-2 (22). Coronavirus can remain on hard surfaces for a long time, and remain 72 hours on plastic, 48 hours on metal, and 24 hours on paper and cardboard. Therefore, the waste collection does not seem to be sufficient to ensure safety and can lead to COVID-19 infection in workers. Therefore, municipal solid waste managers should place appropriate bins for the collection of infectious or special waste in public areas to ensure proper collection operations (22-25). Therefore, the masks are packaged in double-layered medical waste bags and are managed and disposed of by special personnel, or municipal solid waste workers. COVID-19 medical waste should be disposed of by special

Table 1. Daily Face Mask Use (Pieces) and Medical Waste Generation (Tons/Day) During COVID-19 Pandemic in Iran, Based on Equations 1 and 2

Province (City)	P = Population (Persons)	N _{CCS} = Number of COVID-19 Confirmed Cases	U _{PP} = Percentage of Urban Population	Equation 1 = Daily Face Mask Use (Pieces)	Equation 2 = Daily Medical Waste Generation (Tons/Day)
Total (the sum of cities)	79686000	1920394	73.06	46576000	7585.56
Tehran	12808000	-	93.30	9560000	-
Khorasan Razavi	6445000	-	74.20	3825600	-
Isfahan	5091000	-	86.51	3523200	-
Khuzestan	4853000	-	73.19	2841600	-
Fars	4828000	-	70.80	2734400	-
East Azerbaijan	3859000	-	70.69	2182400	-
Alborz	2642000	-	90.99	1923200	-
Western Azerbaijan	3284000	-	64.10	1684000	-
Kerman	3163000	-	59.69	1510400	-
Mazandaran	3209000	-	55.59	1427200	-
Gilan	2560000	-	63.20	1294400	-
Sistan and Baluchestan	2859000	-	51.80	1184800	-
Kermanshah	1983000	-	71.51	1134400	-
Qom	1255000	-	95.54	959200	-
Markazi	1485000	-	77.58	921600	-
Lorestan	1831000	-	61.93	907200	-
Hamedan	1803000	-	59.68	860800	-
Kurdistan	1544000	-	69.30	856000	-
Golestan	1935000	-	52.92	819200	-
Qazvin	1262000	-	76.94	776800	-
Yazd	1110000	-	85.77	761600	-
Hormozgan	1745000	-	51.29	716000	-
Ardebil	1294000	-	67.00	693600	-
Bushehr	1146000	-	69.81	640000	-
Zanjan	1068000	-	65.82	562400	-
Chaharmahal o Bakhtiari	942000	-	60.93	459200	-
Semnan	684000	-	78.36	428800	-
North Khorasan	919000	-	53.21	391200	-
Southern Khorasan	779000	-	59.05	368000	-
Kohgiluyeh and Boyerahmad	714000	-	55.88	319200	-
Ilam	587000	-	65.93	309600	-

vehicles which are disinfected immediately after loading and unloading (2, 26). The priority is to incinerate COVID-19-related waste at 1100°C for 3 minutes. This is the most common and effective way to disinfect and eliminate the coronavirus and other pathogens. However, in some ar-

reas where incineration equipment is not available, medical waste can be also disposed of with high-temperature sterilization (autoclave) and boiled before entrance into the sanitary landfills (27, 28).

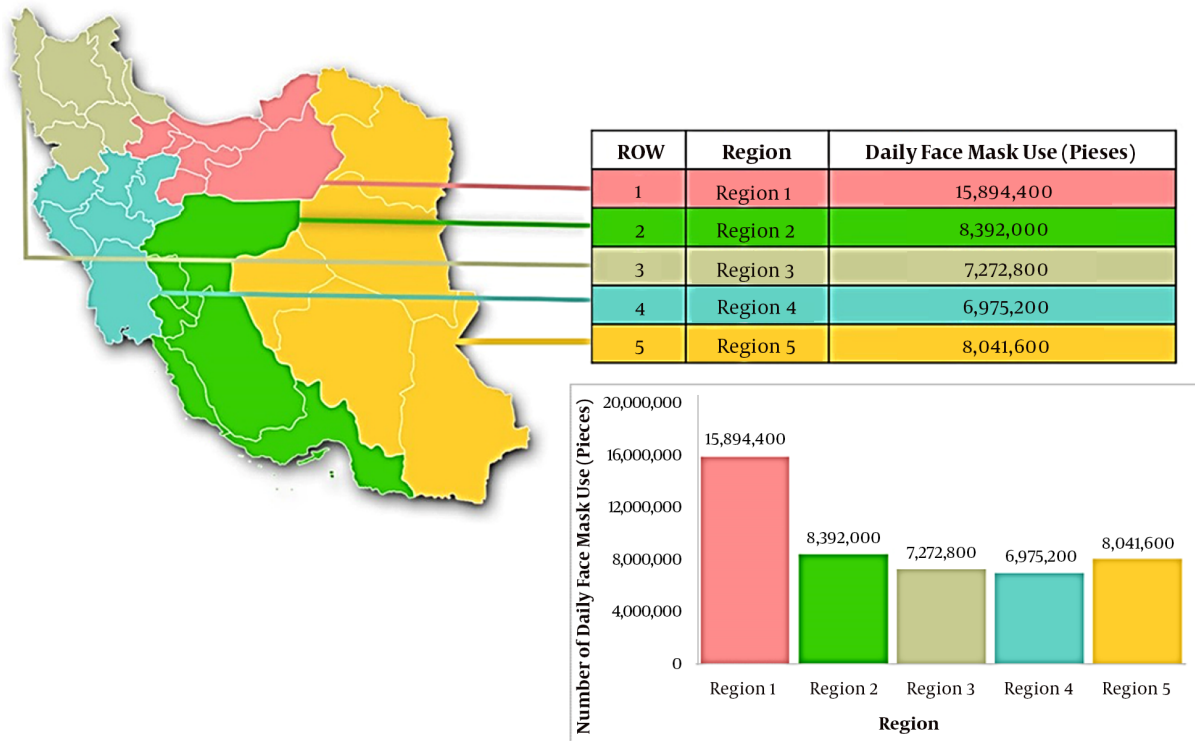


Figure 1. Daily total face masks use (pieces) in 5 regions of Iran during the COVID-19 pandemic, based on Equation 1

4.4. New Challenges in Plastic Waste Management

Governments in many developing countries are taking active steps to control COVID-19, but do not have an appropriate strategy for managing COVID-19 solid waste. For example, in most developing countries, solid waste is disposed of in poorly managed landfills where waste collectors separate recyclable materials without using appropriate PPE. The waste serves as a source of food for livestock such as goats and dogs that roam in these areas and may expose humans and animals to diseases (including COVID-19) and exacerbate their spread. Millions of PPE are now being turned into infectious waste under the irreversible process (11, 29). Most PPEs are composed of plastic, which can worsen the condition of COVID-19 in developing countries with poor waste management strategies. In particular, a recent study (30) showed that the coronavirus can live for up to 9 days on material surfaces (e.g., metals, glass, and plastics). Poor management of the used PPE may increase the risk of COVID-19 transmission in different ways. The WHO has suggested that methods of waste treatment and disposal in healthcare facilities should be subject to controlled heat treatment conditions (8, 31).

4.5. Limitations of the Study

This study was a cross-sectional survey that aimed to provide a quick estimate of the daily consumption rate of face masks and the daily medical waste generation rate during the COVID 19 pandemic in Iran. This study was conducted based on the accuracy of COVID-19 statistics and available information, including population rate, urban population (percentage), and the number of confirmed cases in the country. One of the limitations of this study was the lack of available statistics on the number of confirmed coronavirus cases per city in Iran. The only official statistics available and a reference was the number of confirmed cases in the whole country. Therefore, we were not able to calculate the daily medical waste generation rate separately for each city (province) in the equation used for calculating the medical waste generation rate. Also, the medical waste generation rate (kg/bed per day) is supported by previous studies.

5. Conclusion

Currently, it is critical to prevent and control the COVID-19 pandemic all over the world. This is a new study

to estimate the medical waste generation and face mask use during the COVID-19 pandemic in Iran. The results showed that the continuous increase in the number of confirmed COVID-19 cases has increased the number of used face masks and the medical waste generation rate, and as a result, new challenges have emerged in the field of solid waste management. These emerging challenges in managing solid waste during the COVID-19 pandemic necessitate the development of appropriate waste management policies and strategies.

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Footnotes

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