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Increased personal protective equipment consumption during the COVID-19 pandemic: An emerging concern on the urban waste management and strategies to reduce the environmental impact

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ABSTRACT

Personal protective equipments (PPEs) are essential protective products for individuals exposed to microorganism, toxic substances, and pathogens. However, the advent of the coronavirus pandemic generated a heavy demand for PPE, which has led to a rapid accumulation of plastic waste related to potentially infectious PPE in the urban waste stream. Mismanagement of these wastes can lead to subsequent environmental problems. This study estimates the daily consumption of facemasks, gloves, and daily medical waste generation during the SARs-CoV-2 pandemic in the selected 33 countries worldwide. The results indicate that China used the highest daily facemasks and gloves among these selected countries, followed by India, the US, Brazil, Indonesia, and Japan. Moreover, India is the first one in medical waste production, followed by the USA, Brazil, the United Kingdom, France, and Spain. The article also provides viable strategies and discusses the pros and cons of strategies to address the unprecedented generation of plastic waste material during the pandemic. This manuscript also encourages scientific communities and policymakers to pay exceptional attention to the pandemic's plastic waste.

1. Introduction

The recently discovered coronavirus disease is recognized as a new infectious disease caused by the newly discovered Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) (Feng, Zong, Wang, & Ju, 2020; Mazucanti & Egan, 2020). As per the published articles, the SARS-CoV-2 emerged in Wuhan, China, in December 2019 (Dada & Gyawali, 2021; Marquès, Rovira, Nadal, & Domingo, 2021). It then rapidly spread throughout the world, and the World Health Organization (WHO) called the disease a COVID-19 pandemic on 11 March 2020 (Harding, Broom, & Broom, 2020; Z. Zhang, Xue, & Jin, 2020). As of 28 August 2021, 216,227,881 coronavirus cases were confirmed throughout the world (worldometer, 2021). Coronavirus is mainly spread through the air-born aerosols and droplets from the infected individuals (da Silva, Nascimento, Soares, Sousa, & Mesquita, 2020). Most coronavirus-infected people have shown mild symptoms of fatigue, dry cough, fever, chills, body pain, sore throat, and shortness of breath (Hendryx & Luo, 2020; Rume & Islam, 2020; Zhu, Xie, Huang, & Cao, 2020). However, severe cases have experienced acute and fatal complications, including respiratory failure, cardiac injury, and even death (Holshue et al., 2020; Sohrabi et al., 2020; Wang et al., 2020).

For reducing the spread of coronavirus, different countries have adopted various policies. These policies are generally divided into strict lockdown policies, as adopted in Australia and New Zealand (Baker et al. 2020; Moloney and Moloney 2020), and herd immunity adopted in Sweden (Sunthornwat & Areepong, 2021). On the other hand, the international organizations that focus on global health, such as WHO, have drawn up various recommendations, such as using personal protective equipment (PPE), including facemasks and gloves, frequent hand washing, and social distancing (Nzediegwu & Chang, 2020). Studies show that the more willing governments adopt herd immunity policies, the more cases observed and the greater the need to use PPE products (Rume & Islam, 2020). Conversely, the governments that managed the COVID-19 crisis by adopting a strict lockdown policy reduced the incidence and the need for PPE.

Nonetheless, few countries pursued a strict lockdown policy due to unfavorable economic conditions. Many countries fell their lockdown restriction, which led to a drastic increase in the spreading of the dis-

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ease. As a result, a surge in PPE demand and an unprecedented increase in medical waste production was observed. Thus, a global shortage of PPE was generated at the beginning days of the pandemic. For instance, WHO has estimated that almost 89 million facemasks, 76 million gloves, 30 million gowns, as well as 1.6 million goggles are needed each month for the frontline health workers during the pandemic ("WHO," 2020). Furthermore, according to global health guidelines or by anxiety and the aroused feeling of safety, the use of PPE rapidly spread to the worldwide population (Parashar & Hait, 2020). In response to the widespread global demand for PPE, various countries have increased their PPE production. According to Chinese customs statistics, as of 1 March 2020, the government has exported 195.9 million gloves, 26.7 million N95/KN95 facemasks, 504.8 million surgical facemasks, 17.3 million surgical gowns and 873 thousand goggles (Shruti, Pérez-Guevara, Elizalde-Martínez, & Kutralam-Muniasamy, 2020). Reports also show that the 3M company (in the United States of America) has multiplied its N95 facemasks production to 95 million per month by May 2020, and the annual rate was estimated to incremented from 1.1 to 2 billion facemasks by the end of 2020 (Shruti et al., 2020). Moreover, it has been reported that the single-use facemask market has incremented by tens of times from 2019 to 2020 (E. J. Zhang, Aitchison, Phillips, Shaban, & Kam, 2021).

According to the above-mentioned points, it is crucial to realize that we live in strange and unfamiliar but actual days during the coronavirus outbreak. It implies that the pandemic, initially described as a health crisis, can now be considered a significant threat to various parts of human life, including the environment (Chakraborty & Maity, 2020). It is known that PPEs are mainly composed of polymers that form plastic, including polyurethane, polypropylene, polyacrylonitrile, polystyrene, polycarbonate, polyethylene, and polyester polymers (Fadare & Okoffo, 2020). These polymers are very stable and are regarded as no degradable in the environment. Indeed, it is proposed that the surgical facemasks made of these polymers require about 450 years for efficient decomposition (Fadare & Okoffo, 2020; Kassam, 2020). It is estimated that with the continuation of the current disposal patterns, about 75% of plastic PPE wastes associated with the COVID-19 pandemic will be disposed of in landfills and the aquatic environment (UNCTAD, 2020).

The unprecedented consumption of plastic PPEs and a significant increment in hospitalization during the COVID-19 pandemic have led to a dramatic increase in the production of plastic-based medical wastes. For instance, it has been recorded that the production of medical wastes drastically increased up to 350% and 370% in Spain and China, respectively, during the present pandemic (Klemeš, Van Fan, Tan, & Jiang, 2020; Prata, Silva, Walker, Duarte, & Rocha-Santos, 2020). The city of Wuhan, China, produced an average of 45 tons of hazardous medical waste per day prior to the coronavirus outbreak (Yu, Sun, Solvang, & Zhao, 2020). At the peak of the coronavirus pandemic (15 February to 15 March 2020), it increased to 247 tons per day, almost six times more than before the pandemic (Singh, Tang, Zhang, & Zheng, 2020). In addition, it has been reported that the medical waste generation in Tehran, the Capital of Iran, has increased by 18-62% during the COVID-19 pandemic (Zand & Heir, 2020). Similarly, a hospital in Jordan has recorded tenfold higher medical waste production compared to the normal operational day before the COVID-19 pandemic (Abu-Qdais, Al-Ghazo, & Al-Ghazo, 2020). In Indonesia, approximately after 60 days of the COVID-19 outbreak, 12,740 tons of medical waste were generated (Kojima, Iwasaki, Johannes, & Edita, 2020). During the first month of the pandemic in Bangladesh, 14,500 tons of hazardous medical waste (mostly facemasks and gloves) were generated (ESDO, 2020).

The significant increase in medical waste generation during the COVID-19 pandemic has caused problems in countries with proper waste management. One of the main points required for planning the appropriate management of the medical wastes generated during the COVID-19 pandemic is to estimate the generation rate properly. Mismanagement of these wastes can be the origin of many health and environmental issues, from spreading the disease to increasing the release of emerging contaminants (such as microplastics) into the environment. The estimation of daily consumption of PPE and daily generation of medical wastes is performed by recent research; however, most of them have repeated the same mistakes. Thus, by eliminating common mistakes conducted in similar recent articles, this study aims to provide a more accurate estimation of the daily usage of facemasks and gloves and the amount of medical waste generated per day during the COVID-19 pandemic in the selected countries. The results help the related organizations properly plan and undertake the appropriate policies for adequately managing the wastes related to the COVID-19 pandemic.

2. Methodology

2.1. COVID-19 cases and statistics

In this study, common mistakes of recent articles in estimating plastics and medical waste are eliminated. In this regard, unlike similar studies that used a fixed number of 80 percent for facemasks acceptance rate for different countries, the current study has adopted real facemasks acceptance rate for each selected country, according to the (Imperial-College, 2020). Moreover, unlike recent studies that used cumulative numbers of the COVID-19 cases to estimate the number of medical waste generation per day, this study adopted daily active coronavirus cases to estimate medical waste generation per day. This study has removed recent studies' fundamental mistake in estimating plastic waste generation during COVID-19.

Data of countries' populations, the portion of the urban population, and total confirmed cases of the SARS-CoV-2 were collected from 33 countries worldwide on 28 August 2021, taken from (Worldometers, 2021). These data have been used to present the pandemic spatial variations in different world regions. These data were also used to calculate the daily demand of COVID-19 related facemasks and gloves and the generation of hazardous medical waste per day in selected countries.

2.2. Estimation of daily consumption of facemasks and gloves during the pandemic

The number of facemasks and gloves used daily during the selected period of the COVID-19 pandemic was calculated using Eqs. 1 and 2 (Nzediegwu & Chang, 2020).

$$\mathrm{DMU} = \mathrm{P} \times \mathrm{U_p} \times \mathrm{FAR} \times \frac{\mathrm{FED}}{10000} \tag{1}$$

where DMU is the Daily Facemasks Usage, P is population, U_p is Urban population, FAR is the Facemasks Acceptance Rate (Imperial-College, 2020), and FED is Facemasks Each Day usage for each person in the general population, supposing one facemask each day (Wu, Huang, Zhang, He, & Ming, 2020).

$$\mathrm{DGU} = \mathrm{P} \times \mathrm{U_p} \times \mathrm{GAR} \times \frac{\mathrm{GED}}{10000} \tag{2}$$

where DGU is the Daily Glove Usage, P is population, U_p is Urban population, GAR is the Glove Acceptance Rate, GED is Gloves Each Day per person in the general population, supposing two gloves (one pair) per day.

2.3. Estimation of the medical waste generation per day

In general, the amount of medical waste production is in direct proportion to the number of infected cases and the average generation of medical waste per bed. The daily rate of COVID-19-related medical waste is estimated from Eq. 3 (Sangkham, 2020).

$$\mathrm{MWG} = \frac{NsCC \times \mathrm{MWGR}}{1000} \tag{3}$$

Table 1
Calculated daily usage of facemasks and gloves in some countries with confirmed coronavirus cases.

Country	[1]population	[1]Coronavirus active cases	[1]Urbane population (%)	[2]Facemasks acceptance rate (%)	[4]Average daily facemasks per capita	[3]Total daily facemasks	[4]Gloves acceptance rate (%)	[4]Average daily glove per capita	[3]Total daily gloves	Medical waste generation per day (tons/day)
The U.S.	333,241,257	9,281,054	82.8	73	1	201,424,345	15	2	82,777,128	36,660.16
Canada	38,123,642	40,304	81.3	76	1	23,555,836	15	2	9,298,356	158.7
Mexico	130,493,910	395,270	83.8	85	1	92,950,812	15	2	32,806,169	1,561.3
Brazil	214,301,783	373,534	87.6	89	1	167,078,242	15	2	56,318,509	1,475.5
The U.K.	68,279,355	1,257,757	83.2	72	1	40,902,065	15	2	17,042,527	4,968.1
Germany	84,093,064	163,528	76.3	67	1	42,989,215	15	2	19,248,902	645.9
Spain	46,775,682	279,619	80.3	95	1	35,682,830	15	2	11,268,262	1,104.5
Italy	60,359,173	127,626	69.5	87	1	36,496,617	15	2	12,584,888	504.1
France	65,440,194	277,781	81.5	84	1	44,800,357	15	2	16,000,127	1,097.2
Netherlands	17,178,628	74,165	92.5	22	1	3,495,851	5	2	1,589,023	292.95
Norway	5,470,118	85,710	83.4	8	1	364,966	1	2	91,242	338.6
Denmark	5,792,202	8,376	88.2	12	1	613,047	5	2	255,436	33.09
Finland	5,550,654	86,599	86.1	11	1	525,702	5	2	238956	342.07
Sweden	10,171,893	27,891	88.2	2	1	179,432	0.5	2	89,716	110.17
South Africa	60,170,133	105,876	66.7	80	1	32,106,783	15	2	12,040,044	418.21
Morocco	37,414,634	35,809	63.8	80	1	19,096,429	15	2	7,161,161	141.45
Egypt	104,555,191	29,541	43	80	1	35,966,986	15	2	13,487,620	116.69
Tunisia	11,961,142	3,355	70.1	80	1	6,707,808	15	2	2,515,428	13.25
Ghana	31,818,922	5,355	56.7	80	1	14,433,063	15	2	5,412,399	21.15
Nigeria	212,010,971	10,121	52	80	1	88,196,564	15	2	33,073,711	39.98
Saudi Arabia	35,438,109	2,312	84	73	1	21,730,648	15	2	8,930,403	9.13
United Arab Empire	10,028,079	6,786	86.4	83	1	7,191,336	15	2	2,599,278	26.80
Iran	85,231,406	623,324	75.5	80	1	51,479,769	15	2	19,304,913	2,462.13
India	1,395,642,554	384,888	35	88	1	429,857,907	15	2	146,542,468	1,520.30
Australia	25,840,792	36,346	85.9	32	1	7,103,117	5	2	2,219,724	143.57
Japan	126,029,321	137,249	91.8	87	1	100,654,578	15	2	34,708,475	542.13
China	1,439,323,776	740	60.8	57	1	498,812,048	15	2	262,532,657	2.92
South Korea	51,320,114	26,164	81.8	87	1	36,522,472	15	2	12,593,956	103.35
Philippines	111,261,072	181,951	47.5	92	1	48,621,088	15	2	15,854,703	718.7
Indonesia	276,856,899	109,869	56.4	82	1	128,040,779	15	2	46,844,187	433.98
Thailand	70,002,094	135,966	51.1	78	1	27,901,435	15	2	10,731,321	537.07
Malaysia	32,843,706	239,351	78.4	89	1	22,917,024	15	2	7,724,840	945.44
Vietnam	98,348,196	222,869	37.7	71	1	26,324,862	15	2	11,123,181	880.33

[1] Data retrieved on 28 August 2021, from (worldometer, 2021) And calculation method adapted from Nzediegwu and Chang (Nzediegwu & Chang, 2020).
[2] Adapted from (Imperial-College, 2020) and for African countries (Nzediegwu & Chang, 2020) and for Iran (Sangkham, 2020).
[3] Calculation method adapted from Nzediegwu and Chang (Nzediegwu & Chang, 2020).
[4] Arbitrary data.

where MWG is Medical Waste Generation per day (tons/day), NSCC is the number of confirmed COVID-19 cases, MRWG is the Rate of Medical Waste Generation, considered to be 3.95 kg/bed/day (Sangkham, 2020). This value was considered to be fixed for all the selected countries because the treatment process for the hospitalized COVID-19 cases is almost the same in different countries of the world.

3. Result and discussion

3.1. Daily facemasks and gloves usage and medical waste generation during COVID-19 pandemic

The daily usage rate of facemasks and gloves during the pandemic for healthcare waste management was estimated from Eqs. 1 and 2, and the results are included in Table 1. The results indicated that among the selected countries, China used the highest daily facemasks (498812048 pieces), followed by India, the USA, Brazil, and Indonesia with 429857907, 201424345, 167078242, and 128040779 pieces, respectively (Table 1). Similarly, the highest usage of gloves per day among the selected countries was estimated for China (262532657 pieces of gloves), followed by India, the USA, Brazil, and Indonesia, with 146542468, 82777128, 56318509, and 46844187 pieces, respectively (see Table 1). In addition, in the case of medical waste generation estimated and included in Table 1, the USA (36,660.16 tons/day) is the greatest medical waste generator, followed by the UK (4,968.1 tons/day), Iran (2,462.13 tons/day), Mexico (1,561.3 tons/day), India (1,520.30 tons/day), Brazil (1,475.5 tons/day), Spain (1,104.5 tons/day), France (1,097.2 tons/day). According to the research conducted by (Nzediegwu & Chang, 2020), the daily usage of facemasks and gloves in each country depends on four factors–The population of that country, the percentage of the urban population, the acceptance rate of using facemasks or gloves, and the average daily facemasks and/or glove per person. Therefore, the amount of plastic-based medical waste increases with COVID-19 cases throughout the world, which seriously affects the environment under improper management. The solutions to reducing the public and environmental health impacts possessed by the hazardous medical waste during the coronavirus pandemic are presented in the next section.

3.2. Strategies to reduce the environmental health impact of the plastic waste generated during the coronavirus pandemic

The increased plastic waste generation associated with PPE during the pandemic soon accompanied the increased usage and disposal of single-use- plastics (SUP). For example, demand for plastics has anticipated incrementing by 40% in packaging and about 17% in other applications, including medical usage (Prata et al., 2020). As a result, the pandemic imparts extra pressure on the existing solid waste management system, which might be higher than the municipal waste management system's capacity that can possess environmental pollution. Finally, due to the lack of proper infrastructure to deal with biomedical plastic wastes and their inappropriate disposal in some communities, the number of plastic wastes entering the environment and thereby the adverse impact is increasing. These biomedical plastic wastes have been regarded as probable infectious, toxic, and radioactive pollutants sources that are harmful from environmental and health points of view (Goswami, Goswami, Nautiyal, & Prakash, 2021).

Despite making effective vaccines for the coronavirus (which is a complicated matter), reducing the pandemic's adverse environmental impacts is a complex problem. Researchers, governors, and policymakers need to be aware of the difference between complex problems and complicated ones because they require different strategies as well as different tools, which are not mostly interchangeable. The complicated problems have straight-line solutions and/or step-by-step algorithms that experts can implement with the necessary skills and experience. In contrast, complex problems are creative by nature, with many unpredictable and interconnected moving parts. They are mostly confounding head-scratchers without a straight-line path or clear solution; thus, decision-makers and politicians need to adopt the right strategy to reduce the harms caused by these problems. Scientific investigation of complex problems indicates that they cannot be solved solely by simple or complicated management approaches (Kamensky, 2011). Considering that the pandemic's environmental impact is a complex problem, it might have no clear solution, but the impact can be mitigated by pursuing the following approaches:

3.2.1. Adoption of a severe lockdown policy instead of the herd immunity

WHO advocated severe lockdown to reduce the reproduction rate of the COVID-19 infection (Bedford et al., 2020). In this way, the medical waste generation falls, and the need for PPE will be reduced.

3.2.2. Utilizing paper bags or cotton bags instead of SUP

Cotton bags and paper bags are reusable and thus a more practical option than plastic bags. Cotton bags are washable, making them a more hygienic alternative, contributing to a healthy lifestyle. These cotton bags are woven from thread procured from the plants and thereby are biodegradable. It has also been shown that the coronavirus viability on the surfaces of paper and cotton materials is much shorter than that on plastic products (Corpet, 2021). Therefore, encouraging people to use natural-based bags instead of SUP can be an excellent way to achieve a healthy, sustainable, and environmentally friendly alternative for reducing plastic bag generation.

3.2.3. Redesign plastics and use the biodegradable plastics

As discussed above, the dramatic increase in PPE and SUP consumption, thus in the generation of medical wastes and their subsequent environmental issues, are the adverse outcome of the COVID-19 pandemic. Bio-based or biodegradable plastics can be a viable alternative to synthetic polymeric plastics. Biodegradable or bio-based plastics currently have a production capacity of only 4 million tons worldwide (Bahl, Dolma, Singh, & Sehgal, 2020). Nonetheless, promising efforts have been made to produce biodegradable plastic products, including biodegradable facemasks (Choi et al., 2021). Replacing these products with synthetic plastics is an essential step in reducing the environmental impact caused by the pandemic.

3.2.4. Improve the 4R (reduce, reuse, recycle, and recovery) concept for managing the plastic wastes

Informing the public that the coronavirus survives longer on plastic surfaces than on other surfaces (Corpet, 2021) may reduce using plastic products and decrease plastic waste generation. Moreover, the multiple uses of plastic material and the production of reusable and washable facemasks considerably reduce the environmental problems related to solid waste generation during the pandemic. Further, taking advantage of plastic waste as an energy source as well as recovery of the used plastics as valuable and synthetic products will also be an excellent strategy to deal with the plastic wastes. Improving, developing, and upgrading the existing waste management infrastructure is necessary to achieve the 4R goals and, consequently, to proper management of the plastic wastes generated during the coronavirus pandemic.

3.2.5. Development of clean-up technologies

Recent studies (Ammendolia, Saturno, Brooks, Jacobs, & Jambeck, 2021; Hantoko et al., 2021) have shown significant evidence of improper PPE disposal. Discarded plastic facemasks and gloves could become a substantial threat to aquatic environments (Hasan, Heal, Bashar, & Haque, 2021), which take hundreds of years to be decomposed. Therefore, the design and development of the proper clean-up approach for plastic-contaminated sites can be a good strategy for addressing the plastic materials in the environment. The adverse impact of plastic pollution

Table 2
Advantages and disadvantages of different strategies associated with the generation of unprecedented plastic-based wastes during the COVID-19 pandemic.

Strategies	Advantages	Disadvantages
Adoption of lockdown policy instead of herd immunity	• A safe way to prevent further transmission of the coronavirus • Reduce the need to use PPE • Reduce the hospitalization and thus the medical waste generation	• It endangers the jobs • People cannot stand quarantine for long time
Utilizing paper bags or cotton bags instead of SUP	• A simple way to reduce the single-use plastic consumption • Are environmental-friendly products	• The fabric of the Cotton bag is not moisture-resistant • People rarely wash their reusable bags, So reusable bags can act as a potential route for the transmission of many microorganisms from homes to grocery stores
Redesigning plastics and use biodegradable plastic instead of synthetic polymers	• Bioplastics are degradable and non-toxic • Reduces oil consumption	• The process of bioplastic production is more expensive than the petroleum-based plastics • Bioplastics durability are less than petroleum-based plastics
Improving 4R concept for plastic material	• Waste reduction • Save water • Save energy	• Confined variety of products • High upfront capital cost recycling still is ineffective • Recycle products often have less quality
Development of clean-up technologies	• A low-cost strategy • In-situ bioremediation is a cost-effective measure • It can be possible to completely transform organic contaminants into water, carbon dioxide, and methane	• This method has a slow rate of degradation • Biodegradation of mixtures of xenobiotics may need a consortium of microorganisms

is not limited to a particular region but threatens the world. Therefore, the countermeasures to mitigate the adverse effects of plastic debris require international cooperation from all counties across the globe. Although some studies indicated that fungal degradation obtained 43% in polyethylene degradation by a marine fungus, *Zalerion maritimum* (Paço et al., 2017), the report on the in-situ degradation of plastic particles is limited.

Table 2

4. Limitation of the study

The current work is a cross-sectional study aimed to provide a rapid approximation of potential PPE and medical waste generation associated with the SARs-CoV-2 pandemic in the selected 33 countries worldwide. This examination relies on the reliability of COVID-19 case statistics and available data, including the number of active cases, number of populations, percentage of the urban population, and facemask acceptance rate. However, unlike previous studies that used the fixed number of 80% for facemasks acceptance rate in different countries (Nzediegwu & Chang, 2020; Sangkham, 2020), for a more rational approximation, this study used different facemask acceptance rates for each selected country using the results of a survey conducted by Imperial College London. Moreover, the rates of medical waste generation (kg/bed/day) are considered and supported by the previous studies (Mihai, 2020; Sangkham, 2020).

5. Conclusion and future perspective

The COVID-19 pandemic has adversely affected humans and the environment throughout the world. Depending on the government approach and countries' economies, COVID-19 has different environmental health effects. This study estimates the daily facemasks and gloves used as well as the medical waste generated related to the coronavirus pandemic. The results indicate that the higher number of confirmed coronavirus cases, the more medical waste generation in the world. But the amount of daily PPE (facemasks or gloves), regardless of the number of confirmed coronavirus cases, depends on each country's population, the percentage of the urban population, and the acceptance rate of using that product. For instance, China is the most populous country and the largest consumer of facemasks and gloves in the world. Still, it has reduced the number of confirmed coronavirus cases and, consequently, among the countries with the lowest medical waste generation by effectively controlling the pandemic. Although the coronavirus is a deadly virus and undertaking whole aspects of prevention and control is necessary, its harmful environmental health effects can be mitigated by adopting the proper approaches for waste management. It was mentioned that the best mitigating measures for limiting coronavirus spread are adopting a strict lockdown policy, social distancing, utilizing PPE, discovering an effective drug, and widespread vaccination. However, considering the point that genetic variants of SARS-CoV-2 have been emerging and circulating around the world, changing/modifying the preventive protocols against the COVID-19 is inevitable. In this way, many questions remain unanswered, and their responses via future research will help to better control similar future infectious crises:

- Given the experience of prosperous countries managing the pandemic crisis and reducing its suffering, what is the optimal protocol for dealing with the COVID-19 pandemic from a sustainable development perspective?
- What is the best method for managing the medical wastes generated during the COVID-19 pandemic?
- Is it possible to discover an effective drug for the definitive treatment of coronavirus?
- Can widespread vaccination programs diminish the production of coronavirus-related plastic waste?
- Are current existing vaccines capable of producing a preventive and effective immune response against mutant and genetic drift strains of SARS-CoV-2?
- What is the effect of the vaccination on reducing the consumption of PPEs, thus the medical waste generation in different countries?
- How can the efficiency of on-site plastic cleaning methods be improved?

Availability of data and materials

Data about population, urban population, and coronavirus confirmed cases were retrieved on 28 August 2021, from (worldometer, 2021), and data about facemasks acceptance rate was obtained from a survey (Imperial-College, 2020) and (Nzediegwu & Chang, 2020) and (Sangkham, 2020).

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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