The Massive Misuse of Face Mask as a Risk to COVID-19 Pandemic in Latin American: The Case of Mexico

Melissa Jiménez Gómez Tagle
TU Munchen: Technische Universität München

Virginia Gabriela Cilia-López (✉ gabriela.cilia@uaslp.mx)
Universidad Autonoma de San Luis Potosi  https://orcid.org/0000-0003-0064-4490

Research Article

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Abstract
The COVID-19 pandemic has placed a great challenge in waste management around the world. While the use of face masks has been shown to reduce the number of transmissions of COVID-19, it has also generated a high amount of waste, undermining the capacity of authorities and dumping areas to manage medical waste correctly. Latin American countries are particularly vulnerable because they are not self-sufficient to ensure adequate used facemasks management during the outbreak. The pandemic has led to poor purchasing practices, use, and disposal of this type of product, which can cause environmental contamination and health problems. This article focuses on Latin American using Mexico as a study case since it is one of the countries most affected by the pandemic. That shows the health risks of the population exposed to social inequalities and evaluates the future environmental implications arising from a lack of legislation for correct disposal of waste management in several Latin American countries, such as the generation of microplastics or plastic pollution. Since the pandemic is predicted to last until 2021, this is a good scenario to develop new policies for good urban solid waste management in favor of human health and the environment.

Introduction
Latin America has become the epicenter of COVID-19 starting in May since the World Health Organization (WHO) declared it a pandemic in March 2020 (WHO 2020a). At the beginning of February 2021, 108,822,960 confirmed cases have been registered, of which 48,457,101 to Americas. The most affected countries are United States (27,309,503 cases), Brazil (9,834,513 cases), Colombia (2,195,039 cases), Argentina (2,025,798 cases) and Mexico (1,992,794) (WHO. 2020b). This situation has led to measures in the Latin American region, such as social isolation, massive use of antibacterial gel, facemasks, and gloves by the civilian population to face the COVID-19 pandemic. Although the World Health Organization (WHO) and governments will not agree on whether the use of mouth masks is essential for the entire population, these items have become one of the most demanded products in the world since the beginning of the coronavirus crisis. But the widespread use of protective gear throughout the world creates massive waste disposal and health risk problems.

The COVID-19 pandemic has left great challenges in the handling of municipal solid waste and hazardous medical waste that needs to be managed sustainably. The use of facemasks (FM) will be a continuous measure of protection to stop the spread of saliva and respiratory droplets to others (Cheng et al, 2020; Moreno et al, 2020). FM are products frequently pathogen-contaminated, and ought to be handled as hazardous waste (Klemes et al, 2020). On the other hand, patients with mild symptoms who are self-isolated at home will keep generating contaminated MSW. The MSW and FM in the current pandemic scenario require a substantial structural change in waste management, from the sorting rules, collecting methods, and waste treatment to the safety protocol of the waste collection for workers.

The effect of the COVID-19 pandemic on the environment has already been pointed out, due to an increase in the use of facemasks and gloves. Their improper disposition is the greatest environmental concern about pollution in terrestrial and marine ecosystems (Kalina et al., 2020; Klemes et al., 2020). Besides, there is a risk of exposure to COVID-19, due to the misuse and incorrect disposal of these materials by the civil population, which has not been analyzed nor addressed, especially in developing countries.

Biohazardous and health waste
Biohazardous waste is a material that includes human and nonhuman primate blood, tissue, body fluids, and cell lines. Since the pandemic started and FM use was mandatory in some spaces, have been generated more biohazardous waste than before. That implies a new environmental problem and a new challenge to the current pollution world issue. In this division, Health Waste (HW) includes all generated waste within health care facilities and waste originated from minor sources, including the one produced during health care undertaken at home, which is one of the most common cases, given the asymptomatic patients.

Around 75 to 90% of HW could be compared to municipal solid waste. The problem remains in the 10-25% left, posing environmental and health risks. Minimal exposure to material contaminated with these fluids can result in severe health problems. The HW could be a focus for the transmission of infectious pathogenic microorganisms to the environment through direct contact with them, like inhalation, ingestion, or through the food chain. Incineration would reduce the volume of waste and its potential for infection; however, uncontrolled burning could active toxic emissions of a variety of pollutants (Ferronato and Torreta 2019).

Municipal Solid Waste Management in Latin American
Municipal solid waste management (MSWM) is considered critical public health, as well as economic and environmental concerns, especially in developing countries. The waste fraction generated by households, shops, restaurants, offices, street sweeping, green areas
maintenance, and other small activities, is disposed of mainly in open dumps (Ferronato and Torretta 2019). There are no technological facilities for MSWM treatment especially in Latin America (Ferronato et al. 2018). The Pan-American Health Organization developed the Recommendations for Solid Waste Management, which explains in a very simple way the solid waste management (SWM). It applies to hospital staff, common waste transportation, and special considerations for waste management to be treated outside of hospital facilities but does not address waste management in homes (PAHO 2020).

The SWM in developing countries has received less attention from politicians, researchers, and academics than other urban environmental problems (Cruvinel et al. 2019). The lack of infrastructure for collection, transportation, treatment, and final disposal, management planning, financial resources, know-how, and public attitude reduces the chances of improvement (Ferronato and Torretta 2019). This situation is of particular concern to Latin America because inadequate SWM has effects on the health and quality of life of the population (de Souza et al. 2020).

Use and disposal of facemasks in Latin America

In the USA, it is recommended that facemasks (FM), gloves, tissues, and other contaminated wastes be disposed of in double-bagged by the risk of contamination with pathogens (Association of Cities and Regions for Sustainable Resource Management, 2020). However, the scenario in the Latin American and Caribbean areas is different. First, this region is highly dependent on imports of medical products, as less than 4% of these are sourced within the region itself (ELAC, 2020). Second, this has led to a recurring insufficient scenario supply due to shortage, so the civil population has resorted to disinfection processes for lengthy usage or reuse of FM. However, recent evidence shows that the virus might be especially stable on the surface of surgical masks (one of the most widely used face mask types) for as long as 7-9 days (Chin et al. 2020; Moreno et al. 2020). Third, even more serious, in popular areas of Mexico, there have been reports of the sale of used FM in popular markets and flea markets. The authorities have already alerted the population to discard the FM that should be cut and bagged to prevent others from picking them up from the garbage and selling them again (INFOBAE, 2020). Therefore, in this scenario, the most vulnerable people to COVID-19 are the low-income population because they cannot cover the cost of convenient FM to protect themselves in public spaces and workplaces.

Another risk factor in the Latin American and Caribbean region is the incorrect disposal of used FM and gloves. That is of particular concern for those asymptomatic individuals and patients who do not require hospitalization and are recovered at home. The solid waste generated in those patients’ homes that are not disposed of properly can be a source of infection for the general population and formal and informal waste collection workers. The WHO published a series of protective measures against COVID-19. Those include avoiding touching surfaces in public settings, given the fact that someone with COVID-19 could have touched and spread the virus, frequent cleaning of hands with soap and water, or with an alcohol-based hand rub. In contrast, most waste pickers live with a low daily income or lack of protective equipment when working, increasing the probabilities of transmission in this scenario (WHO, 2020c).

Use and disposal of FM in Mexico

According to article 18 of the General law for the prevention and integral management of waste (LGPGIR, 2014) in Mexico, municipal authorities and the corresponding secretaries should create programs for the integral management of dangerous waste generated in households when disposing of these products, which may contain risk materials. That also applies to offices and institutions. Moreover, states and municipalities that provide the public service of cleaning or that execute programs for the separation, collection, and storage of the waste that might possess hazardous waste, must observe the management criteria established in the Law, these Regulations, and the official Mexican standards. Regardless of the last statements, most governmental authorities are not taking action into this, easing the exposure to infectious and biological waste to the general population.

As stated by some reports from Mexico City, authorities found 3.5 tons of hospital waste were thrown away in the surrounding forests of the city, and around 6000 cubic meters of medical waste piled up in a clandestine dump in the state of Puebla. Despite that the Federal Attorney's Office for Environmental Protection (PROFEPA, in Spanish) had stated that most of these residues must be incinerated, some service providers were not responsible for managing correctly this waste, threatening citizens’ health (Deutsche Welle 2020).

Materials And Methods

In this study we estimated the number of masks that can be discarded in the most populated cities of Mexico, all of them with more than one million inhabitants. To make the estimate, we use with the following equation (Nzediegwu and Chang 2020) with some modifications (Urban and Nakada 2021):
\[ TDF = \frac{\text{Pop} \times \text{Urb} \times \text{FAR} \times \text{ADFPC}}{10,000} \]

where:

- **TDF:** Total daily disposable facemasks
- **Pop.** Total population
- **Urb.:** Urban Population (%)
- **FAR:** Facemask acceptance rate = 80%
- **ADFPC:** Average daily disposable facemasks per capita = 2

**Results And Discussion**

According to the formula, in Mexico, 43,606,224 facemasks are disposable daily only in its most populated cities (Table 1). Such an amount of health waste is a challenge for urban waste management because garbage separation is mandatory for citizens in Mexico City only. Poorly managed medical waste is the major infection source for patients, health care workers, waste handlers, and the general public (Ferronato and Torretta 2019). The solid waste from patients who are treated for infectious diseases in their homes is a risk to waste collection workers and the environment, depending on the conditions of transport and disposal of the waste (Ferronato and Torretta 2019; Gomes y Caldas 2020). In Nicolas Romero town, Mexico, tons of medical residues were thrown away starting in April of 2020. When cleaning inspectors arrived at the zone on May 4th, around 3.5 tons of material, including biological residues and human tissue partially incinerated were found. The case of Nicolas Romero town is one example of bad waste management with future environmental implications (Deutsche Welle, 2020). Environmental contamination due to SWM is as well a global issue. The inadequate SWM has environmental and social impacts, placing at risk the health and life quality of urban populations. This problem is more severe in developing countries, where less than 30% of domestic garbage is handled appropriately.

**Table 1**

| State                  | City           | Total population | Masks discarded per day |
|------------------------|----------------|------------------|-------------------------|
| Ciudad de México       | Ciudad de Mexico | 8,851,080        | 17,702,160              |
| Estado de México       | Ecatepec       | 1,655,015        | 3,310,030               |
| Jalisco                | Guadalajara    | 1,495,182        | 2,990,364               |
| Puebla de Zaragoza     | Puebla         | 1,434,062        | 2,868,124               |
| Baja California        | Tijuana        | 1,321,004        | 2,642,008               |
| Chihuahua              | Ciudad juarez  | 1,300,983        | 2,601,966               |
| Guanajuato             | Leon           | 1,238,962        | 2,477,924               |
| Jalisco                | Zapopan        | 1,142,483        | 2,284,966               |
| Nuevo León              | Monterrey      | 1,135,512        | 2,271,024               |
| Tamaulipas             | Reynosa        | 1,124,244        | 2,248,488               |
| Estado de México       | Nezahualcoyotl | 1,104,585        | 2,209,170               |
| **Total**              |                | **21,803,112**   | **43,606,224**          |

* Considering each person uses 2 units per day, with acceptance by 80% of total population

**The health waste and waste pickers in Latin America**
In worldwide, two million informal recyclers work in SWM, particularly in the low- and middle-income countries, where the waste management is undertaken poorly, causing significant impacts on human health and the environment (Cruvinel et al. 2019; Ferronato and Torretta 2019). Incorrect SWM intensifies the risk of problematic health conditions of waste pickers, an informal working group widely recognized in informal landfills in Latin America and the Caribbean. This population is the first to suffer the consequences of inadequate SWM. Studies have shown that waste pickers face unhealthy situations, such as poor hygiene practices and lack of access to personal protection equipment, or the inadequate use of the same (Cruvinel et al. 2019; Ferronato and Torretta 2019). One study in South Sudan, Africa, evidence that waste pickers working with recyclable materials are at higher risk of developing pulmonary diseases, HIV, and hepatitis C as a result of contact with sharp items and hazardous health waste (Cowling 2013). More worrying, without adequate management of domiciliary waste infected by COVID-19 from patients undergoing treatment at home, waste pickers, formal waste collection workers, and the whole population are at risk of contagion (Ferronato and Torretta 2019; Gomes and Caldas 2020). Furthermore, decomposing organic waste is a rich medium or culture for the growth of numerous micro-organisms, many of which could drive to zoonotic diseases if passed on to humans (Ziraba et al. 2016; Fadare and Okoffo 2020).

In addition to the conditions of labor vulnerability, waste pickers present risk factors that make them more vulnerable to suffer the most severe conditions than the COVID 19 contagion. In a study conducted with waste pickers in Brazil, Colombia, and Mexico, the following health conditions were found: tiredness, coughing, shortness of breath, asthma, allergies, dengue fever, tuberculosis, smoking, hypertension; bronchitis, diabetes, HIV/AIDS infections, hypertension, respiratory diseases, and obesity. Additionally, to their work conditions, the health of waste pickers can be worsened if they are living in marginalized areas (slum areas), which do not have a public water supply or sewer system (Cruvinel et al. 2019). The aforementioned put the waste-pickers within the most vulnerable population to contract COVID-19 or any other disease spread through poor SWM. According to the WHO guidance on water, sanitation program (WASH), hygiene, safe water, sanitation, waste management, and hygienic conditions are essential for preventing and protecting human health against infectious diseases, such as COVID-19. Given the ease of transmission of COVID-19 through contaminated materials or even through feces, waste pickers are at higher risk due to exposure to biological matter, not just with contaminated FM, but with fecal material (WHOc).

**FM as a source of environmental contamination by solid waste mismanagement**

The under-covered issue from these materials is also the generation of microplastics, given the fact that FM is produced from polymers, such as polypropylene, polyurethane, polycrystalline, polystyrene, polycarbonate, polyethylene, or polyester. Polymers can be degraded/fragmented into smaller pieces of particles under 5 µm, known as microplastics, under environmental conditions (Fadare and Okoffo 2020). Besides, microplastics contain toxic chemicals like phthalates, organotin, nonylphenol, polybrominated biphenyl ether, and triclosan, which can be released during chemical or biological degradation processes in open-air conditions. As a consequence, flora, fauna, and the environment are threatened by this kind of contamination. Besides, FM are easily ingested by aquatic organisms, such as fishes affecting the food web that could end up in human consumption and finally in human health problems (Aragaw 2020).

**Alternatives to reduce the spread of COVID 19 by the incorrect use and disposition of FM**

There are several feasible alternatives for disinfecting FM. Heat and ultraviolet germicidal irradiation, to highlight the main ones standing out among them. These methods have proven successful for inactivating the virus COVID-19. However, in Latin America and the Caribbean, this option is not viable for the most vulnerable population and workers involved in formal and informal urban waste management due to the cost involved in these disinfection methods. However, they are the ones who are most at risk if we assume that about 43,606,224 facemasks are discarded only in the most populated cities in Mexico.

Cheaper disinfection methods such as chemicals like soap, ethanol, or sodium hypochlorite have demonstrated their effectiveness as methods of disinfecting FM and medical equipment (Reychler et al. 2005). However, for COVID-19 these methods are not recommended since they would remove the electrostatic mask charge, impairing its filtration capacities (Moreno et al. 2020). Therefore, chemical disinfection methods should be avoided by the general population who intend to reuse FM. For the above mentioned, health authorities should inform the general population about the risks involved in the reuse of FM with or without disinfection. However, chemical methods for disinfection can be part of the process of disposing of FM at home to reduce the risk of exposure to formal and informal workers related to urban solid waste management.
The mandatory use of FM at a global level has been developed as one of the main measures to reduce the contagion risk and dispersion of COVID-19. These materials should be considered as biological waste. However, health authorities, especially in Latin America, do not provide adequate information on how to dispose of these materials once they are used. The information could be distributed through social networks, television, radio, and print media to ensure that it reaches the entire population.

Countries as Rwanda it was introduced a guideline to buffer the environment from potential harm and health risks. According to this guideline, used FM must be segregated and confined from other kinds of waste in domiciliary places or offices. This guideline mentions that the waste should be discarded in a dry place uniquely used for FM disposal away from the population’s houses, workplaces, or any other spaces close to people, within a 4-meter distance from a sleeping area or where people perform activities, especially at open air. Besides, they should not be reused and should be used properly (Mugemana 2020).

Due to the waste generated by the Covid-19 pandemic in Mexico was developed the “Cartilla de Mejores Prácticas para la Prevención del COVID-19 en el Manejo de los Residuos Sólidos Urbanos (RSU)” explains in detail how to handle SUW at home, in public places, and in the cleaning of public transportation, as well as SUW generated by a household of infected people or a non-hospital organization where one or more infected people reside (Ministry of Environment and Natural Resources 2020). However, this information has not been understood by the population since it is frequent to see in the streets and public places the incorrect disposition of used masks (Fig. 1). Which increases the risk of dispersion of COVID-19 and environmental contamination.

Solid waste mismanagement is a global issue in terms of environmental contamination, social inclusion, and economic sustainability, which requires integrated assessments and holistic approaches for the solution (Ferronato and Torretta 2019). Universal FM use is a necessary adjunctive public health measure to decrease the infection risk by COVID-19 in densely populated cities. Among the many adverse consequences of the COVID-19 pandemic, is the sudden surge in the volume of plastic waste, particularly for medical equipment used for health professionals and healthcare purposes that should be considered as side effects. The crucial priority is the destruction of residual pathogens for safe disposal waste. Effective healthcare waste management requires appropriate identification, collection, separation, storage, transportation, treatment, and disposal.

According to the Sustainable Development Goals (SDGs), the correct SWM is part of the environment and health preservation. Stakeholders and governments should know that SWM is a complex system that involves environmental, social, and economic issues. New laws and regulations in Latin America about SWM should include environmental, social, and health beneficial impacts, which must be prioritized by decision-makers and researchers.

**Conclusions**

Latin American countries are particularly vulnerable because they are not self-sufficient to ensure adequate facemasks management during the outbreak. This situation has led to poor purchasing practices, use, and disposal of these products, which can cause environmental contamination and health problems. In Mexico, the competent authorities responsible for waste collection and treatment should create guidelines and procedures to apply during pandemics regarding the correct handling of used FM and biohazardous waste from homes and public places. This kind of intervention will diminish the incorrect disposition of FM and other biohazard materials on dumped inland fields. The correct disposal of used FM can reduce the infection risk for urban solid waste collection workers and the population. Considering that there are already protocols to follow in hospitals and laboratories to manage biohazardous waste, it is a priority to create one for the household patients with COVID-19 in México, given to hospitals saturation. This information must be spread on the mass media for the population.

The COVID-19 pandemic is a good scenario to develop new policies to better SWM in favor of human health and the environment. Good urban solid waste management will be benefitting the most vulnerable population as workers in the formal and informal collection of urban solid waste and look after their health. In the long term, it would also benefit environmental and health conditions in the urban areas in Latin America.

**Declaration**

**Declaration of competing interests.**

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

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Figures
**Figure 1**

Facemasks and gloves left on the streets of México.