The role of medical waste management in achieving environmental safety during the Covid-19 pandemic From the perspective of the World Health Organization

دورإدارة النفايات الطبية في تحقيق السلامة البيئية خلال جائحة كوفيد19 من منظورالمنظمة العالمية للصحة

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Abstract:

Medical wastes are the most dangerous type of waste, given their potential negative effects on both public health and environmental safety. There has been growing concern about how to deal with the huge amounts of waste caused by the Covid-19, which has been spreading rapidly since the end of 2019.

The objective of this study is to track the scientific and methodological analysis of WHO in monitoring medical waste associated with the Covid-19 pandemic and the increasing pressure to reduce its negative effects on human safety and the environment.

Review the main strategic recommendations made in this regard at the global, national and health-care facilities levels (as a frame of reference for the WHO), which are generally focused on providing innovative solutions to improve environmental sustainability through the safe management of medical waste.

Keywords: Medical Waste, Covid-19 Pandemic, Environmental Safety, Personal Protection Equipment PPE, World Health Organization WHO.

Jel Classification Codes: I18, Q53, Q54, M11.

مستخلص:

تعتبر النفايات الطبية جميع المخلفات التي تنشأ عن مختلف أنشطة الرعاية الصحية، وهي أخطر أنواع النفايات، نظرا لآثارها السلبية المحتملة على الصحة العامة والسلامة البيئية معا.

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وقد تزايد القلق بشأن كيفية التعامل مع الكميات الهائلة للنفايات الناتجة عن العدوى بفيروس كورونا الذي مافتئ ينتشر بوتيرة سريعة منذ نهاية سنة 2019.

تهدف هذه الدراسة إلى تتبع التحليل العلمي والمنهجي للمنظمة العالمية للصحة في رصد النفايات الطبية المرتبطة بجائحة كوفيد 19 والضغوط المتزايدة للحد من آثارها السلبية على سلامة الإنسان وبيئته. واستعراض أهم التوصيات الإستراتيجية المقدمة في هذا الخصوص على المستوى العالمي والوطني وعلى مستوى مرافق الرعاية الصحية،(باعتبار المنظمة العالمية للصحة إطارا مرجعيا في ذلك)، والتي تتمحور عموما حول تقديم حلول مبتكرة لتحسين الاستدامة البيئية من خلال الإدارة الآمنة للنفايات الطبية.

الكلمات المفتاحية: النفايات الطبية، جائحة كوفيد19، السلامة البيئية، وسائل الحماية الشخصية، المنظمة العالمية للصحة.

تصنيف Jel: I18, Q53, Q54, M11.

1. Introduction

Medical waste represents all waste originating from various health-care activities in or outside hospitals, and is considered the most dangerous type of waste - after radioactive waste worldwide - especially after scientific and empirical evidence that the absence of an effective system of management causes serious diseases and negative effects.

Although hazardously contaminated infectious health-care wastes constitute a lower proportion of the total amount of health waste, they pose a significant risk to the individual, society and the environment in general through their production, collection, storage, transport or disposal.

1.1 The study Problem:

There has been growing concern about how to deal with waste from the Corona virus, which has been spreading rapidly since the end of 2019.

A report by the World Health Organization (WHO) stated that tens of thousands of tons of excess medical waste resulting from the response to the Corona pandemic, i.e. increased numbers of patients in hospitals as a result of the intensive use of personal protective devices from protective masks, gloves, injections and others, put enormous pressure on health-care waste management systems worldwide.

Therefore, waste generated by hospitals and various health-care facilities must be properly disposed of by waste management personnel, and alternative techniques should be used to manage them properly during the pandemic in order to ensure both environmental safety and human health.

The World Health Organization (WHO) has issued as terms of reference - a detailed report in November 2022 warning of the health and environmental risks of medical waste associated with the Covid-19

How can medical waste from the covid-19 pandemic be treated in safe ways, and what are the efforts of the World Health Organization to do?

Based on the problem of study, the following sub-questions can be asked:

- What is meant by medical waste, what types of waste and what negative effects are associated with it?
- How much of the medical waste from the uses associated with the Corona virus and how can it be managed?
- What is the World Health Organization efforts and recommendations in treating medical waste to ensure environmental health and safety?

1.2Importance of study:

-The management of medical waste in the context of the Corona crisis is of particular importance both in terms of public health and in terms of the safety of the environment.

-The importance of using modern methods for the safe and sustainable management of medical waste.

-How to manage the vast amount of medical waste resulting from uses associated with the Covid-19 pandemic.

1.3Study objectives:

- To highlight the conceptual framework of the related concepts: medical waste, the Covid-19 pandemic, environmental safety.
- To highlight the urgent need to improve the management of waste associated with the Covid-19 pandemic in view of the serious effects on public health and environmental safety.
- Presentation of an analysis of WHO efforts in managing medical waste for the Covid-19 pandemic and monitoring of its important recommendations at the global, national and health-care facilities levels.

1.4Study methodology:

The analytical descriptive methodology study was adopted: in forming the theoretical background of the subject through various references, and the analysis of various data and statistics on study variables.

2. Theoretical framework of the study

2.1 The concept of COVID-19

2.1.1 Definition:

Covid-19 is the name given by the World Health Organization to the virus that causes severe acute respiratory syndrome (Corona).

The first cases of the virus appeared in the Chinese city of Wuhan at the end of December 2019, in the form of severe pneumonia, and the spread of this virus increased to the epidemic stage, and it was declared as a pandemic on March 11, 2020. (Mohan Agarwal, 2020, p. 01)
Krishna Mohan Agarwal et al., Study and overview of the novel corona virus disease (COVID-19), sensors international journal, 2020 p01.

2.1.2 Symptoms of Covid-19

The disease affects people differently, with most cases showing mild symptoms, especially in children and young people. However, some cases can appear severe and serious, with about 20% of those infected requiring medical care in a hospital. People most at risk of developing severe symptoms of the disease are those with underlying diseases, such as cardiovascular disease, diabetes, chronic respiratory diseases, cancer, and other diseases. However, anyone is at risk of severe illness and death from Covid-19, regardless of age. (COVID-19 symptoms and what to do, 2023)

The virus is transmitted through direct contact with respiratory droplets from an infected person resulting from coughing or sneezing. An individual can also be infected by touching surfaces contaminated with the virus and then touching the face (for example, eyes, nose, and mouth).
The time period between exposure to the virus and the onset of symptoms ranges from two to 14days, with an average of five days.(Velavan TP, 2020)

The standard diagnostic method is to perform a PCR swab taken from the nasopharynx or throat. It can also be diagnosed by combining symptoms and risk factors with a chest CT scan that shows signs of pneumonia.

2.1.3 Precautionary measures

to protect people from infection include: physical distancing of at least one meter, or self-isolation until complete recovery, wearing protective masks, and regularly washing hands or rubbing them with alcohol-based sanitizer. Also, take the developed vaccine against the virus and follow the instructions of the local authorities.(coronavirus, 2024)
As a result of the highly contagious nature of the disease, the number of patients in hospitals increased, which led to a rapid increase in the production of medical waste as a result of the extensive use of the amount of

PPE(personal protective equipment) (masks, syringes, bandages, etc.) compared to normal conditions. It became necessary to increase the capacity to deal with this waste, to ensure the health and safety of individuals.

2.2 The concept of medical waste

2.2.1 Definition

Waste is one of the most important issues of concern to States today because of the seriousness of the damage associated with it. Recently, the term "health-care waste" was used instead of the term "medical waste" to cover all types of waste released from health facilities of all kinds.(Al-Saleh, 2011, p. 148)

Medical waste, as with modern environmental issues, has been taken - many definitions, the most important of which are:

The definition of the World Health Organization (WHO), in which medical waste is defined as: "Including all wastes from health institutions, research centers and laboratories, excluding wastes from secondary or dispersed sources such as those resulting from therapeutic activities of persons in the home (dials, insulin injections ...).(clinical-waste-health-care-waste, 2024)

The Environmental Protection Agency (EPA) in U.S.A Medical waste as follows: "All waste produced by health-care facilities, including hospitals, clinics, blood banks, mortuaries, medical laboratories, animal testing centers or units, and private clinics."(Agency, 2015, p. 105)

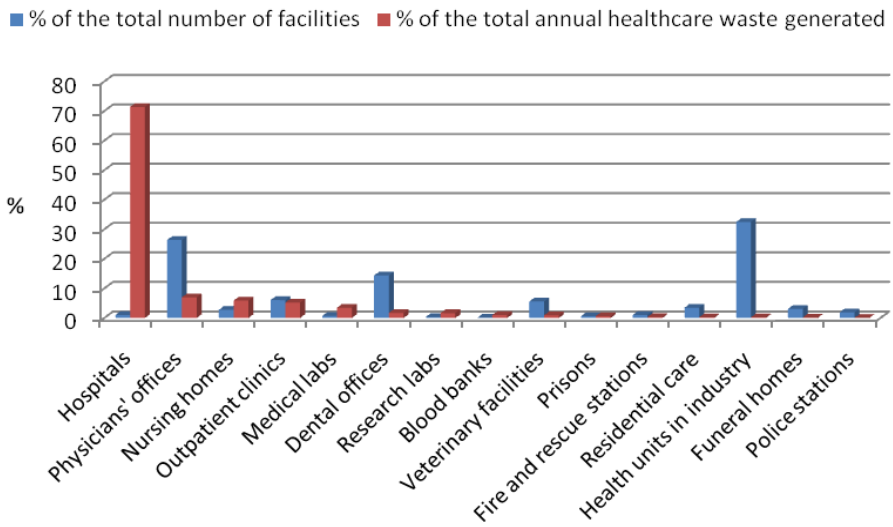
The Algerian legislator, it defined medical waste in Article 3 of Law 01-19 as: “All waste resulting from examination, follow-up, preventive treatment or treatment activities in the field of human and veterinary medicine.”(Law No. 01-19 of December 12, 2001, 2001)

2.2.2 Sources of Health care waste

The main sources of healthcare waste are as follows:

- Hospitals and other health facilities
- Laboratories and research centers
- Morgues and autopsy centers
- Animal research and examination laboratories
- Blood banks and sample collection services
- Nursing homes for the elderly

Figure1: Typical Contributions of Different Health Facilities to Total Healthcare Waste Generated



Source: (United Nations Development Program, 2020, p. 08)

Healthcare waste is all waste generated from healthcare facilities, medical laboratories and biomedical research facilities, as well as waste from secondary or dispersed sources. Although hospitals generate the bulk of healthcare waste by volume, they constitute a small portion of the total number of sources.

Evaluation of waste generation rate data from around the world shows that about 0.5 kg per bed per day is generated in hospitals. However, this figure, and the basic composition of waste, varies greatly depending on the local context, with high-income countries generating much higher levels of waste and plastics.

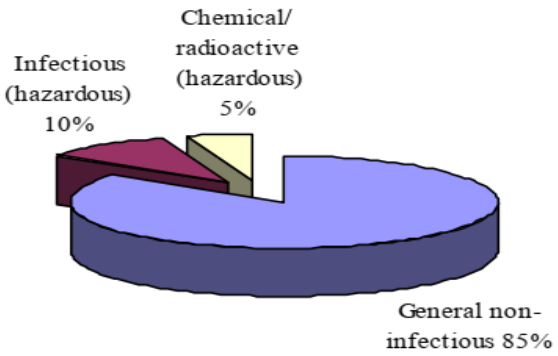
Regarding of medical waste in Home Care Services (HCS) is lower than that of hospitals, which are the main producers. In Turkey, more than 70% of HCS patients produce less than 0.5 kg/patient/day of medical waste (Sonmez, O., Nazik, & Andi, 2018, p. 734)

In developing countries, changes and adaptations resulting from the COVID-19 pandemic will result in additional costs to already precarious HCS that suffer from a lack of medicines, materials and PPE, as well as inadequate waste management (Silvver, 2022 , p. 223)

2.2.3 Classifications and composition health care waste

As a general rule, between 75% and 90% of the waste produced by healthcare facilities is non-risk (non-infectious, non-hazardous) general waste, comparable to domestic waste. Only a small portion of health care waste is regarded as hazardous and may create health risks.

Figure 2: Typical Breakdown of Healthcare Waste



Source: (United Nations Development Program, 2020, p. 13)

- **Healthcare waste types:**

Of the total amount of waste from health-care activities, 85% is non-hazardous, compared to household waste. The remaining 15% are hazardous substances that can be infected, toxic or radioactive.(health-care-waste, 2024) Residues and by-products include a wide range of substances, as shown in the list below: (Al-Enezi, 2008, p. 273)

- **Contaminated wastes**: blood-contaminated wastes, other body fluids (e.g., residues from tossed diagnostic samples), farms and stocks of infectious agents left behind by laboratory work (e.g., morgue and infected animal residues, resulting from laboratory work), or patient residues in isolation wards and equipment (e.g., mop, bandage and medical equipment to be used once);
- **Pathological wastes**: tissues, organs or human fluids, body parts and contaminated animal sacrifices;
- **Acute objects**: syringes, needles, blades, etc.;
- **Chemicals**: e.g. solvents used in laboratory formulations, disinfectants, heavy metals in medical equipment (e.g. mercury in broken thermometers) and batteries;

- **Pharmacological preparations**: drugs and end-of-life, unused and contaminated vaccines;
- **Toxicological wastes of genes**: high-risk, mutagenic, saturated or carcinogenic wastes, such as cell-toxic drugs used to treat cancer, and their metabolites;
- **Radioactive waste**: e.g. products contaminated with radio nuclides, including radioactive diagnostics or materials used in radiotherapy;
- **Non-hazardous or general wastes**: residues that do not pose any particular biological, chemical, radiological or physical hazard.

High-income countries produce, on average, about 0.5 kg of hazardous waste per day per treatment bed; low-income countries produce, on average, 0.2 kg of such waste per day per treatment bed. However, a distinction is often not made between hazardous and non-hazardous health-care residues in low-income countries, which means that the real amount of hazardous waste is much higher.(health-care-waste)

2.2.4 Effects of medical waste

Medical waste, in particular, contains microscopic organisms that may be harmful and can transmit infection to patients in hospitals, health workers, as well as the general public.

Studies have shown that 90% of the diseases in hospitals in developing countries are caused by pollution, and that domestic waste can transport 42 human and even social diseases, such as depression, other social ills from child and other ill-treatment, the main cause of which is abandoned waste in informal and untreated areas. (Al-Namer, 2009, pp. 16-17)

a. On human health:

- Burns resulting from exposure to radiation;
- Injuries resulting from puncture wounds with sharp objects;
- Poisoning and contamination through the action of pharmaceutical preparations, especially antibiotics and cytotoxic drugs;
- Poisoning and pollution through wastewater; And with elements or compounds such as mercury or dioxins that are released during the burning of waste.

b. On environment:

- Garbage dumps can pollute the air, soil, and drinking water if they are not built properly. Occupational hazards exist in waste disposal facilities that are not well designed, managed or maintained.

- Waste is widely burned, but improper burning or burning of unsuitable materials causes the release of pollutants into the air and the release of ash residue. Burned materials containing chlorine can generate dioxins and furans, which are carcinogenic to humans and have been linked to a range of harmful health effects. Burning heavy metals or materials containing a high percentage of metals.(health-care-waste, 2024)

2.2.5 Medical waste management

The most important methods adopted for treating waste and reducing its danger are: (Mediterranean, 2002, pp. 09-10)
Basic Steps in the. Preparation of Health Care Waste Management Plans for Health Care Establishments", WHO Regional Office for the Eastern Mediterranean. 2002, p09-10

a. Incineration or incineration: It is most commonly used in the case of hazardous medical waste.
b.Chemical disinfection: used to eliminate microorganisms found on medical equipment.
c.Steam sterilization: or wet chemical treatment, the waste is first shredded and then exposed to high-pressure, high-temperature steam
e.Throwing in garbage dumps: It is used when there is no way to treat waste before disposing of it.(Cross, 2011, p. 59)
Also, Separation is an important element in managing health care waste efficiently. By separating hazardous waste from non-hazardous waste one can significantly reduce the volume of waste that requires specialized treatment. Other elements of healthcare waste management include waste classification, waste reduction, containers, color coding, labeling, signs, handling, transport, storage, treatment and final disposal or recycling and use.(United Nations Environment Programme (UNEP), 2020)

2.3 The concept of Environmental safety

Since the environment means the physical surroundings in which humans live, including water, air, space, soil, and living organisms. A person must preserve it in order to live in a healthy and disease-free environment.(Majid Ragheb Al-Helou, 2007, p. 39)

2.3.1 Definition

The natural environment consists of four basic components that are closely related to each other: the atmosphere, the hydrosphere, the lithosphere, and

the biosphere. This group of natural elements always seeks to achieve a state of balance through its constant change. However, human activities greatly influence the rate and quality of this change, positively in some cases and negatively in most cases. The term environmental safety refers to preserving the natural environment with its four elements from the negative impact of human activities, especially with regard to chemical pollution.(OECD's Environment, 2013, p. 28)

2.3.2 Environmental safety rules

The basic standards of environmental safety include a set of laws, regulations and procedures that ensure the continued balance of the environment and its developmental integrity, and ensure the preservation of a sound environment suitable for making good use of natural resources. Since the environment is of a local and global nature at the same time, local environmental laws must be integrated with global environmental laws, which are embodied in international treaties and agreements that pay special attention to addressing major environmental issues of a global nature, such as protecting the ozone layer, protecting the marine environment, and protecting against Transporting hazardous waste, etc.

3. The WHO analysis of medical waste in the context of COVID-19

Recent studies indicate that 1 in 3 healthcare facilities in the world do not have safe medical waste management systems. The Covid-19 pandemic has generated large amounts of medical waste, which has exhausted healthcare facilities and exacerbated environmental damage.

3.1 The volume and risks of healthcare waste caused by Corona virus

The massive amounts of additional medical waste due to the COVID-19 pandemic have increased pressure on medical waste management systems locally and globally. The potential risks of this waste to human health and environmental safety have also led to the need to adopt effective systems in this regard.

The WHO report indicates that nearly 87,000 tons of PPE were purchased from March 2020 to November 2021 through the UN Joint Emergency

Initiative to support urgent COVID-19 response needs in countries. It is expected to end up as waste.

Regarding healthcare waste production during the COVID-19 pandemic, Table 1 shows a potential increase in Healthcare waste volumes in five selected cities in Asia. It is estimated that waste will increase Health care from health care facilities associated with COVID-19 is 3.4 kg/person/day.

Table 1: Healthcare waste volumes due to COVID-19 in five selected cities in Asia

city	Population (review world population	Waste production health care (tons/day before COVID-19)	Waste production health care Estimated additional (tons/day during COVID-19)	Percentage ofincrease due to COVID-19
Manila	14 million	47	280	**496**
Jakarta	10.6 million	35	212	**506**
Bangkok	10.5 million	35	210	**500**
Ha No	8 million	27	160	**493**
Kuala Lumpur	7.7 million	26	154	**492**

Source: (Saiid, 2024, p. 134)

Table1 outlines the main types of healthcare waste related to COVID-19. According to an assessment by the United Nations Development Program(UNDP) of five Asian cities, COVID-19 increased the amount of hazardous healthcare waste by 3.4 kilogram/bed/ day.

This is approximately 10 times more than the average volume of hazardous healthcare waste, which ranges from 0.2 to 0.5 kilogram/ bed/ day. (benchmarking-health-care-waste-management-and-drr-capacities-five-asian-countries, 2024)

Although such calculations are dependent on a number of variables, including how healthcare facilities classify waste, they highlight the large and sudden increases in waste volumes that have occurred in some cities and countries.

Table 2: Main types of COVID-19-related healthcare waste

Item	Type of waste	Requires safe handling and treatment
Mask	Infectious	Yes
Gloves	Infectious	Yes
Gown	Infectious	Yes
SARS-CoV-2 rapid antigen test	Nonhazardous	Most components are recyclable; a very small volume of reagent may require safe handling and disposal if dealing with large numbers of tests.
PCR testing cartridge	Chemical	Yes (contains guanidinium thiocyanate)
Vaccine vial	Nonhazardous	No
Vaccine needle	Sharps	Yes (packaging material is recyclable)
Plastic packing and containers	Nonhazardous	No

Source: (Report, waste volumes and practices associated with covid-19, 2022, p. 18)

Furthermore, public use of PPE globally, especially masks, has increased significantly since the start of the COVID-19 pandemic. One estimate suggests that, based on country mask mandates and public mask use, in 2020, up to 3.4 billion single use masks were discarded each day, resulting in a sizable, additional volume of plastic waste. Most of the mask waste for disposal is plastic, and a sizeable proportion of this waste, especially in low- and middle-income countries with limited waste management systems, ends up polluting terrestrial and aquatic ecosystems.(https://www.sciencedirect.com/science, 2024)

The initial and sudden rise in COVID-19 cases globally in March 2020 led to major PPE shortages and huge price increases (up to 300%). Shortages were especially acute in low- and middle-income countries that lacked manufacturing capacity, partly because of stockpiling by high-income countries. At the same time, early in the pandemic, rates of infection of healthcare workers were 4 times greater than rates for the general public.(Orgnization, 2020)

Thus, the lack of PPE became a life-or-death issue. As a result, UN agencies came together to focus on meeting supply needs. Perhaps understandably, but unfortunately, far less attention and fewer resources were

dedicated to other necessary infection prevention and control requirements, to mitigating climate change and to supporting safe waste management. Furthermore, initial unknowns and misinformation about how COVID-19 was transmitted, virus survival in the environment and potential risks posed by COVID-19-related waste led to unnecessary use and overuse of PPE; this continues today.

In March 2020, seven major UN and global health partners came together to create a common system to respond to requests for PPE for COVID-19 Based on this system and the accompanying database, WHO has calculated the amount of PPE sent to countries to address COVID-19 testing, care and treatment.

The WHO African region has received the largest share (47%), followed by the Eastern Mediterranean (23%), European (10%), South East Asian (6%), Western Pacific (4%) and American (3%) regions. An additional 7% has been distributed to a non-specified region. (Report, 2021, p. 09)Global analysisof healthcare waste in the context of COVID-19, WHO Report 2021, P09.

More than 140 million test units were shipped, with the potential to generate 2,600 tons of non-infectious waste (mainly plastic) and 731,000 liters of chemical waste, while more than 8 billion doses of vaccine were shipped globally, generating 144,000 tons of waste. Extras in the form of safety boxes, needles and syringes. (https://www.who.int/news/item/01-02-2022, 2022)https://www.who.int/news/item/01-02-2022

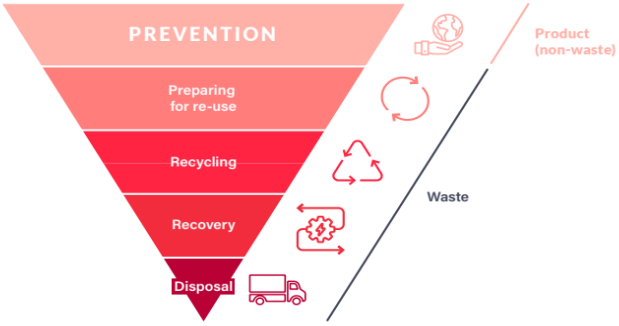
Statistics indicate that 30% of healthcare facilities (60% in least developed countries) are unable to manage current amounts of waste, let alone the additional amount of Covid-19 waste. In addition to the risk of health workers being exposed to needle stick injuries, burns, and disease-causing microorganisms, it also affects communities living near landfills and waste disposal sites that are poorly managed through water and air pollution. (Tonnes of COVID-19 health care waste expose urgent need to improve waste management systems, 2022)

3.2 Innovative solutions for improving environmental sustainability of safe medical waste management

Several practical and scalable solutions exist to safer and more environmentally sustainable management of healthcare waste in the context of COVID-19 and more broadly. These solutions include:

3.2.1Reduction in the amount of unnecessary PPE through safe and rational use, including the application of other infection prevention measures such as hand hygiene;

Figure 3: Waste hierarchy for prioritizing actions to reduce environmental impacts of waste



Source: (Waste Framework Directive, 2024)

The amount of waste generated, through safe and rational use of PPE, is one of the most effective ways to manage and reduce human and environmental impacts. Sending waste to landfill should be a last resort (Fig. 3)

Multimodal approach is a proven way to address glove use and improve hand hygiene providing feedback on use through targeted training and monitoring, role modeling, and providing specific reminders that are appropriate in specific settings.((https://apps.who.int/iris/handle/10665/70030, 2021)

It is important, however, that safety is not compromised and that supplies are planned for and available where glove use and multiple glove changes are needed in a single patient interaction. A 2021WHO document aims to address this. (Europe, 2021)

Similarly, a strategy is necessary to improve the appropriate use of aprons for infection prevention and control.

3.2.2Use of smaller quantities of, and more sustainable, packaging;

Only items that are sterile, such as surgical gloves, should be individually packed. Furthermore, there should be a clear distinction between products sold for public use; those for general, low-risk medical interactions; and those for high-risk medical settings in which packaging as appropriate.

Many high-income countries have had regulations for vaccine packaging in place for more than a decade. These include requirements for more extensive and lower-cost recycling and reuse of packaging components. As with other measures for environmental sustainability, reducing packaging saves significant costs by reducing shipping volumes and weights, as well as handling and disposal of packaging waste. Innovations already in use that can and should be scaled up include

using cornstarch-based foam to replace polystyrene in shipping coolers, reducing secondary packaging so that more vaccine vials and boxes can be included, and reusing cold-chain shipping containers.(Newland S. Sustainability in vaccine packaging. Seattle: Program for Appropriate Technology in health, 2024)

Vaccine stability needs to be improved to allow an increase in the number of doses per vial.

A number of recommendations for reducing packaging and vaccine waste have been under development for several years. Innovation Prioritization Strategy; they are a transformational innovation that has the potential to address many of the barriers to immunization identified by low- and middle-income countries, including waste management.

3.2.3Development and use of safely reusable and easily disinfected PPE (gloves, aprons and masks);

Most high-quality, safe PPE is manufactured for single use. COVID-19-related PPE supply shortages forced both high- and low-income countries to adopt limited reuse of these single-use items. Inherent design elements of single-use items that limit reuse include fit, filtration performance, breathability and contamination. Reuse requires a decontamination process that is safe and standardized, reducing the pathogen burden, while not harming the fit or filtration performance of the PPE, or presenting a residual chemical hazard. In low-resource settings, any decontamination measures need to be simple; most safe decontamination practices currently require complex technology, regular power and water, and skilled operators. More efforts are needed to develop, distribute and use PPE that is designed for safe reuse.

3.2.4 Designing reusable medical and respirator masks for safety and the environment;

Current WHO guidance recommends use of either medical or respirator masks, depending on the type of patient interaction and procedure.

To combat supply shortages early in the pandemic, a number of complicated disinfection approaches were taken to reuse single-use masks

A number of such masks are currently being developed and piloted. For example, a company in Switzerland claims to produce a medical face mask that filters and deactivates bacteria and viruses – includingSARS-CoV-2 – and prevents them from spreading by employing a polycationic surface on the mask. If used daily and washed weekly, the mask can be used210 times, replacing the need for 210 conventional masks.

In the United States found that, if every medical worker used a reusable respirator mask instead of a disposable respirator mask, for all patients encountered during the first 6 months of the pandemic, US$ 4.9 billion would be saved and the waste volume would be reduced from 84 million kilograms to 15 million kilograms. (Jacqueline, 2021, p. 05)

3.2.5Use of PPE made with a greater proportion of renewable, biobased or recyclable materials;

To reduce the environmental impacts of PPE, factors to consider include the type of material, production processes, disposal and recycling. Efforts should be made to replace nonfunctional components of PPE with biobased components while maintaining the intended function of the PPE, including safety, filtration and breathability. Less environmentally harmful alternative materials that also meet infection prevention and control standards are available – for example, nitrile, neoprene and polyurethane examination gloves, rather than those containing polyvinyl chloride (PVC).(Amaral, 2014)

Some manufacturers are using biobased raw materials such as compressed hemp, bagasse, polylactic acid and cellulosic fibers in place of plastic to make medical textiles and masks. (2021, p. 18)International Finance Corporation, nnovation in manufacturing personal protective equipment toward sustainability and circularity 2021, p18.

Incorporating bio based materials into PPE may also lessen the harms from manufacturing and disposal. However, biodegradable materials ideally should be disposed of in separate waste streams to manage methane production; this is often done in high-income countries.

Various strategies to produce PPE that can be recycled are being piloted. Examples are as follows: (2021, p. 23)

a. Compostable face masks: These are being produced in France and in Spain with locally produced hemp fibers. Presenting the first compostable nano fibre mask with FFP2-like filtration capacity–made by Bioinicia and CSIC. Project by Institute of Agro chemistry and Food Technology develops biodegradable antiviral filters for producing protective face masks.

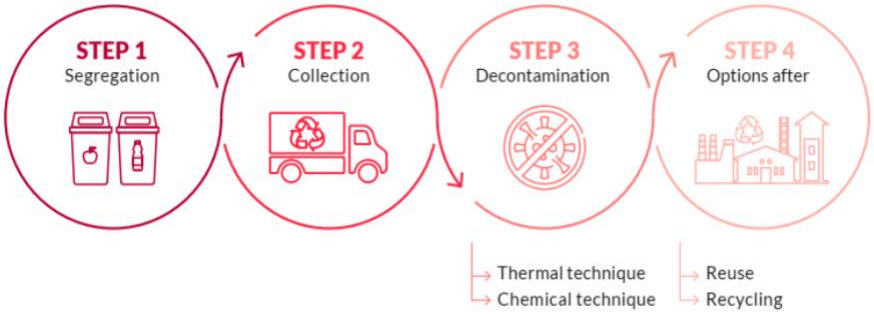
B.Recycling of surgical masks: A company in France collects masks at specific collection points and then stores them for "quarantine" for 4 days. The masks are then ground into small pieces and exposed to ultraviolet light to support decontamination before recycling.

N95 masks can be reused for 3/4times by the same person if stored in paper bags and kept out of reach of other people (Malini R. & Annapurna, April 2021, p. 173)

c.Recycling of used medical masks for repurposing as construction materials: Researchers in Australia found that combining shredded medical masks, which were oven dried for 1 day at 105 °C, with construction materials used for road base and sub-base applications enhances the performance used for enhances the performance of the road material.

The follow Figure illustrates the key steps in managing plastic waste from PPE in line with circular economy principles

Figure 4: Four key steps in managing plastic waste from protection personal equipment



Source: (Corporation I. F., 2021, p. 12)

3.2.6 Implementation of reverse logistics and centralized treatment of waste using non-burn technologies

Reverse logistics uses existing medical supply systems that deliver medical goods (e.g. vaccines, medicines, equipment) to healthcare facilities to

transport healthcare waste to a centralized location where it can be safely treated and disposed of. Modeling of reverse logistics for healthcare waste in the COVID-19 context has been conducted, providing insights on optimizing costs, better tracking waste volumes generated to ensure sufficient capacity for treatment, and developing organizational strategies for collectingCOVID-19 waste from various places (e.g. hospitals, testing centers, quarantine centers), and transporting it to holding and eventual treatment centers.

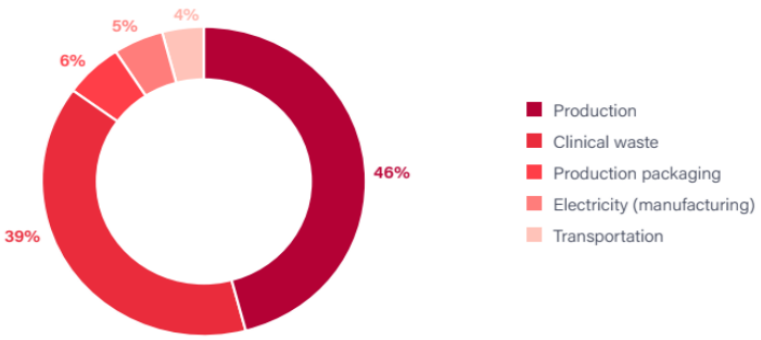
3.2.7Investment in local and regional PPE production, and just-in-time shipments;

In 2020, widespread supply chain disruptions and rising demand (by 280%, from 100 billion units in 2019 to 380 billion units in 2020) deprived a number of the population of high-quality PPE.(Corporation, 2021)

Global platforms for distributing PPE have been critical to filling supply gaps, particularly in low- and middle-income countries. As the pandemic evolves and localized outbreaks become more common, establishing supply centers and portals that are closer to the destination of the PPE may reduce carbon emissions from shipping, and ensure that supplies arrive in a more timely manner to meet near-term needs. Production close to demand can also lead to simpler logistics, and products more appropriate for local settings and needs. More than 60% of global PPE production is in China and the United States– with the exception of gloves, which are mostly made in Malaysia and Thailand (~85%). Procurers should consider offering regional manufacturers preferential access to tenders. The procurement requirements and indicators should consider innovative products that meet the true needs of their users and are environmentally sustainable to effectively compare single-use and multiple-use PPE.(The Global Fund, 2021)

In the United Kingdom during the first six months of the COVID-19 pandemic, the base scenario assumed that all PPE were single use and disposed of clinical waste in high-temperature incinerators for hazardous waste. At that time, about80% of the PPE was shipped from Asia to the United Kingdom. The mean contribution to the overall carbon footprint of PPE items in the United Kingdom was 46% for production, 39% for clinical waste, 6% for production of packaging materials, 5% for electricity used in manufacturing and 4% for transport. (Chantelle, p. 02)

Figure 5: Contribution of different stages of PPE production and use to PPE carbon footprint, United Kingdom



Source: (REPORT, 2021, p. 22)

According to the calculation model, the carbon footprint of PPE could be reduced by 12% through manufacturing PPE in the United Kingdom, saving 12 491 tons of CO2 equivalents over the six-month study period. Reductions occurred due to the ban on foreign travel (2.4%), alongside use of United Kingdom electricity (9.3%) (Which has a higher proportion of renewable sources than most countries of origin assumed in the base scenario). The recent PPE strategy of the United Kingdom Government aims to build a United Kingdom manufacturing base so that there is a resilient domestic supply – with a target of 70% of PPE (excluding gloves) to be manufactured locally.

4. CONCLUSION

4.1 Study Results:

The COVID-19 pandemic has required an unprecedented global response, for which essential supplies, including PPE, diagnostics and vaccines, are critical components. Evidence on the amount of health care waste generated the lack of resourcing to safely manage waste, and the incomplete attention to environmental and climate impacts demonstrate that a more holistic approach is needed.

Although the health sector contribution to COVID-19-related waste is a small proportion compared with the increased volumes generated by the public, it does present an opportunity to direct COVID-19 resources and innovation to sustainably strengthen healthcare waste management, while also putting in place environmentally sustainable policies and practices.

4.2 Study Recommendations:

The World Health Organization has provided clear guidelines for managing medical waste during the pandemic to achieve public health and environmental safety.

Accordingly, this study concluded by presenting the following recommendations:

-The necessity of screening and screening for early detection of infections acquired in the local community and health care facilities and rapid implementation of control measures from the source.

- The need for the World Health Organization to support countries' efforts to modify their strategies regarding Covid-19 to reflect the success achieved and to benefit from national response efforts;

- Preparing emergency plans to combat the virus and determining the costs of these plans with the help of development partners;

- Increase awareness of the dangers of medical waste associated with Corona, especially in developing and poor countries that do not have sufficient experience in medical waste management;

- Strengthen coordination between global donors in health, logistics, infection prevention and control, healthcare waste, and environmental actors;

- Encouraging and investing in more environmentally sustainable personal protective equipment and waste systems;

- Support behavior change away from overuse of PPE, to appropriate use and reusable materials, when possible;

- Investing in the safe management of healthcare waste, as part of broader infection prevention and control, and water, sanitation and hygiene efforts;

- Including waste management in health budgets and investing in recycling;

- Conducting periodic surveys of health care institutions in the field of waste control and tightening administrative penalties against use that is harmful to public health and the environment.

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