Medical waste management during COVID-19 pandemic, a review study

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Abstract. Medical waste management problems are rising due to the crisis brought upon by the coronavirus disease 2019 (COVID-19) as a worldwide pandemic. The security management of medical care worldwide increases their attention due to the high risk of COVID-19 medical waste. This paper gives a review of medical waste management during the COVID-19 pandemic around the world. Furthermore, an effort has been made to prepare a review of the characteristics, generation, collection, transportation, disposal, and treatment technologies of solid waste management worldwide. Detailed data on medical waste management practices, including collection, recovery, and disposal, have been presented. The poor medical waste management in Iraq before and during COVID-19 causes a huge environmental risk and can be a possible reappearing infection source. Hence, the study also points out some recommendations for handling COVID-19 pandemic medical waste properly to reduce possible secondary effects on health and the environment and manage any possible pandemics in the future.

Keywords: COVID-19; medical waste management; treatment; pandemics.

1. Introduction

In the last twenty years, many infectious and fatal diseases, for example; SARS 2003, H1N1 influenza 2009, Ebola virus 2014, and MERS 2014, have not just come about into an enormous number of deaths, yet in addition, brutally influenced the economic development of many countries worldwide [1].

The flare-up of the new COVID-19 has raised tremendous interest around the world. Hence, on the 30th/January/ 2020, the World Health Organization (WHO), announced it as a worldwide wellbeing crisis. On the 11th/February/ 2020, WHO reported a name for the new coronavirus as SARS-CoV-2 and the disease as COVID-19 [2][3] which was first written about the 31st/December/2019 at the Chinese WHO office as an instance of obscure pneumonia from Wuhan, China.

Due to the easy propagation of coronavirus, this made individuals wear face masks as a preparatory case, use gloves and hand sanitizer on a day-by-day premise which produced a huge quantity of medical waste in the environment. As Covid-19 flare-ups and spreads all around the country, there is expanding worry about how to manage waste emerging from infectious patients, staff who take care of them, and medical labs.

Coronavirus started from Wuhan, China in December 2019 and spread to 188 countries in May 2020. World Health Organization (WHO) has reported more than 5 million certain cases worldwide and more than three hundred thousand deaths. Figure (1) shows the rapid increase of the daily confirmed COVID-19 deaths in the world updated 22nd/ Dec. /2020 [4]. The lacking waste management might expand the spread of COVID-19. The rapid increase of confirmed cases of COVID-19 results massive amount of medical waste, for example, around 468.9 tons of medical waste in China daily as reported by the state council...
Office-Peoples Republic of China, 2020). Hence, the world has to fight against the COVID-19 pandemic by handling COVID-19 medical waste systematically, efficiently, and safely.

The objectives of this study are to evaluate; the impacts of medical wastes and the different methods utilized in dealing and managing massive medical wastes produced within the Covid-19 pandemic and to distinguish efficient plans for the management of the rapid increase of medical waste through a short period.

![Figure 1](image-url) the daily confirmed deaths of COVID-19 in the world [4]

2. Classification of Medical Wastes

Medical services offices produce a high amount of solid waste on a per capita basis. Medical waste contents materials that can be infectious during diagnosis, exploration, or treatment. They can be classified into different categories. According to WHO, medical waste is classified into two fundamental types: hazardous and nonhazardous wastes, while, in the US and in some other countries, medical wastes are classified into four main types: General, infectious, Hazardous, and Radioactive waste. A significant number of similar classifications of medical wastes can be used reciprocally relying on the country and region. According to the World Health Organization, medical wastes are categorized into the following:

A large number of similar clinical squanders can be utilized reciprocally, relying upon the country and district. Agreeing to the WHO, medical wastes are characterized into the hazardous and nonhazardous or general wastes. Hazardous wastes are categorized into 7 types as [5]:

1. Contaminating wastes: everything that is infectious and contaminates.
2. Sharps: Wastes like needles, scalpel, broken glass, and razors.
3. Pathological wastes: Human tissues, fluids or body parts.
4. Pharmaceutical wastes: Unused and expired drugs or medicine, like creams, pills, and antibiotics.
5. Genotoxic wastes: Cytotoxic or other hazardous toxic wastes that are carcinogenic, mutagenic, or teratogenic.
6. Radioactive wastes: Waste containing potentially radioactive materials.
7. Chemical wastes: Liquid wastes, typically from machines, batteries, and disinfectants.
8. General or other wastes: All other non-hazardous wastes. About 10 to 15% of medical care waste is considered hazardous and may cause risk to individuals and the environment. In contrast, between 85 to 90% of the medical waste is considered nonhazardous and noninfectious [6].

3. Medical Waste Management

Medical wastes are dangerous as they may contain hidden virus particles within body tissues, such as; things polluted with blood bags, needles, syringes, or any other sharp object, body fluids such as; bandages, cotton swabs, beddings which are contaminated with blood or other body fluids, so on. Therefore, infectious waste is the wastes that may be a reason for human disease and may reasonably be suspected of hosting human pathogenic organisms, or may cause a significant threat or can be hazardous to human health or the environment when inappropriately treated, stored, transported, disposed of or otherwise managed. In the event that medical wastes are not carefully treated or managed by the way of the obligation of rules and legitimate methods, there are probabilities of spreading Covid-19 through the society, which may exceed the edge and average of infections and raise death rates. Specialists in medical wastes assume that medical wastes created within this pandemic must be characterized and dealt with as dangerous and must be managed and arranged independently.

people can be infected with the Covid straightforwardly through pores in the skin or by ingestion and inhalation with objects such as inhalers or ventilating pipes. At the time of this pandemic, infectious waste, for example, contaminated masks, gloves, ventilators, and other defensive hardware, should be disposed of effectively, or it will have inconvenient impacts on people health and the environment. Accordingly, secure dealing with and final removal of wastes can be considered fundamental in viable crisis reaction. In developing countries, masks and gloves form a huge quantity of medical wastes due to inappropriate disposal during the coronavirus pandemic. In the situation of the Covid-19 pandemic, the wastes which are categorized as medical waste depend upon the area or industry the waste is coming from. Thus, no security safety measure is too minor to even think about observing to the furthest reaches in such a manner. As mentioned before, medical waste delivered represents a higher potential for contamination and injury than any other sort of waste.

Consequently, safe handling and managing methods are necessary whenever medical wastes are produced. Therefore, safe management of medical care waste is a critical part of environmental health safety, for sure that when the pandemic expands, the waste produced will increase. Thus, the challenge of treating and managing infectious medical wastes will keep on until the crisis ends [7].

Several researches worldwide concentrated on medical waste management like Jordan [8], Iran, Egypt, Mauritius [9], Turkey [10], Brazil [11], Mongolia, the United States of America [12], the United Kingdom [13], India [14], and Nigeria [15]. Certain guidelines and legislations have been applied in many developed countries for medical waste management systems, which are more efficient than those in several developing countries. In Iraq and many other developing countries such as Iran and India, the medical waste management systems are disqualified and deficient systems [15].

Globally, 168 countries point out medical waste management legislation and regulations, where 57 regarded only medical waste streams, whereas the rest 111 considered numerous waste streams [15].

The study utilized the data collection explanatory method and auxiliary data, which are taken from a general web-sites investigation.

4. Results and discussion

WHO reports that medical care laborers, waste collectors, patients, and the general population are exposed to infections, wounds, and danger caused by medical waste. WHO declares that it is related to the way of
managing medical waste (segregation all medical waste from the genewasterating place, treatment, and removal. Globally about 160 million injections are given to patients yearly. However, not whole contaminated needles and syringes are appropriately deal with afterwards [15][16][17][18][19][20].

The Iraqi Government has initiated some preventive actions in order to reduce the spread of the infection and guarantee to protect Iraqi people against the infection. The preventive actions set up by the Iraqi Government contain lockdown of insignificant activities for certain places of the country and a general ban locally and international flights. Following some attempts to eliminate and step by step facilitate the lockdowns; obligatory wearing face masks in public places, providing sanitizers, temperature check device, keeping up a Physical separation of 2 meters between individuals in working environments and other public places, restriction on social connections in order for lessening the danger of transmission of COVID-19. Limitations in opening Mosques, Churches, and so on, forbiddance of unimportant interstate travel aside from products and enterprises that offers fundamental benefit.

The statistics globally are terrifying, where according to Wordometer, so far coronavirus cases is 62,657,933 worldwide, deaths 1,459,804, and recovered 43,274,638, while total cases in Iraq is 548,821, deaths 12,200, recovered 478,537 [21].

Iraqi doctor association requesting that the government should supply the medical staff with personal protective equipment (PPE). At least 13 doctors have died of COVID-19, and many others have COVID-19 in the network when utilized (PPEs) are not appropriately disposed of as medical waste. The utilization of PPEs is basically for medical staff and certain patients in the emergency room environment.

Proactive actions should be taken to prevent access of waste pickers to its landfills. All buildings should be provided with special collection bags to collect the disposable PPEs and emptied daily by trained people who could get rid of them according to WHO guidelines.

Developing countries are typically not working as per worldwide principles. Thus there have been extra challenges with an expanded measure of possibly contaminated waste which requires extra, cautious taking care of and treatment measures. Global and academic associations have just given rules for polluted waste management. In any case, a considerable lot of those rules address both developed and developing countries, and a couple of rules are arranged explicitly in light of the present situation of coronavirus waste handling in developing countries [22].

The management condition of waste in developing countries is different from that in developed countries. Thus it is hard to employ the same rules. Particularly, developing countries have financial, social, and institutional limitations.

Furthermore, considerable numbers of accessible rules have been stated under normal conditions instead of amidst pandemics. Rules arranged within such situations concentrate on the technological part of waste handling without considering the possible sudden condition of world infection by a pandemic. In developing countries, the generally restricted limit of waste handling is additionally influenced by coronavirus waste that demands extra cautious thought and process. Deficient and improper treatment of medical care waste may have severe public health results and a considerable effect on the environment. The significance of appropriate medical services management has been further considered with the COVID-19 pandemic [22]. Table 1 shows the new risk and challenges during the COVID-19 pandemic in developing countries, and they are defenseless due to the lack of appropriate medical waste management services because of financial, operational, and technical constraints are:
Table 1 - Waste management danger and challenges during COVID-19 pandemic

| Waste produced through medical services facilities |
|---------------------------------------------------|
| 1 Increased measure of produced infectious waste   |
| 2 Stoppage of medical care waste management services |
| 3 Inappropriate treatment in place of medical waste management |
| 4 Interruption of recycling strategy               |
| 5 Inadequate capability for waste handling and removal |

Positively, a realization about possible risk from medical waste services has presently gotten further noticeable, not just the governments, but also clinical specialists and medical waste handlers and inside the common society. Many governments adopt the present laws and guidelines set up by their countries for the polluted medical waste management from hospitals and houses, such as the guidelines stated by Central Pollution Control Board India [23][24][25]. Furthermore, a few governments keep on acquainting new strategies and direction with continuity in taking care of waste within the COVID-19 pandemic, taking into account the extra limit and assets are needed to keep up consistency for legitimate waste handling. Also, governments that do not have their strategies or direction have made moves to apply the worldwide guidelines and direction given by various organizations, such as WHO, UNEP, United Nations Human Settlements Programme (UN-Habitat), the World Bank and other UN organizations, addition to other global associations, for example, Asian Development Bank (ADB) and the International Solid Waste Association (ISWA).

Suitable handling of medical waste needs to be depended on the “3Rs” principles (reducing waste, reusing, and recycling resources) of waste management and consider comprehensive management, beginning from source separation, storage, collection/transport, treatment, and final removal. Generally, medical waste includes around 85% of not infectious waste, 10% of infectious, hazardous waste, and 5% of radioactive and/or chemical waste [26][27][28]. Albeit most governments have put forth a few attempts to improve the circumstance, discoveries from a questionnaire review made by the CCET survey team show they are incapable of conducting even the medical waste that is produced on typical occasions. With these restricted specialized choices and limits, the COVID-19 pandemic and the related expansion in the volume of medical services waste production made extra burdens for the governments. To react to this crisis enough, every government needs to build up an alternate program of action dependent on the regional conditions and needs. The results of the Institute for Global Environmental Strategies (IGES) Center Collaborating with UNEP on Environmental Technologies (CCET) survey team questionnaire is [22]:

1. Source separation methods:
   - Widely used methods: infectious, noninfectious, liquid, sharp, general waste.
   - The second most commonly used method: colour coded bins.
   - Additional methods: Segregate at the origin, utilize of well-marked different containers, utilize duel layered sacks, ensure records of segregated waste, and disinfection of sacks before they are closed.

2. Storage methods:
   - Widely used methods: using the designated storage room.
   - Second, most commonly used methods: Store at least between (2-3) days before collection depending on climate and temperature.
• Additional methods: utilize the cold room, disinfect storage room regularly, close, lock and secure storage room, segregate contaminated waste from other medical care waste in the storage room, store for at least 2 days before collection, and assign devoted sanitation workers.

3. Transport methods:
• Widely used methods: utilizing authorized and immediate delivery contract with waste handling, utilize PPE for transportation workers.
• The second most commonly used method: utilize closed vehicles.
• Additional methods: utilize certain vehicles and supplies for waste transportation, label vehicles and utilize GPS, timely and frequent collection and transportation, disinfect sacks and containers before loading the vehicle, save records of waste transportsinations.

4. Treatment methods:
• Widely used methods: utilize of burning, utilize of certain landfill sites, and utilize autoclaves.
• The second most commonly used methods: chemical or top-level sanitation.
• Additional methods: plasma pyrolysis, auto or dry heat, melting, microwave treatment, cement oven, burning in an open container, deep burial, and open dumpsite.

Figure 2 shows a graphical presentation of the medical waste handling from generation to disinfection to disposal.

![Graphical presentation of medical waste handling](image)

**Figure 2** Graphical presentation of medical waste handling [3]

**Consideration of making emergency plan [29]**
Step 1: Quick evaluation of waste management situation.
Step 2: Improve the emergency policy.
Step 3: Supply the modified waste management service.
Step 4: Check the upright waste management service.
Step 5: Improve the recovery and readiness policy.
Step 6: Resilience development for sustainable Medical care Waste Management (HCWM) and Municipal solid waste management (MSWM).

Table 2 shows that 50% of the world countries have some sort of medical care waste management legislation, but less than 25% have committed medical care waste management. It is worth saying that
medical waste management laws insure more than two third of world inhabitance. Even though this percent looks comparatively high, the rest of a billion of world inhabitance are ‘uncovered’ with medical waste management laws.

The second memorable conclusion is that Europe, which is commonly the part of the world that has the utmost laws concerning particular waste schedules, has to some extent small coverage of specific medical waste management laws.

| Table 2 Worldwide percentage that endorses medical waste management legislation [22] |
|---------------------------------|----------------|----------------|----------------|
|                                | dedicated | general | none            |
| World                           | 24%       | 33%     | 43%             |
| Asia                            | 39%       | 24%     | 37%             |
| Africa                          | 13%       | 50%     | 37%             |
| Northern America                 | 50%       | -----   | 50%             |
| Europe                          | 30%       | 16%     | 56%             |
| Oceania                         | 36%       | -----   | 64%             |

5. Recommendations

In order to improve medical waste management, to avoid the spreading of coronavirus, and to improve readiness for identical situations in the future, the governments should concentrate on and follow the key priority areas stated by IGES [22]:

5.1. Source Separation
- Utilizing twofold sack for possibly contaminated (infectious) waste.
- Segregating contaminated (infectious) waste and leave recyclable things prior to being released.
- Destroying used PPE to keep away from reuse.
- Tight plastic sack just as it is 2/3 full.
- Awareness to keep away from source segregation part, recyclable waste, stop littering and open burning, and so on.
- Providing training for workers in medical care offices.

5.2. Discharge and Collection
- Avoiding opening of waste sacks by waste collectors.
- Using twofold layer, sealed plastic sacks just as they are 2/3 full, and stick a label demonstrating contaminated (infectious) waste.
- Sanitizing plastic sacks.
- Store contaminated waste at the origin and release at determined collecting service.
- Preventing general gathering waste with the contaminated medical waste in the same time or the same wagon.
- Preventing transportation at the time of rush hours.
- Assuring storage area assigned away from patients, people approach, and pests.

5.3. Transportation
- Schedule uncommon collecting duty to collect contaminated (infectious) waste.
- Offering ordinary and expanded waste assortment administrations.
● Possibility of utilizing specific and authorized medical care waste specialist organization.
● Supplying and train utilization of appropriate PPE for waste pickers.
● Straightforward transportation to the handling office or properly approved removal site.
● Sanitizing the assortment of vehicle and leave windows open as possible as can.

5.4. Treatment
● Arranging the handling plan according to the expanded waste quantity.
● Handling contaminated (infectious) waste similar to medical care waste.
● Segregating recyclable materials.
● Sanitize tools and equipment.
● Keeping up social distance and leaving windows open as possible as can, in offices.
● Suitable medical care waste handling processes (for example; autoclave and incineration and avoid burnable technologies)
● Occupational safety and health (OSH) labors in offices.

5.5. Final Disposal
● Treating last removal places (particularly open landfill) to avoid open burning.
● Avoiding waste collecting and giving appropriate PPE and instructions to waste collectors.
● Handling contaminated (infectious) waste similar to medical care waste removal.
● Supply appropriate PPE and information to the workers on location.
● Sanitizing tools and equipment.
● Occupational safety and health (OSH) (formal/informal areas).

6. Conclusions
Actually, coronavirus can survive for about 3 days outside of its host organism on the surface of a surgical mask. Consequently, the waste of coronavirus may spread to the environment if managed improperly. The chemical sanitization utilizing 1% NaOCl solution is the best disinfection solution that can be used in-situ, which can simply spray and not just for COVID-19 waste, yet it is good to disinfect the bigger places too, such as; shopping centers, medical clinic buildings, and isolation centers. Sanitizing PPE and cloths, which can be recycled and reused, with microwave technique can be beneficial. Burning the bigger volume of coronavirus waste is a dependable process.

The techniques like "Recognize, segregate, sterilize, and safe treatment rehearses" have been discovered to be compelling for more secure handling of COVID-19 waste. The on-location management of COVID-19 waste according to the China model to control the spread of coronavirus is appealing, in any case, the restricted limit is a major obstacle were no certain record on discharges. The waste handling processes of Catalonia (Spain) present that the effective management of present resources can be useful to manage the difficulties presented by COVID-19 waste.

Cooperation of people in segregating and proper collecting at the right time of COVID-19 waste alongside a priority removal of the waste amount means the successful management of the produced medical waste. Thus, the mentioned practices will significantly help the prevention and controlling plan of a pandemic of the same occurrence in the future.
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