



A review of the medical waste management system at Covid-19 situation in Bangladesh

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Abstract

Medical waste (MW) poses serious threats to environmental and public health. Throughout the world, existing challenges of medical waste management (MWM) have been heightened in the Covid-19 situation due to an increase in the massive amount of MW. Even before the pandemic, MWM has always been a concern in Bangladesh. The objectives of this research are to review the related national policy initiatives and guidelines in Bangladesh in comparison with the international guidelines, to evaluate the present scenario of the MWM system, and to explore the scope of Impact Assessment (IA) in improving the system. From the analysis, it has been found that several national guidelines have been formulated during this pandemic covering important issues related to the MWM system, which is commendable. Some of these guidelines comply with international guidelines, but there are inconsistencies among these. However, neither the previous MWM policy tools nor these guidelines are implemented accordingly. In this pandemic, an IA framework has also been published in Bangladesh, which is praiseworthy. Although no evidence could be found on its implementation either. Therefore, it is necessary to take initiative for the implementation of this IA framework. Thereby the policy makers will be able to identify the gaps prohibiting the implementation of the MWM policy tools and guidelines. This will enable them to take corrective actions accordingly to improve the MWM system by enhancing the preparedness and capacity against any possible future situations like pandemic overwhelming the MW situation in Bangladesh.

Keywords Medical waste management (MWM) · Health care facilities (HCFs) · Policy initiatives and guidelines · Impact assessment (IA) · Pandemic · Bangladesh

Introduction

Health care facilities (HCFs) are the basic requirement of every civilized society to protect the health of the community, the demand of which is growing around the world with an increased population [1–3]. Activities in the HCFs result in the generation of a huge amount of medical wastes (MW) [1, 2, 4–7]. Moreover, the growth in this sector combined with the increased use of disposable medical products is

resulting in the generation of increased MW [2, 3, 8]. These MWs pose serious threats to environmental and public health, thus create a substantial concern [4, 5, 9–15]. Proper medical waste management (MWM) might not eradicate the complete risk but can minimize the impact on the environment and public health [4, 9, 16, 17]. Therefore, MWM is considered a critical issue throughout the world [5, 11, 18].

Worldwide, studies conducted on MWM mostly include literature review [2, 11, 19], management at HCFs [1, 9, 10, 15–17, 20, 21], and overall management [6, 7, 12, 13, 22–26]. There are also researches on specific aspects of the MWM system, like waste generation [3, 18], and alternative methods for waste treatment and disposal [8]. Potential environmental and health risks associated with MWM in the HCFs were also focused in a study conducted by Bokhoree, Beeharry [5].

The existing challenges of MWM have been magnified in the present Covid-19 pandemic situation leading to an abrupt collapse of the system [27–29]. It has given rise

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to the massive amount of MW especially due to excessive use of plastic products including personal protective equipment (PPE) [28, 30–33]. This infectious disease can spread easily from the pathogen contaminated MWs [28, 30, 31, 34]. The increased waste is also resulting in growing environmental consequences and challenges [28–36]. Therefore, proper MWM is necessary for preventing or reducing the spread of Covid-19 as well as protection of the environment [28–30, 36–38]. Since the MWM system at Covid-19 is not much different than the previous system, it is overwhelmed with the tremendous amount of infectious waste and their shifted composition in this pandemic [28, 39]. Therefore, effective and dynamic responsive changes with additional standard methods are necessary in the MWM system using existing resources and quick solutions [27, 28].

On the other hand, several studies have been carried out realizing the significance of different streams of waste management in the Covid-19 situation. The studies concentrated on the impact of the Covid-19 pandemic on solid waste management [31, 35, 40], municipality waste collection services [41], potential consequences on waste and wastewater services [42], plastic waste management [28, 32] among others. Zand and Heir [33] studied the environmental impacts of the Covid-19 pandemic with emphasis on the waste management sector in Iran. MWM-related studies focused on review on MW handling [30], disinfection and treatment technologies for MW [34, 43]. While, Yu, Sun [36] proposed a methodology to identify locations of temporary facilities and transportation strategies for effective MWM. In addition to these, several international guidelines have been developed on MWM [38, 39, 44]. WHO [45] has also developed a “Health-Care Waste Management Rapid Assessment Tool” which aims at “...*reducing the disease burden caused by poor health care waste management (HCWM) through the promotion of best practices and the development of safety standards...*”.

In the background of the importance of MWM, this research aims to evaluate the MWM system in the Covid-19 situation in Bangladesh, as one of the most densely populated developing countries in the world. The specific objectives of this research are three-fold-

- 1) To review the national policy initiatives and guidelines in Bangladesh addressing the MWM system during the Covid-19 situation in comparison with the international guidelines;
- 2) To review the present scenario of MWM system at Covid-19 situation in Bangladesh;
- 3) To explore the scope of impact assessment (IA) in improving the MWM system at the Covid-19 situation in Bangladesh.

Why MW is a concern in Covid-19 situation in Bangladesh?

Generally, the overall scenario of MW is alarming in Bangladesh due to the increasing number of HCFs generating a huge amount of MW [10]. According to ADB’s hazardous waste inventory of 2008, MW contributes to the second-largest volume of hazardous wastes in the country [46]. Though MWM has always been a great concern in a developing country like Bangladesh, policy measures in this regard are very recent. Country’s first-ever environmental assessment and action plan for the health, nutrition, and population (HNP) sector addressing MWM came to light in 2004, which was later upgraded in 2011 [4]. From 2005, training and awareness for MWM started being developed [4]. The first MWM Rules of Bangladesh was published in 2008 [47]. Some pits for disposal were constructed by 2009 and some Non-Government Organizations (NGOs) developed expertise and came forward for proper MWM [4, 16, 48].

However, appropriate application of the Rules regarding the MWM system is yet to be visible in Bangladesh [16, 48]. Very few HCFs started segregation of waste at source and standardized treatment of waste safeguarding environment [4, 16]. According to Dana [15], authorities and owners of HCFs also lack interest and are not bothered to improve or update their MWM methods as there is a cost involved. Most of them dump their unsegregated and untreated MW in open municipal bins and thereby threatening the environment and human health [4, 16, 48, 49]. More concerning is, that sometimes the waste remains in open bins for 2–3 days [16, 50, 51]. Furthermore, these wastes are handled by poorly educated and unskilled workers with no training and minimum guidance and supervision [52]. They even resale used infectious MW items like a syringe, needle, saline bag, blood bag, test tube, etc. [4, 16]. Apart from open municipal bins, there is also practice of dumping MW in pit near the HCF, open field, roadside, or into water bodies [51]. Some of the HCFs dispose of their untreated liquid chemical wastes into municipal drains [4]. Leaches from these wastes contaminate soil and groundwater through toxicity [15]. At the final stage of disposal, the municipality generally dumps the untreated MW along with the general wastes stream on vacant land or landfills [52]. Thus, mismanagement at each step of MWM in Bangladesh threatens both environment and human health [4, 15, 16, 52]. Along with these, lack of awareness, expertise, logistics (like storage in separate bins, transport facility or even protective gears of cleaners), manpower, and on top of that inadequate implementation of the legal provision hinders proper handling and proper management of MW in Bangladesh [4, 16, 48].

Therefore, even before the Covid-19 situation started, MWM has always been a concern in Bangladesh [53].

In normal condition, MW generation in Bangladesh is estimated around 0.5 kg/patient/day [16, 52]. Whereas, at the Covid-19 situation, this waste generation jumps to 3.4 kg/patient/day [44], which is about 6.8 times higher than normal conditions. In Bangladesh, one Covid-19 patient stays 7–8 days in HCF [54]. As of 5 July 2020, confirmed Covid-19 cases in Bangladesh were 162,417. According to WHO [55] “...Around 1 in every 5 people who are infected with COVID-19 develop difficulty in breathing and require hospital care...”. Accordingly, considering 20% of the total infected needing HCF care, approximately 32,483 (20% of 162,417) patients were admitted to HCFs in Bangladesh till 5 July 2020 since the outbreak. Therefore, since the outbreak, the estimation of cumulative MW at Covid-19 situation in Bangladesh till 5 July 2020 is about 828,316.5 kgs or about 913 tons. Even without considering the infectious waste generated by Covid-19-infected people receiving treatment at home, this amount is overwhelming. These MWs are mostly plastics which are hardly biodegradable and expected to exist longer in the environment if not treated and disposed properly [28, 32]. Failure in proper MWM at Covid-19 situation can even threaten biodiversity and wildlife of Bangladesh [56]. MW generated at this pandemic is expected to have major impact on environment and this alarming impact is yet to be discovered by Bangladesh.

Methodology

This study has been carried out as a qualitative unsystematic descriptive review of national and international policies, legislations and guidelines, and newspaper articles based on Covid-19 MWM collected from secondary sources. For the first objective, different national policies, legislations, and guidelines on MWM in Bangladesh have been collected from the relevant websites of the Ministries in Bangladesh and international guidelines have been collected from the relevant websites of the international organizations. After data collection, a comparative analysis of the national and international policy guidelines has been drawn to understand the extent to which these national policy guidelines address the MWM at Covid-19 situation. For the second objective, relevant newspaper articles have been collected and reviewed to evaluate the MWM system at the Covid-19 scenario in Bangladesh. For the third objective, frameworks for IA regarding MWM in Bangladesh, especially for the Covid-19 situation have been explored and reviewed to understand the scope in this regard.

Policy initiatives and guidelines for Covid-19 MWM in Bangladesh

Leading legal and guideline documents for MWM in general and pandemic situation

For MWM in Bangladesh, the “Medical Waste (Management and Processing) Rules” has been promulgated in 2008 under the Environmental Conservation Act, 1995 [57] by the Ministry of Environment, Forest and Climate Change (MoEFCC). It has been prepared through the active participation of MoEFCC and the Ministry of Health and Family Welfare (MoHFW) with the objective of proper management of MW and thereby protecting the environment. Additionally, DGHS [58] has developed the “Manual for Hospital Waste Management” in 2001 which has been updated in 2010, to manage MW efficiently and economically with a minimal environmental and health impact. This manual is supported by the Rules [47].

In 2018, the “Hospital Infection Prevention and Control Manual” has been developed by the Quality Improvement Secretariat (QIS), Health Economics Unit, Health Services Division, MoHFW, in collaboration with USAID’s MaMoni Health Systems Strengthening Project [59]. The main purpose of this manual is to provide a guideline for HCFs laying down the policies and broad guidelines for infection prevention and control including guidelines for MWM referring to the Rules [47].

In 2019, the “National Strategy for WASH in HCFs 2019–2023: A Framework for Action” has been published by the Directorate General of Health Services (DGHS), MoHFW, funded by UNICEF [60]. This strategy is intended to improve the MWM system at all levels. The actions intended for this strategy included an update of the existing MWM system following WHO standards, develop a training curriculum for HCF regarding new guidelines, etc.

Management of MW and Covid-19 infectious wastes in HCF are similar, but additional provisions are required due to the amount of waste being generated at the Covid-19 situation [39]. Considering the importance, several guidelines and frameworks have been formulated to address the Covid-19 situation in Bangladesh, with some focusing on MW. Most of these documents have been imposed in March 2020. These documents are:

- The “Guideline or Standard Operating Procedure (SOP) for Coronavirus (Covid-19) Related Waste Management in Hospital” formulated by the DGHS and the National Institute of Preventive and Social Medicine (NIPSOM) [61]. The first volume was published in March 2020. It applies to all HCFs those deal with

Covid-19-related waste. The purpose is to provide guidance on MWM against coronavirus; and to save the health of the employee, visitor, and environment from the risk of produced waste for maintaining a safe, healthy, and productive working environment.

- The “National Guideline for Health Care Provider on Infection Prevention and Control of Covid-19 pandemic in Healthcare Setting” has been formulated by the DGHS [37] and published in March 2020. According to the guideline, health care personnel for Covid-19 patients are at high risk of getting the infection. Therefore, precaution and prevention can be done by decontamination, management, and disposal of MW.
- The “Guideline or Standard Operating Procedure (SOP) for Coronavirus (Covid-19) Disinfection and Environmental Infection Prevention” formulated by the DGHS; the Institute of Epidemiology, Disease Control and Research (IEDCR); and the World Health Organization (WHO) [62]. The first volume was published in March 2020 with the purpose to guide environmental cleanliness and disinfection to prevent Covid-19 spread, and to maintain a safe, clean, and healthy environment to ensure the safety of service providers, patients, and inspectors. Despite such focus, this document does not contain any guidelines for MW in HCF.
- The “General Notice” was published by the department of environment (DoE), under the Environmental Conservation Act, 1995 [57] to control environmental pollution and prevention of the spread of coronavirus [63]. This document further refers to the Rules [47] for MWM.

Except for these documents, the importance of the MWM issue for the Covid-19 situation has been addressed in some other guidelines. They are:

- The “Rational Use of Personal Protective Equipment (PPE) for Covid-19” has been imposed by the DGHS, IEDCR, UNICEF, and the WHO in March 2020 [64]. According to the document, all medical workers including cleaners in all areas should wear PPE appropriately. This document referred to the guideline for Coronavirus (Covid-19)-related HCFs Waste management [61].
- The “National Guidelines on Clinical Management of Coronavirus Disease 2019 (COVID-19)” by the DGHS; and the WHO [65]. The seventh version of this document has been published in May 2020. According to the guideline, an effective infection control program requires an MWM, among others.

It can be said that the key legislative document on MWM of Bangladesh is, the Medical Waste (Management and Processing) Rules 2008 [47]. It is praiseworthy that several guidelines and frameworks have been formulated to address

the Covid-19 situation in Bangladesh, with some focusing on MW. But these documents are not legally imposing leaving a wide scope of avoidance.

Designated authority

According to the Rules [47], the designated authority for MWM in Bangladesh consists of the director of the health department, a member from the divisional commissioner’s office, and a representative from DoE. For the management and processing of MW, third parties need a license. But the Rules are not applicable in case of MWM by City Corporation or Municipality. Whereas the MoHFW is responsible for in-house MWM at the large scale, and out-house MWM is the responsibility of the Ministry of Local Government and Rural Development (MoLGRD) including City Corporation or Municipality or can be contracted out through NGOs [4, 60, 63, 66]. In Dhaka, Bogra, and Khulna districts in Bangladesh, the out-house MWM is operated by NGOs with limited coverage in cities [4]. Thus, the Rules are not imposed on local responsible authorities resulting in a gap in the management process [4]. Moreover, it does not specifically designate a responsible authority for MWM at individual HCFs. But, this issue has been addressed in Hospital Infection Prevention and Control Manual” by QIS [59]. In this Manual, it is instructed to develop Hospital Infection Prevention and Control Subcommittee (HIPSCS) and Work Improvement Team in each HCFs including structure, role, and responsibilities of the committee and team.

While conflict of designated authority and responsibility is questionable in the existing MWM policies, responsible handling of Covid-19 MWM is also real concern in Bangladesh. To manage Covid-19 MW safely, responsibility and adequate resources should be assigned at HCFs [38]. This issue also received importance in the guidelines published in the Covid-19 situation. According to those, the nominated person from the relevant department would be liable to abide by the whole process at every HCF [61]. There should be designated trained staff or management officers for MWM [63]. The nominated waste cleaner is responsible for the maintenance of the MW logbook in prescribe format to observe the management process [61].

According to WHO and UNICEF [38], all the people handling MW should wear appropriate PPE and perform hand hygiene after removing it, which has also been suggested by DGHS, IEDCR [64] in Bangladesh. The local government should provide a Covid-19-labeled two-layer color-coded sustainable bag and bin for MW collection [63].

Despite such progressive documents, the problem of coordination among responsible authorities at different scales for MWM remains unaddressed, which poses great difficulties, especially in the Covid-19 situation.

MWM system at Covid-19 situation according to the leading documents

Considering the infectious characteristics of the Covid-19 waste and its huge volume, the Covid-19 MWM becomes overwhelming and requires special attention [38, 39, 44]. Therefore, the capacity to manage the waste should also be increased at every step [38]. In the following sections, the MWM system focusing on the Covid-19 situation as per the policy guidelines in Bangladesh has been discussed and compared with international standards.

On-site separation and management

In the Covid-19 situation, waste separation at the source is of utmost importance to avoid multiple times handling of infected MW considering the risk [38, 39, 44]. Comparison among the national legislation and guidelines for MW separation at source is shown in Table 1. From the comparison, it can be observed that the classification as per the 2008 Rules is clearer and elaborate. The Rules [47] also state that MW should never be mixed with other wastes at any stage of management. The inclusion of such guidelines is commendable, but more consistency is necessary in this regard. Additional waste generated from PPE in the Covid-19 situation requires special attention [38]. DGHS and NIPSOM [61] and DGHS [37] provide directives regarding the disposal of PPE. According to the guidelines, PPE should be disposed of in a biohazard bag or color-coded bin, securely sealed, and labeled marking with the date, and disposing of after 72 h as normal. The disinfection of the reusable waste bins and transport carts is also important in the Covid-19 situation. This issue has been addressed by DGHS and NIPSOM [61], and DoE [63] stating that the reusable waste bins and transport carts should be covered and can be reused after disinfection routinely.

On-site disinfection, treatment, and disposal

Considering the huge amount of waste generated at the HCFs at Covid-19 situation, on-site management including treatment and disposal has been preferred in the international guidelines [38, 39, 44]. According to these guidelines, the Covid-19 MW can be either treated and disposed of on-site or transported offsite for disposal after treatment at the source. Thus, onsite treatment of the waste is necessary. Then the treated waste can be disposed of on-site or offsite. Considering the amount of waste generated, it is important to increase the capacity of the HCFs to handle and treat their MW [38]. Various alternative MW treatment and disposal methods may need to be produced

at HCF considering their capacity. Alongside, systems should be developed to ensure their sustained operation [38]. These methods should minimize the formation and release of chemicals or hazardous emissions, while open burning is discouraged due to the polluting emissions [39].

On the contrary, the MWM Rules [47] do not mention anything about disinfection, treatment, and disposal on site. It guides to treat MW centrally, where the MW are classified into eleven categories and thus corresponding methods for refining and disposing the waste are described accordingly. Despite the importance of considering the infectiousness of Covid-19 medical waste, the DoE [63] (Covid-19 MWM-related notification) complied with the 2008 Rule regarding offsite treatment. For the pandemic, DGHS and NIPSOM [61] have included a flow chart of MWM (Fig. 1) in their document which does not reflect the actual process at all, this is misleading. Therefore, these guidelines inconsistent with the international guidelines.

On the other hand, some other guidelines address on-site MW treatment and disposal. According to DGHS [37] and DoE [63], after tying up the waste bag, it should be disinfected keeping the bag sealed, and should be preserved in a covered bin labeled as Covid-19. This guideline is consistent with ADB [44]. DGHS and NIPSOM [61]; DGHS [37] and DoE [63] suggest decontaminating the infected waste by autoclave or chemical prohibiting reuse. DGHS and NIPSOM [61] and DGHS [37] adds to it that after disinfection, the waste should be incinerated (ideal) or burnt (if incineration is not available) in pits (> 8 feet deep) in premises, behind the HCF building. Though there remains some inconsistency, both guidelines propose the MW should be treated and burnt on site or should be sent to a sanitary landfill. The provision of burning contradicts with UNEP [39] considering the environmental concern. Though, many options for waste treatment and disposal on site have been included in the guidelines, the issue about capacity building of the HCFs has not been included in any of the national guidelines.

In addition to the solid MW, the wastewater generated in HCFs are highly polluted and infectious. For treating this heavy polluting wastewater from the HCFs, inclusion and operation of Effluent Treatment Plant (ETP) in the facilities is necessary to ensure the safety of the discharged wastewater. Considering this context, according to the Environmental Conservation Rules (ECR) 1997 of Bangladesh [67], HCFs are considered under red category polluting projects, for which inclusion of ETP within their plan is mandatory. In the MWM Rules and guidelines, different treatment options for wastewater have been mentioned, but none of them addressed the inclusion of on-site ETPs in the HCFs, though it is mandatory as per ECR, 1997. This also reflect the inconsistency among the Rules and guidelines.

Table 1 Comparison of the national legislation and guidelines for on-site MW separation

Colour code	Medical waste (Management and Processing) Rules, 2008 [47]			National guideline for health care provider on infection prevention and control of Covid-19 pandemic in health-care setting, 2020 [37]			Guideline or standard operating procedure (SOP) for coronavirus (Covid-19) related waste management in hospital, 2020 [61]		
	Waste category	Type of waste	Type of Bin	Waste category	Type of waste	Type of Bin	Waste category	Type of waste	Type of Bin
Black	General	Non-harmful, non-infectious, germfree	Perforated plastic bin	–	General: Leftover meals, administrative rubbish, and paper, sweeping	Two-layered biohazard bag or waste bag in the perforated bin.	–	–	–
Yellow	Harmful	Anatomical, pathological, infectious	Perforated plastic bin	–	Clinical lab waste without a sharp object: Materials used in lab /patient care	When a two-thirds portion of the bag would be filled up, it should be tied up appropriately and kept in a separate covered coloured labeled perforated bin	–	–	–
Red	Sharp	Infected, non-infected, bacterial, disinfected	Perforated thick plastic bin, box	–	Clinical waste with a sharp object: Needles or scalpel blades, knives broken glass material, etc.	Contaminated sharp waste	–	Contaminated sharp waste	Two-layered biohazard bag or waste bag in the perforated bin. When a three-fourth portion of the bag would be filled up, it should be tied up appropriately and kept in a separate covered coloured labeled perforated bin
Blue	Liquid	Harmful, non-harmful, infected, non-infected, bacterial, disinfected, chemical	Perforated plastic bowl, bin	–	Liquid: Vomiting, blood	–	–	Liquid waste	–
Silver	Radioactive	Radioactive	Perforated lid box	–	–	–	–	–	–
Green	Reusable	Non-harmful, non-infected, non-infected	Perforated plastic bin	–	Recyclable: Saline kits	–	–	–	–

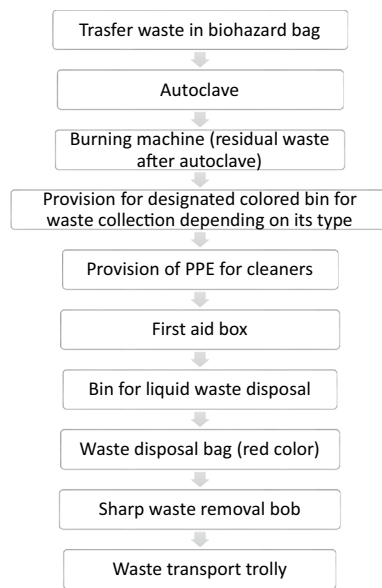


Fig. 1 Process of MWM at HCFs as per the “Guideline or Standard Operating Procedure (SOP) for Coronavirus (Covid-19) Related Waste Management in Hospital” Source: [61], (p.1)

Storage and transportation

According to UNEP [39], considering the overwhelming amount of MW generated during the Covid-19 situation, there should have a designated storage location inside each HCFs to accumulate the Covid-19 waste at the source. This issue has not been addressed in any of the national guidelines.

According to the DoE [47], the MW without being disinfected should not be preserved at HCFs for more than 48 h, which is consistent with UNEP [39]. But if it is necessary to preserve for more than 48 h, then the licensed third party should take permission from the corresponding local government to ensure that the waste would not have any negative effect on human health and the environment.

According to both DoE [47], DoE [63] the MW should be collected and transported from the outside of HCFs only by approved vehicle, by an approved person at time and procedure defined by the local government. Which comply with the international guidelines [39, 44]. But according to ADB [44], additional special vehicles should be used for transporting the Covid-19 MW considering the amount, where the loading area should be separated from the driver’s cabin. While collecting and transporting, the wastes should be kept separated and sealed [39].

Disposal

According to both the Rules and Covid-19 guidelines in Bangladesh, the treated waste should be transported and

disposed of in a designated sanitary landfill [37, 47, 61, 63], which is consistent with international guidelines. According to UNEP [39], the Covid-19 MW should never be disposed of at open dumpsites at any point to prevent harmful consequences on human health and the environment. This issue has not been addressed in any of the guidelines in Bangladesh.

Table 2 shows a comparative analysis of national legislation and guidelines in Bangladesh with international guidelines for the MWM system at the Covid-19 situation. From the analysis, it can be said that the Rules for MWM is required to be amended to incorporate the Rules to enhance preparedness and capacity for accommodating with overwhelmed MW condition resulted due any possible future situations like pandemic. Such amendment is intended to be done as per the MoHFW [60]. But for immediate MWM at the Covid-19 situation, the published guidelines in Bangladesh are timely and appropriate. Despite this fact, all these guidelines need to be synchronized increase uniformity and elaboration. Especially, the guidelines for MW disinfection, treatment, and disposal at source would require rigorous revision and for MW collection and transportation would require more inclusion and detailing. All such revisions should be done complying with international standards considering human health and the environment.

Scenario of MWM at Covid-19 situation in Bangladesh

Most of the HCFs do not get enough support from the local government waste management [68]. Several private and public HCFs mostly in Dhaka city have often claimed to follow proper methods to manage the MW [69, 70]. But according to existing literature, most of the HCFs dump MW at random places, mix up with general waste, and pile up openly outside the facility even at this pandemic [70–73].

In case of the collection of MW by waste collectors or NGOs from the HCFs, it is done in open vans, open drums, or garbage trucks, and also the vehicles used for transporting the waste are not managed properly [72–74]. MW is frequently found in municipal bins [74]. The openly piled wastes are then picked up by waste scavengers [73]. This is increasing the risk on the environment and the health of waste handlers as they do not use proper protective gears [71, 72, 75]. Considering the risk, MW workers reportedly left their jobs or are unwilling to collect resulting in a significant reduction in the number of waste handlers in Bangladesh [56, 74].

In some HCFs, the NGOs working with MWM collect wastes treat, and dump the residue [56, 74]. If this waste gets mixed with municipal wastes, it would not be in their scope to handle it [56]. On the other hand, increased demand for

Table 2 Comparison of national legislation and guidelines in Bangladesh with international guidelines for MWM system at Covid-19 situation

Covid-19 MWM system	International guidelines of ADB, UNEP, and WHO	Bangladesh legislation and guidelines	Special features	Remarks
Responsible authority				
At HCF	Yes	Yes	All staffs should be trained All the people handling MW should wear appropriate PPE and perform hand hygiene after removing it	
At local level	Yes	Yes	Local authorities should provide color-coded double-layered bag and bin to HCF	Inclusion of local authorities missing
General				
Should never be mixed with other wastes at any stage	Yes	Yes		
Cleaners and waste handlers should wear PPE	Yes	Yes		Not included in all guidelines
Source separation and management				
Minimize waste generation	Yes	No		
Coloured perforated bins	Yes	Yes	Colour code as per the waste type	Not included in all guidelines
Leak proof coloured double-layered waste bags	Yes	Yes	Waste bags should be tied up and sealed appropriately after filled up	Not included in all guidelines Inconsistency in the standard for filling up a waste bag
Guideline about PPE	Yes	Yes	PPE disinfection and separation	
Management of reusable waste bin	No	Yes	Should be disinfected before reuse	Commendable consideration
Disinfection, treatment, and disposal at source				
Alternative options	Yes	Yes	Suitable option considering the condition of the HCF	Inconsistent among the guidelines Inconsistent with international standard Lacks detailing
Capacity building of HCF	Yes	No		
Burning	No	Yes		Not suitable for human health and the environment
Send untreated waste in a sanitary landfill	No	Yes		Not suitable for Covid-19 situation
Storage and transport				
Storage on-site	Yes	No		
Storage time	Yes	Yes		
Designated time and procedure	Yes	Yes	Should be collected and transported at designated time and procedure	Lacks detailing regarding the procedure
Approved vehicle	Yes	Yes		Additional special vehicles with loading space separated from the driver's cabin are not considered
Keeping the waste separated while transporting	Yes	No		
Disposal				
Designated sanitary landfill	Yes	Yes		
Prohibition of dumping in open dumpsites at any point	Yes	No		

surgical masks and gloves and open dumping of such MW have also resulted in the washing and reselling of used masks and hand gloves [69, 73, 76].

It is evident that, HCFs are not equipped to treat and manage the highly contagious MW generated from the Covid-19 treatment [74]. Only a few have an on-site treatment system [73]. They mostly have a backyard and are putting their waste into a ditch or burning in a pit, while measures for environmental protection remain questionable [68, 70, 73, 74]. Though, on site ETP is mandatory for HCF in Bangladesh, it has not been included in any of the plans of the government HCFs, whereas only 5–6% of the private HCFs have ETP [77]. Thus, the operational capacity of many of these facilities is also questionable [73]. For central treatment of MW, there is only one incinerator in Dhaka which is not sufficient even in normal conditions [70, 78]. Thus, most of the MW remain untreated. Treated or untreated, these wastes are dumped in landfills. Alarming, the landfills also do not have sufficient capacity [79].

A legal notice has been served in early June 2020 to the Government to take necessary measures for MWM amidst the Covid-19 pandemic [80]. On 22 June 2020, Dhaka North and South City Corporations mentioned starting the process in collaboration with the concerned NGO, however, till mid-July, there was no visible progress in this [75]. Other municipalities were unable to develop Covid-19 WM mechanisms [75].

Thus, reflection and application of the policy guidelines cannot be observed at any step of the MWM system in the Covid-19 situation in Bangladesh.

Scope for IA in improving MWM system at Covid-19 situation in Bangladesh

From the analysis of national policy initiatives, guidelines, and scenario of MWM system at Covid-19 situation in Bangladesh, it can be observed that in documentation this issue has so far been addressed accordingly though, there remains some inconsistency. But the reflection of even these documents was not evident in practice. Therefore, it is necessary to analyze the gap and its impacts through IA.

In Bangladesh, Environmental Impact Assessment (EIA) is mandatory as per ECR 1997, for red category polluting projects including HCFs, waste incinerators, and landfills, among the others [67]. In 2011, the “Environmental Assessment and Action Plan: For the Health, Population and Nutrition Sector Development Program (HPNSDP) 2011–2016” was formulated by the MoHFW [4]. The objectives of this plan included evaluating the then status of MW disposal and formulation of an action plan for management based on identified gaps. Suggested action plans incorporated building awareness and capacity,

developing guidelines and manuals, budget and investment, private sector participation, and ensure the active role of authority. Thus, IA in the MWM sector in Bangladesh is not a brand-new concept. Despite these facts, its application is not satisfactory yet [81].

In this pandemic, another praiseworthy initiative by Bangladesh was the formulation of “Environment and social management framework for Bangladesh (ESMF): Covid-19 emergency response and pandemic preparedness project” by the DGHS published in May 2020 [66]. The framework lists sub-projects like construction, expansion, rehabilitation, and operation of HCFs as a response to Covid-19 pandemic; outlines purpose as providing tools and guidelines for environmental and social (ES) risk categorization, identifying risks, benefit, and impacts of project to minimize risk and enhance benefits; procedures to assess ES risks, and proposing mitigation measures at design and implementation level. The ESMF proposed two templates among others relevant to MWM concern in Covid-19. One identifies potential environmental, social, health, and safety issues associated with the construction and operation of HCFs; and Infection Control and Waste Management Plan (ICWMP) focuses on infection control and MWM practices in HCFs during the operation. Mitigation measures proposed to reduce ES risks in HCFs identified in this framework are:

- Waste generation at HCFs should be minimized as much as possible without compromising health and hygiene, which complies with international guidelines. For example, reusable PPE should be encouraged as much as possible [82]. In this regard, HCFs should dedicate larger areas for temporary storage and disinfection of such reusable PPE on large scale. The inclusion of ETP at HCFs can help treat the wastewater produced from such disinfection along with the mainstream wastewater treatment. From a technical perspective, this measure is undoubtedly unavoidable and proper training to the HCF personnel can effectively reduce the waste generation [18, 83, 84]. However, the increased use and nature of disposable medical products make it difficult to reduce the waste generation in HCFs [2, 3, 8]. Therefore, researchers and manufactures may need to further research and work on reusable medical equipment as well as its scope to enable the HCFs to minimize waste generation and thus contribute to sustainability.
- The initiatives required ensuring proper MW separation at HCFs for new development or up-gradation of the existing facility includes estimating potential waste; ensuring color-coded storage bins to be able to accommodate anticipated volume according to the type of waste, designing training for the healthcare providers to assist source separation of waste.

- Waste minimization, reuse, and recycling using incinerator poses an environmental and social risk and thus should be avoided as much as possible. If it is the only option, then best practices should be implied to ensure safe use and shifting to alternative treatment at the earliest possible time. On this regard, onsite waste treatment and disposal capacity and technical appraisal of the existing facilities should be performed, and corrective measures should be taken if required.
- Timely onsite collection and transport of packaged and labeled wastes in HCFs should be adopted using designated trolleys/carts and routes ensuring routine disinfection of pertaining tools and spaces. HCFs should also ensure hygiene and safety of involved supporting medical workers such as cleaners.
- Waste storage areas should be designated in HCFs separately according to the type of waste and should be disinfected regularly and properly.
- Infectious waste generated in the Covid-19 situation should be removed from the storage area within 24 h of generation- this statement in ESMF contradicts national as well as international guidelines about storage.
- Disposal of residual MW from HCFs at offsite waste disposal facilities provided by local government or private sector should ensure appraisal of the facility and corrective measures as required. Technical adequacy, process capacity, performance record, and operator's capacity of these sites should be examined, and in case of any gaps, corrective measures should be recommended and agreed upon with the government or the private sector operators.
- Emergency Response Plan (ERP) should be developed at the HCFs to adequately address the emergency risk levels.
- To prevent possible exposure, capacity building and training should involve all local players including medical workers, waste management workers, cleaners, as well as third-party waste management service providers.
- To ensure proper monitoring of Covid-19 MW, an information management system should be developed at HCFs for tracking and recording the waste streams at different stages of the MWM system.

This framework might serve the purpose of Rapid Environmental Assessment (REA) of the HCFs in this pandemic. The major stages for REA here would have been collecting the baseline information, impacts identification and assessment, and designing mitigation measures. Though DGHS did not use the term REA, ESMF seems to cover the basic components through the templates. Therefore, the detailing in this document might be sufficient for now to address the primary concerns considering the urgency of the matter. However, to date, authors have not

been able to find any documentation or information on such assessment being done for the HCFs. The issues in the framework comply with the international guidelines for MWM at this pandemic to some extent, but again, these measures are not enforced by law. While the urgency of upgrading the MWM system in a pandemic is unavoidable, assessing and mitigating the impacts of these are still a great challenge for Bangladesh in this situation.

So, despite being positive, IA based on this framework and corresponding mitigation measures may fail to serve the goals if inconsistency keep existing among the documents and no enforcement plan is considered.

Way forward

The ongoing Covid-19 pandemic is not the first in the history of pandemics and surely will not be the last. From the experience of Covid-19 we have learned that the appearance of a pandemic puts extra pressure on the MWM system, therefore needs the extra capacity of the system to absorb. Based on the above discussion, the following initiatives should be taken to improve the MWM system in Bangladesh and to ensure preparedness and adaptability of the system with changing circumstances resulted due to pandemic situations or other likely events in the future.

The legal documents for MWM, especially the Medical Waste (Management and Processing) Rules should be amended to integrate the missing links and to incorporate some of the guidelines to absorb the thrust of the overwhelmed MW condition resulting from pandemic like situations. While doing so, consistency among all the documents and compliance with international standards should be ensured. Coordination among responsible authorities at different scales for MWM is of prime importance for a successful implementation. Considering the limited public capacity, a strong, stable, and knowledgeable private sector is required to be developed to meet the additional demand of MWM attaining quality and quantity in pandemic situations. Proper enforcement and implementation of the legal documents should be ensured. Existing Environmental court should be utilized in such case. In addition to this, integrated inspection and monitoring system should be developed. Initiatives should be taken for IA at HCFs as per the ESMF [66] to implement the mitigation measures accordingly and thereby enhance their capacity for the MWM as per the legislation to make them prepared for any overwhelmed situation. Provision for need-based financial assistance should be considered by the Government for capacity building of different stakeholders involved in MWM in Bangladesh.

Conclusion

This research brings out the important concerns on emerging challenges in MWM due to the Covid-19 pandemic in Bangladesh, as one of the densely populated developing countries in the world. The key legislative document on MWM of Bangladesh is the Medical Waste (Management and Processing) Rules, 2008. Due to the poor implementation of legislation and policy guidelines, the MWM has always been a concern even before the pandemic. During the Covid-19 pandemic, the situation became overwhelmed and worse. However, this legal document still does not address the process for accommodating the emergencies like pandemics and resultant tremendous load of MW. To immediately tackle the MWM situation during the Covid-19 pandemic, several national guidelines have been published in Bangladesh which is timely and appropriate. Thus, the Covid-19 pandemic has raised the urgency from Government's side. Nevertheless, these are not legally imposing. It is also dubious how much of the dedicated measures could be enforced in the lockdown with limited resources. The problem of coordination among responsible authorities at different scales for MWM remains unaddressed, which poses great difficulties, especially in the Covid-19 situation. These documents also need to be synchronized to increase uniformity and elaboration complying with international standards considering human health and the environment. On top of that, reluctance from HCFs owners, lack of knowledge of the caregivers, and general people will only worsen the situation. Therefore, no matter how many guidelines have been formulated, if not legally mandated, it will be difficult to protect the environment and human health from the impacts of mismanagement of MW generated in this pandemic. The newly formulated ESMF framework addresses this concern. However, there is no evidence of its implementation. In this scenario, only carrying out a rapid IA to analyze the gap is not enough but the implementation of the mitigation measures accordingly is of prime importance. This research will guide the policymakers to understand the gap in the MWM system in Bangladesh and thereby take necessary actions to improve the condition by addressing the gaps accordingly. Other developing countries with similar MWM condition may also realize the importance of preparedness and development of the adaptive capacity to accommodate future situations like the Covid-19 pandemic. As future scope of this study, research based on primary data collected from the HCFs and WM sites would aid in better understanding of the scenario on the implementation and bring out a comprehensive picture of compliance through comparison with the documents formulated.

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