

COVID 19 Pandemic and biomedical waste management practices in healthcare system

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ABSTRACT

The whole world was shaken with the pandemic of Coronavirus Disease (COVID-19) in end of the year 2019. Due to its novel origin, it was required to follow all precautions possible. Dealing with the massive amount of infectious healthcare waste became an enormous challenge. This review identifies the impacts of the pandemic on biomedical waste management. This systematic review was made by using keywords “biomedical waste” and “COVID 19” in open access databases like PubMed, Science Direct, Scopus, Google Scholers etc. 2124 articles downloaded and 765 found duplicate and 634 not related to the topic. after scrutiny with inclusion criteria 102 articles were considered to analyze the practices related to biomedical waste management during pandemic using PRISMA guideline.. The COVID-19 waste segregation, collection, storage, transportation, and disposal are a big challenge with all stakeholders. In order to control the virus spread, strict monitoring of the complete waste management cycle is required. Adoption of appropriate guidelines is paramount to worker safety and containment of infection. Sustainable recycling methods are needed to deal with the ever-increasing plastic waste resulting from mandatory personal protective equipment (PPE) usage. The situation also demands a rethinking of the healthcare system. Overall, there was an increase in BMW generation, and municipal waste had increased globally. Pandemic preparedness requires a global public health strategy and long-term investments. This will be vital for making a robust community capable enough to fight against any public health pressures in the future, as well as the pandemic tremors. Systematized efforts from all stakeholders, at all levels, not only refines epidemic preparation but also helps to attain a sustainable development of health for a healthier future.

Keywords: Bio Medical waste management, COVID-19, healthcare system, pandemic, rethinking

Introduction

The Coronavirus Disease (COVID-19) pandemic progressed rapidly throughout China and it revealed the shortfalls in BMW management capacity.^[1] In the last two decades, COVID-19 pandemic is the third major zoonotic coronavirus outbreak after severe acute respiratory syndrome (SARS) in 2002–2003 and the Middle East respiratory syndrome in 2012.^[2,3] Knowledge about the survival period of the virus on different substrates vary

from few hours to a day, and this longer period leads to a high menace of public spread.^[4-12] Improper management of waste and persons handling contaminated waste can unintentionally spread the virus in the community.^[13-16] However, WHO and The Solid Waste Association of North America state that there is no direct evidence that handling of biomedical waste (BMW) can lead to transmission of COVID-19 virus.^[17,18] The demand for PPE is increasing, which indirectly leads to increase in waste generation globally.^[19] The pandemic has altered the dynamics of both hospital and nonhospital waste from generation to treatment^[20-22] including primary care providers and family physicians. Lockdown and infection control measures have increased the use of plastics leading to massive increase in waste generation and this situation is further aggravated due to limited manpower to handle waste.^[23-25] Waste generation has increased

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up to 300% in UK rural communities.^[26,27] The whole spectrum from waste generation to treatment should be reevaluated to reduce the socioeconomic and environmental impacts of waste and help to achieve sustainable communities.^[28] Although the pandemic of COVID-19 had a negative impact globally, yet improvement of water and air quality are a silver lining.^[29] Almost every country has some rules and regulations to deal with BMW from segregation to collection to transport to final disposal methods including the use of proper signages. The BMW management rules apply to every physician or occupier be it tertiary care or primary care even camp services. This systemic review is aimed to find out the broad impacts of the pandemic on the management of hospital (biomedical) waste and the need to rethink the overall waste management system as well as the healthcare delivery system.

Methodology

A through search was done on BMW and COVID-19 in Open Access Databases and Google Scholar in April 2021, which helps to define the scope of the review, to formulate the research questions, and to frame inclusion criteria. Subsequently, PubMed, Google Scholar, Scopus, Science Direct like peer-reviewed literature sources were selected for this review. Numerous publications were available as articles, review articles on the keywords “biomedical waste” and “COVID-19”. Articles were primarily screened based on their title and Abstracts were used to decide their relevance to the topic of the study and to satisfy the inclusion criteria; such articles were included with the following inclusion criteria.

- Duration from January 2020 to March 2021
- Published and available as free access
- Only full access article, Abstract not included.

Around 2124 articles were downloaded using open access Google search engine. 765 duplicate and triplicate articles were removed. After reading the abstract of the remaining 1359, it was found that 634 were not related to the topic. The remaining 725 articles were subjected to the inclusion criteria and another 589 articles were discarded. Rest 136 articles were considered, and it was found that 85 articles were published on 2020, and 17 articles in 2021. As per inclusion criteria, we have not included 34 articles published in 2019. Hence, 102 articles were considered for this review. Figure 1 shows the flow diagram of the methodology used in this study.

Results

Following broad observations or results were found after systematically reviewing the 102 different articles:

1. Socioeconomic and Environmental impact:

- Socioeconomic Changes:* Unfortunately, COVID-19 has shown to be more rampant among poor socioeconomic population.^[30,31] Globally, domestic and international trade has been severely impacted.^[32] Most countries have limited international arrivals to combat the pandemic.^[33]

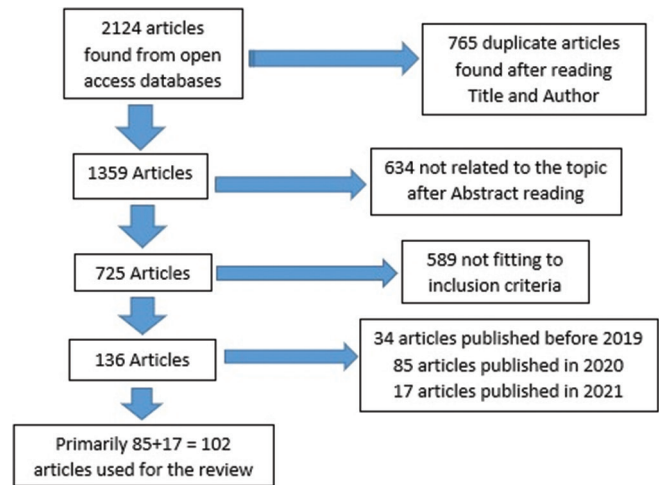


Figure 1: Flow diagram of the study methodology

- Environmental Changes:* In early 2020, Wuhan produced 200 tons of BMW, which is four times the actual capacity of waste disposal facilities.^[34] Persons meeting COVID-19 infected waste can spread the virus in the community. Face masks are one of the major components in this category. Unregulated disposal can severely impact the environment and it is reported that BMW has already severely damaged the coastal environment near Hong Kong.^[35] However, there are some positive effects due to lockdown to control the spread of COVID-19. Restrictions on transportation, businesses, and industrial shutdowns have contributed toward a significant drop in air emissions.^[36,37] Drop in air pollution has been reported in various parts of the world.^[38-40] Satellite images from NASA indicate that NO₂, SO₂, and other environmental pollutants in major epicenters have decreased by 20%–38% in comparison with the same period in 2019.^[41]

2. Impact of Waste Generation:

- Changes in waste characteristics:* Generally, BMW consisting only 10%–25% of healthcare waste,^[42] but, in pandemic, all wastes are considered as BMW. To manage these huge amounts of BMW, the existing waste treatment facilities need to be upgraded.^[43] The average quantity of BMW from hospitals, which was only 0.5 kg/bed/day before the pandemic, has now increased to 3.4 kg/bed/day during the pandemic. In India, waste generation increased from 0.5 kg to 2.5–4 kg/bed/day,^[44] whereas waste generation in Chinese hospitals is reported to be more than 6 kg/bed/day during the pandemic.^[10] Surprisingly waste generation decreased in some regions during this pandemic, whereas it increased in most areas like England, which reported more than 90% higher waste generation than usual.^[45] Manila, Kuala Lumpur, and Bangkok produced 154–280 tons of BMW daily during the pandemic in a scenario where most of the developing countries were already grappling with issues of poor BMW management before the pandemic.^[46-48] Interestingly, home isolation and quarantine measures reduced the generation of BMW in medical institutions

but shifted part of the BMW toward Municipal Solid Waste (MSW).^[49] Detailed data of MSW and BMW generation in different countries are shown in Table 1. COVID-19 transmission is difficult to track; however, surveillance of wastewater is effective in detecting and analyzing the spread of the virus as the result is unbiased and can be used as an early warning system^[50-52] and to assess the efficacy of interventions implemented to stop spread.^[53]

- b) *Waste due to Personal Protective Equipment (PPE)*: In the starting of the pandemic, PPE was used primarily by healthcare personnel only, but as this pandemic continues, PPE is being extensively used by general population. Almost every country has instructed mandatory facemask use for its citizens.^[43] Mask use in some countries varies from 5.5 million to 40 million per day.^[9,54] A mask or PPE is largely composed of plastic (>80%), and mandatory use has transformed the plastic waste generation dynamics causing an explosion of plastic trash.^[43,55,56]
- c) *Plastic waste*: During this pandemic, people have not shown any concern about environment pollution and have begun to promote plastic packaging.^[57] The increase in online shopping in most countries during this pandemic has led to abrupt rise in waste due to packaging material thereby contributing to plastic waste significantly.^[42,56,58,59]
- d) *Food waste*: A study in USA reported that during pandemic cooking at home increased by 54% while 57% conveyed less wasting.^[60] However, individuals waste more food due to excessive food storage fearing an impending crisis. This excessive storage created a situation of food shortage indirectly.^[61] Spain consumption data shows an increase in food purchases (29.8% and 10.9%) in first and second week, and then decreased by 20.3% in the third week of lockdown which may have been due to the onset of a socioeconomic crisis as well as varied opinion about food waste.^[62,63]

3. Impacts on waste management:

- a) *Policy Changes*: As per Centers for Disease Control and Prevention (CDC), Occupational Safety and

Health Association (OSHA), and World Health Organization (WHO), people involved in waste management have an increased risk of COVID-19.^[64] In response to the pandemic, every country has implemented the best suitable management strategies possible.^[65,54] Mobile incineration or autoclaves can be used to dispose of the excess BMW and authorized vehicles should be used for transferring waste with proper recordkeeping.^[53] Strict adherence to prescribed protocols, diligent implementation, regular training, and adoption of methods to reduce waste generation should be followed.^[66-70] Various countries have updated or issued new laws related to BMW to overcome the pandemic.^[44,71]

- b) *Changes in waste handling technologies*: Diverse decontamination and disposal technologies have emerged during this pandemic.^[29,70] Industrial furnaces or cement kilns may also be used safely for incineration.^[53] Fixed or mobile coprocessing facilities are supplementary methods successfully used in China for handling excess BMW.^[72]
- c) *Modification in Waste Management Practices*: Different countries like China, Italy, Spain, India, Japan, etc., have modified their waste management practices during the pandemic, and few common ones are mentioned below:
- Health care waste/BMW: All healthcare waste is infectious and should be collected, transported, treated, and disposed safely as per the standard guideline. Use of appropriate PPE must be followed by waste handlers. Augmentation of capacity to handle additional waste by using new technologies must be done.
 - Household waste/MSW: The risk of infection from MSW cannot be overlooked.^[73] There are no standard guidelines available for household waste/MSW. Infectious waste from home isolation/quarantine when mixed with regular MSW can help spread the infection in the community. Separate collection of this waste must be done, and it must be handled as

Table 1: Waste generation in different regions of the world

Decrease in Waste Generation		Increase in Waste Generation	
Country	Waste generation	Country	Waste Generation
Macao, China Source: Environmental Protection Bureau Macao SAR, 2020	MSW decreased by 17%-25%	England (27)	MSW increased 0-20%
Morocco Source: Ouhssine O, 2020	MSW generation decreased 2%-10%	Tehran, Iran (54)	MSW increased 34.7%. and BMW increased 18%-62%
Trento, Italy (21)	MSW decreased 14% (4058 t/day)	South Korea Source: MoE Korea, 2020	BMW increased 2600 t/day
Milan, Italy Source: AMSA, 2020	Total BMW and MSW decreased 27.5%		
Catalonia, Spain Source: Generalitat de Catalunya, 2020; ACR, 2020	MSW generation decreased 17% (242000t/day) but BMW increased 350% (1200 t/day)		
India: Ahmedabad, India Source: TOI, 2020	MSW decreased by about 20%-40% but BMW increased 67%-82% (1000 kg/day)		
New York, US Source: Waste Advantage, 2020	MSW increased to 30% but commercial waste decreased 50%		
Tokyo, Japan Source: UNEP, 2020	Commercial waste reduced by 57% but MSW increased 110%		

BMW. Dedicated color-coded bags can be used for this purpose in the community.

- iii. PPE waste: In the UK, PPE waste generated from home isolation/quarantine needs to be disposed in a separate black bag. Portugal recommends collecting all PPE waste generated by citizens in watertight trash bags and dispose by incineration or landfill.^[74]
- iv. Disposal of Dead bodies: Although risk of infection from dead body is very less, yet proper PPE use including impermeable apron is recommended for handling dead bodies. The dead body should be packed in watertight plastic bags with all precautions and equipment used for deceased must be disinfected after use.

4. Challenges in Waste Management during the Pandemic:

A COVID-19 patient produces 3.4 kg waste per day and the use of PPE has exploded. Improper disposal from healthcare setups as well as from homes has resulted in these PPE being littered inside the community. These act as a vector for COVID virus spread. Additionally, they add to the plastic waste.^[51,53] India generates about 517 tons of BMW per day. Out of this, 501 tons per day only can be treated in the 200 Common Biomedical Waste Treatment Facilities (CBWTFs) spread over 28 states. Some states do not have CBWTFs at all.^[44] Many other countries like France, Netherlands, and Iran are also facing a similar situation where healthcare waste has increased up to 50%.^[44,53,54] Retaining waste management staff during this pandemic is proving to be a herculean challenge and many EU nations are facing this problem. In many developing countries, there are no effective guidelines or laws for BMW management. Similarly, the urban-rural inequality in waste management is a great challenge. Some of the challenges reported in various literature is mentioned below:

- i. Lack of augmentation of waste treatment facilities to handle the increased load
- ii. Lack of formal training to waste handlers/sanitary workers on dealing with infectious waste, PPE usage, and COVID-19 appropriate behavior
- iii. Irregularity in the supply of PPEs and disinfectants, which increased risk of infection to waste handlers
- iv. Lack of focus on Sewage Treatment Plants as they can be a potential source of infection to the workers and community
- v. No organized system for door-to-door collection of infectious waste from home isolation/quarantine patients in residential areas
- vi. Transport of potentially infectious MSW in open vehicles and trucks as well as manual loading/unloading of waste
- vii. Lack of proper monitoring or review systems in towns and villages
- viii. Increase of charges by the CBWTFs during the pandemic
- ix. Size of collection bag increased leading to incineration issues.

Discussion

WHO reported that the COVID-19 may persist for an extended time, and it can have long-term effect on the environment. The focus has shifted from worrying about the harmful impact of plastic waste to preferring plastic packaging for infection control. The sudden rise in plastic waste has prompted many countries to modify their policies for waste management due to this emergency. The pandemic has drastically changed an individual's lifestyle and consumption patterns.

Socioeconomic Impact: There have been definite changes in the global economy and significant social changes have occurred, which have been already discussed. Though the economy has improved a lot, but still in the second wave, modified lockdowns are impacting a lot of societies.

Impact on Waste Generation: Though some countries have shown a decrease in MSW waste generation due to lockdown, there has been an increase in BMW globally. This is primarily due to increased BMW from hospitals and PPE used in home quarantine or isolation. Overall, the BMW increased in many folds up to 50%.

Impact on Waste management: The management of BMW involves significant interdepartmental collaboration. To be prepared for this pandemic, every country must reevaluate its existing or formulating policies and infrastructure. The real challenge is not in policy formulation but in implementation, which requires tremendous efforts by the governments.

Lesson Learnt and Need to Rethink: This pandemic has brought to light the need for a sustained commitment to improve public health infrastructure. Policymakers must focus on population-based measures rather than individual level institutional care, as these involve much less expenditure. The policymakers and experts need to attend to the following areas^[4]:

1. *Strategies, Policy, and Guidelines:* Though International guidelines on BMW management exist, yet supplementary country-specific rules are needed for both healthcare and nonhealthcare facilities. This emergency created by the pandemic demands to reevaluate the waste management systems in the country and augment them where required.^[4]
2. *Handling of Infectious Waste:* It is vital to have a knowledge about the viability of the virus as this would facilitate appropriate modification of segregation, packaging, storage, and collection interval.^[4,75-78] Use of PPE and hand hygiene among waste handlers need to be improved.
3. *Suitable Disposal Methods:* Selection of appropriate treatment depends not only on internationally recommended guidelines but also on factors like local ecology, worker safety, waste characteristics, available technology, upgrade cost, etc.,. Appropriate waste disposal systems are lacking in many developing countries. It is suggested that to overcome the pandemic such countries should at least set up interim treatment methods as per prevailing international guidelines.

Coprocessing, open burning, and temporary storage as a momentary measure may also be considered.^[53,76,78,79]

4. *Information, Education, and Communication (IEC)*: More than healthcare workers, capacity building is necessary for the public. User-friendly communication channels such as radio, television, and websites with daily updates can be intensified to sensitize the public on the safe handling of waste.^[4]
5. *Data Management and Research*: For planning and policy development, collection of correct and appropriate data is paramount. However, this is often mismanaged during an emergency like this pandemic. Academic institutions must collaborate in data collection and interpretation, which will be invaluable during this pandemic.^[4,78,79]
6. *Rethinking the Role of Hospitals*: The enormous pressure on hospitals due to the COVID-19 patients should enable us to rethink whether these institutions should be the first destinations when people fall sick. It is time to reconsider the role of hospitals for medical treatment.^[75,76] It is also important to consider establishing an Infectious Disease department with proper qualified specialists at every district level hospital and tertiary level hospital and it would perhaps help us handle the situation in a better and decentralized manner. This pandemic has also brought to light glaring deficiencies in hospital management and policy implementation at every level. This mandates that at every district level and above, the hospitals should have a well-developed Hospital Administration department with formally qualified administrators.
7. *Expanding Telehealth services*: The emergence of COVID-19 pandemic has triggered a sustained demand for telehealth. Till now, the broader use of telehealth has been held back by limitations of ethics, payment systems, insurance and regulations, etc., Insurance companies and policymakers need to make amendments to ensure that this important medical tool is widely used during this pandemic and beyond.^[75] It reduces waste generation by reducing the OPD crowd.
8. *Fund Raising and Collaboration*: Local government should realize that enough fund will be required to tackle any future pandemic, which will only be possible through national and international level collaboration considering the only agenda of the nation's health-related problems.^[75,76] Governments at all levels can create special intermediary bodies to cut through red tape and foster joint planning. Switzerland, Georgia, and New Zealand in their responses to the pandemic responded very well using the above approach.^[75,76]

The limitations of the current study are articles published from January 2020 to March 2021 were only considered and only free-access full-text journals were included. While the world is still fighting with the pandemic, we must reconsider our approach to the BMW management system including healthcare systems. The creation of Infectious Disease specialty and Hospital Administration Departments must be considered at every district hospitals and other hospitals at tertiary level. Pandemic preparedness demands a broader global healthcare strategy and

long-term investments even if the current pandemic subsidies, and other urgencies come up. Every physician from primary care to tertiary care needs to be aware of the BMW as per rule and in the context of COVID-19, it becomes most important to manage the medical waste to make a robust community, which can sustain development for a healthier future.

Key points: The lessons learnt from the COVID-19 pandemic, the following key points need to be brought of before any other pandemic emerged:

- Need to reevaluate or formulate strategies, policy, and guidelines in respect to the available resources.
- Should have enough knowledge for the handling of infectious waste.
- Rethinking about suitable disposal methods.
- Information, education, and communication (IEC) and training of the medical workers.
- Data management and research for planning and policy development.
- Rethinking the role of hospitals by establishing Infectious Disease department and Hospital Administration department with formally qualified professionals.
- Need for expanding Telehealth services and eliminating limitations of ethics, payment systems, insurance and regulations, etc., related to telemedicine.
- Fundraising and collaboration: Local government should realize that enough fund would be required from national and international collaboration to tackle any future pandemic.

Highlighted Key Take Home messages/Novelty or new knowledge emerging from this manuscript:

- There is a mismanagement of Biomedical waste generation and disposal in healthcare organization be it primary or tertiary from large quantity waste generation during pandemic.
- There is a shortage of qualified professional in the specialty of Infectious Disease and Hospital Administration nationwide to tackle the pandemic.

Key messages

COVID-19 forced us to rethink our approach for Biomedical Waste management and health care system. Speciality departments in Infectious Disease and Hospital Administration must be considered at every district level hospital and above. Pandemic preparedness demands a broader strategy, which leads to robust herd community, and capable of sustainable development and healthier future.

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Conflicts of interest

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