Toxics Link
for a toxics-free world

HEALTHCARE WASTE

AS A RISK TO THE ENVIRONMENT AND PUBLIC HEALTH

A study by Toxics Link

ABOUT TOXICS LINK

Toxics Link is an environmental NGO, dedicated to bringing toxics related information into the public domain both relating to struggles and problems at the grassroots as well as global information to the local levels. We work with other groups around the country as well as internationally in an understanding that this will help bring the experience of the ground to the fore, and lead to a more meaningful articulation of issues. Toxics Link also engages in on-the ground work especially in areas of municipal, hazardous and medical waste management and food safety among others. We are also involved in a wider range of environmental issues in Delhi and outside as part of a coalition of non-governmental organisations.

Our work on Bio medical waste management has spanned over 20 long years, entailing significant diverse body of work such as policy engagement, improving on ground compliance to the rules, involved in setting standards, creating models in healthcare facilities, ongoing research on occupational safety, training and capacity building of all stakeholders and creation of training modules. The Toxics-Free Health Care programme of Toxics Link has worked extensively for ensuring responsible health care practices and use of safer technologies in India, and strong commitment to a clean and safe environment. The programme aims to green the healthcare practices in the country.

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CONTENTS

ABBREVIATIONS

AMR	Anti-Microbial Resistance
BMW	Bio-Medical Waste
BOD	Biochemical Oxygen Demand
CAUTI	Catheter-Associated Urinary Tract Infection
CLABSI	Central Line-Associated Bloodstream Infections
COD	Chemical Oxygen Demand
HAI	Hospital Acquired Infection
HAV	Hepatitis A Virus
HBV	Hepatitis B Virus
HCF	Health Care Facility
HCV	Hepatitis C Virus
HCW	Health Care Waste
HIV	Human Immune Deficiency Virus
IARC	The International Agency for Research on Cancer
ICU	Intensive Care Unit
MDR-TB	Multi-Drug Resistance Tuberculosis
NCDC	National Centre for Disease Control
RTI	Respiratory tract Infection
TB	Tuberculosis
UNICEF	United Nations International Children's Emergency Fund /United Nations Children's Fund
VAP	Ventilator-Associated Pneumonia
WHO	World Health Organisation

INTRODUCTION

In the last two years, the world has been shaken by the century's worst pandemic, COVID-19, an infectious disease caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The pandemic caused a lot of strain on the existing healthcare infrastructure and also ended up generating a considerable amount of infectious waste, especially during the peaks of the waves and vaccination drives. This, addition to the already large amounts of healthcare waste, became a huge challenge to be managed adequately. The causation relationship between waste, environmental pollution, illness and poor well-being, already established in studies[1] came to the fore once again.

Mismanagement of COVID-19-related healthcare waste has been widely reported across the country, especially in the initial months of the pandemic's spread. This mismanagement has been seen as posing challenges on two levels—first, the risk of spread of infections; and second, the pollution of air, water and soil because of the open burning of or dumping of PPE kits, vaccine vials and medicines.

Thus, in the post-pandemic world, it has become critical to look at the interrelationship among waste, environmental pollution and diseases, especially in the context of healthcare waste, more closely. The pandemic reiterated an important lesson — 'no one is safe until everyone is safe'; but the animal origin of the virus also strengthened the approach of 'One Health,' which upholds the interconnection of people, animals, plants, and their shared environment for better public health outcomes. In this context, this report seeks to review the enivornmental and health challenges of HCW (healthcare waste) generated by healthcare facilities (HCFs), and the impact on public health.

WHAT IS HEALTHCARE WASTE

HCFs are a place where life-saving services are provided, but HCFs are also a potential site for infections as diseases may spread if the waste generated at HCFs is not appropriately managed.

It is essential to emphasise that HCW is referred to as biomedical waste (BMW) in India. However, BMW waste is a broader category, and includes waste generated through various other activities that include but are not limited to surgical interventions, vaccinations, scientific research, laboratory, biotechnological procedures, animal house, veterinary clinics, hospitals, etc.

CATEGORISATION OF HEALTHCARE WASTE

HCW can be broadly categorised as infectious, hazardous and general solid waste based on its direct impact on human health and well-being (Fig 1). The World Health Organisation (WHO) estimates that 85 percent of waste generated by an HCF is more like general solid waste — harmless, such as staionery waste, food waste, etc. Only 15 percent could be infectious and harmful, consisting of chemicals, radioactive materials, and infection-causing substances and organisms, for instance, body parts, blood, body fluids, used syringes, catheters, etc., which could be infected with pathogens.[2]

Figure 1. BMW Categories Based on The Potential Threat to Public Health

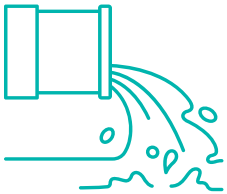
However, the most challenging aspect of infectious waste is that anything exposed to it could become potentially infectious. If this small percentage of infectious waste (15%) is not handled properly, it could contaminate the entire waste and may pollute the environment and put the health and life of organisms at risk. That is why handling waste generated in an HCF is a challenge for many countries, especially for developing and under-developed countries. WHO and UNICEF, in their joint assessment of Water, sanitation, and hygiene (WASH) facilities in 24 low- and middle-income countries found that only 58 percent of sampled facilities from these countries were having proper infrastructure for safe disposal of HCW (WHO and UNICEF, 2015)[3]. Recently, it has been found that one in three HCFs do not manage their HCW safely, across the world.[4]

Thus, untreated or mismanaged waste of HCFs can have pathogens and toxic chemicals that can become a cause of serious environmental and human health risks, as discussed below.

HEALTHCARE WASTE AND THREAT OF ENVIRONMENTAL POLLUTION

1

The waste generated by an HCF is a threat to the environment in both cases — if it is not being segregated and treated or not adequately managed and disposed of. Open burning of or use of faulty incinerators for HCF waste pollutes the air while disposing of it on land or in landfills may pollute the soil and groundwater and the surface water bodies.



According to an estimate, globally the generation rate of HCFs wastewater by each bed is about 400 to 1,000 litres per day

1.1 AIR POLLUTION BY BURNING

In many developing or underdeveloped countries, the open burning of waste has been noted from time to time. If waste is burned openly or in faulty incinerator, it can lead to the emission of toxic gases. A report by R20 Regions of Climate Change reported India as one of the greatest producers of toxic pollutants by open burning of waste alongside Brazil and China.[5]

The open burning of HCF-generated waste may increase the adverse effect on the environment as they not only produce toxic gases such as dioxin and furan, but also release micro-particles (microplastics, for instance) in the air. Medical waste is the third-largest source of dioxin air emission to the environment as per the United States Environment Agency.[6] Dioxin is a toxic chemical; it has been identified as one of the

human carcinogens by the International Agency for Research on Cancer (IARC).

Further, studies of medical waste incinerators in the European Union have found that faulty hospital incinerators were releasing toxic gases such as polycyclic aromatic hydrocarbons (PAH) into the environment in addition to dioxins & furans.[7]

These gases, when released into the environment, can travel up to hundreds of kilometres and harm the health of people who do not even reside near these areas.

1.2 WATER AND SOIL POLLUTION

HCFs generate wastewater in general sanitation-related processes and in various other activities, such as first aid, surgery, laboratory work, diagnosis, radiology, etc. Wastewater generated by an HCF may carry various infectious organisms and hazardous chemicals.

A variety of contaminants present in effluents discharged from HCFs are not only damaging the flora and fauna but is also giving rise to the emerging concern of antibiotic resistance.[8]

1.2.1. Heavy Metals Pollution

Some HCF activities that generate heavy metals[9], such as mercury and chromium, are also a cause of concern. In dentistry, dental amalgam is used to fill the cavity. Dental amalgam is a mixture of metal alloys and mercury. Metal alloys commonly used in dentistry include stainless-steel, nickel-chromium, cobalt-chromium, titanium, and nickel-titanium alloys[10]. A study in Jordan found that many dental practitioners were disposing of their medical waste with regular general waste or pouring it down the drain[11], potentially causing pollution in landfills and water bodies. A similar study in Nigeria (2010) reported high concentrations of lead, mercury and chromium in both soil and water samples near dumping grounds where waste from dental clinics was dumped[12]. According to the United States Environment Agency, medical and dental office waste contributes to about 10% of all mercury emissions in the United States.

Mercury can leach into groundwater and reach aquatic life forms. Inorganic mercury in aquatic environments can readily convert into methylmercury, which can bioaccumulate (deposited in the body of organisms) as it climbs up the food chain and can negatively impact human health in more ways than one.

Image © Tpxics Link

BMW lying in the open

1.2.2. Chemical & Pharmaceutical Pollution

The quality and quantity of the wastewater generated by HCFs may vary according to the size and specialisation of HCFs. According to an estimate, globally the generation rate of HCFs wastewater by each bed is about 400 to 1,000 liter per day.[13] The wastewater from HCFs most likely contain pharmaceuticals and chemicals, such as residue of drugs–analgesics, antibiotics, antidepressants, beta-blockers, metabolites, sulfonamides and chemicals– X-ray contrast media, phenolic compounds, radioactive substances used in nuclear medicine diagnosis and therapy, and liquid chlorine and sodium hypochlorite used as disinfectant, etc.[14] Human excreta could be one of the main sources of drug residues[15], while chemicals are mostly used in medical / diagnosis procedures and cleaning of the HCF premises. Water-soluble drugs and chemicals most likely are biologically active, turning the wastewater of HCFs into a toxic cocktail of drugs and chemicals; as has been reported that the intrinsic toxicity of the hospital effluents can be 5–15 times greater than a municipal effluent.[16]

Discharge of untreated HCF wastewater has been widely reported in India, many African countries, Iran and Egypt, and certain parts of Australia[17]. Gupta and Boojh (2006), in their study on healthcare facilities in Uttar Pradesh, reported that effluent waste from hospitals was being discharged directly into water bodies without any prior disinfection or pre-treatment.[18] A similar study was conducted in Tamil Nadu, and the findings were the same.[19]

Countries lacking efficient wastewater treatment plants may fail to fully decontaminate such water and have an adverse impact on the aquatic environment and on the health of the population who consume this water, as well. For instance, as per the CPCB annual report on inventorisation of STPs (March 2021), Sewage generation in urban India is about 72,368 million litres daily, and only 28 percent of it gets treated. Thus, about 72 percent of total generated sewage gets discharged into the environment untreated[20]. Studies have shown the adverse impact of pharmaceutical pollution on the feminisaton of fish and the sterilisation of frogs.[21]

1.2.3. The Threat of Microorganism and AMR Genes

A new threat to public health, from the misuse or overuse of antimicrobials and poorly managed pharmaceutical waste, is microbes with antimicrobial resistance (AMR) genes.The discharge of untreated wastewater from medical facilities and pharmaceutical industries into the municipal sewage system or into the environment directly may increase the threat of presence of antimicrobial-resistant genes in the municipal wastewater and other water bodies, such as rivers.[22] When a disease-causing microbe develops antimicrobial resistance, it becomes immune to certain antimicrobial drugs which were previously effective on it. Thus, previously curable infections now become incurable and deadly.

Studies have shown that untreated or partially-treated wastewater discharged from HCFs may increase antimicrobial resistance among certain microbes.[23] In India, the presence of antimicrobial-resistant organisms or their genes has been found in rivers and other water bodies.[24] Imprudent use of antimicrobials and poor treatment of wastewater is one of the biggest reasons for the presence of AMRs in India.[25]

A study on rivers Musi and Krishna submitted to NGT reported the presence. of a higher load of diverse kinds of pathogenic bacteria. The study reported pathogenic strains of E. coli, Klebsiella spp., Pseudomonas spp., Enterococcus spp, and Staphylococcus spp.[26]

The study on Musi and Krishna tested a range of antibiotics to map the pattern of AMR. Out of the

Image © Tpxics Link

Mismanaged HCW pose a threat of soil and water pollution

14 antibiotics tested the study found antibiotic resistance (also known as multi-drug resistance or MDR) to two or more drugs at about 29 percent in ***Klebsiella spp*** and 93 percent in ***Pseudomonas app. Staphylococcus spp*** showed almost pan-drug resistance[27]. The emergence of antibiotic resistance in pathogenic bacteria is making it difficult to treat curable skin infections; the situation is more alarming in the case of serious disease-causing pathogens. The emergence of MDR in pathogens is making most of the progress in the field of treatment of microbial diseases futile. The judicious use of antimicrobial substances and their handling and management is a must. Thus the collection, segregation and treatment of healthcare waste, both solid and liquid, are necessary to protect the environment from an infestation of AMR genes.

1.2.4. Health Risk from Polluted Water

HCFs generated wastewater has the potential to spread infectious disease-causing pathogens, such as viruses, bacteria, protozoa, and helminths, coming mainly from infected patients' excreta. Like pharmaceuticals and chemical residues, the pathogens are also flushed into the sewerage pipeline without being neutralised.

As studies have reported that in some countries, wastewater coming from hospitals is generally discharged into the municipal sewer without any treatment where it is treated with urban wastewater or gets discharged in the surface water bodies.

Thus, inadequate management of HCF generated wastewater pollutes water bodies and poses a threat of toxic substances entering the food chain through the aquatic organism, and also creates a conducive environment for the emergence of drug-resistant pathogens.

Such effluents discharged in waterbodies also change the physical and chemical characteristics of the water including pH, BOD, COD, etc.

After having a fair understanding of the impact of the HCFs generated waste on the environment, let us now have a look at the risk it poses to public health.

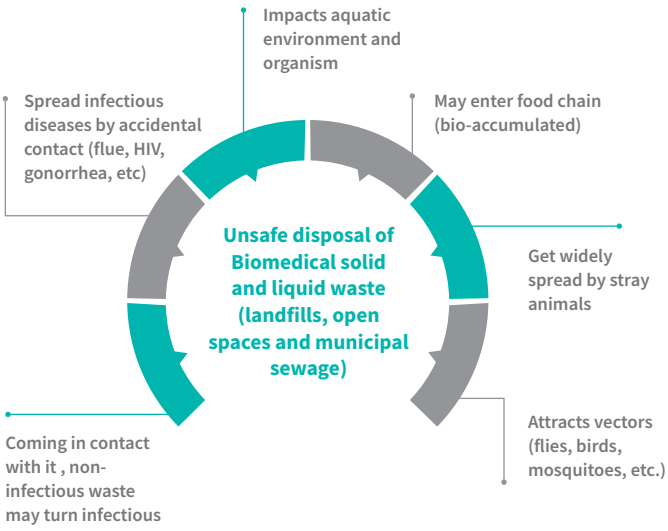
HEALTHCARE WASTE AND PUBLIC HEALTH CHALLENGES

2

As HCW contains a significant amount of infectious agents and harmful chemicals, its poor management can expose a large number of people to serious health risks. Thus, more and more people will need medical treatment, consequently, more HCW will be generated. To control this vicious cycle in the first place, secure and safe management and disposal process at work is a must.

Broadly, potential health risks can be categorised based on exposure to the type of HCW[28]. However, these are not exclusive categories as some waste material could pose one or more types of health risks, such as a contaminated needlestick that could prick the skin and spread infection, too[29].

Figure 2. Healthcare Waste and Public Health Challenges



2.1. HEALTH RISKS OF SHARPS AND INFECTIOUS WASTE

Sharp waste consists of discarded blades, syringes, broken glass, etc., whereas infectious waste contains material and organisms such as virus, bacteria, fungus, and pathological waste such as blood, body fluid, body parts and contaminated sharps.

According to a study published in 2012, about three million health care workers worldwide incur needlestick and sharp injuries every year. The same study also reported that in the United Kingdom, on average, one lakh needle stick injuries are reported on an annual basis[30]. A study conducted in Mexico City found that 96 percent of waste-handling staff had seen intact needles and syringes in waste, while 22 percent had reported needlestick injuries[31].

Use of unsafe injections and needlestick injuries are among the main reasons for the spread of blood-borne pathogens[1]. According to a study, in 2010, unsafe injections were responsible for about 34 thousand new HIV infections and 1700 thousand hepatitis B infections, and 315 thousand hepatitis C infections globally[32].

As per WHO, in the USA, a hospital housekeeper got infected with staphylococcal bacterasemia and endocarditis after a needle injury[33].

WHO has linked injuries from contaminated needles/sharps dumped along with municipal waste to the transmission of diseases such as

Image © Tpxics Link

Mismanaged disposal of sharps poses a risk of injuries and infections

1 "Germs that can have a long-lasting presence in human blood and disease in humans are called bloodborne pathogens. The most common and dangerous germs spread through blood in the hospital are:Hepatitis B virus (HBV) and hepatitis C virus (HCV). These viruses cause infections and liver damage. And, HIV (human immunodeficiency virus). This virus causes HIV/AIDS." https://medlineplus.gov/ency/patientinstructions/000453.htm

Needlestick injury from an injection used for an infected person could pose a risk of infection in a healthy person.

This risk is

30% for Hepatitis B (HBV)

1.8% for Hepatitis C (HCV)

0.3% for HIV infection

hepatitis B, tetanus and typhoid. WHO cautioned that needle stick injury from an injection used for an infected person could pose a risk of infection in a healthy person. This risk is 30% for Hepatitis B (HBV), 1.8% for Hepatitis C (HCV), and 0.3 % for HIV infection.

These are the cases where needlestick injuries are reported and a record is maintained. But in those places where such data is not available, it is very difficult to assess the severity of the problem. In developing countries, about 75 percent of needlestick injuries are not being reported[34].

Further, the use of contaminated syringes and needles for injections may cause several serious ailments. Needle reuse is seen to be a major cause of concern with regard to HCW , especially in poor countries. About 5% of all HIV cases in sub-Saharan African countries are due to the reuse of syringes in medical settings[35]. In 2009, India reported an outbreak of Hepatitis B in the Modasa town of Gujarat. The cause of the outbreak was located in the unsafe injection practices, especially due to the reuse of needles without adequate sterilisation[36].

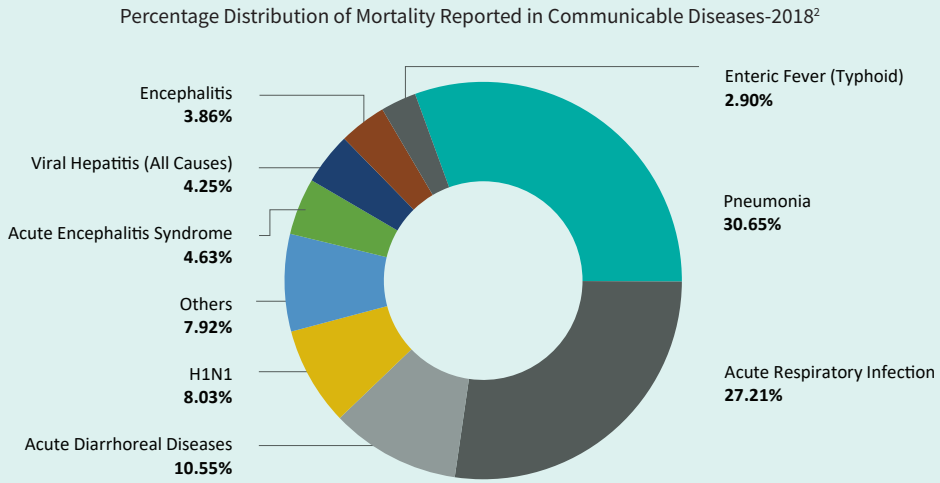
Moreover, sharps or needlestick injuries are not the only ways in which an ifectious disease can spread. It can also be caused by the accidental ingestion of pathogens, such as touching the mouth or nose after contact with infected or contaminated items such as soiled clothes, cotton swabs and bandages, or blood, vomit, faeces, urine or other body fluids of the infected patient. Improper handling of HCW and poor waste management could increase the risk of infectious diseases, as dumping of untreated HCW in the landfills and other open spaces may lead to vector-borne diseases, such as encephalitis, malaria, swine flu, etc.

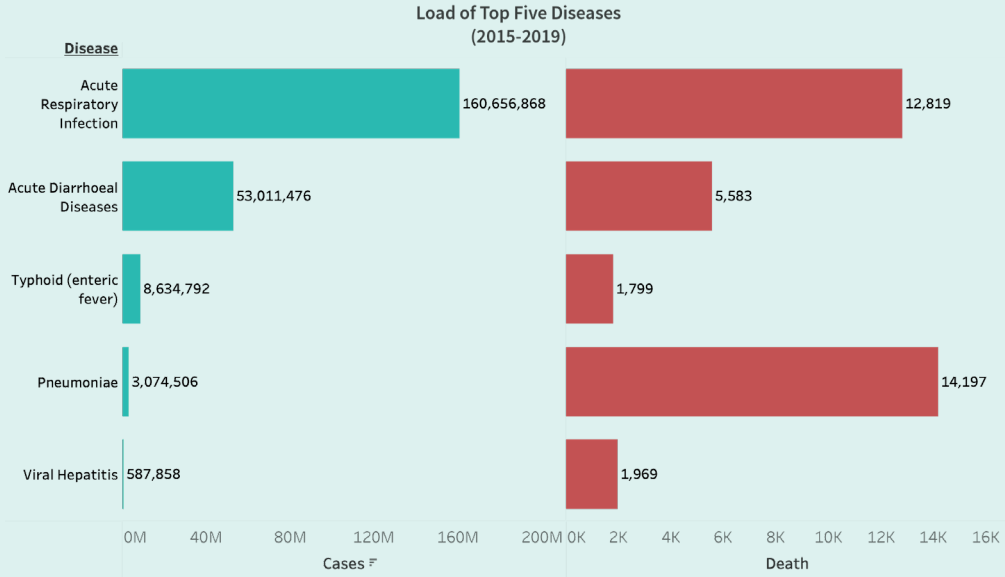
There is no data available that can directly link the HCW and spread of the various infectious diseases in India. However, a fair understanding of the burden of communicable diseases in the country will help understand the health risk of poor management of HCW.

The Burden of Infectious Disease in India

In developing countries, such as India, the burden of microbial infection is comparatively high. As per the available data from The Annual Health Profile of India reports (2015-2019) show, that the burden of communicable diseases is high.[37]

Figure 3. Mortality Reported on Major Communicable Diseases





2 National Health Profile, 2019; https://www.cbhidghs.nic.in/index1.php?lang=1&level=1&sublinkid=75&lid=1135

Figure 4. The Burden of Infectious Disease in India[3]

Number of Reported Cases

	2015	2016	2017	2018
Acute Respiratory Infection	35650451	40810524	42199633	41996260
Acute Diarrhoeal Diseases	12233379	14166574	13416748	13194775
Typhoid (enteric fever)	1845997	2215805	2264453	2308537
Pneumonia	642152	744865	759004	928485
Viral Hepatitis	133625	145970	164289	143974

Number of Reported Deaths

	2015	2016	2017	2018
Acute Respiratory Infection	2661	3164	3254	3740
Acute Diarrhoeal Diseases	1216	1555	1362	1450
Typhoid (enteric fever)	393	511	496	399
Pneumonia	2410	3469	4105	4213
Viral Hepatitis	397	451	537	584

As per latest data, of all the communicable diseases, pneumonia and acute respiratory infection accounted for a higher percentage of death in 2018[38]. Pneumonia accounts for 25 percent of deaths of children aged 5 years or less. The second-most life-threatening infectious disease is the acute diarrhoeal disease.

3 National Health Profile, 2019; https://www.cbhidghs.nic.in/index1.php?lang=1&level=1&sublinkid=75&lid=1135

2.2 HEALTH RISK OF PHARMACEUTICAL AND CHEMICAL WASTE

It includes discarded chemicals and pharmaceuticals, such as mercury, expired and unused medicines, etc.

As we have seen in HCWs and the Environmental Pollution section, poor management of HCF-generated chemical and heavy metal waste, such as phenolic chemicals, mercury, chromium, and metal alloys, contaminates soil and water and poses a risk to human health[39]. For instance, mercury and chromium are amongst the most dangerous neurotoxins known to humankind and can severely impact reproductive health.

When such waste is dumped without adequate treatment, it can seep into the ground and contaminate groundwater. Some elements such as mercury and cadmium, can be absorbed by crops and can also bioaccumulate in organisms. As a consequence, the food chain can get contaminate. Moreover, exposure to these chemicals may occur through unintentional ingestion such as drinking or eating contaminated water and food or coming into contact with such waste, and inhalation of vapours while burning such waste.

Another emerging risk of pharmaceuticals and chemicals is the antimicrobial-resistance genes. The WHO has identified AMR as one of the top ten global public health challenges[40].

The challenge of AMR has put at risk the effective prevention and treatment of a range of infections caused by bacteria, parasites, fungi, and viruses[41] ; for instance, multi-drug resistant (MDR) TB. When drug-susceptible TB bacteria develop resistance to some of the anti-bacterial drugs[4], the curable TB infection may become incurable.

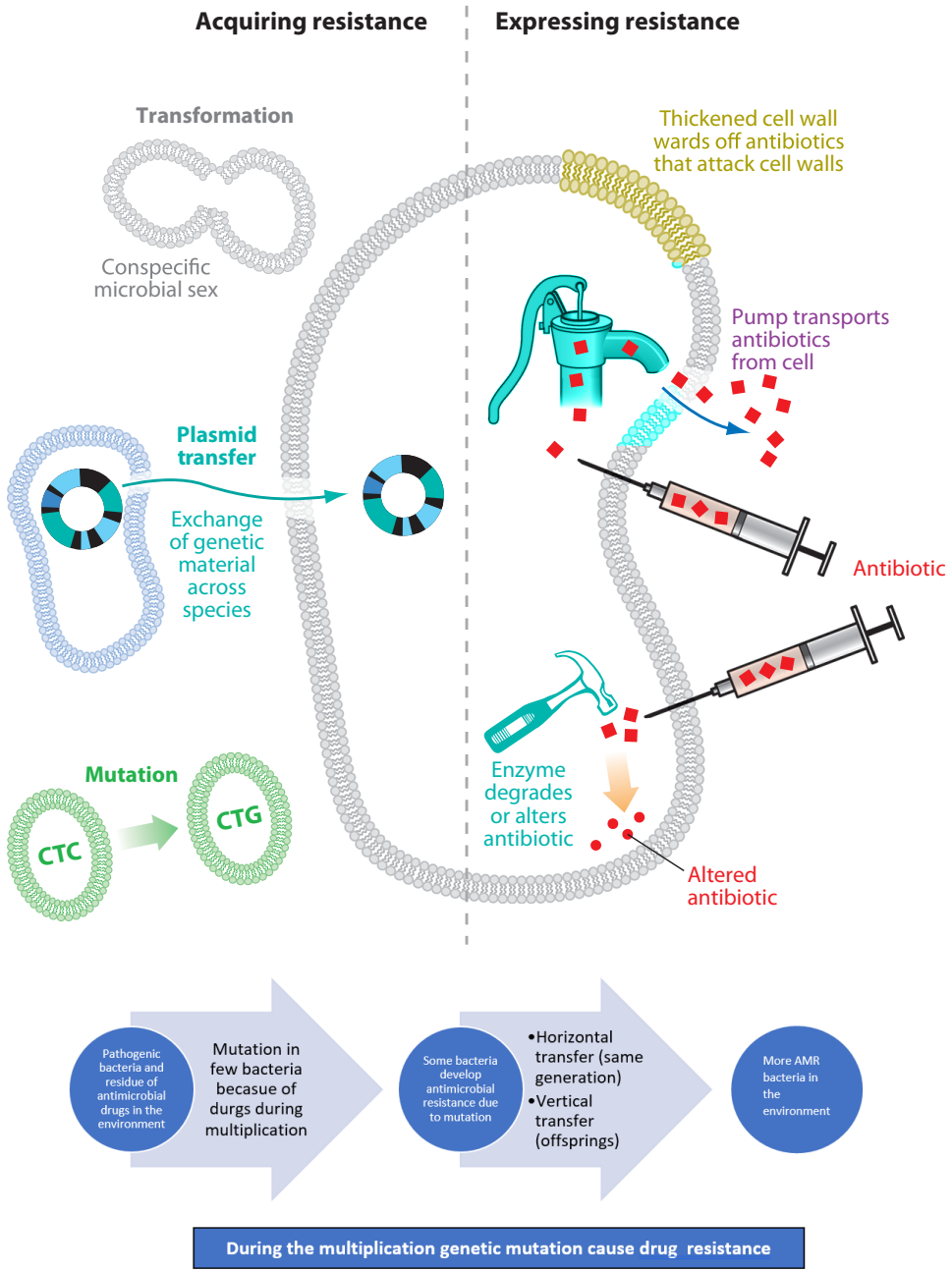
According to WHO, in 2020, India accounted for the highest number of new TB cases in the world. As per the India TB report 2020, 58 percent of the notified 24,04,815 TB patients were tested for universal drug susceptibility. This test is done to see the nature of the infecting bacteria in terms of its ability to resist antibiotic drugs prescribed for the treatment of TB. Five percent of the tested patients were diagnosed with MDR-TB.

A study published in 2007 reported that hospitals and HCFs have a significant role in the transmission of TB, especially in HIV patients. The study also inferred that hospitalised TB patients have a higher risk of developing MDR-TB than out-patients of TB[42].

Further, in the context of India, with the higher microbial infection, the threat of drug resistance microbes becomes very high, too. For instance, it has been reported that in 2008 while only 29 percent of isolates of ***Staphylococcus aureus*** were methicillin-resistant, their share rose to 47 percent by 2014[43]. Methicillin- resistant ***Staphylococcus aureus*** (MRSA) causes hard-to-cure staph infection. Indian priority pathogen list for AMR includes ***Staphylococcus aureus, Klebsiella pneumonia, Escherichia coli, Acinetobacter baumannii, Pseudomonas aeruginosa, Streptococcus pneumoniae, Haemophilus influenzae, Neisseria meningitidis, Shigella*** species***, Enterococcus*** species. & ***Salmonella*** species.

4 Antimicrobial drugs have different lines of defence. The treatment normally starts with the drugs of the first line of defence and if not get cured then stronger drugs of subsequent lines of defense are used. In the case of AMR, it has been seen that drugs from the first line of defence are not working against a particular microbe. For detail please see. https://www.who.int/india/antimicrobial-resistance

Figure 5. Challenges of AMR: Process of a pathogenic bacterial strain turning into antibiotic drug-resistant strain[5]



5 (Source: Kathryn M. Orzech and Mark Nichter (2008). From Resilience to Resistance: Political Ecological Lessons from Antibiotic and Pesticide Resistance. Annual Review of Anthropology , Vol. 37 (2008), pp. 267-270, C1-C2, 271- 282)

The relationship of these pathogens with the HCW is explicit in the WHO listed various types of infections that can be caused by exposure to different types of infectious waste.

Table 1. Types of Infections Caused by Exposure to Healthcare Waste[6]

Type of Infection	Examples of Causative Organisms	Transmission Vehicles	Possible means of exposure[7]
Gastroenteric infections	Enterobacteria, e.g. Salmonella, Shigella spp.; Vibrio cholerae; helminths	Faeces and/or vomit	Soiled clothes and waste infected with pathogens. Accidental Ingestion-such as touching mouth or nose after coming in contact with infected items like cotton swabs, bandages etc.
Respiratory infections	Mycobacterium tuberculosis; measles virus; Streptococcus pneumoniae	Inhaled secretions; saliva	Accidental Ingestion & inhalation- such as touching mouth or nose after coming in contact with infected items such as cotton swabs and dressings etc,
Ocular infection	Herpesvirus	Eye secretions	Accidental contact with eye-fluid of an infected person (Through soiled clothes, napkin papers, and cotton swabs etc.)
Genital infections	Neisseria gonorrhoeae; herpesvirus	Genital secretions	Accidental contact with genital secretions of an infected person (Through soiled clothes, napkin papers, treatment equipment etc.)
Skin infections	Streptococcus spp.	Pus	Accidental contact with Pus during waste handling (Through soiled clothes, cotton swabs, dressings, napkin papers, needles etc.)
Anthrax	Bacillus anthracis	Skin secretions	Accidental contact with skin secretions during waste handling (Through soiled clothes, napkin papers, cotton swabs etc.)
Meningitis	Neisseria meningitides	Cerebro-spinal fluid	Accidental contact during waste handling (Through soiled clothes, used cotton swabs, needles etc.)
Acquired immunodeficiency syndrome (AIDS)	Human immunodeficiency virus (HIV)	Blood, sexual secretions	Accidental contact- through a puncture, abrasion, or cut in the skin with infected sharps.
Haemorrhagic fevers	Junin, Lassa, Ebola, and Marburg viruses	All bloody products and secretions	

6 https://www.who.int/water_sanitation_health/medicalwaste/020to030.pdf
7 Added by the author

Type of Infection	Examples of Causative Organisms	Transmission Vehicles	Possible means of exposure[7]
Septicaemia	Staphylococcus spp.	Blood	Through a puncture, abrasion, or cut in the skin with infected sharps
Bacteraemia	Coagulase-negative Staphylococcus spp.; Staphylococcus aureus; Enterobacter, Enterococcus, Klebsiella, and Streptococcus spp.	Blood	
Candidaemia	Candida albicans	Blood	
Viral hepatitis A	Hepatitis A virus	Faeces	Accidental Ingestion -such as touching mouth or nose after coming in contact with infected items.
Viral hepatitis B and C	Hepatitis B and C viruses	Blood and body fluids	Accidental contact through a puncture, abrasion, or cut in the skin with infected sharps

Microbes developing anti-microbial drug resistance may create a situation where currently available drugs will no longer remain therapeutic and today's curable diseases could become incurable tomorrow!

2.3 HEALTH RISK OF GENOTOXIC AND RADIOACTIVE WASTE

Genotoxic waste contains toxic substances that can have an adverse effect on the genes and cells of the exposed organism. All cytotoxic drugs come under this category. Radioactive waste contains substances that could emit ionising radiation or particles.

Genotoxic and radioactive waste are very harmful to organisms as they are mutagenic (induce mutations in cells), teratogenic (cause the malformation in an embryo), or carcinogenic (cancer-causing). The severity of the health risk from genotoxic and radioactive substances depends upon their toxicity and exposure duration. Substances with low toxicity may pose a health risk if one is exposed to them for a longer period of time. Whereas, high toxicity with less exposure time may have an adverse impact on health.

Poor waste management may expose one to these hazardous substances. Exposure may occur through inhalation of dust or aerosols, skin absorption, accidental ingestion of contaminated food, chemicals or through coming in contact with the faeces, vomit, urine or other bodily fluids from patients treated with cytotoxic drugs. Another most probable way of exposure could be contamination of containers or improper mode or duration of waste storage[44].

WHO BEARS THE BRUNT?

3

People at risk of these diseases from HCW can be divided into two groups--first, those who are susceptible to occupational health hazards, and second, patients and the general public--those who inadvertently come in contact.

3.1 HEALTH RISK TO FRONT-LINE HEALTH WORKERS

All those people who are involved in health care services and waste handling can be identified as front-line healthcare workers. These people, such as medical doctors, nurses, laboratory personnel, hospital waste workers and auxiliary staff, HCW transporters, waste management facility workers and formal and informal waste pickers, are more susceptible to occupational health hazards.

Needles when disposed of uncapped or activities like needle recapping may often be the cause of injury among healthcare workers as well as HCW handling staff.

There is a dearth of data related to disease instances caused by needlestick injuries in India. However, the studies available revealed a substantial number of needlestick injuries occurred due to actitvities such as needle recapping. For instance, a study (Sharma et al 2010) focused on a tertiary health care system in Delhi found that about 79 percent of healthcare workers experienced one or more needlestick injuries in their career. However, only about 8

79%

of healthcare workers experience needlestick injuries in their career

percent took immediate remediation against HIV/AIDS after their injury[45].

Similarly, a study (Goel et al, 2017) on the health care workers of a tertiary care teaching hospital in north India reported that in the three years of the study period a total of 476 needlestick injuries cases happened. Doctors' exposure rates were higher, about 74 percent, whereas among nurses it was only about 19 percent. The study also reported that 11 were found seropositive for HIV, nine for HCV, and 24 for HBV. However, after six months no seroconversion was reported in any of the healthcare workers who sustained needlestick injuries.[46]

Another study (Sriram, 2019) reported that about 10 percent of the total health care providers studied at HCF (a tertiary care teaching hospital in South India) had experienced needlestick injuries and a majority of them opted for immediate remedial action. However, out of these only 62 percent were wearing safety gloves at the time of injury.[47]

3.2 HEALTH RISKS TO PATIENTS AND GENERAL PUBLIC

Patients who have been admitted for a longer period of time are also at a higher risk of exposure to healthcare-associated infection (HAI) in the high-risk environment of the HCFs. Moreover, unhygienic and poorly sanitised surroundings are a flourishing breeding ground for the microbes. Though HAI has been considered as a very common occurence during the delivery of healthcare and a major public health issue, there is a dearth of data related to HAI incidents in India.

However, National Center for Disease Control (NCDC) has reported that Seven percent of patients in developed and 10 percent in developing countries suffer from at least one HAI[48]. The three main types of HAI are ventilator-associated pneumonia (VAP), central-line-associated bloodstream infections (CLABSI), and catheter-associated urinary tract infections (CAUTI). The HAI may affect patients adversely and may increase the cost of the treatment with a longer period of hospitalisation . A recent study (2020) conducted on the ICU patients of a tertiary care hospital of Uttarakhand reported that about 27.2 percent ICU patients had suffered with HAI. VAP or respiratory tract infection (RTI) had the highest prevalence followed by CLABSI or bloodstream infections[49].

Moreover, increasing resistance from antimicrobials among the disease-causing mirocbes has made the cure more difficult. For instance, a study reported a marked increase of resistance to carbapenem among Klebsiella pneumonia–from two percent in 2000 to 52 percent in 2009– within a span of seven years, in one of the tertiary-care hospitals in New Delhi.[50] Though the increase in microbial resistance has largely been associated with the higher consumption of antibiotics but the role of unmanaged or poorly managed HCW in the spread of AMR infection can not be ruled out.

Another vulnerable group is the people who are not directly involved in HCW generating, managing, and handling but accidentally come in contact with such an environment, such as visitors to HCFs, and the general public when they get exposed to the environment contaminated with HCW.

According to a correspondence published in ***The Lancet***, mismanaged HCW is accountable for the death of about 52 lakhs vpeople, including 40 Lakhs children, every year across the world[51].

As mentioned earlier, in 2009, the people of Modasa town in Gujarat bore the brunt of an outbreak of Hepatitis B due to the reuse of poorly sanitised syringes

Moreover, poor management of HCW and dumping of it in municipal landfills could pose the highest risk of contracting infections among Rag pickers and informal waste workers who often, without any safety gear, rummage through waste to salvage items that can be resold in the market, though

Image © Tpxics Link

Ragpickers picking up illegally disposed off BMW from dumpsites

risk of contracting infections among ragpickers and informal waste workers who often, without any safety gear, rummage through waste to salvage items that can be resold in the market. Though there is no data available in support of this argument, news reports during the COVID-19 (or Covid-19) pandemic give a glimpse of the situation.

Thus, collection, segregation, and safe disposal of HCW is a must to save the environment from various kinds of toxic pollutants and minimise public health challenges.

3.2.1 Economic Cost of Infectious Disease

The World Economic Forum (WEF), in its 2021 Global risk perception report, identifed infectious diseases at the top among the highest impact risks of the next decade.[52] Infectious diseases not affect human health and mortality, but they also dent the economy in the form of treatment expenditures and loss of labour income. This, consequently, affect buying capacity and consumption patterns.

Way back in 2008, A published paper estimated that global economy was losing US$ 12 billion every 12th month if the number of TB patients were 8.5 million annually.[53] As per a more recent estimate, TB will affect 20 million lives between 2015 and 2030 This will cost the global economy about US$ 1 trillion.[54]

Waste-pickers picking-up waste without safety ge

India is one of the highest TB burden countries in the world. According to an estimate in 2007, economic cost in terms of lost wages per year was about $300 million in India; the economic cost in terms of lost wages per year was about the indrect cost in terms of absence of labour and loss of productivity was up to $23 billion.[55].

Similarly, economic costs of other infectious diseases are also very high. According to an estimate, only for the year 2016, the global economic cost of the eight vector-borne and infectious disease—HIV/AIDS, malaria, measles, hepatitis, dengue fever, rabies, tuberculosis and yellow fever—was up to US$8 trillion (about Rs 600 trillion). A study also reported a loss of 156 million life years.[56].

Further, the emerging threat of AMR is worsening the situation. On the one hand, cure becomes difficult due to highly resistance microbes ; on the other hand, the incurred cost of treatment and lost productivity also spiral. As per a working paper published by the World Bank in 2017, in the absence of AMR, the world would lose about $85 trillion in GDP (gross domestic product) and $83 trillion in global trade within 2015 and 2050. However, in a high AMR scenario, additional healthcare expenses per year by 2050 would be $1.2 trillion. [57].

Further, for India, as per an estimate the economic cost due to AMR is about Rs 0.64-0.70 trillion.[58] However, there is lack of data related to loss of life, labour supply and productivity due to infectious diseases in general and AMR in particular.

While the socioeconomic and public health cost of infectious diseases in India attracted the attention of policymakers way back in 1974,Indian got its first HCW management rule only in 1998.

BMW- A GREATER PUBLIC HEALTH ISSUE IN INDIA

4

4.1. LEGAL PROVISIONS FOR HCW MANAGEMENT IN INDIA

As mentioned in the introduction, hospital waste or HCW comes under the biomedical waste (BMW) category. Recognising the need for safe and proper disposal of HCW for better public health and wellbeing, in South Asia, India was among the first countries in South Asia to lay down a specific set of rules for biomedical waste management. In July 1998, the Ministry of the Environment and Forest, introduced the Biomedical Waste (Management and Handling) Rules-1998.

These first set of rules to streamline the process of BMW handling from the point of generation to the point of disposal, made it mandatory for BMW generators to assure the safe disposal of waste[59]. This was the time when India introduced the concept of treatment of biomedical waste via the Common Biomedical Waste Treatment Facility (CBWTF) which was responsible for the timely collection of waste from HCFs and their environmentally sound treatment using available

"Bio-Medical Waste"
means any waste, which is generated during the diagnosis, treatment, or immunisation of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps, including human and animal anatomical and soiled waste, discarded medicine and chemical waste',

technologies, . The rule has been amended from time to time.

Further, in 2016, the Ministry of Environment, Forest & Climate Change, published the Biomedical Waste Management Rules in the progression of the 1998 Rules. The Government of India redefines BMW in its Biomedical Waste Management (BMWM) Rules-2016 as[60],*"Bio-medical waste" means any waste, which is generated during the diagnosis, treatment, or immunisation of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps, including human and animal anatomical and soiled waste, discarded medicine and chemical waste'.*

The BMWM rule -2016 is applicable to anyone involved in the generation, collection, store, transportation, treatment, disposing, or handling of BMW in any form including hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, blood banks, Ayush hospitals, clinical establishments, research or educational institutions, health camps, medical or surgical camps, vaccination camps, blood donation camps, first-aid rooms of schools, forensic laboratories, and research labs, etc[61].

The 2016 rules were further amended with an aim to improve segregation, collection, processing, treatment, and disposal of solid and liquid BMW in a comprehensive manner. To control leakage and pilferage of BMW, compulsory training of all the health care workers in BMW handling and management, barcoding system on the bin bags and GPS system for the BMW carrying vehicles have been a few significant inclusions in the rule. The other important addition is the provision for the regular monitoring of the implementation of the rules on the ground with details of the responsible agencies and frequency of the monitoring.

1998

- First Biomedical waste management rule was notified by the Government of India
- The rule made it mandatory for HCFs to ensure safe treatment of BMW by either establishing a tretament facility or by sending it to a CBWTF
- However installation of Effluent Treatment Plant (ETP) was not mandatory

2016

- Ministry of Environment, Forest and Climate Change (MoEFCC) ammended BMW rules to notified Biomedical Waste Management (BMWM) Rule-2016
- Blood donation camps, vaccination camps, surgical camps and everyother healthcare activity is now under the purview of the rule
- Rule has set the goal of phasing-out of chlorinated palstic bags, gloves and blood bags
- Liquid waste generated in an HCF is required to be pretreated and installation of ETP is mandatory.
- Training of all Health care workers in BMW, handling and management is compulsory
- Reporting of all major accidents is mandatory
- Bar coding of BMW containing bags and GPS enabled vehicles is mandatory
- The role of monitoring agencies and the frequency of monitoring of implementations are well defined-
- At country level - MoEFCC (annually)
- At state or UT level - SPCB or PCC
- At district level - District monitoring committee (half-yearly)

4.2 STATUS OF BIOMEDICAL WASTE GENERATION AND MANAGEMENT IN INDIA

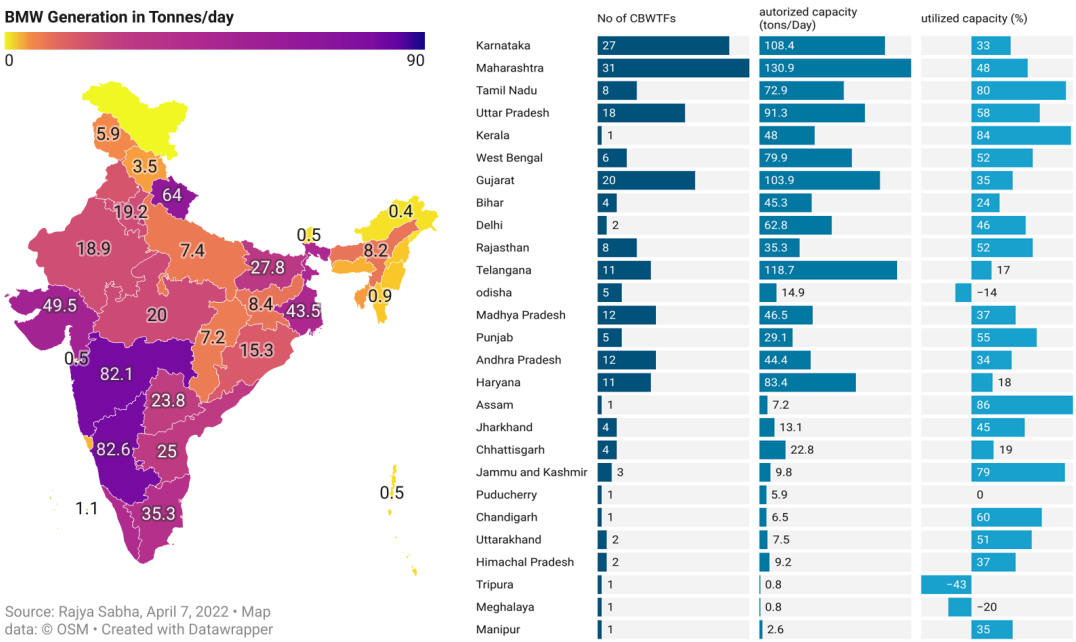
Even after the introduction of legislation against BMW more than two decades ago, India lags far behind in attaining the goal of an efficient on-ground implementation of these rules. Studies by Toxics Link in Gujarat and Jharkhand have highlighted the poor management of HCW at HCFs at various levels--from mismanagement of HCWs in the HCFs to discharge of untreated liquid biomedical effluents[62].

As per the annual report on 2020 BMW management by CPCB, India generates 651 tonnes of BMW per day. Out of this, 581 tonnes are treated at CBWTFs and captive treatment facilities every day. Andaman and Nicobar Islands, Arunachal Pradesh, Goa, Lakshadweep, Mizoram, Nagaland and Sikkim do not have common facilities for treatment and disposal of BMW, These UTs and states practise deep burial disposal.

However, the CPCB report submitted to NGT has also reported that out of the 3,19,907 HCFs in India, about 28,816 HCFs/CBWTFs were reported as violating the provisions of the BMW Rules-2016 [63]. Thus, about 9 percent of the HCFs across the country are not compliant with the BMW rule and are disposing of their HCWs, more likely, in an unsafe manner. Moreover, only 1,55,103 HCFs have got authorisation. There is no data available on how many unauthorised operational HCFs (including animal houses and veterinary hospitals) are attached to any CBWTFs or have captive treatment facilities.

This gap in data neither provides a clear picture of the quantum of BMW generated nor the trajectory of that missing BMW in the country. This missed BMW could be a potential threat to public health and the environment.

Figure 7. Bio-Medical waste Generation (RajyaSabha Question) & Treatment (CPCB-2020)



Source: Rajya Sabha, April 7, 2022 • Map data: © OSM • Created with Datawrapper

For instance, a sharp decline in the number of the Asian vulture in India, Nepal, and Pakistan was reported way back in the 2000s. The cause of death was identified as renal failure due to the diclofenac sodium (a non-steroidal painkiller used in livestock rearing). The cattle treated with the drug had trace amounts of it in their carcasses and Vultures feeding on such carcasses suffered renal failure and died[64].

Though the use of this drug on cattle is banned in India, it is a cautionary incident to understand the need for inventorising veterinary waste and implementation of safe disposal practices.

4.3 HCW IN THE TIME OF COVID-19

For more than two years now, the world has been fighting the COVID-19 pandemic. Many waste/ sanitation staff across the globe are at the risk of contracting the deadly virus as most of them handle COVID waste without adequate protection.

The pandemic has also increased the burden of HCW in the form of plastic-made personal protective equipment (PPE) kits. Used PPE kits are treated as infectious waste and need to be handled accordingly. A study by Toxics Link on COVID-19 waste management in Delhi reported 11-625 percent of jump in covid-19 related waste generation in different time periods. The study inferred that 'Total amount of waste, including COVID waste, is much higher than the BMW generated during the non-COVID month.'[65]

Similarly, A study published in the journal The *Proceedings of the National Academy of Sciences (PNAS),* reported that

"More than eight million tons of pandemic-associated plastic waste have been generated globally, with more than 25,000 tons entering the global ocean. Most of the plastic is from medical waste generated by hospitals that dwarfs the contribution from personal protection equipment and online-shopping package material"[66]. The report also claimes that "The majority of it is contributed by Asia (72%)".

In Bangladesh, a survey conducted by a civil society organisation concluded that many waste workers who were employed in handling used masks, and gloves from municipal grounds had fallen sick a few days later[67]. The case was not very different in India[68]. Used PPE kits and masks were a common sight in the open garbage dumps in many cities, in India, too[69]. Virus-contaminated waste emanating from hospitals and home quarantine centers may further surge in the number of cases, especially among the workers who are directly exposed to it as they deal with this waste on a daily basis with poor safety measures[70].

Further, in India, management of HCW has not been adequate and COVID-19 pandemic has not only aggravated the challenges but also unravel the poor management status of HCW in the country explicitly. This mismanaged waste could pose a threat of environmental pollution and also to public health.

‘NO ONE IS SAFE UNTIL EVERYONE IS SAFE’

5

The debate about the origin of the COVID-19 (SARS-CoV-2) virus has brought the issue of safe handling of biomedical items to the forefront. There are two dominant arguments regarding the origin of the virus–first, zoonotic–transmitted to humans from some animal; and second, accidental leak from a laboratory in Wuhan, China[71]. If the second argument is to be believed, then it is explicit that manhandling of biomedical materials could create health havoc not only on a local level but globally, too. This could be true for HCW, too.

In countries where there is a lack of infrastructure and resources related to HCW inventorisation and management, such as in India, HCW waste has been found lying in open or with the municipal waste putting forth serious challenges to the environment and public health[72].

Thus, the impact of anthropogenic activities on the environment, the spread of antimicrobial resistance across the world, and the threat of COVID-19 like pandemic_imphasise the necessity of a safe and sustainable health care practices and services. Thus, safe and adequate management of the HCW is an inevitable part of health care services. An inadequately managed HCW has the potential to pollute the environment and turn non-hazardous waste into a hazardous one. It can lead to heavy metal pollution to spurring the growth of AMR genes in water and soil. This could lead to severe health issues among health workers, patients and general public. .

WHO has cautioned that the COVID-19 pandemic could have a negative impact on the progress the world has achieved so far in the area of health and wellbeing

This is also true for the HCW that we generate at the household level, such as used sanitary napkins, masks, gloves, PPE kits, diabetes testing kits, unused medicines, an so on. There are many other situations for the generation of HCW at the houehold; for instance; post-surgery recovery, terminal illnesses, lifestyle-rleated diseases such as hypertension and diabetes that require daily interventions in the form of oral and injectable medication and monitoring devices. In most cases, we discard such waste in the municipal bins without segregation. Lack of segregation poses a major threat to the health of sanitation workers, many of whom do not wear protective gear such as PPE kits..

Another big challenge is the lack of infrastructure for the adeqaute handling of HCW. Many states in India do not have CBWTFs and many HCFs use deep burial to dispose of their HCW. We have noticed that many operational HCFs are either unauthorised or not compliant with the BMWM Rule 2016.

To sumarise, unsustainable handling and management of HCW or BMW waste may pose the following threats:

- Environmental threat– The Presence of heavy metals in mismanaged HCW may pollute soil and water. Similarly, discarded medicine, chemicals and untreated wastewater form the HCFs may not only pollute soil and water but also lead to the spread of AMR genes. Also, the, open burning of waste generates toxic fumes (furons and dioxines)
- AMR Threat- Discarded medicines, chemicals and anatomical remains may pose a threat of microbial infections and may also contribute to the growth of antimicrobial resistance.
- Threat to Human Health – Poorly managed HCW translates to the spread of infectious diseases such as HBV, HCV and HIV among healthcare workers. It can also lead to HAI among ICU patients and those who stay in hospitals for longer duration. Inadequately managed HCW could be a cause of the spread of contagious diseases among the wider public.
- Economic cost—Mismanaged HCW is instrumental in spreading infectious diseases. This not only adds to the burden of treatment but also shrinks labour supply and productivity. This leads to a change in consumption patterns and loss of business.

At the policy and rules level, many initiatives have been taken and rules and regulations have been revised but the main challenge is of implementation and enforcement of the same.

5.1 WHAT CAN BE DONE?

Our idea of waste is composed of two things, “care for hygiene and respect for conventions” (Douglas, 1967). In the context of HCW, the idea of hygiene is at the core of waste handling and management. As we have seen above, the burden of infectious disease is very high in India. The increasing threat of antimicrobial drug resistance has made the situation grimmer. The spread of infectious diseases not only costs public health but the price is also paid in the form of socio-economic crisis. All the Sustainable Development Goals (SDGs) are directly or indirectly related to human health. SDG-3 directly deals with health; its stated aim is to ‘ensure healthy lives and promote wellbeing for all at all ages’[73]. However, WHO has cautioned that the COVID-19 pandemic could have a negative impact on the progress the world has achieved so far in the area of health and wellbeing. Because of the pandemic, the Healthcare disruptions could reverse decades of improvements[74].

Thus, to safeguard public health and the environment:-

- Studies have shown that segregation at source and waste collection efficiency is poor in many HCFs of the country. The situation becomes challenging as significant number of HCFs are operational without authorisation and many of them are not attached with the CBWTFs. Thus, inventorisation of BMWs generated by unauthorised veterinary centres, animal houses, and other such units is a must.
- A strict provision is needed to monitor and evaluate the disposal of HCW by unauthorized HCFs.
- Strengthening of surveillance and reporting system for HAI and other infectious diseases is need of the hour.
- Along with the implementation and enforcement of the BMWM rule -2016, installation of new and upgradation of old Infrastructure is a must. As mentioned before, many states and UTs in India either either do not have CBWTFs or their capacity is less than the requirement. The other challenge is of compliant operational status of CBWTFS and CETP. Studies have shown that faulty inclinators and CEPTs cause air and water pollution respectively.
- The Identification of household-generated HCW and its segregation at source could have a far-reaching effect in the area of public health and wellbeing. As Household-generated HCW has the potential to contaminate other kinds of non-hazardous waste streams.
- There is an increased need for continued training and capacity building of healthcare workers in waste management, with a strong focus on occupational health and safety norms.
- Wider public awareness campaigns regarding BMW and its potential health and environmental hazards is one way of empowering people to observe the correct behaviour of waste handling. They should demand the same of HCFs. This could persuade HCFs and other BMW-generating units to follow rules and regulations.
- It is indeed high time to understand the deep and life-threatening implications of poor BMW management. It has the potential to develop into a huge public health crisis because ‘no one is safe until everyone is safe’ in every scenario related to infectious diseases. The ongoing COVID-19 pandemic has already shown us that.

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