HEALTHCARE WASTE, LEGISLATION AND IMPLICATIONS FOR PUBLIC HEALTH: EXPLORATIONS THROUGH THE ONE HEALTH APPROACH

Thesis submitted to Jawaharlal Nehru University in partial fulfillment of the requirements for the award of the degree of

DOCTOR OF PHILOSOPHY

By

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DECLARATION

Date: 23 December 2021

This is to certify that the thesis titled "Healthcare waste, Legislation and Implications for Public Health: Explorations through the One Health Approach" submitted by me under the guidance of Prof. Rajib Dasgupta for the award of the degree of Doctor of Philosophy is my bonafide work and has not been previously submitted for any other degree of this university or any other University.

Place: New Delhi

Date: 23 December 2021

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CERTIFICATE

It is hereby recommend that this thesis may be placed before the examiners for evaluation.

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CONTENT

LIST OF ACRONYMS

ABR	Antibiotic Resistance
AES	Acute Encephalitis Syndrome
AFI	Acute Febrile Illness
AIDS	Acquired Immune Deficiency Syndrome
AMO	Ayurvedic Medical Officer
AMR	Antimicrobial Resistance
ANM	Auxiliary Nurse Midwife
APIs	Active Pharmaceutical Ingredients
ARBs	Antibiotic Resistant Bacterias
ARGs	Antibiotic Resistance Genes
ASHA	Accredited Social Health Activist
AYUSH	Ayurveda, Yoga and Naturopathy, Siddha, and Homeopathy
BAMS	Bachelor of Ayurveda, Medicine and Surgery
BCG	Bacille Calmette-Guerin
BMW	Biomedical Waste
BMWM	Biomedical Waste Management
BTU	British Thermal Unit
CAG	Civic Action Group
CBMWTF	Common Biomedical Waste Treatment Facility
CCHF	Crimean Congo Hemorrhagic Fever
CDC	Centre for Disease Control and Prevention
CHCs	Community Health Centers
CNG	Compressed Natural Gas
CPCB	Central Pollution Control Board
CTE	Consent to Establish

CTO	Consent to Operate
CVDs	Cardiovascular Diseases
CWTDF	Common Waste Treatment & Disposal Facility
DAHD	Department of Animal Husbandry and Dairying
DALYs	Disability-Adjusted Life Years
DDT	Dichlorodiphenyltrichloroethane
Delhi NCR	Delhi National Capital Region
DGHS	Director General of Health Services
DH	District Hospital
E.coli	Escherichia Coli
ECHS	Ex-Servicemen Contributory Health Scheme
EHS	Environmental Health Sciences
EIC	Expected Introductory Concentration
ESI	Employee State Insurance
ETPs	Effluent Treatment Plants
FAO	Food and Agriculture Organization
FDA	Food & Drug Administration
FSSAI	Food Safety & Standards Authority of India
GDP	Gross Domestic Product
GHSA	Global Health Security Agenda
GoH	Government of Haryana
GoI	Government of India
GPS	Global Positioning System
HCDS	Healthcare Delivery System
HEPA	High-Efficiency Particulate Absolute
HI	Health Inspector
HIV	Human Immunodeficiency Virus

HSPCB	Haryana State Pollution Control Board
HWCs	Health & Wellness Centers
ICMR	Indian Council of Medical Research
IDSP	Integrated Disease Surveillance Programme
IMEP	Infection Management Environment Plan
IPC	Infection Prevention and Control Programme
IPD	In-Patient Department
IV	Intra-venous
JE	Japanese Encephalitis
KCEHMM	Kanji- Chopra Environmental Health Model
KFD	Kyasanur Forest Disease
LHV	Lady Health Visitor
LT	Lab Technician
LUVAS	Lala Lajpat Rai University of Veterinary & Animal Sciences
MBBS	Bachelor of Medicine and Bachelor of Surgery
MCD	Municipal Corporation of Delhi
MCH	Maternal and Child Health
MDR	Multi Drug Resistant
MERS	Middle East Respiratory Syndrome
MoEFCC	Ministry of Environment Forest & Climate Change
MoHFW	Ministry of Health and Family Welfare
MPHW	Multi-Purpose Health Worker
NABH	National Accreditation Board for Hospitals & Healthcare Providers
NCD	Non-Communicable Disease
NEAA	National Environment Appellate Authority
NGT	National Green Tribunal
NHM	National Health Mission

NHS	National Health Services
NIAB	National Institute of Animal Biotechnology
ODF	Open Defecation Free
OIE	World Organization for Animal Health
OPD	Out Patient Department
PHCs	Primary Health Centers
PIL	Public Interest Litigation
POPs	Persistent Organic Pollutants
PPE	Personal Protective Equipment
PPM	Particulate Per Million
PPP	Public Private Partnership
PVC	Polyvinyl Chloride
RCTs	Root Canal Treatments
RCZI	Roadmap to Combat Zoonosis in India
RHS	Rural Health Statistics
RMPs	Registered Medical Practitioners
RNA	Ribo Nucleic Acid
RNTCP	Revised National Tuberculosis Control Programme
SARS	Severe Acute Respiratory Syndrome
SARS-Cov-2	Severe Acute Respiratory Syndrome- Cornonavirus-2
SBM	Swachh Bharat Mission
SCBMCH	Srirama Chandra BhanjaMedical College& Hospital
SCs	Sub-Centers
SDGs	Sustainable Development Goals
SDH	Sub Divisional Hospitals
SMO	Senior Medical Officer
SOPs	Standard Operating Procedures

SPCB	State Pollution Control Board
SRA	Strategic Research Agenda
STPs	Sewage Treatment Plants
TB	Tuberculosis
TDS	Total Dissolved Solids
UHC	Universal Health Coverage
UK	United Kingdom
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
UNSC	United Nations Security Council
USA	United States of America
USD	United States Dollar
USEPA	United States Environment Protection Agency
VLDA	Veterinary & Livestock Development Assistants
WB	World Bank
WCED	World Commission on Environment and Development
WHO	World Health Organization
WTO	World Trade Organization
ZLD	Zero Liquid Discharge

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CHAPTER 1

INTRODUCTION TO THE ENVIRONMENT, DEVELOPMENT AND HEALTHCARE WASTE

1.1 HEALTHCARE WASTE AS AN ENVIRONMENTAL EXTERNALITY

Industrialization-led economic growth-oriented development catalyzed by advancements in technology has put enormous pressure on the biosphere. Byproducts of industrial growth have deteriorated the condition of our physical environment, viz. air, water, and soil. Large-scale industrialization has led to the frequent migration from rural to urban areas. It has given rise to unplanned and dense human settlements, poor housing and sanitation, inadequate drinking water supplies, and exposure to a wide variety of toxic pollutants, which is detrimental to health and well-being. Poisonous air due to a mix of vegetable putrefaction, gases of animal substances, exaltations from contaminated streams, and the enormous amount of carbonic acid gases engendered by respiration and fire led to chronic respiratory infections among dwellers. Also, it led to low vitality and physical and mental lassitude. The infected air and water are the potent sources of epidemics in such settlements. A high prevalence of Human Immunodeficiency Virus (HIV) /Acquired Immune Deficiency Syndrome (AIDS) and Tuberculosis (TB) in poorly developed slums in the developing world can be correlated with high infection/ fever in the working-class of industrialized Britain in the early 19th century.

In addition to infectious diseases, chronic diseases like respiratory and cardiovascular diseases (CVDs) have their environmental linkages. Careful analysis of mortality and morbidity patterns in different settlements motivated the authorities to establish sanitary reforms. However, today's industrial and urbanized world carries lot more complexities. Change in the natural environment has affected human health and well-being through multiple pathways. Food habits, psychological and behavioral aspects of human lives have changed drastically. Newer hazardous pollutants are emerging day by day. Human beings get exposed to these pollutants. Healthcare waste generated from various healthcare and industrial activities is one such potential pollutant that poses severe risks to the environment and human health. Like most human activity or intervention, healthcare activities at the institutional and household levels result in adverse environmental externalities. Healthcare waste, treated and untreated, deteriorates the quality of the natural environment and hence affects the health of human beings and other organisms in the ecosystem through multiple channels. Moreover, the generation of healthcare waste or Biomedical Waste (BMW) is not restricted to healthcare activities. Other industrial and agricultural activities like meat production also result in BMW generation, which negatively affects our environment.

1.2 HEALTHCARE WASTE; INTRODUCTION, TYPES AND DISPOSAL

Large-scale sectoral developments in medical technology, agriculture, industrial infrastructure, and newer sectors like information technology have resulted in more content, lavish, and comfortable lives for human beings. However, this economic growth-oriented development has impacted the environment's health in various ways. India's population is getting urbanized under the influence of the macroprocess of development mediated by industrialization and urbanization. In the wake of the growing medical needs of the Indian population due to increased urbanization, healthcare facilities are attempting to keep up (Manzoor & Sharma, 2019). This has led to the growth in waste generation from various sectors, including the medical sector.

"*Healthcare waste is the waste generated by health care activities including a broad range of materials, from used needles and syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices and radioactive materials"* (World Health Organization, 2018).

1.2.1 Healthcare Waste: General Introduction

Waste generation is an unavoidable outcome of healthcare facilities and procedures. An increase in healthcare infrastructure in the public and private sectors has led to an increase in healthcare waste generation. Additionally, disposable materials have increased with the advancements in healthcare technology. This has also led to the enhancement of the problem (Sengodan, 2014). Healthcare facilities nowadays are becoming the epicenter of diseases. The waste generated by them contains potentially harmful microorganisms that could harm visiting patients and their attendants, healthcare workers, and the general public. Other potential infectious risks due to drug-resistant microorganisms may also spread from health facilities to the environment (WHO, 2018). These microorganisms may show antimicrobial resistance (AMR) and are potential contaminants for hospital surfaces and materials. A study of sanitary landfill sites with medical waste in Brazil demonstrated the presence of highly antimicrobial strains of *staphylococcus* bacteria. Overall, only 23 percent of the bacteria were susceptible to all drugs. These putative pathogens in healthcare waste carry important resistance markers (Nascimento, 2015). Among other adverse effects, healthcare waste could result in radiation burns, sharp inflicted injuries, poisoning, and pollution by releasing pharmaceutical products (antibiotics and cytotoxic drugs) in the environment. Also, it may harm the environment through poisoning and pollution by wastewater, by toxic compounds like Mercury (WHO, 2018). Out of the total healthcare waste generated, 85 percent is general non-hazardous waste, whereas the remaining 15 percent is considered hazardous, which could be infectious, toxic, and radioactive (WHO, 2018). Where healthcare waste is incinerated, air pollutants like Dioxins, Furans, and other pollutants may be produced as emissions (WHO, 2018).

Globally, 16 billion injections are administered yearly, but not all the used syringes and needles are disposed of safely. These create opportunities for injuries and infections along with their reuse (WHO, 2018). Additionally, there are chances of injuries and infection to the scavengers of healthcare waste at the disposal sites or while sorting out healthcare waste from healthcare facilities. These scavenging practices are common in many parts of the world, especially in low and middle-income countries. Occupational exposure to municipal and hospital waste collection workers has been the subject of many studies in the light of increased public concern about environmental and workers' health issues (Ferreira et al, 1999).

1.2.2 Types of Healthcare Waste

Healthcare waste or BMW includes all the waste (biological or non-biological) generated as a result of various healthcare activities. Further, this waste can be grouped as; medical waste, infectious waste, and domestic waste (Acharya et al, 2016).

- Medical waste: It includes waste generated due to patient diagnosis, treatment procedures, immunization, and other healthcare activities. Chemical waste such as laboratory chemicals, disinfectants, pharmaceutical waste in the form of expired or discarded medicines, cytotoxic substances, radioactive substances, and contaminated items (equipment or disposable) constitute the majority of medical waste.

- Infectious waste: It is a portion of medical waste that is in contact with a patient or infected individuals and can produce an infectious disease. If medical and other wastes are not collected separately, the majority of this waste is considered infectious waste. It is suspected to carry pathogens of a wide variety (Viruses, Bacteria, Fungi, or Parasites), which can cause diseases in susceptible hosts. Blood contaminated articles or equipment are a potential source of pathogens.

- Domestic waste: Healthcare provisioning and activities also result in the generation of domestic or general waste having similar characteristics to municipal solid waste.

In addition to the waste categories mentioned above, chemical waste contributes to a large proportion of BMW. It may contain volatile heavy metal compounds, the non-halogenated mixture of laboratory solvents, the halogenated mixture of solvents, noxious chemical substances in water solutions, and expired laboratory reagents. Additionally, many chemical compounds, such as Formaldehyde, photographic chemicals, and solvents, are used for cleaning operation equipment and premises of institutions. Moreover, many organic and inorganic chemicals commonly used in healthcare facilities contribute to the overall quantum of BMW. Few gaseous compounds are also used in healthcare operations, such as gases used in anesthesia, Ethylene Oxide, and Nitrous Oxide, which may pose serious challenges to healthcare workers and sanitation workers. Few specialized healthcare activities use some genotoxic compounds, like cytotoxic drugs and Benzene (Acharya et al, 2014).

Most studies have demonstrated that about 80 percent of the waste generated from healthcare activities and processes is general waste, and the rest 20 percent is hazardous waste. This hazardous proportion of waste may be toxic, infectious, and radioactive in nature. In addition to healthcare activities carried out at health institutions, a variety of healthcare activities are executed in a scattered manner at household levels or by informal healthcare workers practicing medicine out of institutions or in the field settings that generate BMW. Similarly, such activities are prevalent in veterinary medicine also, which results in the generation of BMW. Hospitals in major cities generate around 30 tons of BMW every day (Manzoor & Sharma, 2019). Various data sources reflect that only 10-25 percent of total BMW is hazardous. However, inadequate segregation and further mixing it with solid and general waste enhance the quantum of hazardous waste. Hazardous waste comprises infectious waste, radioactive waste, pathological waste, and chemical waste, etc.

1.2.3 Healthcare Waste Generation

Healthcare waste is generated from healthcare activities of wide varieties. A more significant proportion of it is generated from different types of healthcare facilities. The quantity of healthcare waste generated depends upon the size and type of healthcare facilities. Apart from human healthcare facilities, healthcare waste is generated from veterinary facilities. Additionally, along with treatment facilities, healthcare waste is generated from laboratories, other diagnostic facilities, agricultural processes, livestock and meat industries, and pharmaceutical industries.

If the segregation of waste (hazardous and non-hazardous) is not done properly at the point of generation, non-hazardous waste could become infectious and prove harmful. This would also increase the cost of handling BMW. According to World Health Organization (WHO), the rate of hazardous waste generation in high-income countries is 0.5 Kg/bed/day, whereas, in low-income countries, it is around 0.2 Kg/bed/day. Some studies report BMW generation in the range of 0.71 to 2.31 Kg/bed/day. BMW generation was 61.3 gm/day/bed in a teaching hospital of Coimbatore (Sengodan 2014). The total quantity of BMW generated in Bangalore is 40 tons/day. Out of this, 45-50 percent is infectious. Segregation is done only in 30 percent of the hospitals (Banstola et al, 2017). Another study conducted in 14 hospitals in Pokhra, Nepal, revealed that BMW generation ranges from 0.33 to 1.96 Kg/bed/day. The quantity of BMW generated (in Kg/bed/day) is about 4.5 in the United States of America (USA), 2.7 in the Netherlands, 2.5 in France, and 2.63-3.8 in Latin American countries. The production ratio of infectious waste (in Kg/bed/day) in the USA is 1.2, 0.8 in Japan, 0.4 in Singapore, 0.2 in India, 0.1 in Bangladesh, Pakistan, and Sri Lanka. The percentage of hazardous waste in Denmark is 5 percent and 28 percent in the USA (Banstola et al, 2017). Hospitals with surgical and maternity services produce more waste than hospitals with eye and dental services

(Banstola et al, 2017). However, in low-income countries, often hazardous waste is not separated from non-hazardous waste making the actual quantity of hazardous waste much higher (WHO, 2018). Also, it is demonstrated that if segregation of waste is done correctly, it could also decrease BMW generation (Sengodan, 2014). This study had reported a decrease in BMW generation despite an increase in inpatient number in 2012.

1.2.3.1 BMW in Domestic/Animal Husbandry/Meat Industry Waste

Home management of illnesses is common in many developing countries, especially in countries that account for higher out-of-pocket expenses for the management of illness due to weak regulatory affairs. Moreover, generation of medical waste at household is unavoidable to a certain extent, e.g., discarded sanitary napkins, discarded pharmaceuticals, and disposable syringes and needles, especially from households having cases of insulin-dependent diabetes. These activities produce medical waste, which could be harmful to the environment and community health as this waste is not treated or disposed of in similar ways as hospital-generated medical waste. Medical waste generated from households is generally perceived to be less harmful than facility-generated medical waste. However, hospital waste may find its way to proper disposal, whereas household-generated medical waste is often amalgamated with general household waste and disposed of to open landfill sites. The quantity of household medical waste may reach up to 0.1 percent of the total mixed municipal solid waste stream (Yordanova et al, 2014).

Human and animal excreta, usually not considered as BMW, can be considered as BMW under certain circumstances. However, it is the channel through which many microorganisms and Active Pharmaceutical Ingredients (APIs) circulate in the environment and may pose serious challenges for the environment and human and animal health. Many microorganisms and viruses are transmitted through the fecal-oral route in animals and humans. Human and animal excreta containing these microorganisms in abundance could increase exposure to disease causative microorganisms. Similarly, a lot of pharmaceutical compounds are consumed by both human beings and animals for various therapeutic and non-therapeutic purposes. These compounds are partially metabolized and may get released into the environment through excreta and urine. These partially metabolized pharmaceutical compounds, especially antibiotics, may lead to resistance of various kinds in humans and animals. Therefore, technically human and animal excreta carry the properties of BMW and may affect the environment and human health adversely. Excretory products also help in maintaining and circulating Antibiotic Resistance Genes (ARGs) in the environment (Li et al, 2014). Therefore, ARGs are disseminated into the receiving environment (air, soil, and water) and enhance the likelihood of increased exposure to the agriculture workers or people involved in animal husbandry (He et al, 2020).

Animal and poultry farming for meat yielding also leads to the generation of a lot of BMW in the form of anatomical waste such as animal leftover parts (blood, body fluids, bones, skin, head, and intestine). Such anatomical waste contains, harbors, and may transmit various harmful pathogens to the susceptible hosts. These leftover parts may also lead to the release of ARGs and APIs into the environment, if not adequately disposed of. Therefore, there are several pathways and channels for the circulation of microorganisms, APIs and ARGs in the environment.

1.2.3.2 Dental Waste

Waste generated from various dental practices may contain Amalgam (Mercury and Silver alloy), fixer and developers, dental bitewings, empty Amalgam capsules, discarded lead shields, and disinfectants with high or low concentrations of Formaldehyde or Glutaraldehyde. The waste could also contain hazardous heavy metals like Chromium and Cadmium. This waste has the potential to affect human and environmental health. Amalgam may act as a neurotoxin and is considered to be the most toxic non-radioactive element. Additionally, dental waste may include waste generated from routinely used consumables such as rubber gloves, disposable needles and syringes, and other chlorine-containing materials (Adedigba et al, 2010).

Fixer solutions used for X-ray developments must be processed to recover Silver. Amalgam contains Mercury and Silver; therefore, it cannot be incinerated as it may lead to the production of harmful vapors, which may enter into the food chain of the organisms. Lead foiled packets and aprons are also to be treated and recycled. Using chair-side traps to prevent Amalgam from going into the drains is advised. Open dumping of such waste could lead to huge and long-term environmental contamination and hence could affect animals and human beings adversely (Adedigba et al, 2010).

1.2.3.3 Composition of BMW

WHO has emphasized that segregation of BMW at source is the key to adequate and proper BMW Management (BMWM) as only 15 percent of the BMW is the infectious waste. Inadequately segregated waste could turn non-infectious general waste into infectious waste. Infectious waste varies considerably in its composition; celluloid material (paper and cloths) constitutes 50 to 70 percent of infectious waste. 20-60 percent is plastic waste, 10-20 percent is contributed by glassware, and fluids may contribute about 1 to 10 percent. It may have a total moisture content of 8.5 percent to 17 percent, 8 percent incombustible by weight, and a heating value of 7500 British Thermal Unit (BTU)/lb (Tiwari & Kadu, 2013). A study conducted by Al-Salam (2010) in Damanhour city demonstrated that hazardous waste in hospital waste was 38.9 percent. Twenty years back, Indian hospitals were generating between 0.5 to 2.0 Kg/bed/day BMW. Infectious waste contribution to this waste was 30-35 percent, and disposable syringes constituted around 0.3 to 0.5 percent of the BMW (Patil & Shekdar, 2001). Nepal was estimated to generate 1.7 Kg/person/day hospital waste. Out of which around 30 percent pose serious challenges to the health of communities (Joshi, 2013).

Different studies have demonstrated the composition of BMW generated from various healthcare activities differently. It was agreed that infectious and hazardous waste might constitute between 15 to 40 percent of BMW. This variation, in turn, depends upon the handling practices of BMW. Inappropriate segregation of BMW at the source may lead to an increase in the proportion of infectious and hazardous BMW.

1.2.4 Disposal of BMW

Improper treatment and disposal of healthcare waste pose a health risk due to the release of toxic pollutants and pathogens into the environment. Landfills in residential areas or inhabited areas could lead to serious health problems through contamination of drinking water. Inadequate incineration of unsuitable healthcare waste is also a serious threat to the environment and human health. The absence of a proper waste management system, lack of awareness about its health hazard, insufficient financial resources, and untrained human resource, along with poor control on waste disposal, are the most critical problems faced concerning healthcare waste management (Das & Biswas, 2016).

Developing countries usually employ open landfills and burning as a waste disposal method for various reasons such as resource crunch. Problem is compounded manifolds when medical waste from various sources finds its way to open dumpsites along with municipal solid waste (Ali et al, 2013). However, the quantity of BMW in total municipal solid waste is around 1 percent to 1.5 percent (Tiwari & Kadu, 2013). Another study conducted by Ali et al (2016) in Gujranwala, Pakistan, demonstrated that in the wake of limited compliance to the environmental legislation, a considerable amount of BMW is transported and disposed of along with solid municipal waste at open landfills or dumpsites. Manual scavengers with bare hands extract recyclable items from this waste to sell it in the market.

Though public awareness regarding the adverse effect of healthcare waste has improved considerably, there are still huge gaps to be filled out in terms of disposing of healthcare waste properly. Healthcare waste of wide characteristics is generated from various medical treatments. WHO/ United Nations Children's Fund (UNICEF), in a joint assessment in 2015, found that only 58 percent of facilities from 24 countries had an adequate system in place for the safe disposal of healthcare waste (WHO, 2018). Healthcare waste management received little attention in Southeast Asian countries until the last millennium. With the outbreak of Severe Acute Respiratory Syndrome (SARS) in 2002, many countries reviewed their healthcare waste management system, which was further catalyzed by the Avian flu (H5N1) outbreak (Kuhling & Pieper, 2012).

Convention waste treatment technologies are not designed to remove ARGs and Antibiotic Resistance Bacterias (ARBs). Even the most effluent treatment plants and hospital/ municipal wastewater treatment plants can partially remove their concentration from these sources (He et al, 2020). However, it has been demonstrated that composting process or usages of additives may significantly remove or decrease the abundance of ARGs in manure by decreasing the bioavailability of heavy metals in the waste (Awasthi et al, 2019).

1.2.5 Environmental Externalities of BMW

One of the fundamental ethics of healthcare practice is *‘do not harm’* but ironically, healthcare services cause significant pollution and consequently indirect adverse effects on public health (Eckelman & Sherman, 2016). It has been argued that every decision/ choice we make affects our environment positively or negatively. These associated environmental externalities, in turn, affect our health positively or negatively. Investments in unsustainable technologies, the establishment of industries, deforestation for industrial activities, and relocation of hazardous industries like pharmaceutical industries from developed countries to developing or poor countries have affected the natural environment adversely in these countries. The deterioration in the air quality of Delhi National Capital Region (Delhi NCR) is a recent example of the deterioration of the natural environment or negative environmental externality due to poor environmental decision-making. Although healthcare institutions and services are necessary components of social services, choices of technology employed for health services provisioning along with mismanagement of healthcare waste has resulted in negative environmental externalities. Report of UNCED (1999) has mentioned that 5.2 million people, including 4 million children, die from waste-related diseases. WHO has estimated that 21 million Hepatitis B infections, 260000 HIV infections, and 2 million Hepatitis C infections per year are caused by contaminated syringes. In the recent past, the growth of the medical sector globally is combined with the increased use of disposable items, which has resulted in a considerable increase in healthcare waste generation (Syed et al, 2012).

Concerns related to global warming and rising surface temperatures have been mounting since the 1980s. Additionally, this debate is compounded by decreasing natural energy resources and increasing energy costs. Quantification of emissions and disease burden due to adverse effects of healthcare services is critical to improving the safety and quality of the healthcare services to guide mitigation and improvement strategies to leverage health care leadership in sustainable development (Eckelman & Sherman, 2016). Health professionals and researchers are leading advocates of this debate. However, the health sector is one of the major contributors to this process. Healthcare establishments consume energy to provide services viz. power for medical equipment and procedures, lighting, water resources, air conditioning, heating, procurement services, laundry, kitchen and generate wastes of variety. Apart from direct energy consumption, carbon emission from healthcare services is a significant concern. Also, there are a number of healthcare services that are non-institutional in nature and provided by a variety of health practitioners, especially in developing countries, are responsible for direct or indirect energy consumption and various emissions (greenhouse gases or pollutants).

There have been very few efforts towards measuring the environmental and economic sustainability of health services. The health sector is poorly represented or studied in terms of greenhouse gas emissions and energy consumption. Research scholars with a background in engineering, architecture, and environmental sciences have made some efforts in this direction. Hospitals are considered energy-intensive buildings. In the USA, hospitals are the second most energy-intensive buildings after food service facilities (Eckelman & Sherman, 2016). The most notable effort was made by National Health Services (NHS) Britain, which estimated that total carbon emission due to its activities was 21.3 million metric tons in 2004, equivalent to 426 Kg/person. A similar study of the USA healthcare system demonstrated that the USA health services were responsible for a total of 545.5 million metric tons of carbon emission in 2007, i.e., 1510 Kg/person. This difference may be attributable to factors like per capita health expenditure in the USA, which is 240 percent higher than that of the UK. USA spent nearly one-fifth of its Gross Domestic Product (GDP) on healthcare with approximately 3 trillion US Dollars (USD) in 2013. There has been over a 30 percent increase in carbon emission from USA healthcare activities in the past decade. (Eckelman & Sherman, 2016). More than 50 percent of the emission comes from upstream or downstream production and waste management practices. Emission from health services activities in the USA is comparable to other sectors (Brown et al, 2012).

Populations living in different corners of the globe exert differential pressure on the biosphere. Australia’s total carbon emission in 2007 and 2008 was reported to be around 547 and 553 million metric tons of CO_2, which is comparable to the carbon emission of the USA health services alone (roughly 7 percent of total carbon emission by the USA in 2007). Another study estimated that the USA healthcare services are responsible for 8 percent carbon out of total USA carbon emissions (Eckelman &

Sherman, 2016). It means a 10 percent reduction in the USA healthcare carbon emission would mean a total of 10 percent carbon emission reduction of Australian carbon emission (Brown et al, 2012). The USA healthcare system is responsible for a significant fraction of national air pollution emissions and impacts, including acid rains (12 percent), air pollution (9 percent), smog formation (10 percent), greenhouse gas emission (10 percent), stratospheric ozone depletion (1 percent) and carcinogenic and non-carcinogenic air toxins (1-2 percent) (Eckelman & Sherman, 2016). Some health systems have tried to reduce their carbon emissions by employing green procurement strategies and adopting effective and sustainable waste management practices.

Greenhouse gases are a critical category of emissions from healthcare activities that may pose severe and negative consequences for the environment and human health. There are several other pollutants and emissions which are resulted from a variety of healthcare services that impact the environment and health directly or indirectly. Healthcare waste contains highly toxic chemicals, substances like poisonous metals, pathogenic viruses and bacteria, pharmaceutical compounds, especially antibiotics and other cytotoxic pollutants, which pose a serious threat to the environment and human health. The healthcare sector is interconnected to various other industries like the pharmaceutical and medical devices industry. These industries are responsible for multiple emissions (particulate matter, Sulfur, Nitrogen Oxides, persistent organic pollutants and toxic metals) at their level (Eckelman & Sherman, 2016). Medical waste poses a serious health risk for patients, attendants, doctors, nurses, and other staff working in a healthcare establishment (Hassan et al, 2008).

There are various strategies and methodologies employed to estimate the environmental and health impacts of healthcare services. Researchers have tried to establish linkages between adverse environmental conditions and disease burden due to healthcare activities. Studies conducted by NHS measured carbon emission due to healthcare activities in NHS. Another study conducted by Eckelman and Sherman (2016) tried to demonstrate emissions per dollar expenditure on healthcare activities and attempted to link these emissions with different categories of diseases. Further, this study tried to calculate the associated disease burden in terms of Disability-Adjusted Life Years (DALYs). These specific efforts were made by certain developed countries like USA and UK. However, the capacities of most countries to monitor environmental and biological exposures remain inadequate, and many developing countries still lack comprehensive policies to deal with healthcare waste effectively.

ABR, a burning issue in the current scenario, is often conferred by specific genes called ARGs. Human activities like healthcare waste generation and the failure of wastewater treatment facilities in removing these genes from the wastewater have resulted in the accumulation of ARGs in the environment. Similarly, many industries like pharmaceuticals are also responsible for these problems (Singhal et al, 2017).

1.3 DEVELOPMENT AND ENVIRONMENT

Various human activities have led to multiple environmental and health impacts. A minimal emission level and subsequent health impacts are inevitable as these developmental activities and services are required. But unjustified use of resources and unsustainable developments lead to adverse environmental consequences. After independence, India followed the colonial root of development based on extensive use of natural resources. Undue emphasis was laid on economic growth, which was envisaged to be achieved by setting up industries, urban infrastructure, green revolution, construction of dams, etc. Resource-intensive industrialization, technicalization, and commercialized agriculture are hallmarks of development in India, which is growth-oriented in nature. Adverse environmental changes are resultant or one of the major outcomes of such a developmental model. These changes have led to ecological imbalances, which are complex in nature (Nayar, 1998). Undue emphasis on economic growth, which is resource-intensive, has undermined the relationship between humans and ecology.

Large-scale industrialization, urbanization, and consumer needs have led to the deterioration of the natural environment. The process of industrialization-led and technology-oriented development has adversely affected the various pathways and mutual transactions between the natural environment and the human population.

Friedrich Engels described the condition of early 19th century Britain when it was undergoing colossal industrialization. It is a classic example of human-led exploitation of the natural environment and its effects on human health. Both atmosphere and environment were conducive to the transmission of infection among dwellers of lower socioeconomic strata. While describing the "conditions of working-class in England", Engels proved these facts 180 years back, much before the modern era of microbiology. Poor living conditions viz. environmental conditions, poor housing conditions, poor sanitation, a diet without nutrition, and inadequate clothing resulted in the ill health of the working-class in Britain at the time of industrialization. Having known that diseases or deaths are inevitable consequences, people were forced to live in those miserable conditions. Engels very rightly labeled it as "social murder."

Similar trends of industrialization and urbanization of Britain in the early 19th century could be observed in modern Indian cities. After independence, India continued to follow the colonial development model, which was based on the exploitation of natural resources and investment in exploitative industrialization and technology. This development has led to large-scale migration from rural areas to industrial cities.

The green revolution in India is considered as one of the major components of economic growth, achieved by India with the help of international aid. Agricultural District Programme was initiated in certain elite districts of India. It was based on strategies of external inputs where credit became necessary. Fertilizers and pesticides were extensively used. Many studies have suggested that this model of agriculture development has resulted in ecological problems. This model did not help the poor to come out of the cycle of poverty but only benefited a certain section of the agriculture community (Nayar, 1998). Apart from the green revolution, a technology-oriented and resource-intensive approach of development was adopted for the large-scale industry setup. These industries have resulted in deforestation, depletion of natural resources, etc., which ultimately have resulted in soil, water, and air pollution leading to further ecological imbalances. Also, large-scale industrialization has resulted in out-migration from rural to urban areas leading to unplanned growth of cities and increased urbanization, which is putting enormous pressure on the biosphere. These growth patterns have been experienced in the past by today's developed world. Engle had described the condition of the English working-class in his writings. These environmental problems led to the deterioration in health conditions of the population at a large scale. Such growth patterns affect the condition of healthcare infrastructure and the health of the people. An American spends twice on healthcare than other industrialized countries without commensurate health benefits.

Development in healthcare technology and institution-based care has resulted in highly energy-intensive healthcare services systems around the globe. USA spent around 3 trillion USD on healthcare in 2013, roughly one-fifth of its GDP (Eckelman & Sherman, 2016). Extensive usage of pharmaceutical products, especially antibiotics, has resulted in ecological imbalances. APIs are a serious threat to the environment. Unorganized and inappropriate disposal of general and healthcare waste may pose huge risks to human health and the health of other organisms in an ecosystem.

There is mounting evidence that economic growth-oriented development did not result in the well-being of the poor. However, in the developed world, the feasibility of more economic growth was questioned due to increasing environmental concerns. Stockholm Conference of 1972 echoed the ideological difference between developed and developing countries when India declared ‘Poverty as Greatest Polluter’ and criticized developed countries for their resource-intensive development. Sustainable development is a fashionable buzzword in today’s world that came to the forefront after the “World Commission on Environment and Development” (WCED) report. It implies meeting the need of current generations without compromising the ability of future generations to meet their requirement. Sustainable development can become pro-poor only if it starts with affluence and results in the unsustainability of the rich (Nayar, 1998).

The sustainable development debate shifted the concerns of contradiction between development and environment to means of sustainable development. The question is no longer asked as; do development and environment contradict each other? Traditional development patterns have undermined ecological sustainability, whereas rhetoric of sustainable development is expected to meet and carry forward ecological sustainability. However, there is an absence of theoretical and analytical frameworks, which makes it difficult to interpret whether modified policies and strategies will result in an environmentally sound form of development. Sustainable development is often used interchangeably with environmentally sound and ecologically sustainable development (Lele, 1991).

1.3.1 Urbanization and Industrialization

Cities have expanded and multiplied rapidly worldwide over time, especially in the last two centuries. Cities may be perceived as the engine of economic growth, but at the same time, they are sources of poverty, inequality, and health hazard. The urban population has increased from 5 to 50 percent in the last two centuries (McMicheal, 2000). Increasing urbanization reflects other changes like growing industrialization and migration from rural to urban areas searching for employment to avoid food insecurities. With urbanization and industrialization comes the problem of inadequate housing, sanitation, clean drinking water supply, and disease and deaths. This process of industrialization and urbanization started way back with the industrial revolution in Europe.

With increased urbanization and industrialization, human beings are posing enormous pressure on the biosphere or natural environment. Any alteration in the external environment of humans can affect a broad array of diseases and health and its behavior and impact on a population in an unpredictable manner (Portier, 2011). The modern urban environment combines industrialization, crowding, waste generation, and dense transport system compounded by peri-urban poverty that surrounds most cities in developing nations pose various environmental hazards to the population. The growth of slums and shantytowns in and around cities is an expression of persistent and widening economic inequalities. Worldwide, poorer residents of large cities bear the brunt of environmental degradation as industrial activities are often concentrated near impoverished communities.

Urbanization process may affect broad array of infectious diseases. Many diseases are re-emerging, like vector-borne diseases and various newer infections coming up with changing relationship of human beings with environment. Inadequate sanitation compounded by overcrowding is creating opportunities for otherwise marginal microbes. The urban population faces various specific environmental hazards which make it vulnerable to many diseases. This process was very well captured and reflected by Engels in his writings. Additionally, urban ecological footprints pose challenges for global sustainability. The urbanized developed world consists of one-fifth of the world's population, but it is responsible for about three-quarters of all human-made emissions of greenhouse gases. Contribution of developed countries to such environmental externalities is huge e.g., 500000 residents of Vancouver who occupy just 11400 hectares use ecological output and services of 2.3 million hectares. The scale of these environmental externalities is growing (McMichael, 2000).

1.3.2 Globalization

Economic globalization has resulted in an international division of labor. In particular, the manufacturing of low-end products and low-end processes (industry causing more pollution) has widely been outsourced to developing countries where labor is cheap, and workplace standards are unregulated[2].

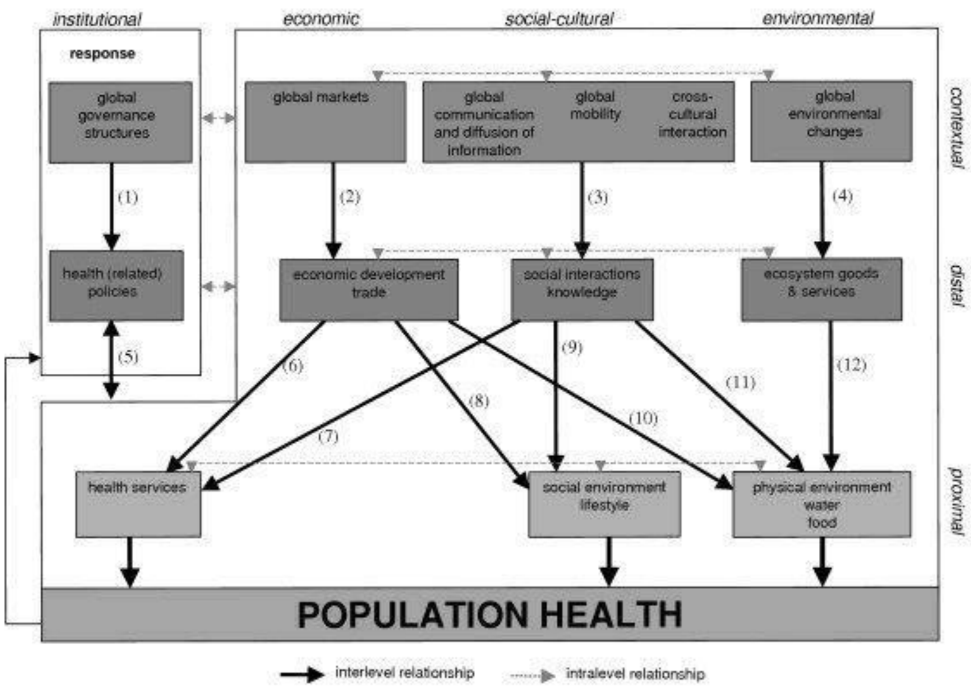
International laws like *'The Hatch Waxman Act'* promoted the outsourcing and production of generic medicines, especially in third-world countries like India. Central Pollution Control Board (CPCB) and Ministry of Environment Forest and Climate Change (MoEFCC) placed the pharmaceutical industry among 17 highly polluting industries (Mathew & Unnikrishnan, 2012).

As discussed in previous sections, the health of human beings is resultant of various socioeconomic, political, cultural, and ecological phenomena. Therefore, human health is an integrated outcome of these determinants. These determinants are further influenced and affected by large-scale processes such as globalization. It is a *"complex phenomena: it is interactive co-evolution of multiple, technological, cultural, economic, institutional, social and environmental trends at all conceivable spatiotemporal scales"* (Huynen et al, 2005, p.2). Globalization is characterized by global integration and intensification of economic, environmental, cultural, political, and social processes at various levels such as national, state, etc. These processes operate at different hierarchical levels and dynamically affect human health and the environment through different pathways. With globalization, there comes; global trade-in markets, global governance through agencies like WHO and World Bank (WB), global communication, cross-cultural interactions, global mobility, and global environmental changes. Globalization affects the interdependence among the various nations. Climate changes, ozone depletion, global decline in the quality of the natural environment are global environmental threats.

These processes and features of globalization operate at different contextual levels of health determinations and affect human health by influencing various distal and proximal factors. The process of globalization also influences the distal and proximal factors by influencing the contextual determinants (e.g., global governance structures like WHO) at the institutional, economic, sociocultural, and environmental levels.

Distal factors are health policies, trade, economic development, social interaction, and ecosystem goods. WHO and WB are the two most essential agencies responsible for global governance, health-related trade-off, formulating programmes and policies, and other structural adjustment programmes. World Trade Organization (WTO) provides a framework for protecting the population from the health hazards of free trade between nations. Further, these distal factors influence more proximal factors, which have the potential to affect human health directly and immediately, like health services, drinking water supply, environmental pollution, nutrition, sanitation, etc. Food, water, and the quality of the physical environment are major proximal factors that affect human health. At the environmental level, effects of globalization manifested through global environmental changes, e.g., relocation of hazardous industries from a developed nation to third-world countries. Processes like this adversely affect the quality of the natural environment and ecosystem in these countries. Further, the quality and quantity of food and water deteriorated in these regions due to unfair trade-offs. Similarly, globalization operates at different hierarchical levels and affects the quality of the environment and human health through different pathways and linkages (Figure 1.1) (Huynen et al, 2005).

Figure 1.1 Conceptual Model for Globalization and Population Health



Source Huynen et al, 2005*

Globalization has resulted in the creation of global markets. A variety of goods and services are traded in these markets. These goods and services may affect human health directly or indirectly. According to WTO (2019), total trade had increased 14 times from 1950 to 1997. Illegal trade of drugs, legal or illegal trade of hazardous substances may be detrimental to human health and the environment. Migration is also another important aspect of globalization. Cross-nation mobility creates newer opportunities for transmission of infections, thereby affecting the incidence and prevalence of diseases. Also, the process of globalization has affected sociocultural dynamics like smoking, drinking, and food habits. There has been an increasing trend of smoking and drinking habits, especially in third-world countries, along with the global relocation of the tobacco industry to developing countries. Globally, there is the trend of increased consumption of diets rich in salt, sugar, and oil (Huynen et al, 2005). These processes have resulted in an increased prevalence of lifestyle diseases.

Market-oriented trade-offs between developed and developing worlds have created a peculiar situation where third-world countries and developing nations are facing the brunt of environmental hazards. Weak environmental regulatory and monitoring system in developing countries has led their population to face various environmental hazards. Due to increasing restrictions and regulations in their own countries, developed nations started exporting hazardous technology and pollutants to third-world countries. Waste management companies of the west started looking for newer dumping sites in African, Caribbean, and Latin American countries. In Africa alone, waste dumping sites increased tenfold between 1987 and 1989 (Coughlin, 1996). It was recognized that developed countries are dumping their waste in less politically and economically powerful countries. African countries faced this environmental racism and continued to do so. Chemicals like Dichloro-diphenyl-trichloroethane (DDT) which were banned in America, were then used in other developing countries. Similarly, various polluting industries like pharmaceutical industries shifted their operation to third-world countries. India is now one of the biggest drug manufacturers in the world. Often the result of such industrial production is consumed by the western world.

1.4 ENVIRONMENT AND ENVIRONMENTAL HEALTH

The condition of the natural and built environment is a precursor to human health. The natural environment is essential for human life, and it is a fundamental determinant of human health and well-being. The built environment is primarily that part of the environment that has come into existence due to human interventions. It is made by human activities, which includes housing, transportation, dams, power plants, industries, hospitals, and open spaces. The built environment results from various complex processes (economic, social, political, and historical processes). None of the natural environment remains in the city as even gardens and water channels are made by humans.

1.4.1 Environment, Ecology, and Biosphere

Day-to-day human activities and processes (social, economic, political, and historical) interfere with the physical environment to affect the health and well-being of the population. Fundamental factors like natural environment (climate, topography and water supply), macro-social factors (political and economic order and historical conditions), and inequalities (distribution of wealth, political influence, educational opportunities, and employment) influence the health and well-being of the population via multiple pathways through differential access to power, information, and resources. These fundamental factors determine the nature of the built environment (land use, transportation system, waste management systems, public health regulations) and the nature of social contexts like public and fiscal policies, community participation, quality education, civic participation, and the workplace. These factors operate at the community level. Further, these community-level factors influence proximate factors at the interpersonal level. These relative factors are stressors on (neighborhood, housing conditions, violence, police response, financial insecurity, and environmental toxins), health behaviors like dietary practices, physical activity, and extent of social integration, etc. These proximate factors then influence the health outcomes like asthma, diabetes, and CVDs, and well-being (life satisfaction, happiness, and hope) of the communities (Northridge et al, 2003).

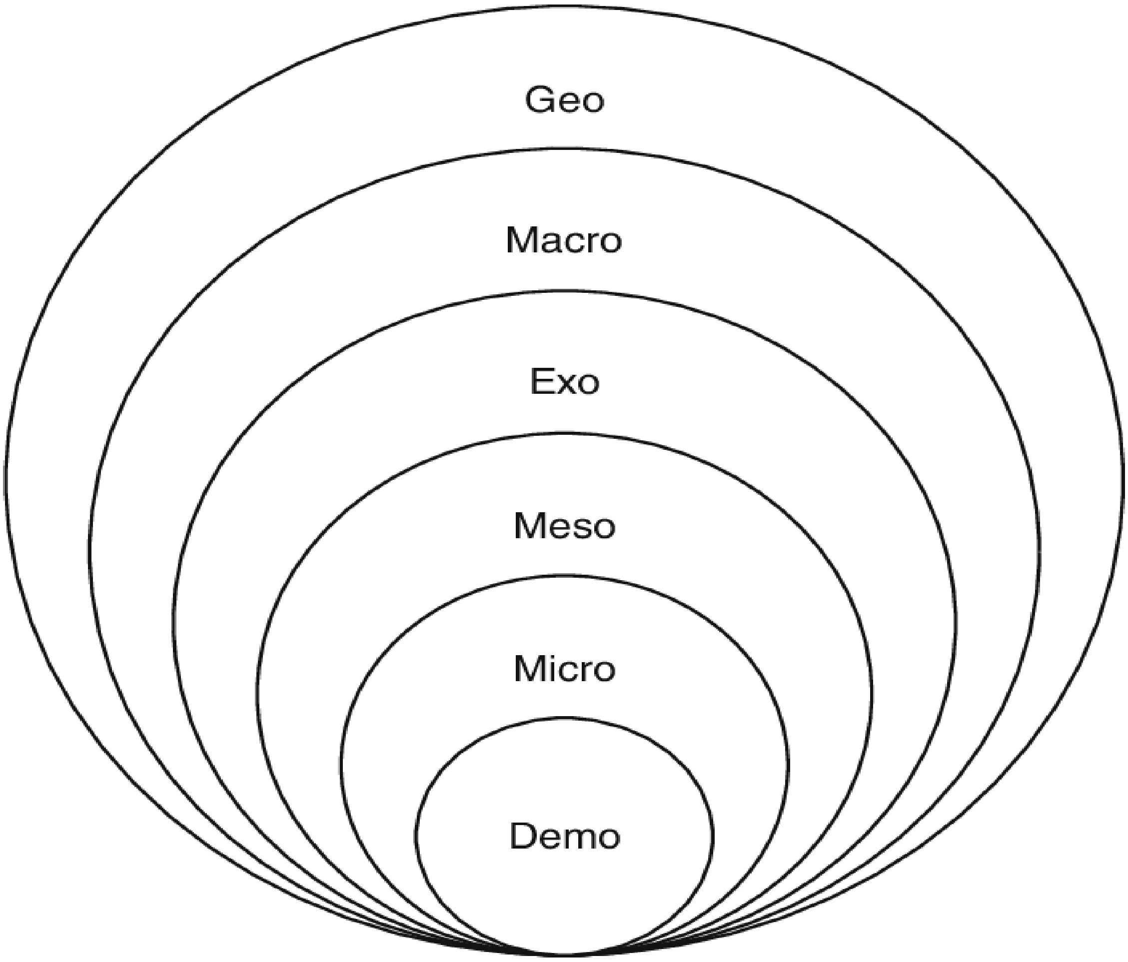
Environmental changes (built environment) encompass social processes like urbanization, industrialization, transportation, and ecological processes, e.g., nature of land use and water resources, biodiversity loss, etc. These changes are often anthropogenic in nature which may be distal or proximal. There is a close link between distal and proximal environmental changes. Distal environmental changes like deforestation, urbanization and climate change, etc., affect and influence the proximal environmental changes like population density, air quality which further deteriorates the transmission cycle of pathogen and also influences individual behavior. These changes ultimately affect the health of the communities. Distal changes do not affect the health directly, but through a series of changes and various linkages, e.g., construction of a dam doesn't affect health directly but through various processes like deforestation, biodiversity loss, risk of floods, inadequate nutrition, changes in the transmission cycle of various pathogens, etc. (Eisenberg et al, 2007). Increased rate of hospitalization, irrational usage of antibiotics, and mismanagement of a variety of healthcare waste may affect human health through a series of changes in ABR, exposure to harmful microorganisms, and exposure to hazardous pollutants.

During the modern era of public health, fluctuated attention was paid to the relationship between the environment and poor health. Despite a flawed rationale based on theories of miasma or contagion, these interventions could control many infectious diseases even in the absence of comprehensive knowledge. Further, advances in germ theory gradually ignored the importance of the environment. However, in the recent past, attempts were made (e.g., eco-social approach) to return to the roots of public health (Eisenberg et al, 2007). The health and well-being of communities are influenced and determined by the extent of various environmental exposures and individual and population abilities to deal with those exposures. The life-course epidemiology approach includes various pathways (biological, behavioral, and psychological) that operate across the individual's life course and across generations to influence the development of chronic diseases. Therefore, it is the study of long-term effects of chronic disease risk of physical and social exposures during gestation, childhood, adolescence, young adulthood, and later adult life (Northridge et al, 2003).

An ecological model of health focuses both on individual and social environmental factors. Health and unhealthy behaviors may be determined partially by the nature of the built environment. Therefore built environment does not only directly affect human health and well-being but also indirectly influences the healthy and unhealthy behaviors in individuals and populations. Therefore, ecological model health interventions aim to change community, interpersonal, organizational, and public policy factors that support and maintain unhealthy behaviors. It is also assumed that positive changes in the social environment influence the healthy behaviors of individuals, and positive support of individuals is necessary for designing and implementing the environmental changes (McLeroy et al, 1988). It is a two-way phenomenon where individual behavior and social environment or built environment affects each other. In contrast to this, the victim-blaming approach of disease is based on the assumption that an individual's lifestyle is the major determinant of the diseases and the ill health is resultant of personal failure that ignores the crucial nature of the connection between individual behavior and social environments. With this hypothesis, policymakers try to devise solutions for environmental problems focused on individual behaviors. Emission of toxins and pollutants are perceived to be major environmental problems, whereas fundamental reasons (political, economic, and social dimensions) for environmental deteriorations are largely ignored. Solution and prevention strategies based on individual behaviors may yield marginal success in mitigating the burden of diseases, but large-scale improvements in the environment and environmental health could not be envisaged until solutions are devised focusing on these fundamental processes (social, political, and economic).

The ecological perspective to health believes that both individual behavior and environmental determinants are responsible for health, but at the same time, individual behaviors are governed by environmental processes at various levels. At the microsystem level, face-to-face interactions, as in families, influence human behavior. Individuals are involved in multiple settings like schools, offices, etc., at the mesosystem level. The exosystem refers to larger social systems and processes in which these microsystems and mesosystems are located, e.g., cultural beliefs govern human behavior at various levels. In turn, this effect on the larger environment affects the microenvironment and individual behavior. Therefore, there is a reciprocal relationship between individual and environment (McLeroy et al, 1988). Figure 1.2 represents a similar ecological model;

Figure 1.2 Ecological Model



Source Moskell & Allred, 2013*

A public health model based on the triad of the host, agent, and environment could be viewed as an ecological model as any change in environment could affect the interaction of agent and host and the further manifestation of disease. The ecological model believes that individual behavior is affected by and affects the social environment (McLeroy et al, 1988). There is enough evidence demonstrating that an active lifestyle, adequate nutrition, and reduced exposure to various hazardous pollutants and toxins could reduce the burden of diseases. However, urban, suburban and rural environmental conditions are not conducive enough or enabling to facilitate healthy behaviors among individuals or communities (Perdue et al, 2003).

The squalid living conditions of the industrialized world in the 19th century gave rise to urban planning and the public health profession (Northridge et al, 2003). It was then that the connection between the built environment and human health was reflected upon. It was most obvious when infectious diseases were a primary concern for public health. Even today, in the age of chronic diseases, the nature of the built environment remains an important determinant of an individual's lifestyle (Perdue et al, 2003). Therefore, the built environment affects human health and the pattern of chronic non-communicable and communicable diseases.

There had been close collaboration between urban health planning and public health advocates during the sanitary reforms in Europe. Improved sanitary conditions had put a check on infectious diseases. Effective planning and implementation transformed the health of the urban population in the industrialized population of Europe. Somehow this collaboration disappeared in the post-world war 2 era (Northridge et al, 2003). By the mid-20th century, infectious diseases were under control in industrialized countries, and urban planning was viewed as a matter of aesthetics and economics. The public health community started focusing more on individual behaviors rather than large-scale issues such as urban planning (Perdue et al, 2003).

Most of the environmental intervention conducted (e.g., banning of lead painting) to date has occurred at neighborhood sites. However, the most desirable and important population health and environmental interventions, such as lowering the emission of greenhouse gases, will require commitment at higher levels (national and international level) (Northridge et al, 2003). Therefore, conflict of interest always affects environmental decision-making.

Environmental decision-making with respect to waste management strategies or BMWM strategies is focused only on timely segregation and use of proper technology for effective waste management. However, little attention is paid to the strategies and long-term policies that are focused on reducing waste generation or eliminating processes or industries responsible for hazardous waste generation. Therefore, the problem of waste is seen as environmental pollutants, toxins, and exposures. Fundamental social, political, and economic processes behind the quantity and type of waste generation are largely ignored.

Urban planning and industry planning in current times are governed by a set of laws and regulations enacted by the state. There are laws and regulations for the nature of zoning or division of zones for housing, playground, parks, industry, and school, etc. therefore, it is more of a regulatory phenomenon. However, the enactment or implementation of these regulations is often mediated by political and economic interests. Such a phenomenon guides environmental decisions. Therefore, a regulatory framework pertaining to the environment is key to the nature of the built environment and hence human health. In addition to the legal tools, public health professionals could add an important dimension to planning activities.

1.4.2 Environmental Health

It is a vast field that encompasses the direct pathological effects of chemicals, radiation, and some biological agents and includes effects on health and well-being of the broad physical, psychological, social, and aesthetic environment, including housing, transport, and working condition, etc. It includes all those aspects of human health and diseases that are determined by factors in the environment (Bertollini et al, 2007).

Environmental health poses a common challenge to society as a whole. The impact of economic and non-economic human activities and the use of unsustainable technologies pose a threat to human health globally. Pollution of natural (air, water and soil) and built environment (psychosocial) environment is putting not only humans at risk but also posing a risk to other organisms in the ecosystem (Chopra & Kanji, 2011). Every human being needs a good environment for sustainable well-being and quality of life. However, human activities continue to threaten and alter natural and built environments. Therefore, human being plays the role of both destroyer and victim. Processes of urbanization, industrialization, commercialization of agriculture, and an increase in scientific technologies and other revolutions have adversely affected the environment. Effects of environmental risk factors are exacerbated by adverse social and economic conditions like conflict, poverty, and malnutrition, due to which these impacts are more serious in the developing world. The rate of urbanization has outpaced the rate of infrastructure needs, and this urbanization process is here to stay. Poor, predominantly urban poor, suffer disproportionately from a wide range of health problems.

Till now, no holistic and scientific tool has been made to measure the phenomenon of environmental health. Kanji-Chopra Environmental Health Model (KCEHM) is one effort in this direction which tries to assess the burden of environmental health risk to the society by using and constructing a latent variable structural equations model. It is a measurement tool or index of environmental health which measures the extent to which a society is experiencing environmental health hazards.

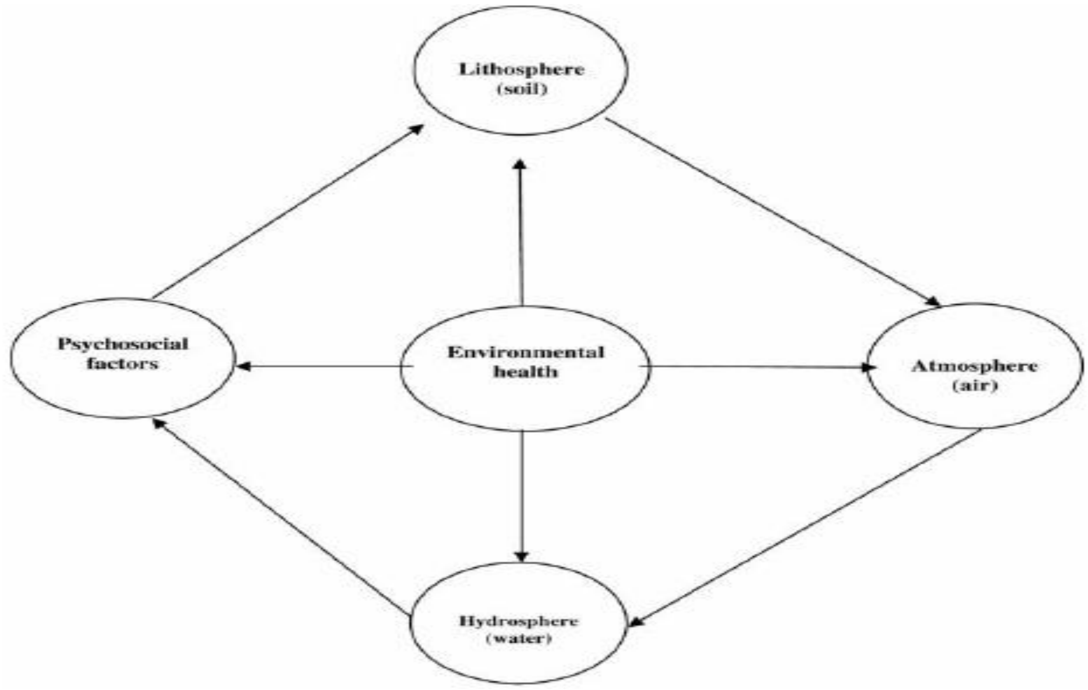
1.4.3 Environmental Stress in Humans

The health profile of society doesn't depend merely on health services infrastructure but also upon the clean environment, ecological, structural, and socioeconomic changes. Release and management of hazardous waste materials (solid, liquid, and gas) is a major concern in environmental health. Substandard housing, sanitation, and lack of access to clean drinking water remain a challenge in developing societies. It makes these societies more vulnerable to environmental health hazards. The fundamental right to life, adequate food, health, shelter, livelihood, and culture are determined by the extent and quality of environmental conditions. Stresses on the environment (as a result of human activities) along with other psychosocial factors such as work stress, mobbing, and violence contaminate air, food, water and land affecting human health, respectively (Chopra and Kanji, 2011). In China, it was concluded that environmental risk factors, especially pollution of air and water, are a major source of mortality and morbidity. Over the years, environmental risk factors have affected the broad arena of communicable and non-communicable diseases (NCDs). According to WHO's World Health Report (2007), environmental risk factors affect 85 out of 102 diseases and injuries. 80 percent of the world's diseases, especially in developing countries, can be linked to water.

1.4.4 Conceptualizing Environmental Health

The term "Environmental Health" comprises two words, viz. Environmental and *Health*. Environmental is related to the environment, which denotes surroundings. It comprises physical, social, and cultural conditions that affect an individual's growth. WHO (1948) has defined health as *a "state of complete physical, mental and social well-being and not merely an absence of disease"*. Therefore, environmental health comprises those aspects of human health (physical, mental and social well-being) that are determined by the condition of physical, chemical, biological, and psychological factors in the natural and built environment. It includes both direct pathological effects of environment and indirect effects on health and well-being broadly physical, social, and psychological environment. Environmental health concerns broad arena of subjects such as air quality, water quality, food safety, disaster preparedness, hazardous waste management, liquid waste disposal, medical waste, occupational health, noise pollution, industrial hygiene, radiological health, toxic and chemical exposure, ozone depletion, biodiversity loss and so forth (Chopra & Kanji, 2011). It aims to prevent diseases from environmental risk factors and create health-supportive environments. To conclude, environmental health is the sum of conditions, forces or influences, and substances in the environment that affect the physical and mental well-being of people.

Figure 1.3 Environmental Health Conceptual Model



Source- Chopra and Kanji, 2011*

Therefore, the environmental health conceptual model must include the atmosphere, lithosphere, hydrosphere, and psychosocial environment. Mutual interaction or interplay between these environments affects health.

Authors have tried to include all the environmental health risk factors that provide a mechanism to communicate environmental information through the system. It isn't easy to establish the causation as these factors are highly correlated in real life. This model acts as a communication vehicle, bringing out factors like psychosocial factors, which otherwise would have been neglected. This model uses systems' components within certain boundaries of built and natural environment. Environmental Health Index is comprised of physical contact index, biochemical interaction index, water pollution index, and psychosocial factors. The risk of environmental health to society will depend upon many natural and man-made dimensions that would affect human health. Following are the latent variables used in this model:

- Natural and built environment system
- Physical Contact (Land)

- Bio-chemical interactions (air)
- Water Pollution
- Psychosocial Factors

The way these variables are developed and supported will determine the degree of environmental health. Structural equation modeling helps to test the relationship. To estimate the strength of these causal connections, it is necessary for each of the variables to be operational in terms of measurement variables. A measurement instrument or questionnaire is then used to obtain the score and process the data to develop an index. Based on this measurement, improvement strategies can be designed and implemented. Finally, this model can be used to measure environmental health in terms of physical and mental well-being. Also, it can be used to develop the mechanisms for achieving environmental health targets.

1.5 EVOLUTION OF EMERGING AND RE-EMERGING INFECTIONS AND ROLE OF ENVIRONMENT

Broadly, human beings are dependent on the natural environment for their existence and survival. Human beings' need for food and livelihood has shaped their inextricable linkages with the natural environment. These needs give rise to a modified version of the natural environment, i.e., the built environment. However, ever-increasing consumption patterns have deteriorated this relationship between humans and the environment.

1.5.1 Impact of Focus on Economic Growth

Economic activities have changed the land use patterns, and human beings are continuously entering into forest lands leading to deforestation. Since the inception of agricultural activities, the ecological footprints of humankind are constantly increasing on the planet earth. In continuous efforts for a secure and comfortable life for us, human beings put enormous stress on the environment posing adverse consequences to other living and non-living entities of the biosphere. The human population constitutes a small fraction of all the living creatures of the ecosystem, but agriculture intensification and economic activities lead to a huge loss in biodiversity

(Nulkar et al, 2021). This macroprocess has blurred the distinctions between forest microbes, animal microbes, and human microbes.

1.5.2 Role of Environment in Transmission Dynamics (Pathogen Spillover)

Biodiversity is diversity or variability among living creatures in the ecosystem that is considered a critical element of the earth's support system. Like an external environment where many organisms, including human beings, survive. The human body is also an ecosystem within itself where huge microbiota survives on the human body. Most of the time, this relationship is symbiotic in nature. Our need for food, clean air, water, and energy is fulfilled by the ecosystem, which generates these services due to many microprocesses mediated by living organisms and their surroundings. Biodiversity is, therefore, critical for economic activities and agriculture as well. However, any alteration in a natural environment, which is often mediated or catalyzed by human interventions in the form of deforestation, pollution, change in land use and mining, etc., results in pathogen spillover or cross-over of microorganisms among species. This process ultimately pushes the microorganism/pathogens to look on to new habitats, which lead to the emergence and re-emergence of infectious diseases. Additionally, it poses a serious risk to environmental sustainability and hence challenges the economic stability, food security, and overall well-being of humankind (Nulkar et al, 2021).

United Nations Environment Programme (UNEP) report (2016) has suggested that intensification of human activities is encroaching the natural habitats of many organisms, leading to the risk of new emerging diseases and their amplification. Increasing human population coupled with the change in land use, deforestation, urbanization, and changing climatic patterns have influenced the complex human-vector-pathogen relationships. Furthermore, ongoing processes like globalization and faster movements of humans have opened up new horizons for emerging and re-emerging infections to spread rapidly in the form of pandemics. Geopolitical and socioeconomic issues influence the movements of humans and the environment and add complexity to their relationship (Mourya et al, 2021). These broader processes influence and impact the human-animal-environment interface, which is expanding. This fragile relationship of humans with animals and vectors plays a critical role in an exponential rise in the number of outbreaks of these emerging and re-emerging infections and their geographical expansions (Sharma & Tilak, 2021). Severe Acute Respiratory Syndrome-Cornonavirus-2 (SARS-Cov-2) is the latest example of disease of the human-animal-environment interface where Coronavirus crossed the species barrier through an unknown intermediate.

The majority of literature about zoonotic diseases talks about viral and bacterial pathogen transmission from animals to humans. Fungal infection or transmission at the human-animal-environment interface is hardly discussed. However, fungal infection is responsible for considerable mortality and may pose severe threats to the ecosystem. It may pose serious challenges to crops and stored food grains. However, profound long-term effects of fungal transmission and infection are highly neglected (Banerjee et al, 2021).

1.6 DISEASES OF HUMAN-ANIMAL-ENVIRONMENT INTERFACE ORIGIN

Human beings share their ecological context with animals and the environment. Human activities have a direct or indirect impact on animals and the environment. Therefore, this human-animal-environment interface gives rise to various issues, including emerging and re-emerging infections. India is also home to 536.76 million cattles and 851.81 million poultry birds (DAHD, 2019). India produced the largest quantity of milk, 103 billion eggs, and 8.1 million of meat during 2018-19. It contributes 28.4 percent to the total agriculture GDP of the nation (DAHD, 2019). Animal husbandry, poultry, and meat industry are highly fragmented in India. Traditional husbandry practices and backyard practices, like backyard poultry, lead to higher chances for cross-infection due to limited biosecurity and biosafety measures (Kumar et al, 2021). Following are a few key diseases of the human-animal-environment interface;

1.6.1 Brucellosis

Brucellosis is a significant disease of animal and public health concerns. It is reported in humans, domestic, and marine animals. The disease may cause abortion and other reproductive disorders in animals. Nearly 80 million households are engaged in milk production, and more than 75 percent of these animals are owned by small and marginal farmers (Kumar et al, 2021). As people live close to animals, it may lead to greater opportunities for pathogens to cross over hosts. Regular sero-surveillance is part of the national programme for the control of brucellosis.

1.6.2 Leptospirosis

Leptospirosis is a huge burden for animal and human health as it may cause reproductive disorders leading to reduced production in animals. It is endemic in most southern states and a few coastal states. This disease is believed to be highly underreported and underdiagnosed. It is reported from non-endemic states also with overall high sero-prevalence (Kumar et al, 2021). The government of India has launched a dedicated programme for the prevention and control of Leptospirosis.

1.6.3 Japanese Encephalitis (JE)

JE virus causes severe encephalitis syndrome in humans and abortion in pigs. JE is prevalent in South Asia, Southeast Asia, and the Asia Pacific region. It claimed 25125 lives in 2015. JE is endemic in 303 districts of 24 states in India (Kumar et al, 2021). The Government of India (GoI) has launched a national programme for the prevention and control of JE/Acute Encephalitis Syndrome (AES). It emphasized the active surveillance in humans and amplifying host pigs. Pigs are considered a potential reservoir of the pathogen. Sharing an immediate environment with pigs adds to environmental contamination and increases the opportunity of transmission to humans (Sahoo et al, 2021).

1.6.4 Kyasanur Forest Disease (KFD)

KFD virus was discovered in 1957 as tick-borne encephalitis, genus *Flavivirus* of *Flavivirdae* family. Indigenous KFD vaccine was also developed in 1960. Monkeys are the reservoir of the virus. Rodents and shrews are other reservoirs of viruses that share space with human beings (Nulkar et al, 2021). People are involved in certain farming practices in southern states like collecting wood and dried leaves and grazing animals at risk of tick bites and contracting the infection. Contact with monkey carcasses is also a major risk factor (Mourya et al, 2021). Therefore, understanding of forest ecosystem is of utmost importance for the better conceptualization of this disease and to devise better control strategies (Kumar et al, 2021).

1.6.5 Nipah Virus Disease

It causes severe acute febrile encephalitis in human beings. Bats are considered a reservoir of the virus, which sheds the virus through feces and urine. Deforestation and fruit orchard planting has increased the interaction of humans and bats, leading to changes in the transmission dynamics of the virus (Nulkar et al, 2021).

1.6.6 Anthrax

Anthrax is a significant disease of bacterial origin and a major public health concern. It causes uncontrolled deaths in herbivores and is endemic in many states like Odisha, Karnataka, and Jharkhand. This disease often occurs in the form of outbreaks (Kumar et al, 2021). Predisposing factors are linked to the behavior of the community. Infection in a human occurs when there is contact with carcasses, infected animal products, inhalation of spores (Mansingh et al, 2021).

1.6.7 Rabies

Rabies is an important disease of public health concern worldwide. In India, dogs are responsible for 97 percent of infections. There were 74 Lacs animal bites in 2018, as per Integrated Disease Surveillance Programme (IDSP). Around 517 deaths were reported due to Rabies in 2017 (Kumar et al, 2021). Vaccination strategies for canines and post-exposure prophylaxis of humans are major control strategies.

1.6.8 Avian Influenza

H5N1 is a highly pathogenic influenza that poses a serious threat to the poultry industry along with public health due to its pandemic potential. Different parts of the country experienced many outbreaks. The country witnessed the first highly pathogenic Avian Influenza outbreak in 2006.

1.6.9 Crimean Congo Hemorrhagic Fever (CCHF)

The presence of CCHF was first confirmed in 2011 in Ahmadabad hospital. Tajikistan strain was isolated in a confirmed case. People involved with livestock are at risk of contracting an infection through tick bites or through butchering. Later, it was also revealed that people who performed the last rituals were also getting infected (Mourya et al, 2021).

1.6.10 Scrub Typhus

Multiple regions in India experienced outbreaks of Acute Febrile Illness (AFI) with neurological manifestations. AES outbreaks that occur in the monsoon season may have multiple underlying infectious etiologies. Scrub typhus is one of the diseases of public health concern that arises at the human-animal-environment interface. Infection is transmitted by Trombiculidae mite. Small rodents and shrews usually maintain the mite population. Scrub typhus is endemic in several Southeast Asia countries and may have high case fatalities. Children having exposure to outdoor environments have higher chances of getting infected (Murhekar et al, 2021).

1.7 ENVIRONMENT DECISION-MAKING

Concepts of public health are largely based on the principle of prevention. Environmental Health Sciences under the domain of public health focuses on understanding the environment and people affecting each other and how to make an environment that improves the public health and health of different species in the ecosystem.

Sustainable development is a very long debated widespread issue discussed in various international conferences and conventions. Various developed and developing countries have pledged to take care of environmental issues while pursuing their developmental goals. However, there is mounting evidence suggesting that human beings are devastating the ecosystem and environment, and the severity of human impact is increasing in a manner that we are leaving little margin for error in our environmental decisions (Sexton, 2006).

An environmental decision is an action guided by those choices which, whenever are made, affect the present or future quality of the environment in which we live. Individuals, groups, organizations and societies often make these environmental choices, which affect the environment directly or indirectly. These choices, in turn, affect the ecosystem and further the quality of life of human beings and other living organisms. These choices include our day-to-day decisions, from choosing a paper or plastic carry bag in a grocery store to decisions on mega projects like road construction by governments. However, a decision is taken at any level by individuals, groups, or societies could be labeled as flawed when it fails to protect the interest of present and future generations in terms of their right to access a healthy and clean environment.

There are various regulating agencies at national and international levels across the globe which plays the role of a regulator on the basis of the guiding principle of sustainable development directly or indirectly. In America, decisions about environmental health protection are usually made by United States Environment Protection Agency (USEPA) and Food and Drug Administration (FDA). Similarly, in India, MoEFCC, Food Safety and Standards Authority of India (FSSAI), National Green Tribunal (NGT), and CPCB are among few authorities in India which are responsible for environmental decision making directly or indirectly. The decisions of environmental regulators are often controversial because either the process or outcome is unacceptable to a few key stakeholders based on their key interests (Sexton, 2006). There is a history of confrontation among key stakeholders on the issues of environmental decisions around the globe. Business houses often argue that any growing industry should not be put on competitive disadvantage through environmental regulations on the ground of minimal environmental gains, whereas environmental advocates believe that environmental regulatory framework should be more powerful to safeguard the ecosystem from polluting industries and preserve the environment for future generations. Basic dissimilarities among the different stakeholder groups affect their perceptions, responses, and hence environmental decisions. Different stakeholders are derived from different philosophies. "*Regulatory agencies are bothered that their activities occur within the existing framework of laws and should be politically acceptable, business groups believe that maintaining a strong economy will ensure a healthy environment. Environment advocates believe that preserving a healthy environment will ensure a strong economy. Affected communities assert that those who enjoy the benefits of technology should bear the cost and vice versa"* (Sexton, 2006, p.213). Though these stakeholders are on the same note of the need for environmental protection but largely disagree on the question of *how* and *why.*

Historically, environmental decisions have tended to be one-sided, serving the interest of one stakeholder while neglecting the interest of the other. Discharging hazardous and chemical waste in rivers, open dumping of municipal and hospital wastes, and underfunding of public transportation throughout the world are some such environmental decisions that have put the sake of the interest of present and future generations about having a clean and healthy environment to live in at stake.

1.8 ENVIRONMENTAL MOVEMENTS, JUDICIAL ACTIVISM AND ENVIRONMENT JURISPRUDENCE

Indian environmental movements differ from those of the West's environmental movements, which were concerned with environmental preservation and the issue of economic equity and social justice. These movements happened across the states in response to threats of dislocating people and making them devoid of their fundamental human rights to land, water, and ecological stability. Most of the movements started at the grass-root level with limited resources for safeguarding the interest of the poor. Democratic values and decentralized decision-making are common in most of the movements.

In addition, there were local movements against deforestation, desertification, and Stalinization in different areas. Local movements like *Pani Chetna, Pani Panchayat, and Mukti Sangharsh* advocated the ecological principles for water use. These movements were challenging the narrowly conceived development based on short-term criteria of exploitation of natural resources. These movements demonstrated that this kind of development is destructive to nature and leads to economic deprivation. This has resulted in the migration of local men to plains where they could only get service jobs. Therefore, these development activities have resulted in the depletion of forests, soil erosion, and other resources for local sustenance.

Chipko Andolan started in the 1970s in response to the denial of forest assets to the local cooperatives at the village level. These trees were given to the contractors for use to make cricket bats. This movement cut across two different ethnic groups (Pahari & Bhotias). This movement worked on a large scale. *Chipko* activists were prepared for each confrontation by informing people about the movement’s purpose. Workshop and training sessions were also done along with supporting research and publication of results. Similarly, Save the Narmada Movement and Silent Valley Movement in Kerala are examples of grass-root environmental movements. These movements cut across social and cultural differences. They united people of different ages, sex, caste, class, and religion to save the environment. Women's participation was prominent as leaders and participants. The movements also proved to be integrative at the national level involving people from various parts of the country.

1.8.1 Philosophies behind Environmental Movements

It was envisaged that developmental pathways adopted by the governments across the globe has adversely impacted the natural environment. It has deteriorated the quality of natural environment and pose severely challenges to health of human beings and other organisms of the ecosystem. The debates around these developments and their impacts have given rise to different environmental ideologies and reasoning. Necessities of development, their effect on environment and impacts on health have been seen differently by different communities, researchers, ideologists, environmentalists and policy makers. Radical ecologists believe that mere abolition of private ownership of means of production cannot guarantee the ecological stability as both the socialists and capitalists countries are on almost similar path of industrial development (Guha, 1988).

Third world environmental problems and their environmentalism are qualitatively different from industrialized world in terms of its origin and emphases. Environmentalism of third world countries or developing countries is more focused on survival and subsistence whereas environmentalism of developed countries is focused on access to clean and beautiful environment for enhancement of quality of life (Guha, 1988). Many peasant movements that aimed to protect their traditional rights to the forest, land, and water have been termed as environment movements by sympathetic intellectuals (Guha, 1988). More vocal among them '*the environmentalists'* demanded for complete replacement of development strategies with an ecologically conscious development path. Indian environment movement is largely backed by three main perspectives;

- Crusading Gandhian
- Appropriate Technology

- Ecological Marxists

These environmental perspectives see genesis of the problem differently and hence tries to articulate addressing the problem differently. This identification is however, not exhaustive but indicative. Crusading Gandhians relies predominantly on religious idioms rejecting the modern way of life. It envisaged that way of life of rural communities is exemplar of ecological and social harmony. Therefore, it upholds the idea of strengthening villages for ecological sustainability. However, this rural romanticist of Gandhi was interpreted differently. Another school of thought termed as “Appropriate Technology” is lesser stringent in opposing the industrial societies. They reiterate working synthesis of agriculture and industry at same time involving modern and eastern technological traditions. Appropriate technologists have done pioneering work in the creation and diffusion of resource conserving, labour intensive and socially liberating technologies (Guha, 1988). Another set of environmental philosophers embraces a variety of groups (ecological Marxists) whose environmentalism is shaped by protracted engagement with conventional political philosophies. They are most closely associated with people’s science movement e.g. Kerala *Sastra Sahitya Parishad*. They have a greater emphasis on confrontational movements. Systemic economic change is envisaged as logically prior to ecological stability and political action is seen as overriding priority (Guha, 1988).

Rural romanticism of Gandhians has led them to emphasize agrarian environmental problems exclusively. While doing this, they have largely ignored the problem of urban India and the urban poor. Appropriate technologists believe that some degree of industrialization is a must. Ecological Marxists here are at somewhat better strand as their natural focus groups are miners and workers.

1.8.2 Judicial Activism and Environment Jurisprudence

In addition to various environmental movements, environmental jurisprudence played a crucial role in safeguarding the environment and the interests of people. Various landmark judgments came as a result of environmental activism. Mr. M C Mehta is a Supreme Court lawyer and renowned environmentalist. His public interest litigations pertaining to environmental protection have resulted in various landmark judgments. Following are some notable cases;

1. MC Mehta vs. the State of Odisha: Laid the foundation of environmental jurisprudence in India. A writ petition was filed by MC Mehta regarding pollution from the sewage of Srirama Chandra Bhanja Medical College and Hospital (SCBMCH) which was causing health problems to the citizen. It was alleged that pollution caused by wastewater flow from SCBMCH is causing water-borne diseases and other health problems to the citizens of Cuttack. In the judgment, a bench of judges referred to the 42nd constitution amendment which had laid the foundation of Articles 48A and 51A.

   It was ordered that if there is a necessity of having a sewage treatment plant, the same may be constructed without further delay. Also, the Municipal Corporation of Cuttack ensured that sewage must be operated in such a way as to prevent the entry of sewage water into the river through it.

2. Public Interest Litigation (PIL) against vehicular pollution: Orders of lead-free petrol, Compressed Natural Gas (CNG), and other modes of fuel passed were in the court. Delhi had become the first city in the world whose public transport runs completely on CNG.

3. Oleum Gas Leak case: The fertilizer plant was situated very near to the inhabited area. It was established that such a hazardous industry could not be allowed in the proximity of population and hence was relocated. This judgment laid down the principle of absolute liability, and the Public Liability Insurance Act was passed.

4. Delhi Sewage Treatment Plant case: Millions of people living along the banks of the Yamuna river were exposed to hazardous effects of polluted water in the absence of sewage treatment plants. In the judgment on PIL regarding this case, the court had ordered to establish sewage treatment plant in 16 different localities in Delhi.

Similarly, a number of PILs filed by MC Mehta have resulted in the formulation of principles that have directed public policies regarding environmental protection through prevention and control of pollution.

1. Subhash Kumar vs. the State of Bihar (1991): A case dealing with industrial pollution discharge into a river, the court noted that Article 21 includes the "enjoyment of pollution-free water and air for full enjoyment of life." It further noted that should such environmental pollution occur, individuals are entitled to a remedy, including "removing the pollution of water or air" which may be detrimental to the quality of life.

2. BL Wadehra vs. Union of India case: PIL filed by Dr. BL Wadehra regarding the poor waste management in the city of Delhi. According to the Municipal Corporation of Delhi (MCD), there were 19 hospitals, 156 dispensaries, 160 maternity, and child welfare centers, 5 PHCs, and 14 clinics functioning under MCD. No hospital other than Ranjan Babu TB hospital has installed an incinerator. Similarly, some facilities under the control of the GoI or the Delhi govt. had incinerators, but most were devoid of them.

   In the judgment, authorities were directed to construct or install an incinerator in all facilities with 50 or more beds within nine months. Also, other facilities were directed to make their own arrangements of collection, storage, and disposal of hospital waste. These incinerators should function in accordance with the standards laid down by CPCB. Hazardous medical waste should be segregated at the generation site and disinfected before the final disposal.

These landmark judgments played a pivotal role in enacting various environmental protection laws to protect citizens and the environment.

There is an inextricable linkage between human beings and the environment. Human beings are dependent on their natural environment for existence and survival. They share their immediate environment with a wide variety of plants, animals and microorganisms. Any change in this immediate environment would impact the human-animal-environment interface broadly. There is mounting evidence that economic growth-oriented development has deteriorated the quality of natural environment. It poses severe challenges to not just human health but also to the health of other organisms also. Health sector developments that are mediated by technological advancements with respect to diagnosis and treatment have led to large-scale increment in biomedical waste generation. Inadequate management of biomedical produced by wide array of healthcare activities put negative externalities to the environment and hence affects the health of the vulnerable population. Such developmental processes in health and other sectors are altering this relationship of human beings with their environment and the relationship between human beings and animals including microorganisms. These developmental processes have created the space for the flourishing of different environmental movements motivated by different environmental ideologies across the globe.

CHAPTER 2

DEVELOPMENTS IN HEALTHCARE AND LEGISLATIVE FRAMEWORK: SITUATING PROBLEM OF HEALTH CARE WASTE

2.1 HISTORY AND DEVELOPMENT OF MEDICAL CARE

2.1.1 Social History of Medical Care

Historically, hospitals were closely associated with pilgrimages and had religious foundations. People, who fell sick while undertaking pilgrimage activities, were taken care of by these institutions. Most of the monasteries created hospitium for travelers. Between 1066 and 1550, Britain established 700 such institutions (Turner, 2006). Such institutions were founded by almost every religion. The purpose of these institutions was believed to be liturgical rather than therapeutic. Reformation and dissolution of religious foundations triggered the closure of most medieval hospitals in London, Britain, and there were only three hospitals for a population of 2 Lac in 1600 (Turner, 2006). Leprosy was prevalent for a longer duration in those times, and it triggered the specialized care known as Lazar house for Leprosy patients. Plague and Leprosy provided historical settings to Michel Foucault for understanding the development of medical organizations as institutions of social surveillance.

Later, Plague was very prevalent, which caused large-scale mortality. Therefore, a rapid decline in population was observed in different corners of the world. This decline in population affected the growth of such care centers due to decreased demand. Later, when hospitals were established as charities, it was observed that those institutions were an expression of civic pride due to care of the poor and were the physical manifestation of the urban culture of philanthropy and voluntarism. As a result of the French revolution, significant developments in medicine laid the foundation of empiricism in medical training. Classification of disease found its roots in these spaces and medical gaze. Further, these institutions were crucial for social understanding or the social construction of diseases.

Multiple factors are responsible for the development of biomedicine. Interaction of changes in science and technology, pharmaceutical sector, urban structure, professional structures, and public policy within overall changes in the emblem of urbanization mediated the development in medicine (Knox, 1982). The strong beliefs in experimental foundations/ evidence basis for the development of medicine triggered the decline of other systems like Homeopathy faced such challenges due to the adoption of Flexner’s criteria for medical education. A similar pattern is also observed in developing countries like India and China, where traditional medicine faced a crisis due to large-scale changes in medical education and practices by colonial rule.

Hospitals had considerable effects on acute infectious diseases and conditions which required surgical interventions. However, in this era of a double burden of disease, this healthcare infrastructure has not impacted the morbidity due to chronic or lifestyle diseases. The growth of genetics and emphasis on information systems may transform the medical profession in the coming years. Also, there are important contradictions within biomedicine as pharmaceutical companies are emphasizing on research and development of drugs required for chronic conditions like diabetes and CVDs. A patient would require these drugs lifelong. Therefore, there are contradictions between the medical ethics of curing a patient and the medical economy.

In the post-second world war era, doctors were criticized as ‘priests of medicine’, especially in research hospitals. With the rise of medical technology, there were erosions in patient-doctor relationships as technology was believed to be leading to physician-centered medicine rather than patient-centered medicine. With these technological advancements, there were rising concerns about medical harm. Literature regarding medical liability has been continuously rising since the 1950s. Technical problems of medicine have become global, and the risk of medical failures may lead to adverse and severe consequences to health systems (Turner, 2006).

Sickness and diseases have been ever-present since the inception of humankind. The unique role of the physician has developed in response to diseased conditions. The disease is an elusive entity. In some ways, it does not exist until we agree that it does by naming, perceiving, and responding to it. Therefore, they are socially constructed in response to alongside developments (Rosenberg, 1989). This construction of definitions led to the development of social policies, e.g., the medicalization of the pregnancy condition and child birthing processes, which has created a number of programmes and policies related to maternal and child health in developing countries. Once framed (diagnosis of a particular disease) in a crystallized form, the sufferer becomes an actor, e.g., mammography can reveal and label a symptom-free woman as a breast cancer patient. It leads to irrevocable changes in her life (Rosenberg, 1989).

2.1.2 Evolution/ History of Medical Care

In the early 19^{th} century, patients' homes used to be the setting of medical care. The majority of the population relied on the services of family members with available and cheaper means of treatment like camphor, cod liver oil, and slippery elm. Physicians used to travel to cater their services for severe cases. Then hospitals became the settings that used to serve the poor who had no resources to avail the home visit services of a physician (Reardon & Reardon, 1995). They used to practice heroic measures like bleeding, leeching, and dosing the mineral poisons for purposes like purgation, while other poor who did not have any kinship support used to rely on the workhouse. There were systems like gatekeeping/ preventing the non-deserving poor from seeking medical care in charity hospitals. Apothecaries, surgeons, and physicians used to constitute the tier-system in Britain, where apothecaries catered services to a majority of the population, and physicians and surgeons performed more specialized functions. Additionally, there were other providers like pos-doctors, abortionists, baby catchers, faith healers, and quacks (Knox, 1982). A similar pattern was observed in different corners of the globe before the developments of biomedicine.

As mentioned, a patient's home used to be the setting of medical care in the early 19^{th} century, but there was a shift in this setting from home to a specialized set called the hospital as a result of many social and technical developments. Industrialization led to urbanization mediated large-scale migration from rural areas to urban places. This agglomeration of the population in limited space resulted in deterioration of the immediate environment in these urban settings, which triggered the disease development. This large-scale urbanization divorced medical care from home and triggered the demand for healthcare by the urban middle class (Reardon & Reardon, 1995). Simultaneous creation of markets and development in science and medical technology created the further demand for healthcare. The interaction of these factors was responsible for the establishment of healthcare facilities. Philanthropists established their hospitals after industrial gains. Physicians started relocating their clinics and hospitals to newly created urban middle-class settings where business was more profitable. Other developments like the discovery of the telephone helped in organizing these services well, e.g., the telephone was useful in an orderly arrangement of surgery appointments (Knox, 1982).

As mentioned above, hospitals earlier were based on a religious foundation. In the Medieval era, hospitals were largely connected to churches in Europe. Prayers were performed for spiritual healing, and these institutions offered care rather than therapeutic practices. After the reformation and dissolution of religious foundations, there were fundamental changes in the funding and functioning of hospitals. In the early 18th century, hospitals were constructed as charities by philanthropists. A group of London merchants founded Westminster hospital in London, which is followed by Guy's (1725), London infirmary (1734), and Middlesex hospital (1746). This pattern was observed in America also, where Philadelphia Hospital was founded in 1751.

The French revolution had a significant impact on the development of medicine. Traditional text-based leanings were undermined by cadaver-based practical learning of pathological conditions. Recording the symptoms through clinical consultations replaced observations and listing to the body. This transformation resulting from the French revolution provided historical context for Foucault's '*The Birth of the Clinic'* in 1973. These methodologies changed the way medical training was imparted. Paris was a great center of medical education, and it influenced other countries to establish such institutions in those countries. Anatomy was dominant in the medical curriculum. Bodies were stolen for dissection.

Many sectoral developments affected the development in medicine, e.g., the development of microscopes laid the foundations for emerging disciplines such as cell biology and histology. It became one of the essential tools for medical education. The development of ophthalmoscopes led to the development of Ophthalmology specialization. Similarly, the development of X-ray machines led to the creation of Radiology specialization (Knox, 1982)

Western medicine is built upon principles of self-reliance, individualism, and self-help. These principles helped in raising the status of general physicians. With the rise of neoliberal policies, corporate control on health care, and expansion of markets, there were changes in underlying conditions which were helpful in sustaining the autonomy of medical professionals. With the rise of neoliberal policies, the concept of an aggressive entrepreneur came in place, which undermined the autonomy of physicians. They were being hired as employees of private health facilities, which were established on the idea of profit-making. Contemporary developments in developed countries brought the concept of specialization along with growth in technology with respect to medicine and biomedical devices. These developments further reinforced the idea of profit generations to recover the investments already done on research and development of medical technologies. These developments resulted in the erosion of patient-doctor relationships as patients were now seen as clients. Simultaneous developments like the provisioning of health insurance led to the proliferation of private health facilities.

2.1.3 Changing Epidemiology – Shifts in Disease Pattern

India is undergoing a phase of transition in terms of disease burden. Historically, India was suffering from communicable diseases, but at the present time, this disease burden has translated to double burden as we are now facing the brunt of NCDs along with communicable diseases. This transition has been termed as a double burden of disease. In addition to this, some scholars believe that India is now facing a triple burden of disease where road traffic injuries and accidents are major causes of deaths. Road traffic injuries are placed with cardiovascular deaths as major causes of deaths in the Global Burden of Disease Report. This type of transition is reflected in terms of the nature of medical institutions in present times where institution-based and intervention-based curative care is provided.

2.1.4 Demographic Transition

There has been a considerable decline in death rates in the 20th century. Life expectancy has been rising with the advent of economic securities, nutrition, sanitation, and health services. A reduction in birth rates complements this process. The population has been urbanized to a larger extent. Under the influence of macroprocesses, developed countries have experienced this transition. In addition to this, developing countries like India are undergoing a demographic transition in a manner where the elderly population is increasing. This larger cohort of the elderly population and the increasing burden of NCDs influence the demand for curative services as these diseases need intervention-based care for a continuous and more extended time period. Therefore, this transition of demography has an impact on the disease burden of society.

2.1.5 Germ Theory- Growth of Hospitals

The development of the germ theory of diseases created a need for doctors to work in laboratories and hospitals to diagnose and treat diseases (Reardon & Reardon, 1995). The acceptance of germ theory and anesthesia was most critical for the expansion of hospital-based care along with radical reforms like professionalization, regulation such as licensing, and standardization of medical care. Acceptance of germ theory triggered the research work to identify germs responsible for particular diseases, which helped in the discovery of specific conditions. Simultaneous developments like the discovery of antiseptics and therapeutic developments precipitated the shift of medical care settings from patients' homes to hospitals. Further developments like ophthalmoscopes and X-ray machines gave rise to specialization like Ophthalmology and Radiology (Knox, 1982).

Since the conception of hospital-based care, the medical profession has transformed itself on the basis of technological advancements and other biomedical devices (Turner, 2006). With the changing culture of medical practice, the status of general physicians has also changed. Processes like industrialization, urbanization, economic growth, and development in transport systems have created the market for medical services. Economic transformations in the medical profession happened due to government policies, market dynamics, and processes like globalization and the commercialization of healthcare. The autonomy and sovereignty exercised by medical professionals have been reinforced by the development of licensing laws and the state's legal system. Private healthcare infrastructure has flourished with the rise of corporate control and expansion of markets around the globe.

At the time of independence, private sector health provisioning was limited only to 5 to 10 percent. In current times, it accounts for 82 percent of outpatient visits and 58 percent of inpatient expenditure (Sengupta & Nundy, 2005). Policy decisions by successive governments favored the growth of the private sector at the expense of public sector resources, e.g., extending subsidies to the private sector and public-private partnerships (PPP). Initially, the private sector was limited to solo practitioners. Later big corporate hospitals and multispecialty hospitals came in to picture. These technology-driven corporate hospitals now dominate the upper end of the market. Private health infrastructure is mainly unregulated in India. Profit-making mottos of these hospitals also lead to unethical practices where unnecessary procedures are done to maximize profits. Health insurance is a catalyzing factor in this process.

India has witnessed tremendous growth in its healthcare infrastructure in recent times, but most of this growth is catalyzed by private providers. India's public sector spends 0.9 percent of its GDP on healthcare, which is among the lowest in the world. After neoliberal economic reforms, public investment in healthcare has fallen from 1.3 percent of GDP in 1993 after neoliberal economic reforms. At the same time, India's private sector is among the top 20 spenders of the world. The private sector in India spends 4.2 percent of GDP on Health. 82 percent of people spend from their pockets to buy healthcare. Some 5-10 percent is covered under health insurance, and the rest of the 9 percent is taken care of by their employers (Sengupta & Nundy, 2005). Private sector investment in health is only profit-oriented. Therefore, the private sector focuses primarily on secondary and tertiary care, which is more institution-based and technology involving care.

Comparatively cheaper private care has attracted patients from different countries who come on medical visas and avail private health care services. The private health sector of India provides quality care at significantly lower prices, e.g., a shoulder surgery would cost around 10000 Pounds in the UK but it would cost only 1700 Pounds in India (Sengupta & Nundy, 2005). All of the above factors have transformed healthcare provisioning in India, where the highly unregulated private health sector is proliferating day by day, leading to unnecessary medication, unnecessary procedures, and other unethical practices.

2.1.6 Colonial Period- Growth of Medical Practice

There is a pattern of plurality in terms of the provisioning of healthcare in India, where public and private players exist simultaneously. Both public and private players bear many distinctive characteristics with respect to provisioning, regulation, and financing of the services. Primarily, two types of institutions exist in India’s health service system: for-profit and not-for-profit healthcare facilities. Historically, in the 19th century and before the world war 2, medical institutions were not-for-profit, functioning on the notion of either charity or philanthropy. This nature of charity was sustained by the support of religious institutions and, to some extent, the support of the state. However, the post-world war 2 era brought a phase of transformation in these institutions, which changed their nature from not-for-profit to for-profit due to multiple factors.

The notion of the state became dominant post-world war 2. India, after independence, adopted a welfare state prospect in which the state is responsible for certain levels of social security mechanisms. This nature of the state has provided the space for private organizations to play a role in the state's prospect, which laid the basis for the rise of a mixed economy and the existence of non-public institutions in the provisioning of the services. With liberalization and globalization, the state continued to diminish its role in the provisioning of various services and a further increase in private provisioning of the services. Most of the healthcare institutions were charitable and voluntary in nature until world war 2, and later welfarist prospect of the state helped in their existence and functioning, directly or indirectly. Apart from the mixed economy, other factors influenced and shaped the nature of health institutions and the provisioning of services.

The emergence of the middle class in a market-driven economy catalyzed the process of medical institutions' shaping. Post liberalization, there was a more significant role played by the market. The middle-class population enjoys greater advantages in terms of cultural and material aspects than the population of lower socioeconomic strata, and it has changed their values and aspirations. This driving force has made the middle class enter these institutions. In addition to this factor, the following transitions have shaped the nature of medical care in the country.

2.1.7 Changes in Medical Practice

Transition in the understanding of disease causation: Historically, diseases were thought to be caused by Miasmata or bad air. Environmental factors were perceived to be the reason for diseases. Later, in the era of germ theory, it was believed that microorganisms were responsible for diseases. That was the infectious disease epidemiology era. However, in the chronic disease epidemiology era, causation is perceived as multiple, and risk factors are largely individuals. These are understood as lifestyle diseases. Therefore, the focal point is the individual and their lifestyle. Hence, solutions are devised which are largely individual-focused and curative. This type of understanding of disease also creates the demand for more and more institution-oriented intervention and curative services.

2.1.8 Technology Advancements in Healthcare and Environment

2.1.8.1 Technological Advances Leading to the Magnification of Healthcare Waste Problem

WHO (2016) emphasizes that no one should catch infections while receiving healthcare. Therefore under its Infection Prevention and Control (IPC) programme, WHO (2016) recommends that needles and syringes should never be reused. Injections administration is among the most common healthcare procedures. According to WHO (2016), at least 16 billion injections are administered every year. It is also estimated that up to 70 percent of injections are given unnecessarily and in an unsafe way in some countries. These practices are responsible for increased blood-borne virus infections. A study sponsored by WHO in 2014 estimated that in 2010, up to 1.7 million people were infected with Hepatitis B virus, up to 315000 with Hepatitis C infection, and as many as 33800 with HIV due to unsafe injection practices. Healthcare-associated infection is a major problem and it is identified to be 10 percent among all the life-threatening infections in Southeast Asia (Das, 2016). WHO (2016) has launched the injection safety campaign. It is advocating for unreusable needles and syringes. Further, in 2015 WHO issued new injection safety guidelines where it is urging member states to switch to 'smart syringes.' These syringes have features that prevent them from getting reused.

WHO (2015) emphasizes that by investing in injection safety, countries at the national and sub-national levels can save money on healthcare expenditure which is occurring as a result of unsafe injection practices and burden the healthcare system of the country. On the one hand, policies are in line for a complete switch to modern disposable syringes, and on the other hand, malpractice of using disposable syringes is still in place. A study conducted by Mujeeb et al (2003) in Karachi Pakistan revealed that many clinical laboratories are reusing syringes; some traders buy these disposable syringes in bulk and sell them in the market after cleaning and repackaging them. Such practices could also be there in other developing countries (Mujeeb et al, 2003). Studies reveal that the use of disposable needles and syringes does little good to beneficiaries. Instead, it magnifies the problem of healthcare waste and ultimately affects the environment and health of the people.

Apart from needles and syringes, there is a wide debate on the effectiveness of gowns and drapes in healthcare facilities in preventing the spread of infections. Gowns and drapes are widely used in healthcare facilities across the globe. Drapes have been used during the invasive procedures to maintain the sterility of the environmental surface, equipment, and patients. Scientific studies have demonstrated mixed results about the efficacy of gowns and drapes.

2.1.8.2 Concerns of Patient Safety

Healthcare activities involve multiple processes from different stakeholders. Every point in these processes can contain inherent risks of various kinds. Moreover, the nature of these risks and their scale is highly contextualized as healthcare provisioning, availability, accessibility, and resourcing vary greatly among and within the countries. These risks can pose severe and adverse harms to patients and their families. Therefore, ensuring patient safety is being recognized as key to achieve the Universal Health Coverage (UHC). Patient safety is defined by WHO as; "*Patient safety is a framework of organized activities that creates cultures, processes, procedures, behaviors, technologies and environments in health care that consistently and sustainably lower risks, reduce the occurrence of avoidable harm, make errors less likely and reduce impact of harm when it does occur"* (WHO, 2021, p.1).

"*Do not harm*" principle requires that potential risks or harm posed by a medical treatment must be weighed against its potential to improve the patient's condition. Patient harm due to unsafe care is large and a huge public health challenge. Patient safety related incidences can cause adverse impacts such as disability, enhanced sufferings and even deaths to victims. Therefore, financial and social costs of safety could be very high. It has been estimated that one in every 10 patients is subjected to the adverse events while receiving hospital care in high income countries.

Additionally, available evidences reflect that such adverse events contribute to 2.6 million deaths every year and responsible for 134 million adverse events due to unsafe care in low and middle income countries. Estimated social costs patient harm can be valued at one to two trillion USD every year (WHO, 2021).

Biomedical waste or healthcare waste is generated as a byproduct of wide variety of healthcare activities which poses serious risks and challenges not only to healthcare workers and patients but also to attendants and families of patients, sanitation workers and other population at risk. WHO (2021) has mentioned that the nature and scale of these risks varies greatly depending upon healthcare infrastructure and provisioning of services. India has a mixed provisioning of the healthcare services where a variety of providers provide healthcare services especially in highly unregulated private sector. Therefore, gravity of such problems could be huge and underestimated.

Patient safety and quality in healthcare services and activities is an important aspect. WHO (2021) has reiterated that UHC is an inspiring goal which focuses on the provisioning of safe and quality healthcare services to all individuals and communities without any financial hardship. Achieving UHC is envisaged as imperative to meet Sustainable Development Goals (SDGs). Without ensuring the patient safety or healthcare without harm, benefits of UHC cannot be fully realized. Therefore, 72nd World Health Assembly (WHA) in May 2019 adopted resolution WHA72.6 on “Global action on patient safety” in order to prioritize patient safety as an essential foundation step in building, designing, operating and evaluating the performance of all healthcare systems (WHO, 2021).

2.2 PHARMACEUTICAL INDUSTRY AND ENVIRONMENT

2.2.1 Pharmaceutical Industries: APIs in Environment

Rapid urbanization and industrialization have led to enormous environmental degradation. A large influx of people to urban areas resulted in many folds of depletion of natural resources such as forests, water, and fertile land. In Orissa alone, there is four folds increase in water withdrawal from different sources in the last two decades (Jena, 2008). Apart from this, many hazardous industries dispose of their waste directly into the environment, causing different health hazards to humans and other organisms. This discharge exceeds the self-purification capacity of these reservoirs. The pharmaceutical industry is one of the most potent hazardous industries responsible for environmental pollution. Most of these industries do not follow the norms and dispose of their effluents directly into the rivers and landfill sites. APIs can enter the natural environment during manufacture, usage, and disposal. Insufficient removal of APIs by treatment plants is responsible for the release of pharmaceuticals into the environment. Even developed countries are also suffering from this problem as pharmaceuticals have been detected in surface and ground drinking water in most developed countries like the USA (Mathew & Unnikrishnan, 2012). Pharmaceuticals have multiple uses, viz. for treatment and livestock industries. Multiple uses open up multiple channels for their release into the environment.

More than 4000 pharmaceuticals are used worldwide for medical and veterinary purposes (Arnold et al, 2014). Earlier pesticides were only recognized environmental pollutants in the healthcare industry, and pollution from prescription drugs were least anticipated until some recent adverse events were reported. Commonly used in humans and animals, the analgesic drug Diclofenac Sodium is responsible for the extinction of nearly 95 percent of the vultures in the Indian subcontinent. Vultures died of renal failure caused by Diclofenac Sodium toxicity (Mathew & Unnikrishnan, 2012).

This “Asian Vulture” extinction provides a classic example of the potential ecological hazards of biologically active compounds. However, the effect of APIs based on ecologically relevant assessment is very little explored (Kookana et al, 2014). Also, these APIs have effects on the behavior and reproduction of many organisms. Another alarm was raised by a report of a Swedish scientist who reported a very high content of APIs of 59 drugs in sewage effluents in Patancheru in the suburbs of Hyderabad. 11 drugs were detected at the highest ever level on the planet. Sewage wastewater in Patancheru had 150 times the highest drug level in the USA. Even a small quantity of pharmaceuticals may pose potential harm to organisms, e.g., near 40 percent reductions were noticed in the population of Tadpoles in Patancheru (Mathew & Unnikrishnan, 2012).

Drugs are among the most non-biodegradable products in the environment. Many pharmaceuticals may persist in the environment for longer durations, e.g., Carbamazepine (an anticonvulsant drug) can stay unchanged in the soil for 40 days.

Similarly, an antidepressant drug, Fluoxetine, gets partially metabolized and excreted by humans. This drug is not entirely removed by sewage treatment and exhibits minimum degradation in soil over many months (Arnold et al, 2014). Their remains present in the environment slowly accumulate in the body of various terrestrial and aquatic organisms. Such long-term exposure to many drugs makes these organisms resistant to those drugs. A high concentration of antibiotics in the sewage would lead to high exposure to microorganisms which ultimately cause the selective survival of highly resistant microorganisms. This phenomenon would lead to the evolution of highly resistant microorganisms. India was recently blamed for producing such a multidrug-resistant (MDR) organism named New Delhi Superbug. As some drugs are immune to their degradation, this property could hamper the microbial degradation of other organisms in the sewage. Sometimes APIs are also responsible for a reduction in the population of the decomposing organisms leading to slow degradation of the waste or sewage.

Based on the potential of causing hazards, MoEFCC has classified various industries in Red, Orange, and Green color codes.

Discharge of high concentration of APIs in the environment may occur due to lack of wastewater treatment facilities or inappropriate disposal of wastewater into the freshwater stream and landfill sites. About 75 percent of the population is living in Asian and African countries; still, there is very little regulatory development in these countries. Though high-income countries and low-income countries have their specific disease burden and different consumption patterns of APIs, the use of APIs in both types of economies is still increasing. Bioaccumulation of APIs in the ecological food chain is happening, which affects the aquatic and terrestrial life (Arnold et al, 2014). Environmental exposure of APIs may depend upon the following factors; a. population and demography b. access to health system c. size and nature of manufacturing sector d. ecology of receiving environment and e. availability and effectiveness of regulatory mechanisms f. consumption rates of APIs g. non-conventional APIs- an alternate system of medicine h. shifting global manufacturing base to Asia and other regions. Exposure-related factors may be urbanization and sewer connectivity, sewage treatment infrastructure, and efficiency. Environmental monitoring of APIs in Sewage Treatment Plants (STPs) is very limited in low and middle-income countries (Kookana et al, 2014).

Most of the country's rivers are heavily polluted as major cities in the country are located on the banks of these rivers. The rapid urbanization and industrialization in the absence of basic infrastructure and sanitation have led to the manifolds increase in pollution in these rivers. Most of the untreated wastes and industrial effluents get disposed of in these rivers, which cause harm to the population dependent on these natural resources. Also, it poses a serious environmental threat to the population of different organisms other than the human population. Mahanadi river alone, which runs through 494 Km in Orissa with 34 cities located on its stretch, receives around 345000 cubic meters (OPCB) of domestic wastewater discharge in it. Several medium and small industries dispose of about 100000 cubic meters of wastewater into Mahanadi (Jena 2008).

CPCB and MoEFCC placed the pharmaceutical industry among 17 highly polluting industries (Mathew & Unnikrishnan, 2012). Processes like globalization and laws like The Hatch Waxman Act promoted the outsourcing and production of generic medicines, especially in third-world countries like India. Outsourcing such industries to countries like India, where salaries are so less is profitable for both parties. Now there are needs felt for the formal protocols for drug decomposition and destruction worldwide. Many countries have taken initiatives in this matter.

2.2.2 BMW Disposal Practices in Pharma Industry:

Baddi-Barotiwala-Nalagarh in district Solan of Himachal Pradesh is one of the largest pharmaceutical manufacturing hubs. There are more than 500 small, medium, and large-scale pharma manufacturing units that manufacture both finished medicinal products as well as APIs. This region constitutes around 35 percent of total pharma production in India (Sinha, 2017). Like other industrial waste products (solid and liquid), waste from pharmaceutical industries affects human health adversely. It affects human health directly and indirectly through environmental degradation. Effluents from these industries are often discharged and disposed of into rivers to minimize the cost of production and maximize profits. This phenomenon is contributing to AMR in microbes.

Residents of nearby villages allege that most pharmaceutical industries do not follow the prescribed norms. They hand over their solid waste products to scrape dealers who burn or throw them in the open to minimize the cost of waste handling. Similarly, liquid waste from these industries runs through underground pipes, *nallas*, and canals to get mixed finally into the river. This phenomenon has led to the pollution of freshwater of Sirsa river. Sometimes, effluents are injected into the ground through a bore-well or discharged during rains and nights. This leaves the whole industrial area prone to antibiotic pollution.

Some large-scale manufacturing units have installed Zero Liquid Discharge (ZLD) plants to curb the pollution. However, installing a state of art ZLD plant requires at least 3 Crores of investment and 10 Lacs per month as an operational cost (Sinha, 2017). Therefore, to cut the operational costs, these pharma units do not process the whole of the effluent through these plants. Similarly, small and medium scale industries are required to install Effluent Treatment Plants (ETPs) for primary and secondary treatment of pharmaceutical waste, but these plants are often abandoned in order to minimize the costs. Many small-scale industries could not set up these plants as the cost of setting and operating such plants may exceed from setting a manufacturing unit itself. A common wastewater treatment facility has also been installed in Baddi to combat such issues, but this facility also is not working to its full capacity because most of the small-scale industries prefer to discharge their waste without spending a penny. Apart from the issues listed above, environmental monitoring of such ETPs and ZLDs is very limited. Also, effluent standards are limited to only chemical contaminants such as heavy metals, which need to be revised. Environmental legislation must be revised to ensure no APIs in the pharma effluents.

India's National Action Plan on AMR focuses on its environmental aspect;

- Surveillance of APIs residue in the environment and associated AMR, including pharma manufacturing discharge
- Prescribed standards of antibiotic residues in industrial discharge
- Environmental risk and impact assessment of pharmaceutical industrial units

- Development of legislation, awareness, and incentives
- Regular training of environmental regulators, industry people on AMR, and the need to control it

2.3 HEALTHCARE WASTE AND ITS MANAGEMENT

2.3.1 Classification of Healthcare Waste

The term BMW has been defined as *"any waste that is generated during diagnosis, treatment or immunization of human beings or animals or in the research activities pertaining to or in the production or testing of biological and includes categories mentioned in Schedule I of the government of India's BMW (Management and Handling Rules) 1998*" (MoEFCC, 1998).

Healthcare waste is broadly categorized as infectious and non-infectious waste. This waste may be hazardous or non-hazardous to human health. Infectious waste contains pathogens in sufficient concentrations or quantity, which results in unavoidable exposure to human beings and other organisms in the environment through various pathways. Another categorization is based on the recyclability of healthcare waste as recyclable or non-recyclable. The healthcare waste includes culture and spatulas of infectious agents from the laboratory and waste from autopsy and surgical wards (Patil & Shekdar, 2001).

Waste that has been in contact with animals inoculated with infectious agents or suffering from infectious diseases may also include human tissues and body parts, organs, body fluids contaminated items, cotton dressings, glass, syringes and needles, blood-contaminated items, radioactive materials from radiology departments and liquid discharge from various departments. Non-infectious waste includes paper, packing material, food residue, and waste generated from visitors' activities.

In addition to an allopathic system of medicine, there are various other codified systems of medicine that are practiced widely by government and private health practitioners such as Ayurveda, Homeopathy, Siddha, etc. A lot of plants, animal products, minerals, and heavy metals are used for their drug preparation and treatment of patients. Inappropriate handling and disposal activities may lead to contamination of the environment which may pose serious risks for the environment and human health.

Dental waste is a subset of hazardous BMW. Dental health activities result in the generation of a variety of waste like Mercury, needles and syringes, contaminated cotton, glass, plastic, extracted teeth, and other byproducts (Sharma et al, 2013). This waste can be hazardous to the environment and human health.

2.3.2 Growth in Healthcare Waste

Growth in medical technology has catalyzed the gains in therapeutic improvements. Medical technology in addition to therapeutic advances such as pharmaceutical products presents a simultaneous risk to human well-being and social stability (Turner, 2006). Heavy reliance on medical technology and hospital-based care has resulted in the increased generation of hazardous waste like APIs. Apart from the hospital channel, this waste, such as APIs in human excretory products and antibiotics used for animal husbandry, gets dispersed in the environment through various channels. It enters the food chain of various organisms and animals in different ways.

The problem of healthcare waste is increasing with an ever-increasing number of hospitals, nursing homes, and clinics (Hassan et al, 2008). The increasing burden of chronic diseases has resulted in growth in institution-based healthcare services. This phenomenon has led to the increasing problem of growing healthcare waste, a serious and potent threat to the environment and human health. A number of procedures and therapies are executed in various departments of a healthcare establishment, viz. laboratory, surgical, radiology, and so on. In addition to these bigger hospital settings, healthcare in India is provided by smaller nursing homes, clinics, and non-institutional settings by registered or unregistered medical practitioners. Different kinds of procedures like laboratory tests, surgery, biopsy, gangrenous organs, suction, chemotherapy, radiotherapy, dialysis, delivery, etc. are carried out in different healthcare establishments, which results in the generation of infectious and non-infectious hazardous wastes like sharps, radioactive waste, chemical waste, biological waste and pharmaceuticals compounds including antibiotics (Hassan et al, 2008).

With every technological innovation, there come risks associated with its use. These risks may be posed to users as well as to non-users of these technologies. To ensure the full benefits of medical technology and innovations, regulation and assessment of these risks are necessary. The globalization of markets makes legislative and political regulations problematic. There are apprehensions on the abilities of regulatory frameworks and governments in dealing with associated risks from the use of medical technology (Turner, 2006). In addition to the above factors, the growth of science and technology in the medical field influenced the nature of medical care and the way it functions. In this market-oriented economy, investment in the latest technologies is perceived to be a good deal.

- Provisioning of healthcare services (general and veterinary medicine)
- Nature of provisioning and providers
- Locating problem of health care waste management
- Other sectors generating BMW

2.3.3 Mismanagement of Healthcare Waste

According to WHO (2018), the proportion of hazardous waste is around 15 percent out of total healthcare waste, and the rest 85 percent is non-hazardous, but it becomes a problem when hazardous waste is not segregated from non-hazardous waste, or hazardous waste is dumped and mixed with general municipal waste. Most of the developing countries are facing this issue due to the inadequacy of the environmental regulatory framework required to deal with the problem.

There are a number of factors responsible for the mismanagement of healthcare waste, viz;

- Delay in the waste disposal
- Improper and late segregation of waste is a major problem. In a survey conducted by Srishti, Delhi Pollution Control Committee, and Delhi Health Ministry of medical waste management, it has been observed that only 20 percent of hospitals are achieving good segregation. It has also been noticed that segregation is not done at source and surprisingly, wrong bags are used for segregation of healthcare waste in hospitals of Delhi (Singh, 2001).

- Inadequate and untrained staff for segregation

- Lack of incinerator and autoclave for the waste disposal

Most Delhi hospitals dump their waste in a nearby bin, which then goes to a landfill site in Gazipur. There are also problems of healthcare waste being mixed with municipal waste. Some hospitals reportedly burn their waste at 400 degrees Celcius against prescribed norms of temperature above 900 degrees Celcius (Singh, 2001).

Apart from solid medical waste, liquid waste generated from operation theatres, laboratories, blood banks, etc., is discharged directly into the municipal sewage system without prior treatment, causing problems of environmental degradation and affecting human health directly or indirectly. Also, discharge from pharmaceutical industries and lack of effluent treatment plants lead to the accumulation of APIs in the environment, causing its degradation.

Additionally, there are problems like bioaccumulation of various drugs, especially antibiotics, in the ecological food chain due to the heavy and unregulated use of antibiotics in livestock industries.

2.3.4 Impact of Healthcare Waste on Health and Environment

In its context of urbanization and industrialization, developing countries like India are facing traditional health problems like respiratory and enteric infections due to poverty, unregulated industrialization like inadequate sanitation, housing, and various chemical and toxic environmental hazards. In contrast, developed countries have considerably averted those scenarios in current times. Healthcare and pharmaceutical industries continue to do so as a BMW of wide varieties is generated from various healthcare and industrial activities which pose serious threats to human health directly or indirectly.

Chemical exposures, healthcare-associated infections, radiations, burns, microbial infections, ABR, etc., could be termed modern health hazards. There is a shift from traditional hazards to modern hazards with the development processes. This transition came before the epidemiological transition (Corvalan, 1999). Remains of APIs present in the environment slowly accumulate in the body of various terrestrial and aquatic organisms. Such long-term exposure to many drugs makes them resistant to those drugs. A high concentration of antibiotics in the sewage would lead to high exposure to microorganisms which ultimately cause the selective survival of highly resistant microorganisms. Some drugs are resistant to their degradation, and this property of these drugs could hamper the microbial degradation of other organisms in the sewage.

A review focused on injection practices in developing countries in 2000 estimated that injection with contaminated syringes was responsible for the 21 million Hepatitis B infections, which is 32 percent of all the new infections, 2 million Hepatitis C infection which is 40 percent of all the new infections, 2.6 Lacs of HIV infections which is 15 percent of all the new infections. In India, needle prick injuries were responsible for 20 Lacs new Hepatitis B cases, 4 Lacs Hepatitis C, and 30000 HIV cases in a year (Rao, 2008). Hospital-acquired infections have been identified as one of the key indicators for BMW management. The prevalence of hospital-acquired infection was found to be 10 percent in Southeast Asia (Sharma et al, 2013). Another study conducted by Jindal et al. in 2006 demonstrated that sero-prevalence of Hepatitis C is higher among healthcare workers. Due to their nature of duties, healthcare workers are more exposed to the risk of needle prick injuries, exposure to blood and blood-related products, etc.

2.3.5 Healthcare waste Management Scenarios

In the whole process of economic growth, industrialization, agriculture yield, a huge amount of waste is generated. Some of this waste is decomposed, and most of it is dumped somewhere in the cities or waste collection sites. According to the Civic Action Group (CAG) report of the GoI in 2009, it was observed that there is poor commitment, poor management, and lack of awareness among top management in various healthcare establishments (Kumari et al, 2013). The brunt of environmental degradation caused by this waste, especially hazardous waste, is borne by vulnerable sections of society. Also, in this era of consumerism, people get their health adversely impacted while fulfilling personal and professional desires. Their health is also affected not only in the physical world but also in psychological terms. In response to providing diversified health services to the community, the number of hospitals is increasing in India (Sharma & Gupta, 2017). However, in this whole process, the amount of healthcare waste generated is increasing.

2.3.6 Mismanagement of Healthcare Waste in India

A study conducted by Singh and Prakash (2007) in India showed that the percentage of medical waste in the total general waste stream was comparatively high, ranging from 12.5 percent to 69.3 percent, indicating poor waste handling processes (Syed et al, 2012). It is estimated that India generates 0.33 million tons of healthcare waste annually, and the waste generation rate ranges from 0.5 to 2.0 Kg/bed/day (Mathur et al, 2011). Apart from it, the majority of the rural and considerable urban populations avail health services from various private practitioners in non-institution-based settings. BMW generated from their services is not generally included in the estimation. This waste is often dumped with general waste, which leads to environmental risks to the population, health workers, and rag pickers.

The majority of the Indian population resides in (IV) villages where healthcare infrastructure is inadequate. Private practitioners are the major providers of health services in rural areas. There are prevalent practices of high usage of IV and multi-dose vials. These practices lead to multiple usages of syringes and needles in rural areas, which increase the risk of infections like Hepatitis B and C and HIV (Rao, 2008). In such settings, medical waste segregation and its proper disposal are hard to imagine. However, in big cities like Delhi and other metro cities, where infrastructure for proper disposal is present, practices of throwing BMW waste on roads and dumping this waste with general municipal waste in dustbins raise serious concerns. Dumping BMW with general waste is a very common practice, especially in developing countries. Many of the countries have no comprehensive policy for effective BMW management. Developed countries have made some efforts toward effective medical waste management. However, this issue has not received adequate attention in developing countries (Patwary et al, 2011).

Health and environmental hazards associated with waste produced by health care institutions are widely described. In most of the developing countries, workers handling BMW are inadequately trained and without a basic understanding of hazards involved in handling and disposal of BMW. Additionally, equipment for personal protection are generally not provided to the medical waste handlers. Apart from the issues pertaining to human resources, financial resources and technology employed for the disposal of BMW are inefficient. Most of the incineration facilities are not up to date. The emission level of various categories of pollutants is very high, which is not monitored by authorities. In the given context of inadequate resources and legislation, inappropriate and unethical practices are employed to dispose of BMW (Patwary et al, 2011). Many studies in India and Bangladesh have suggested that BMW is thrown in open spaces, roads, and municipal bins. Liquid medical waste is discharged directly into the sewerage system, which may pose a serious threat to the ecosystem through various pathways. These practices may result in contamination of our natural environment, viz. air, water, and soil.

Segregation, storage, handling, transportation, and disposal of BMW are usually performed by class IV workers or helpers in the health facilities. A study conducted by Rao (2008) revealed that only 40 percent of the institution imparted training for workers or helpers regarding BMW management. A significant number of healthcare workers are untrained in BMW management practices, leading to the improper handling and disposal of BMW generated from healthcare facilities. Moreover, in developing countries like India, healthcare waste is collected in mixed form, often transported and disposed of along with the municipal waste. Authorities are failing to install appropriate systems for different reasons like non-availability of appropriate technology, inadequate financial resources, absence of professional training on healthcare waste management, etc. (Patil & Shekdar, 2001). General shortcomings of the existing healthcare waste management system are;

1. Increased quantity of infectious waste due to mixed collection and non-segregation

2. Absence of color-coded storage containers for different categories of waste

3. Non-availability of treatment and processing devices compatible with waste generation

4. Lack of common treatment facilities and accessibility to them

5. Unorganized waste collection, handling, and disposal

6. Inadequate human and financial resources

7. Lack of training for workers involved in the management of healthcare waste (Patil & Shekdar, 2001)

Additionally, implementation of rules and regulations viz. Environmental Protection Act and BMW Management and Handling Rules face challenges in settings like India. There is a considerable lack of knowledge and awareness pertaining to these rules and regulations among healthcare workers and occupiers of the healthcare facilities.

Many developed countries have made considerable achievements in terms of the efficient management of BMW. These countries have invested in appropriate technology and developing systematic healthcare waste management. However, the social, economic, and political context of developed countries is different from that of developing countries. For instance, in India, the majority of the population is living in rural areas which are served by private health practitioners (registered and unregistered) in non-institutional settings. Development and establishment of the state of arts incinerators are not possible in such settings. It requires intervening through larger institutional mechanisms. Context-specific policies and appropriate technology are required for the effective management of healthcare waste.

2.3.7 Public and Private Dichotomy in BMW management

Many studies have been conducted nationally and internationally to study the BMW management practices of public and private sector hospitals. Most of these studies indicate that there is a significant difference between public and private hospitals in terms of healthcare waste generation. A large number of studies reveal that private hospitals generate more BMW than public hospitals. However, few studies show that public facilities generate more BMW (Sharma et al, 2017).

2.3.8 Constituents and Management

The waste generation rate in hospitals depends upon the number of beds and special facilities provided. The USEPA estimated the generation of 7 Kg healthcare waste per bed per day, whereas this rate ranges from 2.5 Kg to 4 Kg/bed/day in hospitals of Taiwan (Li & Jenq, 1993). Major components of healthcare waste are infectious, pathological, anatomical, radioactive, hazardous, waste chemical and sharp wastes. These kinds of medical wastes have different properties and have different disposal methods. Primarily, to dispose of the healthcare waste and design or plan the disposal systems for healthcare waste, the first step should be to determine the composition of healthcare waste. Therefore, the physical and chemical composition must be known to the handler, e.g., if we were to plan for an incinerator, knowledge of moisture, solid, and ash content of waste would be the first step. A major component of healthcare waste is non-infectious hence less harmful. However, if not collected, stored, and disposed of on time and mixed with infectious waste, it could be more harmful. In the study conducted in Taiwan, National Taiwan University Hospital, the waste generation rate was 4.6 Kg/bed/day, out of which 4.1 Kg/bed /day was non-infectious and 0.34 Kg/bed/day was an infectious waste (Li & Jenq, 1993). The rate of healthcare waste generation in Delhi is about 1.5 Kg/bed/day, with a total of 60 tons per day (Singh, 2001).

The composition of healthcare waste would determine the appropriate method for its disposal. Most of the recyclable waste is combustible. If recyclable waste is segregated and recycled at first instance, then it will lower the calorific value of healthcare waste and make it inappropriate for incineration. The higher heat value of waste demands less supplemental fuel in incinerators. The generation of hospital waste is much higher in the USA than in Taiwan due to more use of disposable items in the USA. The content of solids was 58 percent, moisture was 38 percent, and ashes were 4 percent by weight, whereas total elemental carbon was 34 percent with oxygen (15 percent). The lower and higher calorific values were 3400 kcal/kg and 3900 Kcal/Kg, respectively (Li & Jenq, 1993).

2.4 INSTITUTIONAL FRAMEWORK

2.4.1 Ministry of Environment, Forest and Climate Change (MoEFCC)

It is the nodal agency in the administrative structure of the central government for the planning, promotion, coordination, and overseeing of the implementation of India's environmental and forest policies and programmes.

The primary concerns of the ministry are the implementation of policies and programmes relating to the conservation of the country's natural resources, including its lakes and rivers, biodiversity, forests, and wildlife, ensuring the welfare of animals, and the prevention and abatement of pollution (MoEFCC, 2016).

2.4.2 Department of Environment (Govt. of Haryana)

The Department of Environment, Haryana is a Ministry and Department of the Government of Haryana in India. This department came into existence when Haryana was established as a new state after being separated from Punjab. This department looks after environmental-related concerns in the state of Haryana. The Haryana State Pollution Control Board (HSPCB) is the implementing agency, and the Department of Environment exercises administrative control over its functioning.

2.4.3 Pollution Control Boards (Centre and State)

Haryana State Pollution Control Board

The HSPCB is a statutory authority entrusted with the duty to implement environmental laws and rules within the jurisdiction of the state of Haryana. The board is responsible for the proper implementation of statutes, judicial and legislative pronouncements pertaining to environmental protection within the state. HSPCB was constituted under the Water (Prevention and Control of Pollution) Act, 1974 vide notification number 86(4) (iv) 73/33298 dated 19th September 1974 initially for prevention and control of water pollution and maintaining or restoring wholesomeness of water. Section 4 of the Water (Prevention and Control of Pollution) Act, 1974 and Section 5 of the Air (Prevention and Control of Pollution) Act, 1981 provides the power to the State Government to constitute the State Pollution Control Board (SPCB) in the respective states. HSPCB was also entrusted with the additional responsibility of implementing the Water (Prevention and Control of Pollution) Cess Act, 1977, keeping in view the augmentation of the resources of SPCB. HSPCB was also given additional responsibility under the Air (Prevention and Control of Pollution) Act, 1981, to take necessary steps to preserve the quality of air and control of air pollution. Subsequently, HSPCB was given responsibilities of implementing a series of other environmental acts, legislations, and rules, either directly or indirectly. Board is also responsible for the solution of inter-state pollution matters with the pollution control board of neighboring states. HSPCB is responsible for giving authorization under Hazardous Waste (Management, Handling and Transboundary

Movement) Rules 2008 and authorization under BMW Management and Handling Rules 1998. Also, authorization of service providers under BMW Management and Handling Rules 1998 for treatment and disposal of BMW in Common Biomedical Waste Treatment Facility (CBMWTF) is granted by HSPCB.

Composition of the board: As per said provisions of the Act, the board comprises a Chairman, a Member Secretary, and fifteen other members nominated by the State Government. The members of the Board include the representative of the government, local authorities, and state-controlled corporations. Some persons represent the interest of agriculture, fishery or industry, or trade. There are 12 regional offices of the board in the state. Also, the board has established four laboratories of its own to carry out the work of collection and analysis of different types of effluents/ water samples and air emission samples from various industries of the state.

2.4.4 National Green Tribunal

Environment Court

Through the exercise of its special powers, the Haryana government constituted two environment courts of Judicial Magistrate 1st class in the state on 6th February 1997. These courts are supposed to try and inquire into the cases arising within the jurisdiction of Haryana under the Water (Prevention and Control of Pollution) Act, 1974 (Act. No. 6 of 1974), the Air (Prevention and Control of Pollution) Act, 1981 (Act No. 14 of 1981), the Environment Protection Act, 1986 (Act No. 29 of 1986) the Public Liability Insurance Act, 1991 (Act No. 6 of 1991), the Indian Forest Act, 1927 (Act No. XVI of 1927), the Wild Life (Protection) Act, 1972 (Act No. 53 of 1972). The Judicial Magistrates 1st class of these courts shall exercise jurisdiction on the original side under these Acts, and the appeals and revisions against the judgment, decisions, and orders of these courts shall be regulated by the provisions of the Code of Criminal Procedure.

2.5 EXISTING FRAMEWORK OF ENVIRONMENTAL LAW AND LEGISLATION

2.5.1 Environmental Laws and Rules (MoEFCC, 2017)

- ***Water (Prevention and Control of Pollution) Act 1974, amended 1988*** and rules made there under; The Act provides (i) for the prevention and control of water pollution and for maintaining and restoring the wholesomeness of water, (ii) for the establishment of Boards for the prevention and control of water pollution, and (iii) for conferring on and assigning to such boards the powers and functions relating thereto and for matters connected therewith.

- ***The Water (Prevention and Control of Pollution) Cess Act, 1977, amended in 1992, 2003 and Rules made thereunder***; The Act aims to provide for the levy and collection of cess on water consumed by persons carrying on certain industries and by local authorities, to augment the resource of the Central Board and the State Boards for the prevention and control of water pollution constituted under the Water Act.

- ***The Air (Prevention and Control of Pollution) Act, 1981, amended in 1987, and Rules made thereunder***; The prime objective of the Act is to provide (i) for the prevention, control, and abatement of air pollution, (ii) for the establishment of Board, and (iii) for the conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith.

- ***The Environment Protection Act 1986***: The first comprehensive Act intending to protect the environment as a whole which came soon after the Bhopal Gas Tragedy. It was enacted under Article 253 (legislation for giving effect to international agreements) referring to the United Nations Conference on Human Environment in Stockholm in 1972. The major objective of the Act was to provide the protection and improvement for the environment and for matters connected therewith. It has detailed definitions of environment, pollutants, and pollution, etc. it has also mentioned the power of the central government and the court.

- ***The Manufacture, Storage and Import of Hazardous Chemicals rules, 1989, amended in 2000***: The main intention of these rules is to impose restrictions on the manufacture and storage of hazardous chemicals and control the import of hazardous chemicals, which are not permitted to import under this Rule.
- ***Bureau of Indian Standards***: brought out the first standard, IS 12625:1989, entitled 'Solid Waste Hospital Guidelines for Management'.
- ***National Environment Tribunal Act, 1995:*** An Act to provide for strict liability for damages arising out of any accident occurring while handling any hazardous substance and for the establishment of a National Environment Tribunal for effective and expeditious disposal of cases arising from such calamity, with a view to giving relief and compensation for damages to persons, property and the environment and matters connected therewith or incidental thereto. National Environment Tribunal was established under this Act.
- ***National Environment Appellate Authority Act, 1997:*** An Act to provide for the establishment of a National Environment Appellate Authority (NEAA) to hear appeals with respect to restriction of areas in which any industries, operations or processes or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards under the Environment Protection Act, 1986 and for matters connected therewith or incidental thereto.
- ***The Municipal Solid Waste (Management and Handling) Rules, 2000***. The main thrust of these rules is for implementation of the provision of these rules in the prescribed schedule by the concerned authorities and for any infrastructure development for collection, storage, segregation, transportation processing, and final disposal of municipal solid waste in an environmentally sound manner to prevent contaminations of groundwater, surface water, and ambient air quality.
- ***The Noise Pollution (Regulation and Control) Rules, 2000 amended in 2006.***
- ***The Batteries (Management and Handling) Rules, 2001.***
- ***The Ozone Depleting Substances (Regulation and Control) Rules, 2001.***

- ***The Public Liability Insurance Act, 1991, amended in 1992, and Rules made thereunder;*** The Act aims at providing immediate relief to the persons affected by accidents occurring while handling and using any hazardous substances beyond thresh hold limits prescribed under the Act.
- ***State or Union Territory Level Environment Impact Assessment Authority:*** This authority was constituted under the Environment Protection Rules, 1986 for imposing certain restrictions and prohibitions on new projects or activities or on the expansion or modernization of existing projects or activities based on their potential environmental impacts as indicated in the Schedule to the notification, being undertaken in any part of India, unless prior environmental clearance has been accorded.
- ***Infection Management Environment Plan (IMEP) 2007:*** National Rural Health Mission Adopted IMEP, which intended to manage healthcare waste effectively.
- ***The Hazardous Wastes (Management, Handling and Trans-boundary Movement) Rules, 2008***: These rules demand that the various categories of hazardous waste, as mentioned in the rules and generated, are properly stored, treated, and disposed of to ensure that the handling of such waste does not cause any ecological disturbance and damage to the environment.
- ***National Green Tribunal:*** The National Environment Tribunal Act, 1995 and The NEAAAct, 1997 were repealed, and the NGT was established on 18.10.2010 under the NGT Act 2010 for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to the environment and giving relief and compensation for damages to persons and property and matters connected therewith or incidental thereto. It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multidisciplinary issues. The Tribunal's jurisdiction in environmental matters is expected to provide speedy environmental justice and help decrease the burden of litigation in the higher courts.
- ***The Plastics Waste (Management and Handling) Rules, 2011***: These Rules were notified to lay down the conditions on the manufacture, stocking distribution, sale, and uses of plastics carry bags, sachets, containers, and

plastic waste management, including Recycling recovery or disposal of plastic waste.

- ***Highly Polluting 17 Category Industries:*** MoEFCC issued a notification on January 16, 1991, to ensure compliance with environmental standards in polluting industries. The Drug and Pharmaceutical industry is one of them. These industries are supposed to be followed up on a regular basis by CPCB and SPCB.
- ***Consent to Establish (CTE) and Consent to Operate (CTO):*** These consents are granted by the regional officers of the HSPCB. All regional officers are delegated with powers to grant/ refuse CTE and CTO under the Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981, in their respective area of jurisdiction.
- ***Authorization under Bio-Medical Waste (Management and Handling) Rules 1998:*** Every occupier of the facility who is engaged in handling, generation, collection, storage, packaging, transportation, use, treatment, processing, recycling, recovery, pre-processing, co-processing, utilization, offering for sale, transfer or disposal of the hazardous wastes and other wastes shall be required to obtain authorization from prescribed authorities e.g., every occupier of hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, blood banks, Ayurveda, Yoga and Naturopathy, Siddha, and Homeopathy (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 generating BMW is required to apply for Authorization under BMW (Management and Handling) Rules 2016 (HSPCB, 2017).

2.5.2 BMW Management and Handling Rules in India

BMW (Management and Handling) Rules 1998 (Amended in 2000, 2003, and 2016):

These rules aim for the management, handling, and safe disposal of BMW generated from health care establishments in an environmentally sound manner to ensure that handling of such waste does not cause any damage to the environment and danger to living creatures.

“BMW means any waste which is generated during the diagnosis, treatment or immunization of human beings or animal or research activities pertaining thereto or in the production or testing of biological or in health camps, including the categories mentioned in Schedule I appended to these rules” (MoEFCC, 1998). The prescribed authority for implementing the provisions of these rules shall be SPCB in respect of States.

India first notified the BMW management rules in 1998, and it was the forerunner among the nations that developed and implemented such rules. These rules were then amended in 2000, 2003, and 2011. MoEFCC, after formulating Hazardous Waste Management and Handling Rules 1989 under the Environmental Protection Act, formulated BMW Management and Handling Rules 1998. Four amendments have been made since then in these rules. The latest is BMW rules 2016, which has four schedules, five forms, and 18 rules.

These modified rules aim to improve the coverage with further simplification of categories and process of authorization for producers and managers of BMW. Further, these rules emphasize the segregation, transportation, disposal methods to reduce the environmental pollution due to BMW. Additionally, coverage is expanded beyond clinics and hospitals by extending the coverage to even immunization camps, surgical camps, and school health facilities. Following are the few key modifications/ improvements in BMW Management and Handling Rules 2016 as compared to BMW rules of 1998 (Datta et al, 2018);

- The word “Handling” is added to BMW Management and Handling Rules of 2016 which enhances the clarity about implementation and stakeholders.
- Emission standards for incinerators have been added in BMW Management and Handling Rules to curb the environmental pollution from the process of treatment and disposal.
- Scope of coverage has been increased by extending the coverage to immunization and surgical camps, school health activities, etc.
- BMW Management and Handling Rules make it compulsory to pre-treat certain waste onsite before disposing of it or handing it over to CBMWTF e.g.,

pre-treatment is mandatory for blood bags, microbiological and laboratory waste.

- Waste categories have been reduced to 4 to bring up more clarity.
- Amended rules also emphasize newer technologies like the establishment of bar-coding and Global Positioning System (GPS) for better monitoring of BMWM.
- BMW Management and Handling Rules aim to phase out the chlorinated plastic bags and other items comprised of disposable plastic to avoid harmful emissions from incinerators.
- Amended rules also emphasize on institutionalizing the process of monitoring through various mechanisms like the creation of district-level committees.
- BMW waste is now categorized into four categories.
- Duties of operator and health facilities are listed.
- Schedules and reporting forms are reduced.
- Chemical pre-treatment with 10 percent sodium hypochlorite is necessary.
- Limits for carcinogens from incinerators are specified.
- Outsourcing is strictly recommended if the waste disposal facility is within a 75 Km radius of the hospital.
- Newer methods like plasma pyrolysis/ hydrolysis/ encapsulation/ inertisation were introduced.
- Metallic body implants are to be discarded in translucent puncture-proof boxes.
- The majority of waste is recommended to be recycled as compared to the discarding policies of 1998.

Authorization is necessary for all healthcare facilities generating BMW, including camps and AYUSH facilities.

Though BMW Management and Handling Rules 2016 aimed at enhancing coverage and improving overall BMW management of BMW generated from a wide variety of healthcare activities, to culminate the desired impacts of these rules, the extent of implementation needs to be enhanced through the institutionalization of various processes. Additionally, contextualization of these rules needs to be done in order to make them more inclusive for a wide variety of health providers and effective and sustainable BMW management of BMW generated by them.

Table 2.1 BMW Management and Handling Rules 2016

Category of Waste	**Waste Types**	**Color-Code and Bin/Bag Type**	**Treatment and Disposal Options**
Yellow	Human and Animal Anatomical waste Soiled Waste	Non-chlorinated yellow color plastic bag	Plasma pyrolysis, incineration or deep burial
	Chemical or Chemical Liquid waste	Separate collection leading to effluent treatment plant	Pre-treat with non-chlorinated items and then mix with other waste
	Discarded medicines	Non-chlorinated yellow color plastic bag	Return back to manufacturer or incineration at >1200 degree temp.
	Blood and Body fluid contaminated linen/ beddings	Non-chlorinated yellow color plastic bag	Non-chlorinated chemical treatment and incineration
	Microbiology or Clinical Laboratory waste	Autoclave safe plastic bags and containers	Pre-treat with non-chlorinated chemical and incinerate
Red	Recyclable contaminated waste	Non-chlorinated red color plastic bag	Microwaving/ Hydroclaving or autoclaving and then shredding or mutilation. Treated waste be sent to recyclers
White	Waste sharps and metals	Leak or puncture proof and temper proof containers	Autoclave or dry heat sterilization followed by mutilation, shredding or encapsulation in metal container and then final disposal to iron foundries
Blue	Metallic body implants and glassware	Box made up of cardboard with blue-color marking	Disinfection through Microwaving/ Hydroclaving or autoclaving and then sent for recycling

Some major changes in schedules of BMW rules 2016 as compared to that of BMW rules 1998 are;

- Schedule 1; to avoid confusion due to a large number of waste categories which are reduced to 4, and a new white-colored container is introduced.

- Schedule 2; specify the standards for treatment and disposal of BMW. A new rule regarding CBMWTF is introduced. It is strongly recommended that a facility disposes of its BMW through CBMWTF if it is available within a radius of 75 Km.

- Schedule 3; enlists the duties of prescribed authorities and their duties.

Some other addition in BMW rules 2016:

- To provide training to the workers involved in BMW disposal.

- To ensure occupational safety to the workers.

- To develop a system of reporting for unintended accidents.

- Periodic medical examination and immunization of workers involved.

- To ensure timely collection.

- Prescribed authorities must be informed about ill practices.

- Liability of the occupier, operator of a facility.

- *Annual report:* Every occupier or operator of a common BMW treatment facility shall submit an annual report to the prescribed authority in Form-IV on or before the 30^{th} of June of every year. All records shall be subject to inspection and verification by HSPCB at any time.

CHAPTER 3

CONCEPTUAL FRAMEWORK AND METHODOLOGY

3.1 ENVIRONMENTAL WORLDVIEWS

Developmental models are closely linked with and influenced by environmental worldview. The economic growth-oriented development model is based on reductionist approaches, which conceptualizes development fragmented into narrow disciplines. This is devoid of a holistic ecological vision. It prioritizes the highly technocratic and resource incentive solutions which fail to contextualize ecological concerns within it. These viewpoints are labeled as eco-catastrophic, ecological doom, or ecological disaster (Nayar, 1998).

Many policymakers and scholars have envisaged population growth as a major reason for ecological problems in developing countries. They did not bother to examine their own resource-intensive and technology-oriented production system. Such scholars are believed to belong to the ecological school. They see population growth as the prime factor which is responsible for ecological destruction. They envisage technocratic solutions like fertility control, appropriate technology for control of pollution, and improved communication as a solution to this problem in these countries. Such scholars get devoid from the discussion on the social, political, and economic genesis of environmental problems. Developed countries sell their technocratic solutions to developing countries, e.g., the green revolution, but they fail to contextualize technological solutions to the social, political, and economic issues of third-world countries.

Another school of thought considers technology as the major determinant of environmental degradation. Commoner approaches the problem by labeling technology as a dominant factor for environmental deterioration. The extensive use of technology by humans to draw resources from the environment and put undue stresses on the environment and their biological needs for air, food, and water, especially in developed countries, has resulted in environmental degradation. Population growth plays only a secondary role in this whole process of deterioration of the environment.

In contrast to economic growth-oriented development, the basic need approach was proposed in order to set the inner limits to basic human consumption and the outer limits of the planet’s physical resources. This approach is elaborated in reference to the developing countries. Developed countries proposed to aid and assist developing countries in achieving fundamental need-oriented growth. However, the role of the ruling classes is undermined in this approach.

Club of Rome approach focuses on links between population growth, depletion of natural resources, and environmental pollution. It has been envisaged that if the present trend of population growth, industrialization, food production, and resource depletion continues, there will be limits to growth in the coming one hundred years. It calls for global equilibrium as a solution to this problem. This state can be achieved by changes in human psychology. Many scholars have criticized this approach, citing that there is no match between the extent of resources and technology used by developed countries and developing countries. Developed countries are more responsible for environmental degradation due to their extensive industrial activities and pollution level.

The dualistic world view considers the environment or atmosphere as an external entity that is external to human beings. Everything external to humans is the environment. This conception of the environment has resulted in the over-exploitation of natural resources.

Neoclassical economics perceive environmental goods like any other commodity for which there is a market to trade. They believe that environmentalism is possible within the purview of governing economic paradigm. Such proponents believe in tools like cost-benefit analysis for the decision-making processes. They use two approaches, predominantly viz. ‘externality’ and ‘commodity.’ The externality approach believes that the firm should pay social cost exceeding the private cost causing pollution. However, scholars have widely criticized it, e.g., dumping waste into rivers cannot be analyzed by cost-benefit analysis. Another approach that sees environmental goods as commodities treats the environment as divisible, and it does not acknowledge the interrelationship between these goods in the ecosystem. The market mechanism has failed to efficiently allocate environmental goods and services because these are not discrete and divisible entities.

Marxists believe that environmental deterioration cannot be isolated from the organization of capital, the mode of production, and power structure in society. The process of labor of a man regulates and controls the material reaction between him and the nature. Ecological consciousness has developed under the global capitalist system. This ecological consciousness need not be consciousness in the real sense. This is more pro-ecological in essence. The ideology of environmentalism is anti-ecological in essence, which is exercised as state-sponsored environmentalism.

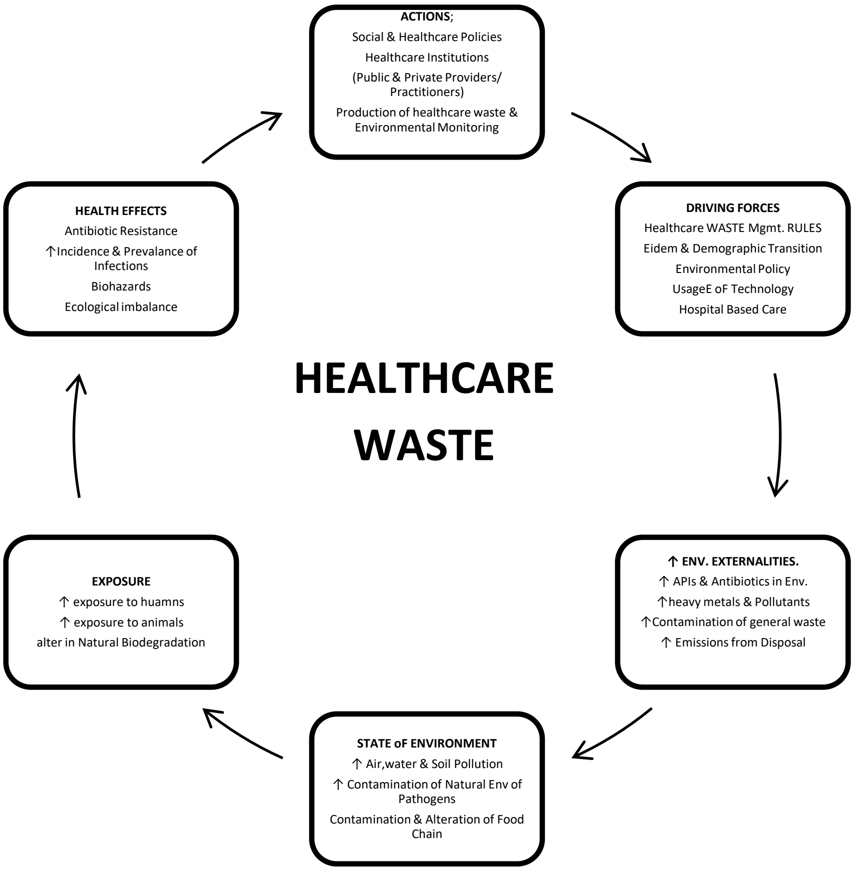
The environmental context for a fisherman, peasant, or tribal is analyzed and determined by external forces which exist beyond his local, regional, or national boundaries. Some economists labeled the poorer section of society as a destroyer of nature. They are criticized for the overuse of natural resources.

3.2 CONCEPTUALIZATION; UNDERSTANDING LINKAGES

The importance of investing in improvements to the people's health and their environment as a prerequisite for sustainable development has been recognized at the highest decision-making platforms. It is envisaged that human beings are at the center of concerns for sustainable development (Corvalan et al, 1999). Changes in human health and disease patterns in a population over time indicate the interplay of human biology, culture, and environmental conditions. In other words, human ecology, which comprises society's culture, habitats, and its relation with the wider environment, is the major and foremost determinant of the health of the populations. Over the centuries, there have been profound changes in human ecology, especially in food production, urban living, social structure, reproductive behavior, and demographic profiles (McMicheal, 2002). The majority of these changes have happened in the past two centuries under the influence of processes like industrialization and urbanization. These two processes have impacted the environment the most. It has been discussed and understood that appropriate developments must occur in the industry, agriculture, and energy if sustained health improvements are to be attained (Corvalan et al, 1999).

WHO (1997) report on "Health and Environment in Sustainable Development" has revealed that globalization, industrialization and urbanization are driving forces and affect the choices (actions) made for development processes, usage of a particular technology and infrastructure development of a particular type. These driving forces and actions are mutually connected. Other driving forces such as BMW Management and Handling Rules, epidemiological and demographical transitions, and technological development determine the pressure on the environment or environmental externalities in terms of BMW production and its release into the environment. Driving forces would determine the efficiency of healthcare waste management systems, which affects the state of the environment in terms of contamination of the natural environment (air, water, and soil) with pathogens, heavy metals and toxic pollutants. These processes lead to increased exposures (antibiotics, pathogens, toxic pollutants and APIs, etc.) to humans and other organisms in an ecosystem. This may lead to contamination of food chains. This increased exposure may result in disease conditions and other environmental consequences like climate change, increased carbon emissions, ecological imbalances, hampering natural biodegradation processes, and AMR. In this whole cycle, actions of society are connected to and directly impact driving forces, environmental externalities, state of the environment, exposure, and effects on environment and human health. These linkages are crucial to understand the relationship between healthcare services, pollution, and environmental degradation. These linkages are also crucial for assessing the relationship between the nature of health services provided and their effect on ecology, human health and the biosphere. Additionally, the strength and weaknesses of driving forces could not be understood without looking into these linkages.

Figure 3.1 Process of Healthcare Waste Generation and Influencing Factor and its Effect



Human beings share their ecological context with animals and the environment. Human interventions viz. industrialization, agriculture, deforestation, urbanization, and globalization have affected the environment of animals and the environment as a whole. At the same time, environmental changes, viz. climate change, natural calamities like earthquakes, floods, and famines affect humans and animals in many ways. The macroprocesses like urbanization and climate change lead to the changes in diseases patterns and epidemiology of a number of diseases.

Historically, human health has been impacted by changes in its ecological context. Famines have caused huge mortality in the past, impacting humans and animals. Floods have impacted humankind in similar ways. Such natural calamities are also, to some extent, believed to be a result of unmindful human interventions such as deforestation and other activities in the name of development that ultimately affect the natural environment. The cause-effect phenomena in the above mentioned macroprocesses have been studied well, but there are still unexplored processes like public health problems that require further explorations with multidisciplinary approaches. In addition to these human interventions, many factors have changed the interaction between people, animals, and plants/environments in a number of ways. This interaction is continuously changing and shaped by further processes and interactions within subsystems of an ecosystem.

3.2.1 One Health Approach

"One Health is a collaborative, multisectoral, and transdisciplinary approach—working at the local, regional, national, and global levels—with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment" (CDC, 2021).

One Health recognizes that the health of humans, animals, and ecosystems is interconnected. It involves applying a coordinated, collaborative, multidisciplinary, and cross-sectoral approach to address potential or existing risks that originate at the animal-human-ecosystems interface (One Health Global Network, 2021).

WHO (2018) defines 'One Health' as an *"approach to designing and implementing programmes, policies, legislation, and research in which multiple sectors communicate and work together to achieve better public health outcomes."*

One health approach focuses basically on health issues that arise on the human-animals-environment interface. An increase in the human population with the development of agricultural societies has impacted the geographies of the human population. In this whole process, animals (both domestic and wild) played a vital role as animals live in close contact with human beings. Human beings are using them for nutrition, trade, travel, sports, education, research, and other purposes. Close contact with animals and their environment provide an opportunity for pathogens to get transmitted to humans and make them diseased (CDC, 2021). Similarly, changes in the earth's ecosystem due to human interventions put the health of these animals at risk. The process of globalization has made trade and travel easier or vice versa. It has opened up new domains for transmission of disease with the potential of a pandemic.

The areas of work in which 'One Health' approach is particularly relevant include food safety, the control of zoonosis (diseases that can spread between animals and humans, such as flu, rabies, and Rift Valley Fever), and combating ABR (WHO, 2018). There are a number of similar microbes which infect both animals and humans, as they share the ecosystems. Efforts by just one sector cannot prevent or eliminate the problem. One health issue encompasses a wide variety of problems that may affect human health in direct and indirect ways, e.g., environmental contamination, zoonotic diseases, vector-borne diseases, biosecurity, food security and safety, and other health threats which are shared by animals, humans, and the environment. Apart from the increased risk of communicable diseases, non-communicable health problems, occupational health issues, and injuries are directly related to the nature and properties of the built environment and hence can be benefitted from one health approach (CDC, 2021).

3.2.1.1 Multi-sectoral and Trans-disciplinarity of One Health Approach

It is believed that no one person or organization or sector can address the complex issues of the human-animal-environmental interface alone (CDC, 2021). It requires the cooperation of multiple stakeholders from different fields, viz. human health like the doctor, nurses, paramedics, and epidemiologists, etc., animal health like veterinary physicians and para veterinary personnel, etc., and plant health like agriculture experts and ecologists, lawyers, activists, policymakers, communities, and institutions.

3.2.1.2 Importance of One Health

One health approach is considered as a comprehensive approach for solving complex health problems involving the human-animal-environment interface. Principal drivers of most of the zoonotic infections are associated with human activities, viz. deforestation, agriculture, international trade and travel, urbanization, and other processes (Mackenzie & Jeggo, 2019). Although the emergence and transmission pathways of Coronavirus causing pandemic Covid-19 are debatable, a wide array of human activities helped in the proliferation of the pandemic. The term “One Health” was first used in the context of SARS and subsequently associated with highly pathogenic Avian influenza H5N1 (Mackenzie & Jeggo, 2019). Following such events, the importance of concepts like “One Health” envisaged combating multi-country outbreaks and epidemics. Collaborative efforts from experts of different fields with a transdisciplinary approach could be the key to finding a sustainable solution to such health issues. Recent global experiences of fighting with the Covid-19 pandemic would have definitely strengthened the idea of concepts like "One Health," where key strategies formulation involved different stakeholders and key interventions cut across different systems and subsystems. Therefore, the One Health approach could guide an effective strategic framework for a sustainable solution to health issues arising at the human-animal-environmental interface.

The conceptualization of emerging infectious diseases affects how epidemiologists and others perceive or interpret the causes and consequences of disease emergence (Rosenthal et al, 2015). Modern health problems are very complex in nature as they are multifactorial and spread across host and species and regional boundaries due to various social and developmental processes. Therefore, if these problems are approached from a veterinary, medical, and ecological perspective alone, a sustainable solution is very unlikely to be framed (Mackenzie & Jeggo, 2019). Through integrated efforts from the expertise of different fields, and one health approach could identify the source of emerging pathogens and minimize the threats of potential outbreaks (Zowalaty & Jarhult, 2020). One health approach lays the basis of such effective conceptualization, which can translate into an effective and sustainable strategic framework to solve the problems. Researchers have demonstrated that solutions involving one health approach can prove cost-effective and may lead to sustainability (Fitzpatrick et al, 2016). Some studies have demonstrated that improvements in livestock health could translate into poverty reduction in certain economies (Rist et al, 2015).

3.2.1.3 Environment Role in Pathogen Spillover

Historically, humankind has faced numerous infectious disease events which have shaped human history for millennia. These infectious disease events include; outbreak of Measles 11000 years ago in early agrarian societies, the Black Death in the 14th century, the introduction of Smallpox in the 1500s, and the Spanish flu in 1918. Host-pathogen dynamics are continuously changing in the overall context of changing environmental dynamics, largely influenced by human activities. Such environmental dynamics give rise to phenomena like "Viral Traffic" and "Pathogen Spillover." The variety of host range and pathogen emergence depends upon social and environmental drivers (Rosenthal et al, 2015). The transmission in a complex system could be from human to animal or animal to human and from animal and human to the environment and vice versa. Within animals, there could be the interspecies transmission of pathogens. Backyard farming culture involving multi-animal farming may be responsible for such transmission. Environmental factors such as exposure to contaminated water may influence inter-species transmission. (Short et al, 2015).

3.2.1.4 Causal Agents- No Single Pathway

Understanding pathways of emergence would affect the conceptualization of the problem and vice versa. Medical specialists, veterinary personnel, or an ecologist would tend to establish linkages on the basis of their domain knowledge. An ecologist would be interested in emerging pathogens, while a medical and public health professional would tend to focus on emerging diseases (Rosenthal et al, 2015). Therefore, their linear perspectives would insufficiently conceptualize the problem whenever they do it in silos. Studies have demonstrated that the emergence of diseases rarely occurs as a result of one pathway only. Most of the diseases emerged via multiple routes (Rosenthal et al, 2015). A single discipline, country, or institution will not be able to respond to such complex health problems (Zowalaty & Jarhult, 2020). Therefore, understanding such multiple pathways would require expertise from different fields.

3.2.1.5 Macroecological Perspective

Studies have demonstrated that the microbiological system is closely linked with man. The human can be in a symbiotic, beneficial, or pathogenic relationship with the organisms. Any change in its immediate environment changes its relationship with these organisms and microorganisms. The human being's way of life, technological advancements, behavior, and even his mere existence foster the conquest of some disease organisms, the emergence of others, and his introduction to unfamiliar ones. Therefore, the infectious disease picture is subjected to change as life itself (Sencer, 1971). Environmental drivers impact the emergence of newer threats through a number of pathways. Therefore, to better understand such linkages, a macroecological perspective is needed to frame effective and sustainable strategic frameworks. The current pandemic of Covid-19 is thought to be originated from bats and passed to human beings through undetermined animal intermediate in the Wuhan meat market in China. If this transmission pathway is known, disease and pandemic management would be more effective (Zowalaty & Jarhult, 2020). One health approach corresponds to the macroecological perspective, which sees things through the systems approach. Therefore, the macroecological perspective could answer many unsolved questions with respect to emerging infections and other issues arising at the human-animal-environmental interface.

3.2.1.6 Unfinished Agenda of Application of the Concept "One Health"

One Health is a naïve approach in terms of application of the concept to complex systems. Despite the wide acceptability of the importance of one health in solving complex health issues, isolated silo thinking persists, especially in the public health sector (Zinsstag et al, 2011). There have been efforts to link human and animal health, but the environmental aspect of this human-animal-environmental interface is less explored as literature concerning this aspect is scanty. Additionally, the application of this approach is usually practiced at specific locations or in specific communities or specific events or outbreaks and it is still more responsive in nature to specific outbreaks and events. As discussed earlier, one health approach could be used to solve complex system issues; its potential needs to be tapped by policymakers and decision-makers.

Implementation of one health approach for controlling emerging infections and outbreaks may involve strict implementation of legislation, collaborative interdisciplinary control measures involving public health, veterinary medicine, and agriculture sector, and further understanding implications of behavioral aspect at the human-animal-environmental interface. These measures may focus on improved biosecurity of animal/livestock farms during their transportation and sale, surveillance of live animal and meat markets, awareness generation among the public regarding zoonosis, and the importance of this cooperative approach (Zowalaty & Jarhult, 2020). Such an integrated system approach having a macroecological perspective could influence the conceptualization of health problems of human beings, animals, and the environment. Therefore, it could impact decisions related to controlling measures for such issues. However, demonstrating evidence of added values of one approach is an unfinished agenda (Zinsstag et al, 2011).

3.2.1.7 Complexity of the Problem; ABR

ABR is recognized as one health challenge because of the rapid emergence and dissemination of resistant bacteria and genes among human beings, animals (domestic and wild), and the environment (Rousham et al, 2018). ABR is a systemic issue as it is a problem of complex systems. This systemic issue is largely driven by efforts to meet food-related demands and other issues related to increasing more and more resource-demanding populations (Zowalaty & Jarhult, 2020). Antibiotics usage is not restricted to human medicine and veterinary medicine only. It has a wide array of usage in animal husbandry, aquaculture, and agriculture. Therefore, environmental contamination results from multiple pathways involving different subsystems, viz. veterinary medicine, human medicine, fisheries, meat industry, poultry, agriculture, and animal farms. It also involves the implementation of rules and regulations and policies. The interconnectedness of these subsystems is affected by human activities and intervention, leading to complex phenomena of ABR. Moreover, relationships among these subsystems behave differently in different contexts, viz. developing and developed countries. Health impacts of ABR are of greater concern in low and middle-income countries due to poorer sanitary conditions, inadequate access to safe drinking water, poor access to health services, the high load of infectious diseases, and greater likelihood of community-acquired resistant infections (Rousham et al, 2018).

Exposure to antibiotics or APIs in antibiotics could happen in different manners and pathways. The common route is through inadequate management of fecal waste in animal husbandry, poultry, and the human population. Fish workers could be exposed to antibiotics in aquaculture, and poultry workers are also exposed in similar ways. Poultry feces used to feed fishes and as manure may contaminate soil, water, and air in different ways. The food chain of animals and human beings may involve these fishes and poultry leading to exposure to antibiotics. Antibiotics and hormonal drugs used in agriculture and animal farms pose serious challenges to environmental health and a threat to human and animal health through different pathways. Inadequate waste management practices and BMW management practices also contribute to environmental contamination leading to ABR (Rousham et al, 2018). Therefore, ABR is an issue of a complex system encompassing different subsystems. Unless the interconnectedness of these pathways is understood, it is hard to devise effective solutions. Therefore, the One Health approach is imperative to understand such complex phenomena to formulate sustainable solutions.

Poultry receives higher quantities of antimicrobials than other livestock. These antimicrobials are ultimately released into the environment through different channels. Antimicrobials used in animals are released into the atmosphere through their urine and feces. Untreated animal waste is also used in subsistence economies. The occupational risk of resistance carriage has rarely been assessed. Korean fisheries workers had a significantly higher proportion of resistant E.Coli due to their exposure to antibiotics used in aquaculture. There are examples of human-to-environment transmission of resistant genes through pharmaceutical plants, hospital effluents, recycling of medical waste products, and untreated wastewater. There are examples of contamination of rural river water with resistant genes by urban pilgrims at religious sites of the river. Domestic animals and human beings share their environment in rural areas. Therefore, they are exposed to animal excreta. Animal slaughterhouses are another site of exposure to anatomical waste and blood-containing antimicrobials. Liquid and solid wastes from these sites are discarded often in open and municipal drains/sewage (Rousham et al, 2018).

3.3 SYSTEMS THINKING

Complex problems of real world need non-linear approaches for better conceptualization. Systems thinking has the potential to lay the basis for such frameworks. Systems thinking concept application has yielded unexpected results in public health (Zinsstag et al, 2011). A system has been defined as a whole complex entity of a particular kind, and this whole is more than just a sum of parts of a whole (Checkland, 1999). Any system has some emergent properties, e.g., vehicular movement of bicycle after assembling of its parts. This whole may have further smaller multiple wholes that could have their emergent properties. Therefore, the systems approach supports the idea of layered structures. Systems must adapt to change in the environment through communication and control, e.g., the body adapts to temperature change in the environment. So there is interconnectedness among subparts of a system with functional communication and feedback mechanism. The notion of the adaptive whole is a central image in systems thinking. Systems thinking is a process of thinking using systems ideas. From its emergence in organismic biology, systems thinking has emerged as a meta discipline, which can be used to explain the subject matter of different fields (Checkland, 1999). In changing environment or context, dynamic interaction between subparts of the system leads to the creation of complex adaptive systems (Atun, 2012).

Human beings are inextricably connected with animals (domestic and wild) and their social and ecological environment. Similarly, these animals are connected with human beings and their environment in a number of ways. Therefore, the environment too is affected by human interventions and activities. Problems that arise from such systems of interconnectedness are often complex and hard to solve by the reductionist approach. It requires an integrated approach with systems thinking to understand their problems. A strategic framework for reducing the risk of infectious diseases, which originates at the human-animal-environment interface, was evolved as a trademarked term "One World One Health" (Zinsstag et al, 2011). The integrative approach of one health corresponds to the systems thinking or the systems approach. A system is constituted by interconnected (with feedback loops) subsystems of non-linear relationships. Complex transmission dynamics can be explained and demonstrated using the systems thinking or systems approach.

3.4 CONCEPTUAL FRAMEWORK

Health services systems or healthcare delivery systems are located within the larger whole of the health system. This complex whole (Health System) has properties beyond the properties of component parts or subsystems. These subsystems interact with each other and influence the outcome of a whole in a particular context. Interacting subsystems or parts influence each other with positive or negative feedback leading to the collective determination of the system's behavior. These interconnected subsystems of whole share a non-linear relationship among themselves leading to a dynamic complexity (Atun, 2012). Therefore, to understand the behavior of the whole system, it is imperative to understand the interconnectedness and interdependence of the subsystems. The majority of the studies conducted around the problem of healthcare waste and public health consequences have implied management perspectives. However, if we consider healthcare waste as an outcome of the system in spite of considering it as an outcome of healthcare activities or services, it would demand further methodological complex frameworks to understand the phenomena. Application of the systems thinking on the present research problem of healthcare waste generation and management would lead to a complete change of perspective of looking at the problem. Taking insights from one health approach, which is close to the systems approach, pushed the researcher to adopt methodological holism to study the present phenomena related to healthcare waste. Therefore, one health approach and embedded systems thinking within One Health helped in the conceptualization of the research problem in a completely different and naïve way.

Systems thinking imply careful consideration of possible consequences of actions and policies (Atun, 2012). If we consider healthcare waste or waste generation as an outcome of a system, there will be different subsystems or components of a whole which are interconnected in some ways to form the whole. Healthcare waste generation is an inevitable phenomenon in health care delivery systems. A variety of healthcare waste is generated as a result of healthcare activities performed at different healthcare institutions in the hierarchy, both in the public and private sectors. Indian healthcare delivery system is complex within itself. There is mixed provisioning of healthcare services where the private sector is highly unregulated. Therefore, the extent of regulations influences or affects the provisioning of services. There are informal practitioners in the private sector who are not registered under any system but still are able to practice, and their numbers are huge. They are not part of the formal healthcare provisioning system, but they are present even at the village level. Such practitioners generate an ample amount of BMW, and more importantly, waste generated by them is widely dispersed geographically. Even the general waste management in the rural areas is not adequate. Other institutional practitioners may find it easier to manage their BMW in an environmentally sound manner if they are authorized or located in the vicinity of the CBMWTF. Similar problems may be faced by smaller healthcare facilities of the public sector which generate a small amount of BMW. Additionally, a lot of BMW in the form of syringes, needles and discarded medicine is generated at the household level as a result of self-medication or home-based care. It may get mixed with general solid waste, turning the whole waste into infectious waste. In addition to the treatment activities, there are laboratories and pharmacies which too generate some amount of BMW, which may be hazardous and infectious in nature contributing to the overall burden of healthcare waste.

This inner circle of the healthcare delivery system is encompassed within the outer circle of the healthcare services system. It includes different healthcare institutions which produce healthcare workers of different hierarchies. It also includes pharmaceutical industries, ambulance services, medical equipment industries, BMW treatment facilities, and other support services which help in effective healthcare delivery systems. Further, it is encircled by the health system, which includes communities, policies and regulations, governance, education, culture, beliefs, and nutrition, etc. These health system components are linked and influence health services and healthcare delivery system, e.g., talking in terms of BMW, which is generated through a variety of activities at the level of the healthcare delivery system is a systemic problem. The extent of generation and management would depend upon a lot of factors, viz. types of facilities and levels, regulation of facilities, authorization of facilities, environmental monitoring, and available infrastructure for adequate management. All these components would, in turn, depend upon the extent of implementation of BMW Management and Handling Rules and environmental protection laws, awareness, general waste management practices, and policies. There is interconnectedness among these components or subparts of the whole. Communication and feedback mechanisms of these layered structures make it a complex whole of its kind.

This complex whole (system of healthcare waste generation) also shares interconnectedness with similar layered structures of veterinary medicine, fisheries, piggeries, aquaculture, agriculture, poultry, meat and leather industry, animal husbandry, and animal slaughterhouses. Apart from veterinary medicine, rests are not directly associated with healthcare waste generation. We can find that a lot of solid and liquid waste generated from these sectors corresponds to BMW, e.g., animal slaughterhouses and poultry. They produce a lot of anatomical and blood-related waste, which is considered mainly solid waste and liquid waste, respectively. Additionally, a huge amount of antibiotics and pharmaceutical usage in these industries/ sectors establish their interconnectedness with other components of this whole system. This justifies their inclusion in the system. Further, this inclusion automatically leads to the adoption of the "One Health" approach directly or indirectly. One health approach goes with systems thinking as both values interconnectedness within the systems. Figure 3.2 illustrates the conceptual framework of the study.

CONCEPTUAL FRAMEWORK

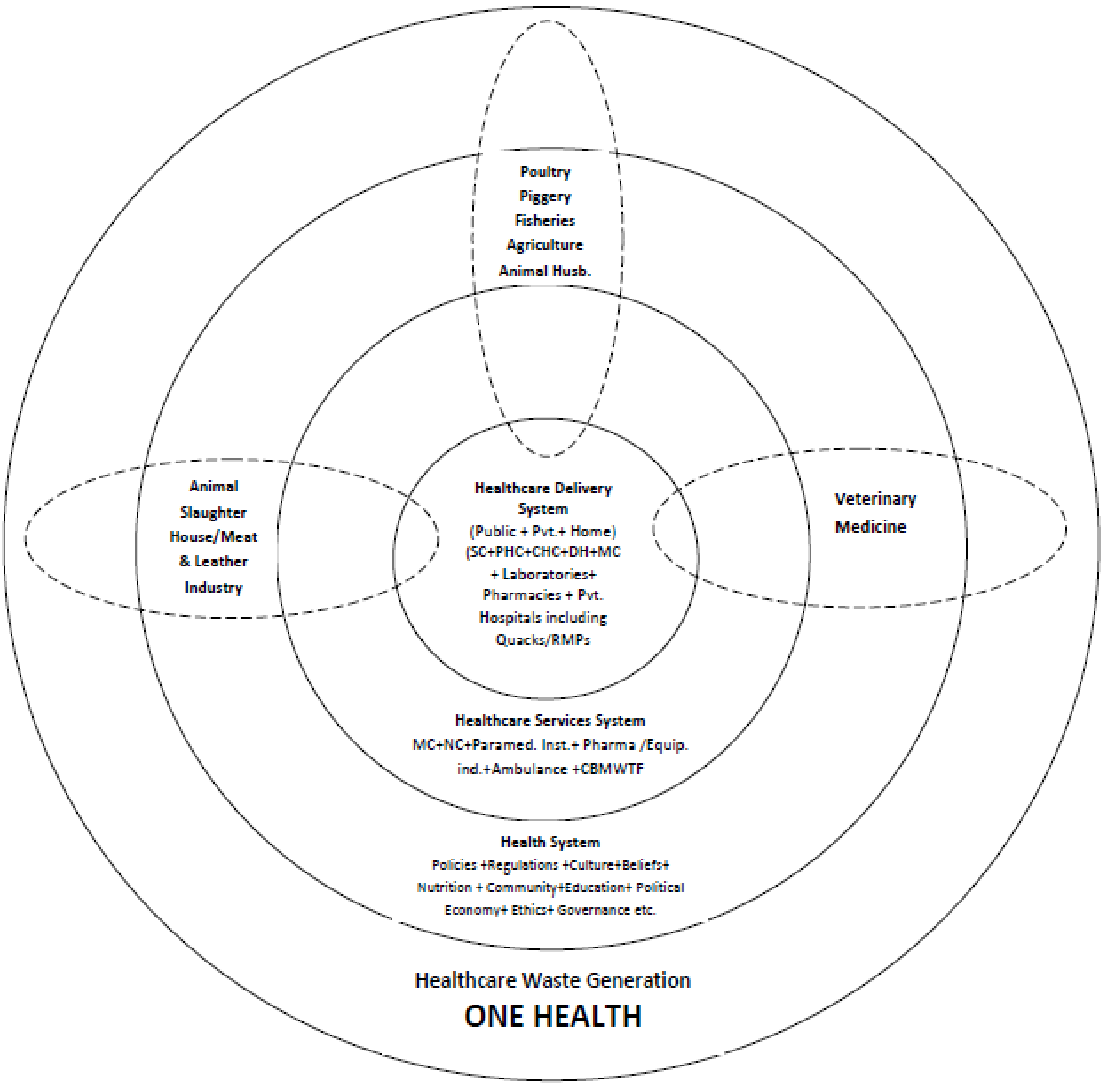
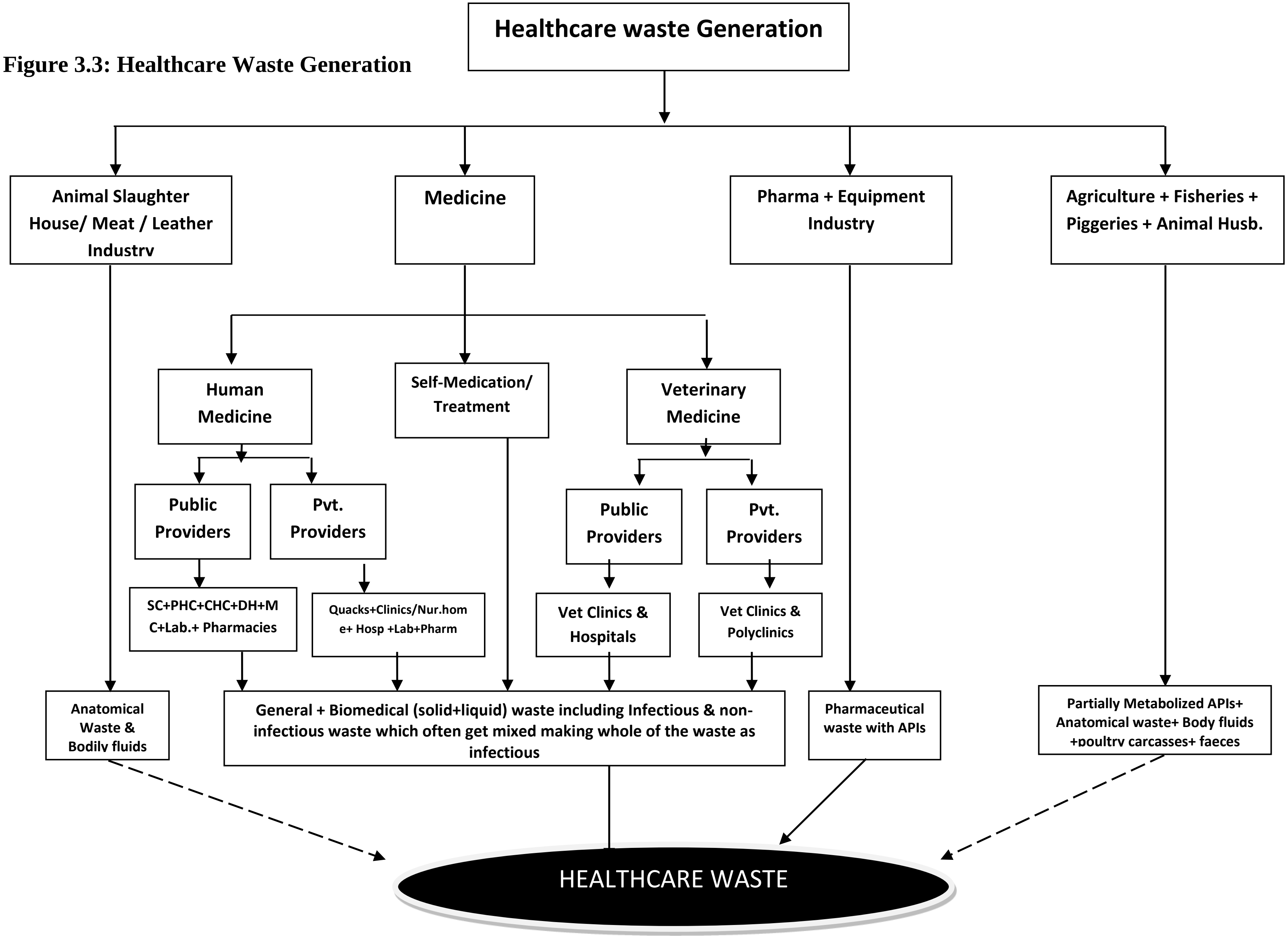


Figure: 3.2 Conceptual Framework

The present study aims to understand the depth of phenomena (problems of healthcare waste) with the help of the "One Health" approach and embedded "Systems Thinking" within the One Health approach. The application of these concepts provided the basis to the framework, which could further provide new insights into the phenomena. The problem of healthcare waste was looked at through different dimensions/angles, viz. household healthcare waste generation, infrastructural issues, regulatory aspects, informal healthcare workers, industries (pharma, poultry, meat, and agriculture, etc.) in addition to the conventional approaches of looking at the problem of healthcare waste. Broader phenomena that operate in the environment/context and influence different system components were also studied in detail. Different routes of environmental contamination were also explored using one health approach.

Figure 3.3: Healthcare Waste Generation



3.5 METHODOLOGY

Any scientific research implies the practice of objectivity in every step of the research, right from the inception of the research idea, design of the study, methods used to achieve the objectives, process of carrying it out, analysis, and interpretation. To achieve objectivity researcher tried to minimize the various biases which could have threatened the reliability/ validity of the study (Bowling, 2000). Practicing rigor in research is a significant tool to achieve objectivity. However, most of the social science studies are value-laden (Bowling, 2000). Studies are affected by the cultural, social, and political context of the researcher. Therefore, it is hard to achieve objectivity and make things value-neutral. Here the researcher himself is a graduate in Ayurvedic medicine, and public health with experience of working in a hospital/Public health system. The idea of studying this research problem had its root in the past experiences of the researcher.

3.5.1 Aim of the Study

To understand the problem of healthcare waste causing environmental degradation and affecting human health using the "One Health" approach. Also, it focused on the development of environmental legislation and rules pertaining to health and explored their adequacy in addressing the environmental degradation due to healthcare waste in India.

3.5.2 Objectives

1a. To review the evolution of environmental protection laws, especially BMW rules in India.

1b. To explore the role of environmental jurisprudence in shaping those laws.

1c. To review the effects of healthcare waste on environment degradation and ecology and adequacy of law in dealing with the problem of healthcare waste.

2. To explore the characteristics, challenges, perceptions regarding healthcare waste management through the case study of a district health system of Hisar district of Haryana.

3.5.3 Research Questions

1. What is the history of environmental movements in India?

2. What are the international imperatives which shaped the formation of laws to protect the environment in India?

3. What are the landmark cases of environmental jurisprudence in India that led to environmental protection laws, especially BMW rules?

4. Which constitutional factors played an important role in shaping the environmental legislation in India?

5. What are the different points of generation and characteristics of healthcare waste from different sectors, viz. health facilities, households, meat industry, poultry, agriculture and animal husbandry, etc.?

6. How do advancements in healthcare technology, especially the pharmaceutical industry and disposable syringes, affect the environment?

7. What are current guidelines and provisions under "Swachh Bharat" and BMW Management and Handling Rules for healthcare waste management?

8. What are the different practices (handling, segregation, storage, and disposal) related to healthcare waste generated from households, healthcare facilities, and other sectors in the district health system of Hisar?

9. What are the different challenges (guidelines, manpower, financial and managerial) with healthcare waste management in the given context of law and legislation in Hisar district?

10. How does healthcare waste contribute to environmental degradation and ecological destruction?

11. How adequate are the legislations and rules in dealing with the problem of healthcare waste in the study area of Hisar district?

3.5.4 Approach to the Study: Inductive and Phenomenological

To begin with, the study aimed to build an idea about the phenomena of interest through observation and in-depth collection of information. It did not have a beforehand hypothesis to test; rather, it attempted to explore the phenomena and then generate a testable hypothesis from it, which could further be tested through more observations and collection of information. Very little knowledge existed about this phenomenon; therefore, there was a maximum opportunity for exploration. Hence, inductive hypothesis generation was needed.

In contrast to Positivist's approach who tries to study the phenomena of interest through quantitative methods and further aims to measure it, the researcher presents the study with phenomenological belief that reality is multiple and socially constructed. Here in this study, the phenomena of interest were studied at different levels, e.g., healthcare personnel and facilities dealing with healthcare waste in public facilities at different levels (SCs, PHCs, CHCs, SDHs, District Hospital), Private Health Facilities (Multispecialty Hospitals, Nursing Homes and Clinics) and Informal and Registered Medical Practitioners (RMPs). Further, in these facilities, in-depth information was collected from doctors, administrators, and staff involved in handling healthcare waste. Additionally, information was collected from the staff of municipal corporations, personnel from BMW handling and treatment facilities, and personnel from pollution control board authorities. Therefore, rich information from a variety of stakeholders was collected. Their views in their natural settings were recorded and interpreted.

Present study implied "Systems Thinking" by using the "One Health" approach to understand the phenomena. Therefore, in addition to healthcare services systems, data was collected from other sectors and subsystems (veterinary, animal husbandry, poultry, meat industry and animal slaughterhouses, fisheries, piggeries, agriculture, and aquaculture), which together form the complex whole. Additionally, other broader processes like regulatory affairs were explored in relation to the research phenomena. The interconnectedness of these broader phenomena and their influence of subsystems of the complex whole was explored using primary and secondary data.

3.5.5 Study Design: Observational Study

The study aimed to understand the problem of healthcare waste management in relation to environmental laws. Therefore, it was a naturalistic inquiry. Information related to the healthcare waste generation and management practices in different healthcare facilities at different levels was collected through observation and without altering the natural setting or affecting the subjects or respondents. It aimed to understand and explore the problem without value judgment. It focused on the meaning of the problem to the participants in the study setting. Research phenomena were explored considering healthcare waste as an outcome of the whole system, which is a result of the interplay of different components or subsystems using observation and interview data.

3.5.6 Research Methods: Qualitative

Methods are valid if applied to the appropriate research question, and both should complement each other (Bowling, 2000). Qualitative and inductive approaches usually begin with observation. The phenomenon of interest that the present study aims to explore is one of the least explored or worked upon. Though healthcare waste has been studied with a management perspective, it has not been studied in terms of macroecological perspective and its effect on ecology. Also, it has not been explored in relation to environmental laws and rules and waste generation from other sectors like poultry and meat industries. Characterization of anatomical waste in such industries is different from the characterization of waste in the health sector. The present problem has been mostly studied in silos. There was little pre-existing knowledge about this phenomenon. Therefore, qualitative techniques were essential to explore this. Qualitative methods are helpful in getting insightful and rich data sets to understand the problem. Also, qualitative methods enabled the researcher to capture the subjectivity of the respondents and settings. Moreover, qualitative methods were suitable to explore the functioning of organizations. It could be helpful to generate qualified hypothesis which could further be tested with a set of quantitative data.

The present study did not have any specific hypothesis beforehand as the study's major focus was to explore the phenomena of environmental degradation due to healthcare waste generated as a systemic outcome of complex whole and adequacy of environmental legislation and rules to deal with the problem of healthcare waste. The present study sought to generate a posteriori hypothesis by examining data collected from healthcare facilities through direct observations and respondent's interviews. It attempted to look upon relationships between the variables. Though there were possibilities of having an idea about the relationship between variables through this study, it was not possible to depict the strength of this relation.

3.5.7 Sampling

The sampling method implied in qualitative studies is usually purposive because the sight/ setting of data collection are deliberately chosen by the researcher where phenomena of interest are explored in its natural setting. Therefore, purposive sampling was implied to achieve the objectives of the study. In-depth information was collected from key stakeholders and institutions through observation and in-depth interview methods.

1. Public Health Facilities: District Hospital (DH), SDH, CHC, PHC, and SC.
2. Private Health Facilities: Multispecialty Hospitals, Nursing Homes, Clinics and Informal Health Workers.
3. Veterinary healthcare facilities, animal slaughterhouse, poultry, pharma industry, waste sites, animal husbandry, and agriculture sector.
4. Personnel from authorities responsible for the implementation of various environmental protection laws and personnel from local municipal authorities.
5. Key informants from poultry/meat industry, including animal husbandry

3.5.8 Scheme of Data Collection (Sample)

Data were collected by interviewing the following respondents;

- Public Health Institutions/Providers
    - Senior Doctors (Physicians/ Surgeons)
    - Dentists

- AYUSH Practitioners
- Nurses
- Laboratory Technicians/Radiology Staff
- Auxiliary Nurse Midwife (ANM)/ Multi-Purpose Health Worker (MPHW)
- Sanitary Staff

- Private Health Institutions/Providers
  - Senior Doctors (Physicians/ Surgeons)
  - Dentists
  - AYUSH Practitioners
  - Nurses
  - Laboratory Technicians/Radiology Staff
  - Assistants
  - Sanitary Staff
- Veterinary Services
  - Doctors
  - Veterinary and Livestock Development Assistants (VLDA)
- Pollution Control Board
  - Officials/ staff from the regional office of pollution control
- Municipal Workers
  - Officials
  - Municipal workers
- Slaughterhouse, poultry, piggeries, animal husbandry, etc.
- CBMWTF Officials
- Observational visit to any pharmaceutical industry

Table 3.1 Respondent's Profile

Serial Number	Respondent Type/Profile	Number of Respondents Interviewed
1	District Health Officer, Hisar	1
2	Deputy Civil Surgeon, Hisar	2
3	Nodal Officer- BMW management, Hisar	1
4	Senior Medical Officer, CHC Barwala	1
5	Medical Officer, PHC	1
6	Homeopathic Medical Officer, PHC Agroha	1
7	Medical Officers/Practitioners, Private	2
8	Dental Surgeon, Private	1
9	Ayurvedic Medical Officer, Private	2
10	Health Inspector/Lady Health Visitor, CHC Barwala	2
11	Pharmacist, CHC Barwala	1
12	Lab Technicians, CHC Barwala	2
13	Lab Technician, PHC Agroha	1
14	MPHW, CHC Barwala	2
15	MPHW,Hisar	2
16	MPHW/ANM SC- Nangthala, SC-Khedar	4
17	Informal Health Workers, Private	2
18	Lab Technician Private	1
19	Municipal Workers/Sanitary Workers Public+Private	3
20	Labor room Nurse or Assistant (Public+Private)	2
20	Veterinary Doctors+ Paramedics, Public (LUVAS)	9
21	Maharaja Agrasen Medical College, Agroha (Hisar)	2 (informal Conversation)
22	HSPCB, Hisar Regional Office	1 (informal Conversation)
23	Officials of Municipal Corporation Barwala and Hisar	2 (informal Conversation)
24	Key Informants from Meat/Poultry/Fisheries/AH	4
	Total	**52**

3.5.9 Data Collection

Both Primary and Secondary

3.5.10 Methods of Primary Data Collection

Systematic observation is a classic method of natural sciences and a mainstream method in social sciences, particularly in organizational analysis, e.g., the functioning of a hospital. Observation of actions, behavior, and interactions pertaining to healthcare waste management in various healthcare facilities was a helpful tool to understand more than what people said about complex situations. Therefore, it was helpful in comprehending the phenomena of interest in detail. The observation was strictly done for different variables of healthcare waste management (related to waste collection, storage, transportation, pre-treatment, and final treatment and disposal) not just in healthcare facilities but also in other sectors generating waste having characteristics of BMW like poultry and animal slaughterhouse. At the end of each observatory session, field notes were prepared regarding raw observation without value judgment. Feelings of the researcher were written in another diary. However, observation is usually used as a part of triangulation methods, e.g., it is often coupled with the investigation.

Data Pertaining to Health System/Programmes/Sector

a. Observation data from healthcare and veterinary health facilities, with respect to generation, segregation, storage, handling, transportation, treatment, and final disposal of BMW. Additionally, observation of disposal practices of animal/bird carcasses and leftover parts after meat yielding.

b. In-depth interviews from public and private healthcare and veterinary facilities with respect to challenges, practices, and their perception of the adequacy of environmental laws especially BMW Management and Handling Rules.

c. In-depth interviews with administrators of both the systems regarding challenges faced by them and their perceptions of BMWM practices at lower-level facilities like Sub-Centers (SC).

d. An in-depth conversation with informal health workers and individual veterinary practitioners regarding waste generation, disposal, and challenges faced by them with respect to BMWM.

e. An in-depth conversation with key informants of meat/poultry/fisheries industries with respect to characteristics of bio-waste generated by industry and contribution to the overall burden or quantum of healthcare waste.

f. Secondary information or data was collected with respect to BMWM rules and practices of different countries, Evolution of environmental protection laws, and different approaches and methodological complexities to find solutions for the problem.

g. Environmental rules and guidelines issued by governments and authorities were referred to in detail as a reference to Standard Operating Procedures (SOPs).

3.5.11 Data/Evidence Triangulation

Qualitative studies aim to explore the depth of the problem. Hence it is imperative to achieve the richness in the data to a considerable level. The nature of the qualitative data or information requires testing the validity of the information. Convergence of information from different data sources leads to the enhanced quality of the information. Therefore, triangulation methods are the key to comprehensive understanding of the research phenomena. Triangulation can be of different types depending upon its employment for research methods triangulation, investigator triangulation, theory triangulation and data source triangulation (Carter et al, 2014). Present study employed data source triangulation as a method of evidence triangulation where data or information on some key aspects from different data sources was converged to ensure the validity of data.

Validation of data collected through observation was done by in-depth interviews of healthcare personnel and authorities responsible for implementing BMW Management and Handling Rules and other environmental protection laws. In-depth information was collected from the respondents at various levels in different sectors in addition to the health sector regarding their perceptions, challenges, and management of waste.

Evidence triangulation was done by visiting the CBMWTF located in Hisar and the regional office of the Pollution Control Board, Hisar. Information collected from various respondents of healthcare and veterinary health systems was compared with information provided at CBMWTF and HSPCB offices. A comparison was made in terms of the number of health facilities that exist and are covered by CBMWTF, the amount of waste generated, disposal practices mentioned by respondents, and operators of CBMWTF. Additionally, data were compared with respect to dynamics of storage, segregation, handling, and transportation of BMW.

Further, evidence was triangulated in terms of characteristics of BMW and waste generated by other sectors corresponding to similar characteristics. Finally, a hypothetical econometric model was devised, which was fed by primary and secondary data, and some realistic assumptions for elements were devised where data was not available to predict the quantum of the BMW generated and proportion treated by different sectors. This model can be useful for the conceptualization of problems in a different way.

Guidelines and rules issued by authorities and the government were taken as references for triangulating evidence revealed by respondents. Additionally, information from secondary sources was used to triangulate the information received from primary data to discuss the problem of BMWM in a district health system.

Table 3.2: Scheme of Data Collection (Primary and Secondary)

Sr.No:	Research Question	Secondary Literature Review with respect to	Primary Data Collection (Key Informants Interviews and Observation)
1	Environmental Movements in India	Development model in colonial time. History of environmental movements in India. Environmental legislation in Colonial time. Underlying Principles to environmental movements. The ideology behind environmental movements.	
2	Role of International Imperatives on Environment	International conferences and Declarations on the environment. Principles executed. Impact on Indian environment policies	
3	Role of environmental Jurisprudence in shaping laws	Landmark cases related to environment and health. Constitutional factors. Structure of current environmental laws and legislation. Structure of legislation with respect to healthcare waste	
4	Characteristics of Healthcare waste	Different types of Healthcare waste. Characteristic /composition of healthcare waste. Environmental and Health hazard of healthcare waste. Occupational hazard and generation of waste (having characteristics of BMW) from other sectors like the meat industry, poultry, agriculture, and animal husbandry.	Interview with Healthcare personnel (Doctors and staff) involved in the handling of Healthcare waste. Interview with Municipal Corporation staff and respondents involved in different sectors mentioned.
5	Environmental impact of Advancement in Healthcare technology	Impact of globalization in the pharmaceutical industry on the environment in developing countries. Role of Pharmaceutical industry on environmental degradation. Impact of single-use of syringe policy.	Interviews with doctors. Interview with veterinarian and expertise in the field of animal husbandry, poultry, and meat industry.

6	Current Guidelines under "Swachh Bharat" and BMW Management and Handling Rules	BMW management rules in India. Current provision under "Swachh Bharat" Programme like 'Kayakalp' project.	Interview with doctors and healthcare facility staff involved in handling BMW.
7	Practices of management of healthcare waste	Different practices for management of solid waste in healthcare facilities. Management of liquid waste in healthcare facilities. Management of household generated BMW and similar waste in different sectors like poultry, meat industry, animal husbandry, and agriculture	Observation (Healthcare facilities). Interview with healthcare personnel. Interview with laboratory staff. Interview with community members and respondents of mentioned sectors.
8	Challenges with respect to Healthcare waste management	Appropriateness of Technology For BMW management. Knowledge Attitude Practices studies on healthcare waste management. Institutional responses to healthcare waste. Law and legislation	Interview with healthcare staff (Doctors and staff) and municipal workers/ others involved in the handling of healthcare waste
9	Impact of Healthcare waste on env. Degradation and ecological destruction and Health	Environmental degradation due to Healthcare waste. Ecological impact of healthcare waste. The direct and indirect impact of healthcare waste on human health.	Interview with Healthcare personnel (Doctors and staff) and manual scavengers involved in handling Healthcare waste
10	Adequacy of Law and legislation to deal with the problem of healthcare waste	Law and legislation pertaining to environmental protection and healthcare waste in India. Response of above laws to environmental degradation affecting human health	Interviews with doctors and authorities of SPCB

Information related to their knowledge pertaining to healthcare waste causing environmental degradation and affecting human health directly or indirectly and various environmental protection laws, including BMW Management and Handling Rules along with adequacy (strength and weaknesses) of this regulatory framework was collected. Also, it was tried to collect the information from authorities responsible for environmental monitoring and implementation of the regulatory framework in order to explore the gaps.

Secondary Data: secondary information was collected through research and review work published in scholarly journals, Gazettes of India for various environmental acts and laws, reports and archives of central and state pollution control boards, judgment of cases pertaining to environmental jurisprudence, etc.

3.5.12 Data Collection Tools

Careful data recording was done through field notes, documents, and tape recording, wherever possible. Unstructured observations were made in healthcare facilities and CBMWTF, animal slaughterhouse, poultry, animal husbandry, and agriculture sector.

Semi-structured in-depth interview schedule (open-ended) for healthcare personnel (doctors and staff involved in management and handling of BMW, informal health providers, and authorities responsible for the implementation of environmental protection laws was used to collect the information.

A systematic search of available secondary data was done from authorities and internet sources.

3.5.13 District Hisar as a Case Study

Traditionally, the problem of healthcare waste generation and management has been studied with management angles only where input, process, and outcomes are measured to explain the phenomena. Healthcare waste and its disposal used to be measured in terms of grams per bed per day. However, health care waste generation and management are being conceptualized differently in this study which involves systems thinking. The whole process of biomedical or healthcare, or bio-waste generation was seen as a complex multi-faceted phenomenon as such waste is not just getting generated in healthcare institutions. It is also generated in households, veterinary, and meat/poultry industries as well. Case studies have been a method choice for studying such multi-faceted and complex phenomena. Case studies explain such complex processes through in-depth explorations in real life settings. This method was employed for an in-depth appreciation of an issue. It is a widely accepted and established research design for studying complex social processes. Case studies are termed naturalistic inquiries as it tends to study phenomena of interest without influencing the settings (Crowe et al, 2011).

As described, healthcare waste generation and management is a multi-faceted problem resulting from a complex whole comprising different subsystems like human medicine, veterinary, animal husbandry, meat/poultry industry, and pharmaceutical industry, etc. However, boundaries between these subsystems and processes and their interconnectedness are very much blurred. Case studies are thought to be helpful in explaining such phenomena where boundaries between phenomena and context are not clear (Yin, 1981). Therefore, a case study as a method was perceived to be able to establish these linkages and explain casual pathways to some extent.

The present study employed the "One Health" approach for the exploration of the complex phenomena as healthcare waste and waste corresponds to characteristics of healthcare waste such as anatomical waste from the meat industry, and poultry is being generated at a number of points as a result of multiple processes. Public health provisioning results in BMW generation; private health providers also generate BMW, whereas providers like informal health workers who are not part of formal health provisioning are also generating waste. Similar processes in veterinary medicine also generate some waste. Additionally, other sectors like animal husbandry, poultry, meat, and other industries generate waste with the characteristics of BMW. Weaker regulations and household-based care also result in BMW. These processes are influenced by a number of factors like regulation, policy and governance, implementation of the law, and community awareness. These factors may represent parts and subparts of subsystems. This is why systems thinking was also guiding the study's conceptual framework. Additionally, systems thinking is embedded and entails in the One Health approach. Therefore, this system operates within a given context of regulation and institutions. District health authorities are responsible for the provisioning of services in a particular region. These areas are divided into administrative units of the district. Considering this context, the district was chosen as a case to study the phenomena of interest. Almost similar administrative and infrastructural context is present in most of the districts in the forms of Chief Medical Officer, District Health Office, District Surveillance Unit, District Veterinary Officer, District Pollution Control Office, District Animal Husbandry Office, and other important offices. Similar hierarchies also exist from SC to Medical Colleges in most of the districts. This forms the basis of selecting the district as a case. Due to familiarity with the region and past experience of the researcher of working with the district health office and other logistical reasons, district Hisar was selected as a case among other options.

Parts of this complex system as subsystems were studied in the context of district Hisar itself as healthcare waste generation was considered as an outcome of the system, and there are different components of this system that are interacting with each other and generating the waste. Hence, Hisar was taken as a case study to represent the case. Practices of healthcare waste generation and management were explored in terms of institutional arrangements in different sectors. Also, analysis of perception and challenges was done at the level of respondents/healthcare personnel involved in handling and management of healthcare waste. This data was complemented and triangulated with information collected from operators of CBMWTF and the regional office of HSPCB in Hisar. Secondary information on these subsystems was also used to answer the research questions and explain the phenomena. Detailed description of district Hisar with respect to biomedical waste generation is given at the end of this chapter.

3.5.14 Data Analysis

Predominantly, the study employed qualitative information or data, and hence data were analyzed accordingly. Data were analyzed through methods for qualitative data analysis. Information collected through in-depth interviews was analyzed by processing this qualitative data into various themes. Theoretical analysis of observational data was done through coding. Field notes of observations were transcribed. Also, data from field notes of observation were divided into themes and categorized further to analyze. Categorization of data was done in a systematic way for further analysis. There was a slight difference between information collected from different types of stakeholders. However, information related to one particular theme or sub-theme was processed and categorized accordingly. The quantitative information collected under this particular theme was extrapolated to the whole district to understand the magnitude of the problem.

Secondary data was analyzed through a thematic review of available information. Finally, processed secondary and primary information was coupled to answer the research questions. For some of the research questions, information gathered from secondary sources was used to answer.

3.5.14.1 Multi-sectoralism Examination in analysis

The study focuses on the problem of healthcare waste generated not only through healthcare services but also on the bio-waste generated by industries like animal husbandry, poultry/meat, and fishery industries having similar characteristics. Therefore, it was envisaged that the sectoral approach or reductionist approach would not be able to answer research questions. One Health was envisaged as a key approach to conceptualizing systemic problems at the human-animal-environment interface. The problem of healthcare waste generation is not restricted to healthcare activities for human beings. Veterinary healthcare activities also result in the generation of a huge amount of BMW. We may recognize it or not, but the waste generated by other industries like the meat and poultry industries has similar characteristics to BMW. As the study's conceptual framework was guided by the One Health approach and systems thinking, it was imperative to consider this problem as a complex issue of a human-animal-environment interface.

Waste generation (BMW and other wastes of similar characteristics) was envisaged as a complex system's phenomena where the complex whole comprises different subsystems like human medicine, veterinary medicine, and industry. Further, this system is influenced by other subsystems like governance, regulation, policies, and community. Due to these subsystems only, informal health workers or individual workers exist in the health and veterinary subsystems of the complex whole. Therefore, the contribution of these multiple sectors or subsystems was studied with respect to complex phenomena, i.e., the quantum of overall bio-waste or BMW generation and treatment.

Data with respect to health facilities infrastructure in the public and private health systems and their respective contribution to waste generation and management were collected. The primary information was collected through in-depth interviews of key informants, operators of CBMWTF, and authorities like the regional offices of HSPCB. A similar approach was employed for the veterinary health sector. Further, industries like animal husbandry, fisheries, poultry, and meat industry were examined through primary data, which will be further complemented and triangulated by secondary information.

Finally, a hypothetical econometric model was constructed to reflect and predict the sectoral contribution to overall complex phenomena. The decision tree arm of this model was based on the conceptual framework of the model, which was guided by the One Health and Systems Thinking approach.

3.5.15 Methodology of Econometric Model

Econometric modeling is an important tool for making predictions and estimations based on existing information along with some realistic assumptions. However, conceptualization is the most important part of the development of the econometric model. The present study has conceptualized the research problem through the 'One Health' approach, which corresponds to and entails systems thinking. BMW or waste corresponds to characteristics of BMW is generated by general human medicine, veterinary medicine, plant medicine, households, pharmaceutical industry, and other industrial processes like meat and poultry industry and animal husbandry. Therefore, waste generated by all these sectors was counted under total BMW generation in district Hisar of Haryana state.

The BMWM model is a decision tree model which is based on probabilities of various encompassing events. The probabilities are considered based on the primary data collection and secondary literature review. It is a district-based model describing the process of BMW generation at various points in the district with an assumption that similar systems exist in other districts. The model is based on BMW generation calculations and their inputs.

Total BMW generation was calculated based on the sum of the total calculation of the various contributing factors. The list of contributing factors was inclusive of major components, but the list was not exhaustive. The Healthcare Delivery System (HCDS), industry, and household were considered as the main contributors. HCDS was divided into human and veterinary medicine. Both human and veterinary medicine was divided into public and private health systems. The public and private health systems were divided based on four health facility levels (1-4). Total BMW was calculated in kilos. The probabilities were calculated for each mentioned level. The lists of probabilities were described in the probability sheet. Industry wastes were divided into Pharmaceuticals, Poultry, Meat, Fishery, Lab, and Pharmacy industry.

Total waste was divided into infectious and non-infectious waste, and the probabilities of these events are based on the primary data and secondary literature review. The infectious and non-infectious waste was divided into treated and non-treated waste. The division of treated and non-treated waste was considered based on a secondary literature review. It was assumed that treated waste would not treat all the microbes which can cause the diseases. It was assumed that the treated waste could cause one infection per million treatments, whereas the same probability is considered as two infections per million treatments for untreated waste. Based on the secondary literature, it was assumed that treated and non-treated waste would contribute to NCD, infectious diseases, and AMR. There might be other impacts of improper waste management, but the present model has considered only NCD, infectious diseases, and AMR. All the values were depicted in per annum terms. The probabilities of infectious diseases were calculated based on the averages of various infectious diseases caused by BMW. The lower and higher range of averages was considered for calculation purposes.

Data with respect to amount of BMW generated by different levels of facilities the in public and private sectors were calculated based on primary and secondary information. Data with respect to animal husbandry activities, meat and egg production, death or killing of various animals in district Hisar were available on DAHD, Government of Haryana. Additionally, amount of waste generation while yielding meat from various animals and birds was taken from secondary sources and further extrapolated to a number of dead/killed animals/birds in a particular year in district Hisar. Furthermore, BMW generation from various lab and pharmaceutical processes and households was collected from secondary sources.

It was considered that all the material in infectious waste is equally potent to cause a disease/infection. The needle was considered as 1 gm for calculation purposes. Per bed, waste was considered in Kg. Liquid waste was not included in the model due to the unavailability of data, although it exists as a part of BMW. The impact of per unit waste was considered the same. Hisar population is considered as 1743931 (Govt. of Haryana, 2021). The average weight of chicken meat was considered 0.6 Kg. The average weight of sheep carcasses was considered as 9 Kg. The average goat carcasses weight was considered as 12 Kg. The average weight of pig removable was considered as 28 Kg. The fish consumption was considered as 105 Kg /person per year. The fish waste was considered as 25 percent of the total weight and pharma waste was considered as 12 Kg/year/pharmacy. The average waste per person in a lab was considered as 60 gm. Pharma industry waste was assumed as 35 Kg/day/industry. Data with respect to BMW treatment and disposal in district Hisar were collected from the respective CBMWTF. Finally, this data of CBMWTF were compared and correlated with calculations of the econometric model to estimate the gravity of the overall problem of BMWM in district Hisar.

3.5.16 Ethical Consideration

Ethical approval was taken from higher authorities prior to the primary data collection. The permission was sought from the office of the Civil Surgeon of the district or office of the Director General of Health Services (DGHS) or Senior Medical Officers/ Officer in Charge for data collection from public health facilities. Similarly, permission was taken from the head of private health institutions to collect information. Also, permission was sought from authorities of the SPCB and Municipal Corporations for the collection of information.

The research study was conducted solely for academic purposes, and the objectives of the study were communicated to all the respondents in the language they understood. The participation of respondents in the study was completely voluntary, and the respondents were free to exit from the study at any point in time. Empathetic behavior and professional attitude were maintained with the respondents throughout the research process. Permission was taken from the respondents before the audio recording of the interview. Consent was taken from the participants after explaining the purpose and procedures of the study. Confidentiality and privacy were maintained at all times. No insensitive questions were asked during the interview, and if the respondent was found uncomfortable in sharing any details and experience, the interview was discontinued. Respondents were informed at the beginning of the interview that they have the choice to refuse the interview or discontinue the interview at any point in time or to withdraw from the interview at any later time if they wish so. The names of the doctors and paramedical staff working in health institutions were not revealed and kept anonymous, and the information given by them will be kept confidential. Confidentiality was maintained at all times, and no unauthorized person could have access to the information.

3.6 DISTRICT HISAR AND ITS HEALTH SYSTEM

3.6.1 General Medicine

3.6.1.1 Public Health Services System

India adopted the welfare state approach, the dominant approach after independence in 1947. The state plays a leading role in determining priorities, financing, and provisioning services (Ravichandran, 2009). The Bhore committee recommendations of a three-tiered healthcare services system aimed at providing comprehensive healthcare services and hence limited the role of the private sector. It was done to ensure the equitable access of health services irrespective of the socioeconomic conditions of the population (Choksi et al, 2016). However, with decreasing investments in health, the public sector has undermined the need for quality of care for the masses. National health accounts reveal that 71 percent of the funding of health services is done by the private sector, of which 68.8 percent is contributed by households (Ravichandran, 2009). Subsequent health policies constantly echo and emphasize the need for increased involvement of the private health sector which reflects in the present healthcare delivery system of district Hisar (Table 3.3).

Table 3.3: Healthcare Facilities in District Hisar

Type of Facility	Level of Facility	Number of Facilities
General Medicine Public	Medical College (PPP mode)	1
	DH/SDH	3
	CHC	10
	PHC	38
	SC/HWC	210
	AYUSH Clinics/Dispensaries	66
General Medicine Private	Multispecialty Hospitals	75
	Clinics/Nursing Homes	412
	AYUSH Clinics	94 (estimated)
	Dental Facilities	100 (estimated)
	Individual Practitioners/RMP	3500 (estimated)

Source: *RHS 2019-20, MoHFW, GoI, AYUSH Department, Haryana and Primary Data*

Medical College Agroha, named Maharaja Agrasen Medical Education and Scientific Research Society, was established at Agroha (Haryana) on 18th April 1988 to provide health care services and medical education. It is a 550 bedded hospital located in district Hisar of Haryana. It has an average daily OPD of about 2500 patients, which amounts to 500000 per year. It conducts around 40 major surgeries a day and 81 minor surgeries on a daily basis.

District Hospital Hisar is also named after Maharaja Agrasen as Maharaja Agrasen Civil Hospital Hisar, which is a 200 bedded hospital providing services to the district's residence and to the citizens of other districts and states. There are two SDH in the district Hisar named SDH Hansi located at block Hansi and SDH Barwala located at block Barwala. These are 50 bedded hospitals in the district Hisar. Further, there are 10 CHCs having bed strengths ranging from 10 to 30 beds. Further, there are 38 PHCs in the district with a bed strength ranging from 6 to 15 beds. Few PHCs have been upgraded as 24x7 PHCs depending upon the load. The lowermost units of a public health system are SCs which are considered as non-bedded facilities. These facilities serve as immediate government health facilities which may provide services in the mode of institution-based or outreach services in the form of camps like immunization camps. There are 210 health SCs in Hisar district. A newer cadre of Accredited Social Health Activist (ASHA) workers was introduced in the system with National Health Mission (NHM). These workers are assigned population at village level. They provide their services in outreach mode most of the time. There are a total of 66 dispensaries functioning under the AYUSH departments both as independent facilities and in integration mode with modern medicine under one roof of CHC or PHCs.

In addition to these hierarchies, there are few health establishments that work independently of this public health infrastructure. There are Employee State Insurance (ESI) dispensaries, Ex-Servicemen Contributory Health Scheme (ECHS) polyclinics, University Hospital of Guru Jambheshwar University of Science and Technology, and Chaudhary Charan Singh Haryana Agricultural University Hisar, Army Hospital, and Railway Hospitals which have their own administration and management.

3.6.1.2 Private Health Services

The private health system that works independently of the public health system is considered highly unregulated. There is a different kind of hierarchy in the private health services system as there are different levels of services, but they are not interconnected among themselves like public health system facilities. These levels may be connected only for referral services. There are about 75 estimated multispecialty and specialist hospitals with varying bed strengths, where five multispecialty hospitals have bed strengths of more than 100. There are hospitals that are run by two or more multispecialty coming together to provide specialty services. Also, there are hospitals like Jindal Hospital and Adhaar Hospital, which are run by corporate entities. In addition to these hospitals, there are an estimated 412 facilities running as clinics or nursing homes with varying bed strengths. These facilities are often run by single specialists, Bachelor of Medicine and Bachelor of Surgery (MBBS) doctors, or Bachelor of Ayurveda, Medicine and Surgery (BAMS) doctors practicing allopathic medicine. These are uniformly distributed across blocks or cities. Their presence in the rural area is not as dense as in urban or semi-urban areas. In addition to this, there are around 100 dental practitioners practicing dentistry in the whole of the district. Another and most accessed level in private provisioning is informal health workers.

The Indian health system has demonstrated significant transformation after liberalization with increasing private sector involvement in health service provisioning. Evidence has revealed that India lags far behind in international standards in terms of quality of care and requisite infrastructure, with respect to beds per 1000 population. It will require huge investments to meet those standards. In the wake of decreasing investments in public health infrastructure, public providers are seen as key to meeting those standards of infrastructure and quality of care. Indian healthcare focuses on pertinent aspects of cost-effectiveness while providing quality and consumerism. The quality of specialist care and facilities is skewed towards urban areas (Shah, 2010). This skewness and lack of public health infrastructure have created space for informal health workers in disadvantaged communities or population subgroups in rural areas and urban slums as a large proportion of private healthcare services are provided by under-qualified or unqualified medical practitioners (Shah, 2010). In district Hisar, there are around 3500 estimated informal healthcare workers practicing in the private sector (Table 3.4).

Table 3.4 Informal Health Workers Practicing in District Hisar

Serial number	**Region**	**Estimated number of Informal health workers**
1	District Headquarter	550
2	Barwala Block	54
3	Hansi Block	73
4	Adampur Block	37
5	Uklana Block	46
6	Narnaund Block	42
7	Rural Area (Villages)	2698
	Total	**3500**

Source* -Estimates based on primary data

In the absence of adequate public healthcare infrastructure, most of the curative healthcare services are provided by private healthcare facilities, which may range from small clinics to big corporate hospitals. The focus of these facilities is secondary or curative care only. Hospitals with surgical and maternity services produce more waste than hospitals with eye and dental services (Banstola et al, 2017). The nature of healthcare waste may vary from needles, syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices, and radioactive materials. Apart from these facilities, healthcare services are also provided by registered medical practitioners and informal practitioners in rural and urban areas. Healthcare waste generated from their practice is openly dumped.

Home management of illness is prevalent in developing countries like India in the absence of adequate healthcare infrastructure. Therefore, a variety of medical waste is generated from households too. This waste may not find its way to the treatment facilities in a manner in which hospital waste could find.

3.6.2 Veterinary Health Service and Department of Animal Husbandry

Veterinary health infrastructure plays a pivotal role in the district and state as livestock contributes to the state's rural economy. Haryana state is home to "Murrah" and "Hariana Cow" germplasm. These germplasms are often exported to other states and abroad for increasing milk yielding. Indeed, the state is proud of its position, achievements, livestock wealth, and the significant contributions of this sector to the state economy (Govt. of Haryana, 2021). Therefore, animal husbandry activities are the prime source of income for various communities and population subgroups in Haryana. It is a major source of employment throughout the year for the rural population. According to the livestock census, there were 657532 cattles in district Hisar in 2019 (Table 3.6). Additionally, other industries like the poultry sector, fisheries, and piggeries are served by veterinary healthcare personnel. Therefore, veterinary health infrastructure is the key to sustaining this sector in Haryana.

Veterinary and department of animal husbandry were established more than a century year ago in the state. It plays an important role in maintaining the livestock's health and provides breeding facilities to precious livestock in the state. The state had 314 veterinary institutions in 1966 when it was separated from Punjab. Now there are

2860 veterinary institutions throughout the state. District Hisar is home to the largest veterinary institution, i.e., Veterinary College Hospital of Lala Lajpat Rai Veterinary University, which serves as a super specialty facility not only for the whole of the state but serves other states too. There are various departments with Out Patient Department (OPD) and In-Patient Department (IPD) facilities. Livestock surgeries are also conducted here. Additionally, there are 86 government veterinary hospitals in the district where a veterinary doctor is posted in addition to several veterinary livestock development assistants, which are field workers in the veterinary. Further, there are 139 veterinary dispensaries located across villages in the Hisar district. These facilities provide veterinary services to rural households. One veterinary dispensary serves 3-4 villages under it. These facilities provide outreach services like livestock immunization, delivery assistance, and prophylaxis services in the field.

Table 3.5 Veterinary Health Facilities in the District Hisar

Types of Facility	**Levels of Facility**	**Number of Facilities**
Veterinary Public	Veterinary College Hospital	1
	Govt. Veterinary Hospitals	86
	Research Facilities	8
	Veterinary Clinics	139
Veterinary Private	Veterinary Hospitals/Clinics	8
	Individual Practitioners	550 (estimated)

Source: *Department of Animal husbandry and Dairying (DAHD), Govt. of Haryana, 2021 and estimations based on primary data*

In addition to above mentioned public veterinary health facilities, a few private veterinary facilities also provide veterinary services to domestic animals and pets. Some of these are qualified veterinary personnel, and many of them are non-qualified. An estimated 550 veterinary practitioners practice veterinary medicine on an individual basis, like informal health workers in rural areas. Out of these practitioners, an estimated 70 percent are non-qualified veterinary health workers who provide services like livestock delivery assistance, administration of injections, and others.

Table 3.6: Livestock Census, District Hisar, Haryana

Serial Number	Animal Category	Number of Domestic Animals
1	Cattles	170440
2	Buffalo	426486
3	Sheep	33689
4	Goat	18864
5	Horse	570
6	Pony	43
7	Mule	106
8	Donkey	70
9	Pig	4157
10	Camel	341
11	Dog	2727
12	Rabbit	39
	Total	**657532**

Source- DAHD, Govt. of Haryana*

3.6.3 Current Programmes Focusing on BMW Management

3.6.3.1 Swachh Bharat Mission (SBM)

This initiative towards total "Swachhta" in public health facilities under "Swachh Bharat Mission" aims to build the confidence of the users in public health facilities. 'Swachhta Guidelines' have been developed to support the states in implementing the 'Swachh Bharat Abhiyan' in public health facilities. 'Swachhta Guidelines' for public health facilities were released on 15th May 2015 to promote Cleanliness, Hygiene, and Infection Control Practices in public health facilities. The Guidelines provide details on the planning, frequency, methods, monitoring, etc., with regard to Swachhta in public health facilities. These guidelines are a part of the series of operational guidelines for quality assurance in public health facilities, ensuring clean and hygienic facilities (MoHFW, 2015).

3.6.3.2 Swachh Swasth Sarvatra

It is an inter-ministerial joint initiative between the Ministry of Drinking Water and Sanitation and the Ministry of Health, and Family Welfare (MoHFW) that was launched in 2016. It was launched with an objective to build on and leverage the achievements of two complementary programmes– SBM and Kayakalp. Under this initiative, CHCs in Open Defecation Free (ODF) blocks will be supported to achieve Kayakalp certification, and Gram Panchayat of Kayakalp PHCs will be prioritized to become ODF (MoHFW, 2017).

3.6.3.3 Kayakalp Project

It is an initiative to promote cleanliness, hygiene, and sanitation in public health facilities. Under this initiative, public health facilities would be appraised, and such public healthcare facilities that show exemplary performance meeting standards of protocols of cleanliness, hygiene, and infection control will receive awards and commendation. Kayakalp initiative is expected to encourage every public health facility in the country to work towards standards of excellence to help the health institutions stay clean and hygienic, which will further enhance the confidence of people seeking care. This is not limited to physical cleanliness but also to developing systems and procedures for activities such as BMW disposal or protocols. Under this initiative, the number of awards is as under;

- Best two hospitals in each state (one in smaller states)
- Best two CHCs/SDHs in each state (one in smaller states)
- Best PHC in every district

Scoring for the Kayakalp award is done on the following six parameters;

1. Hospital Upkeep
2. Sanitation and Hygiene

3. Waste Management

4. Infection Control

5. Support Services

6. Hygiene Promotion

Under waste management, further sub-themes to be looked upon are; status of implementation of BMW Management and Handling Rules 2016, segregation and transportation of BMW, sharp management, storage of BMW, disposal of BMW, management of hazardous waste, solid general waste management in health facilities, liquid waste management, equipment and supplies for BMW management and statuary compliances (MoHFW, 2017).

Prior to the Kayakalp, the government had devised inspection protocols for the state's CHCs and Civil Hospitals.

CHC: The inspection checklist includes whether the wards follow BMW management rules or not. Another check is whether color-coded disposal bins and bags are available or not. Also, the final disposal of BMW is organized as per norms or not. It also talks about whether incinerator or effluent treatment plants are available or not. It does not talk specifically about the liquid or pathological waste generated from the laboratories and health facilities. Also, the availability and accessibility of the CBMWTF are not given space in the inspection checklist of the CHC.

Civil Hospitals: This inspection list is a mere extension of the previous inspection checklist of CHC. It also includes the check on BMW management rules in the wards, if they are followed or not. Again, on similar lines, it talks about the presence of color-coded bags, final organized disposal of BMW, and facility of incinerator and effluent treatment plant in the hospital facility. This inspection list for the hospital has no extra element as compared to the CHC inspection protocol.

CHAPTER 4

HEALTHCARE WASTE MANAGEMENT IN HISAR

4.1 UNDERLYING BROADER PROCESSES AFFECTING HEALTHCARE WASTE GENERATION AND MANAGEMENT

4.1.1 Curative vs. Preventive Services

Health services constitute preventive, curative, promotive, and rehabilitative services. Preventive health services are the focus of most public health strategies for improving population health. It is believed that if we invest in preventive health services, future needs for curative health services would be lesser. The primary health approach is a widely discussed phenomenon. However, with the advancements in healthcare technology and infrastructure, and the overall change of context from public to private provisioning of healthcare, emphasis has also shifted from preventive health services to curative health services. Curative health services are resource-intensive and seen as a tool for revenue generation by the private sector. The under-funded public sector and other macroprocesses have created space for the growth of the private sector, which is more focused on curative services. Preventive health services largely remained the liability of the public sector. Curative services result in the generation of more BMW than preventive services due to the involvement of more technology. As the type of services determines the quantity of healthcare waste generation, a surgical ward generates more healthcare waste than a medicine department; preventive services generate lesser healthcare waste than curative services. Hence, private health facilities generate a much more significant amount of healthcare waste as they are focused on the curative type of services.

Opinions are varied in this particular aspect, according to traditional medicine practitioners.

> "Allopathic medicine is focused on curative aspects of health; it does not focus on the preventive aspects. The curative procedure would lead to the generation of more BMW than preventive procedures. Changing technologies affect the behavior of the consumer also. We live in an era of consumerism, and it has spread like an infection in the medical field" (Homeopathic Medical Officer of a PHC).

> "Further, it is emphasized that not much waste is generated from ayurvedic facilities. Most of the medicinal substances we use are eco-friendly. Also, most pharma products can biodegrade in the natural environment. However, pathological or anatomical waste may be generated to some extent and stored in different color-coded bins". (Ayurvedic Medical Officer).

> We have no clear boundaries about the provision of health services according to needs or levels. It is a mix of systems, and everybody is present everywhere to provide services. In other words, there is no clear hierarchy in terms of service provisioning (Medical officer of a CHC).

A homeopathic practitioner in a primary health center also echoed this view as;

> "The major difference, as I discussed, is the provisioning of types of services. Preventive services are not able to generate revenues to the extent which curative services would generate. Most of the private healthcare facilities are focused on the revenue generation approach. Therefore, they are most interested in the provisioning of curative services."

4.1.2 Growth of the Private Sector

There are certain macroprocesses, like underfunding of the public health system and developments in technology and healthcare infrastructure, which catalyzed the growth of the private sector. Keeping in view the increasing need for healthcare facilities, the private sector is very much in demand and well-liked by all the stakeholders. It may be said that private hospitals provide much faster and speedy care to the patients, but they are also a reason for unwanted health practices by healthcare professionals. The increase in technology for disease diagnosis and treatment has made this sector very strong and trustworthy. Nevertheless, private hospitals have also invited increased numbers of tests and reliability of doctors on these tests, unlike ethical practices where a disease must be diagnosed based on the skills and experience of a doctor. This, in turn, is leading to higher numbers of labs with cheap offers, especially in cities, generating more BMW. This waste is not regularly managed and monitored, leading to the failure of BMW Acts and Rules. But how do we ensure BMW management in this sector? What steps should be taken to make them accountable? To answer these questions, one of the solutions may lie in imposing social responsibility.

> Moreover, privatization of healthcare has magnified the problem. A nearby private hospital (X Hospital) conducts 70 percent of its deliveries as cesarean. These are inevitable byproducts of growth in the private sector. A lot of the least required procedures are executed in the private sector. With the development of the private health sector, the nature of health provisioning has changed drastically. Doctors are over-dependent on technology for diagnosis (Senior Administrator of DH).

Although several underlying factors and macroprocesses are responsible for the growth of the private sector, mere growth of the private sector does not form the basis of the problem. The major problem lies with the regulations on the private sector as it is highly unmanaged/ unregulated/uncontrolled, and its expansion is enormous in India. This expansion is not just limited to smaller nursing homes or clinics. In addition to this, various health providers, like informal health workers and unregistered medical practitioners, have flourished both in urban and rural areas. The underlying reasons for this process are the uncontrolled and unregulated nature of the private sector. The private sector in veterinary medicine is not as developed as in general human medicine. Most of the veterinary health care services are provided by state-run healthcare facilities. With the advancements in technologies and an increase in facilities, the generation of waste has also increased. Private labs provide cheap offers in cities and collect samples in bulk. How would you ensure BMW management in such settings?

4.1.3 Dental Health Services

The common healthcare waste generated during dental procedures is Mercury, Lead, infectious cotton/ gauze, files, sharps, chemicals, etc., as a result of tooth restorations, scaling, Root Canal Treatments (RCTs), anesthesia, X-ray, respectively. These all are hazardous wastes and pose a significant threat to health and the environment.

> "Some of the chemicals used during these procedures are toxic, like mercury, when kept open or exposed to the environment, may cause mercury toxicity"(Private Dental Practitioner, Hisar).

Most extra Amalgam is generally thrown in the waste openly or goes down the sink, which becomes an ecological concern for environmentalists. Most of the waste generated is due to products used during dental procedures like teeth restorations, RCTs, dental surgeries, scaling, etc. Dental files used in RCTs are very small in size and must be handled carefully. They may break during the procedure and lead to blood contamination. The sharps like needles and files used in RCT, if not treated properly, may increase the risks of diseases like Hepatitis and HIV. Hence, it is clear that knowledge about healthcare waste management is scarce among dental professionals. They have not been completely part of the BMW management system yet, and it is one of the most significant loopholes in our system.

4.1.4 Growth of Health Insurance

Rising medical needs along with growth in the private sector have put stress on consumers' pockets. Out-of-pocket health expenditure is increasing continuously, proving catastrophic for a large section of the population. In such context, a mechanism of financial protection like health insurance is envisaged as a possible and suitable solution for providing financial security to people. Therefore, health insurance growth is directly proportional to the development of private healthcare infrastructure. If a better and well-equipped public health sector exists, there would be little need for a financial protection mechanism. There has been a steep rise in unethical and needless health practices with the increase in health policies. The concept of consumerism has taken its toll on medical treatments. People have been more carefree about treatment costs as it is to be borne by the insurance companies. There has been a tendency to visit health facilities for minor illnesses, which is poor health-seeking behavior. Health insurance may aggravate adoption to negative health behavior like less exercise, more smoke, and drinking habits leading to chronic lifestyle diseases demanding more diagnostic facilities and treatment throughout life. Varied experiences have been seen in different countries related to health insurance. It has resulted in overall expenditure on the provisioning of health services. The private sector has flourished in most countries where health insurance is seen as a financial protection mechanism. Additionally, moral hazard is one of the health insurance-associated phenomena which both consumers and healthcare providers exploit. Therefore, indirectly, health insurance is contributing to medical consumerism to an extent.

4.1.5 Growth of Tertiary Care Center

Healthcare waste management becomes more challenging with the rise in the level of healthcare facilities. Tertiary healthcare facilities invite more patients leading to more use of diagnostic tools and treatment modalities, generating a vast amount of BMW than hospitals at primary and secondary levels. The multispecialty and superspecialty hospitals provide sophisticated health services at the cost of significant waste generation, which is hazardous to human health and the environment. In veterinary institutions, the BMW generated is almost the same as any other facility treating humans. There are sharps, infectious waste, biological waste, plastic waste, etc., as a result of the treatment of animals. Larger hospitals generate a considerable amount of BMW, and facilities with a smaller number of beds, a lower amount of healthcare waste. However, such facilities would be lesser than the overall number of informal health workers or smaller clinics in a district. Advancements in medical technology along with shifts in some macroprocesses have invited the growth of tertiary care hospitals. Earlier tertiary care hospitals were limited to public sector medical colleges only. Over the decades, the shifts in provisioning of care from public to private and liberalization policies have created space for the growth of tertiary care hospitals like corporate hospitals in India. These hospitals tend to provide high-end services which involve huge costs to the consumer. Also, processes like developments in the health insurance sector catalyzed such development processes in tertiary care infrastructure. Most tertiary care hospitals would be present on panels of different government medical schemes or health insurance.

4.1.6 Provisioning of Health Services by Informal Health Workers

Though we do not have a well-established and demarcated health services infrastructure, people receive medical facilities through many channels and providers. Changing the culture of medical practices and medical needs of people and technological advancements have transformed the ways of health services provisioning. The major problem lies with quacks and informal health workers. The situation is worse at lower levels in villages or clinics run by informal health workers.

> “Such practitioners provide more than 50 percent of the services in the field setting. Imagine there are more than 600 villages in the district Hisar. Each village has around 8-10 informal health practitioners in their respective areas". One of the senior multi-purpose health workers of the public health system revealed, "The city of Hisar has around 350-400 informal health workers and their numbers in 600 villages is huge. There would be around 50 such clinics in the small town of Barwala" (Senior Administrator, District Hospital).

Hence, you can imagine the quantum of BMW generated daily. One of the male health workers posted at an SC revealed:

> “10-15 medical practitioners can be found in a village with about 5000 population. They provide several treatment procedures to the local population. The population of his village is around 4000, which has 12-15 informal healthcare providers. Similarly, in other villages, the number of informal practitioners practicing medicine is huge. They do not feel abiding by any legislation. Also, there is least awareness among them about such rules” (MPHW, District Hospital).

We do not consider such practitioners usually while talking about the management of BMW. But the hard reality is they exist and practice and generate BMW in community settings. Administration of injections and drip/ IV fluid is a prevalent practice in rural areas. Such practices lead to the generation of a large amount of BMW. They practice in smaller pockets of the population, informally in their clinics or through home visits. There is a considerable lack of awareness among such practitioners related to BMW, as mentioned by one of the health workers at the SC level.

> At the village level, healthcare providers are very much unaware of the existence of such rules. I am sure none of them tends even to bury the BMW generated by them. All of them throw their waste in the open. How many villages do we have in Haryana? Around 6000! Can we imagine how many informal health workers are there in Haryana and how much waste they produce every day? They do not perform specialized procedures, but most of them administer injections. They must be throwing a large number of needles every day in the open environment or mixing it with the general waste (MPHW of a SC).

When the researcher tried to explore such practices through conversation with one of the informal practitioners, he mentioned;

> "Yes! Many practitioners do that. See, many practitioners have started practicing medicine without having the necessary experience. They are not aware of the standard procedures to be adopted. As I mentioned, there are 12-15 informal healthcare workers in each ward or area with no practice experience. Additionally, pharmacists also practice medicine and deliver over-the-counter drugs without any prescriptions. It is a common practice in villages too."

Therefore, informal healthcare providers and the over-the-counter availability of drugs have compounded the problem of healthcare waste generation. These health workers are not a part of the health services system. Therefore, liabilities and responsibilities are not fixed on them. Also, they are not part of any regular monitoring or any hierarchy.

Estimating the number of such practitioners based on survey data collected by field health workers revealed that an estimated 3500 informal health workers are practicing in district Hisar. If we combine informal health workers of veterinary and dental health services, these numbers cross the mark of 4000.

Table 4.1 Types of Facility and Number of Practitioners.

Type of Facility	Level of Facility	Number of Facilities
General Medicine Public	Medical College	1
	DH/ SDH	3
	CHC	10
	PHC	38
	SC /Health and Wellness Centers (HWCs)	210
	AYUSH Clinics/Dispensaries	66
General Medicine Private	Multispecialty Hospitals	75
	Clinics/Nursing Homes	412
	AYUSH Clinics	94 (estimated)
	Dental Facilities	100 (estimated)
	Individual Practitioners/Registered Medical Practitioners (RMPs)	3500 (estimated)
Veterinary Public	Veterinary College Hospital	1
	Govt. Veterinary Hospitals	86
	Research Facilities	8
	Veterinary Clinics	139
Veterinary Private	Veterinary Hospitals/Clinics	8
	Individual Practitioners	550 (estimated)
Industry (Pharma etc.)	Pharma Manufacturing Industries	6

Sources:* 1. *DAHD, Govt. of Haryana, 2020, 2. Rural Health Statistics (RHS); 2020-21, 3. HSPCB report, 2020, 4. Department of AYUSH, Govt. of Haryana 5. Estimates based on institutional and individual surveys.*

These estimated 3500 informal health workers are distributed in districts, blocks, and villages, uniformly. Bigger villages may contain a greater number of health care workers. Table 4.2 reveals the block and village-wise distribution of these informal health workers.

Table 4.2 Distribution of Informal Health Workers in District Hisar

Serial number	**Region**	**Estimated number of Informal health workers**
1	District Headquarter	550
2	Barwala Block	54
3	Hansi Block	73
4	Adampur Block	37
5	Uklana Block	46
6	Narnaund Block	42
7	Rural Area (Villages)	2698
	Total	3500

Source: estimation based on survey data of field health workers/Primary data*

It can be pointed out that such workers generate only a small amount of healthcare waste, which is true in a sense. However, the major issue in BMW generation and management is the distribution of different points of generation of BMW. Most of them are located in rural areas where even domestic waste is not managed adequately. Therefore, whatever small amount of BMW is generated, it gets mixed with household waste making it infectious and hazardous. Primary data has revealed that informal health workers generate a variety of infectious and non-infectious waste (Table 4.3).

Table 4.3 Items used/healthcare waste generated by Informal healthcare workers on an average daily basis

Serial	Items	Weight of Item	Numbers of Items Used in a Day	Effective Weight
1	glass saline bottle	125 gms	2	125
2	plastic saline	7.5 gms	2	15
3	weight of IV set	22 gm	2	44
4	weight of needle with syringe	4.7 gm	10	47
5	weight of 10 ampule	18 gms	2	36
6	bandages/cotton	27+50 gm	1	77
7	Betadine/dettol	100 ml	1	100
	Total			**444 gms**

Source: Primary data collected from informal health workers in SC Khedar and SC Nangthala areas.*

A single informal healthcare worker generates an estimated 444 gms of healthcare waste daily. Out of which 168 gms is infectious waste in the forms of needles and IV sets along with soiled cotton and dressings. It constitutes an estimated 44 percent of total healthcare waste generated by general medical practitioners in the private sector that usually gets mixed with municipal solid waste.

4.1.7 Uncontrolled /Unregulated Private System

As discussed, various factors and macroprocesses have triggered the shifts in the provisioning of health services from the public to the private sector in India. Private sector expansion and growth have been tremendous. However, this growth is mainly uncontrolled or unregulated. One of the primary reasons for the flourishing of various healthcare providers especially, informal health care providers, is the least control and regulation on such processes. There is no clear hierarchy or linkages among different levels of healthcare institutions and practitioners in the private sector. No one is accountable to no one. Everyone is practicing medicine in an uncontrolled manner.

Moreover, government health authorities or health providers have no control over such growth.

> “The private sector often violates the law, and it is evident, but we have no power, not even for the generation of a simple challan. This unregulated context encourages them to indulge in unethical practices confidently” (Medical Officer of a CHC).

In a health system like India, where we have a variety of health practitioners and the sector is dominated by private players, it is hard to imagine the dynamics of such provisioning. We have no control over the private sector as much of it is unregulated. We have a kind of uncontrolled healthcare system where people hardly follow the rules. These underlying reasons lead to the violations of the laws as a common practice in the private sector. Greater control or regulation on the private sector is required for the proper implementation of the law. Table 4.4 reveals the number of healthcare facilities covered by CBMWTF in the private and public sectors. Out of 412 clinics and nursing homes (1 bed to 10 beds in strengths), only 249 are covered by BMW treatment facilities. CBMWTF covers only 7 of 100 dental facilities. The number of informal healthcare workers in the private sector (both in human medicine and veterinary medicine) is huge, but not even a single informal healthcare worker manages their healthcare waste.

Table 4.4 Healthcare Facilities Covered by CBMWTF in 2019

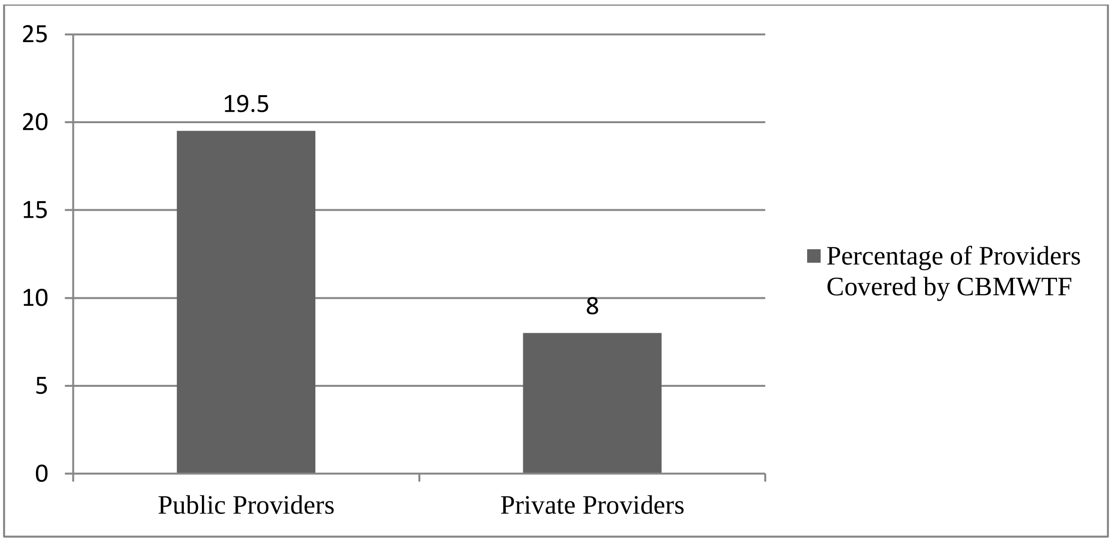
Type of Facility	Level of Facility	Number of Facilities	Covered by CBMWTF
General Medicine Public	Medical College	1	1
	DH/SDH	3	3
	CHC	10	10
	PHC	38	38
	SC/HWC	210	0
	AYUSH Clinics/Dispensaries	66	12
General Medicine Private	Multispecialty Hospitals	75	70
	Clinics/Nursing Homes	412	249
	AYUSH Clinics	94 (estimated)	12
	Dental Facilities	100 (estimated)	7
	Individual	3500 (estimated)	0

	Practitioners/RMPs		
Veterinary Public	Veterinary College Hospital	1	1
	Govt. Veterinary Hospitals	86	2
	Research Facilities	8	2
	Veterinary Clinics	139	0
Veterinary Private	Veterinary Hospitals/Clinics	8	0
	Individual Practitioners	550 (estimated)	0
Industry (Pharma etc.)	Pharma Manufacturing Industries	6	5

Source: *DAHD, Govt. of Haryana, 2020, 2. RHS; 2020-21, 3. HSPCB report, 2020, 4. Department of AYUSH, Govt. of Haryana 5. Estimates based on institutional and individual surveys.*

There is a considerable difference between the numbers of facilities covered by CBMWTF in the public and private sectors. CBMWTF covers most of the public sector facilities above the level of sub-center. However, comparatively, a lesser number of facilities are covered by CBMWTF in the private sector (figure 4.1).

Figure 4.1 Percentage of Providers Covered by CBMWTF



Source: Primary data*

4.1.8 Unnecessary Interventions or Surgeries

With the growing private provisioning of healthcare services, the delivery of unnecessary and least required interventions is a much-debated issue.

> "The private sector also indulges in malpractices and performs unnecessary procedures. They do not feel bound by rules as they are running as an unregulated entity" (Senior Administrator, District Hospital).

Moreover, processes as health insurance have led to the growth of unnecessary intervention on account of moral hazard. A senior doctor from the public health sector said, "health insurance has catalyzed the unethical and unnecessary provisioning of healthcare interventions." Such processes may generate a significant amount of BMW that could have otherwise been avoided.

> "Waste generation is an unavoidable phenomenon. However, unlike human medicine, unnecessary interventions or medical procedures are not common in veterinary medicine. It may be due to the lack of private health facilities for animals. Everybody knows that how private healthcare institutions prescribe or conduct unnecessary medical procedures to medical consumers" (Senior Veterinary Surgeon, LUVAS).

Veterinary medicine is not practiced on such a large scale, and most of the services are provided by government veterinary institutions. Hardly any unnecessary procedure is carried out on animals. However, it was emphasized by a lot of veterinary specialists that many unnecessary procedures are done in veterinary medicine, e.g., the use of oxytocin to increase the production of ethically wrong milk, which also harms the animals. In this way, the medical ethics of *'do not harm*' is violated in many ways. Such practices of veterinary medicine do not only affect animals but human beings also, directly or indirectly.

4.2 HIERARCHY AND BMW

4.2.1 Classification of Healthcare Waste

The scientific disposal of BMW depends upon its proper segregation. This segregation is based on the appropriate categorization and classification of BMW. Healthcare activities generate a variety of waste which may be classified as general or BMW, infectious or non-infectious waste, recyclable or non-recyclable waste, solid or liquid waste, hazardous or non-hazardous waste, plastic or non-plastic waste, and dry waste or wet waste. Additionally, it may be categorized as anatomical waste, pathological waste, cytotoxic waste, and radiological waste. Different types of healthcare activities or institutions generate different types of waste.

Moreover, healthcare activities are also carried out at household levels, resulting in the generation of some quantity of BMW and general municipal waste. However, in addition to these above-mentioned broader categories, a few BMW categories are detrimental to the environment but not very common. These may be harmful radiations as a byproduct of certain healthcare activities, poisonous and toxic waste like lead and Mercury, heavy metals in pharmaceutical formulations, and other chemical waste. In current times of the Covid-19 pandemic, certain uncommon types of BMW such as Personal Protective Equipment (PPE), especially infected masks, hand sanitizer, and other plastic waste, pose severe environmental challenges.

4.2.2 Type of Healthcare Facilities and BMW

Healthcare activities and procedures are of wide varieties and numerous in numbers, which result in the generation of BMW. These activities are not restricted only to procedures carried out by healthcare workers. Additional activities viz. pharmaceutical manufacturing, drug dispensing, radiological procedures, procurement, logistical services, monitoring and evaluation activities, and other administrative activities in the healthcare sector result in a wide variety of waste generation and substantial carbon emissions. A few developed countries made some efforts to estimate carbon emission as a result of healthcare activities. However, such studies are not of academic interest in developing countries.

As discussed earlier, different categories of healthcare activities result in the differential generation of healthcare waste. Preventive healthcare activities would result in minimal waste generation as compared to curative actions. Tertiary and secondary level healthcare activities result in the generation of more healthcare waste than the primary level of services. Based on several dynamics, private healthcare services would generate more healthcare waste than public health services. Corporate and multispecialty healthcare facilities generate a larger quantity of waste than smaller hospitals. IPD services would generate more BMW than OPD due to more number of procedures.

Additionally, mechanisms like health insurance have boosted the growth of the private health sector in the last two decades. Health insurance nowadays is seen as a potential financial mechanism for financing health services. The development of the private sector and health insurance go hand in hand. Moreover, most of the health insurance schemes cover expenditure for IPD services. Moral hazards from patient and provider sides and the unregulated and uncontrolled nature of the private sector lead to unnecessary procedures, resulting in excessive generation of BMW.

> "The major factor, in my opinion, is the kind of medicine we practice today. Back in the 1990s, when I started my medical carrier, we were not too reliant on diagnostic services or complex medical interventions. With the growth of the private health sector, the nature of health provisioning has changed drastically. Doctors are over-dependent on technology for diagnosis. Also, treatment procedures involve too much technology. People visit health facilities much frequently now to avail the services. The private sector also indulges in malpractices as a lot of unnecessary procedures are performed. In addition, health insurance mechanisms have catalyzed this process. Therefore, only one factor is not responsible for the generation of medical waste, but it is a complex phenomenon involving many factors" (Senior Administrator, District Hospital).

> "The major difference, as I discussed, is the provisioning of types of services. Preventive services are not able to generate revenues to the extent which curative services would generate. Most of the private healthcare facilities are focused on the revenue generation approach. Therefore, they are most interested in the provisioning of curative services. Moreover, mechanisms like health insurance have catalyzed this provision of curative services as most health insurances provide coverage for in-patient procedures/ treatments. Again, this process is a boosting factor for the growth of the private sector. So, multiple factors may not directly affect the generation of BMW but must be affecting it indirectly" (Ayurvedic Practitioner, Hisar).

> "Many factors are responsible for medical waste generation, like bigger facilities generate more BMW than smaller facilities. Private hospitals, especially larger hospitals, generate more BMW than public hospitals. There are a lot of healthcare providers in the villages like quacks or unregistered medical practitioners and veterinary practitioners who generate a lot of medical waste in the field. All of this BMW is thrown or burnt in the open. We have an uncontrolled healthcare system where people hardly follow rules that become the reason for the overall situation" (HI of a CHC).

> "The quantity and variety of waste generation depend upon many factors. Bigger hospitals with large numbers of beds generate more and variable BMW than smaller facilities with fewer beds where a small quantity of BMW with lesser variety is generated. The BMW generated by the medical practitioners at the village level usually comprises syringes and needles. In laboratories also, BMW includes needles and syringes, some reagents, blood-stained cotton or blood samples, urine, and other types of samples. Larger laboratories would generate a more significant amount of BMW" (LT of a CHC).

> "There are many factors responsible for the different quantities of BMW generation in various healthcare facilities. A laboratory might be generating more BMW than a doctor's OPD service. Even the smallest laboratory generates a huge amount of BMW, which may be challenging to manage. Larger hospitals with more beds generate more BMW than smaller hospitals and clinics" (LT of CHC).

> "Allopathic medicine is focused on curative aspects of health, and it does not focus on the preventive aspects. The curative procedure would lead to the generation of more BMW than preventive procedures. Changing technologies affect the behavior of the consumer also. We

live in an era of consumerism, and it has spread like an infection in the medical field, too" (AMO, HISAR).

"A district hospital produces the most significant amount of BMW after medical college. So there is a direct link between the number of beds a health facility has and the amount of BMW generation. CHCs and PHCs generate lesser quantities of BMW. Private health facilities generate a much larger amount as they are focused on the curative type of services. Preventive and rehabilitative services would result in a lesser amount of BMW generation. Surgical facilities will generate more medical waste than other facilities. A smaller level of health facilities like clinics and individual/ informal health workers would generate a smaller amount of BMW, mostly in the forms of sharps and plastic" (Practitioner, District Hospital).

As discussed above, healthcare waste generation is not a linear process. Its generation is affected by different factors, and its management is affected by other factors. Earlier, diseases were managed by diet control and altering environmental factors. Development in medicine has led to an increase in intervention-oriented treatment practices guided by an evidence-based medicine approach. The role of diagnostic processes and therapeutic procedures is paramount in today‘s modern medicine. Uncontrolled and unregulated growth in the private sector has catalyzed these ongoing developments. All these processes have impacted the nature of medical consumerism, leading to an increased generation of BMW.

"It is a multi-factorial problem. There are several factors responsible for the increased generation of healthcare waste. The first and foremost, in my view, is an increase in intervention-based healthcare facilities, resulting in the generation of a vast quantity of BMW. Earlier, surgeons were known to practice medicine with the least of the intervention. They primarily made the diagnosis with their hands, eyes, and ability to relate signs and ask questions from the patient. However, nowadays, it has become a fashion to get the various investigations done and performance of unnecessary interventions. Privatization of healthcare has magnified the problem. Additionally, policies like health insurance encourage the practices of unethical and unnecessary interventions in healthcare institutions. Inadequate implementation of the laws or rules on the BMW management and handling further adds to the problem. Smaller clinics and unregistered medical practitioners dump their waste openly or in the dustbins meant for municipal waste" (SMO of a CHC).

"There is no single major factor, but yes, growth has been seen in the health infrastructure or provisioning of services since the last few years. Earlier, people used to go to smaller hospitals in blocks or nursing homes to avail healthcare services. Nowadays, the existence of smaller clinics and unregistered medical practitioners is ubiquitous in every village. Unnecessary treatment is also provided to patients by all types of providers. These developments have led to an increase in healthcare waste generation. People do not want to wait for diseases to aggravate and go to the healthcare facilities for minor illnesses, which ultimately gets converted into poor-health-seeking behavior. Economic conditions have also improved over the years, so patients go to healthcare facilities and easily pay for the services" (MPHW of a SC).

"We may consider many factors like the type of hospital, the number of patients, type of treatment, ethical/ unethical practices, etc. Here, I think private hospitals can be held responsible for a huge amount of healthcare waste generation as these hospitals are in the habit of following unnecessary treatment regimes. A large number of medicines, redundant practices, and untrained healthcare workers contribute to more and more healthcare waste generation. This waste is required to be managed under the established guidelines. However, most of them are ignored as there is no strict surveillance to counter these futile practices" (Private Ayurvedic Practitioner).

The quantity of healthcare waste directly depends upon the volume of healthcare services provided in any context. Table 4.5 reveals the estimated amount of healthcare waste generated by different hierarchy levels in the public and private sectors.

Table 4.5 Estimated Amount of Healthcare Waste Generated on an Annual Basis

Sector	**Types of Facility**	**Bed Strengths**	**Total Waste per annum**	**Percentage of waste**
Public Sector	Medical College	450 Beds	367911 Kg	62 % of Public
	DH/SDH	200 beds	163516 Kg	27 % of Public
	CHC+PHC	4- 30	54093 Kg	1 % of Public
	SC	0	26061 Kg	0.04% of Public
Private Sector	Corporate/Multispeciality	11-150	273750 Kg	21 % of Pvt.
	Nursing Homes/Clinics	1-10	442380 Kg	34 % of Pvt.
	Informal Health Workers	0	567210 Kg	44 % of Pvt.

Source: Estimation based on primary data/secondary data*

Waste generation at different sources might not reflect their actual contribution to overall environmental and public health hazards, e.g., only 0.04 percent of total waste in the public sector is generated at the SC level. If we look cautiously, most of the vaccination and Maternal and Child Health (MCH) services are provided at this level. A maximum number of needles and syringes are generated here, which may reflect small in terms of weight, but its potential for transmission of infection and causing injury is much more than other types of waste. Moreover, such waste, both from the public and private sectors, is not adequately managed and gets mixed with municipal waste, leading to huge environmental and public health challenges.

Medical facilities are provided to the people through many channels and providers. Informal healthcare providers occupy a big space in the Indian healthcare system. These workers are not a recognized part of the formal healthcare services system. Therefore, the implementation framework for BMW management activities and environmental laws does not cater to them. Moreover, the private sector is largely unregulated in India, making it easier for them to practice freely but harder to manage their BMW appropriately. Additionally, rural areas lack requisite infrastructure and resources for general as well as BMW management.

> "You can find 10-15 medical practitioners in a village with a population of about 5000. They provide many treatment procedures to the local population. Can we expect the proper management of BMW from them? As far as quantity is concerned, I don't think anybody in the health system or authorities has tried to assess or measure the amount of waste produced in such a health system" (MPHW of a SC).

> "Many factors can affect the quantity of BMW. Smaller labs generate little BMW as compared to larger facilities. Not only laboratories but hospitals generate a different amount of BMW, which directly depends on their bed strength. However, many practitioners in villages generate BMW without being a part of a hospital or clinic" (LT of a PHC).

> "Several factors can be responsible for such situations, e.g., the type of health facility. A health institution or facility having a bed will generate more BMW than a facility without a bed. Informal health workers generate some quantity of healthcare waste, but the fact is, they are present more in numbers in villages. Smaller healthcare facilities, including smaller laboratories, also generate some BMW, and most of them do not manage their waste according to the rules. Smaller towns and villages do not have the required infrastructure to effectively manage BMW" (LT of a CHC).

> "Larger hospitals must be generating more BMW than smaller clinics and nursing homes, but their number is small compared to informal health workers. Informal health workers might not generate much waste, but their waste usually does not find its way towards a BMW treatment facility. Also, they generate BMW in a fragmented manner at different locations, which generally gets mixed with general waste. It leads to contamination of all the general waste" (HI of a CHC).

In addition to the healthcare services provided at institutions, several healthcare services are provided as home-based care or outreach services. Immunization services and fever mass surveys in malaria control programmes are the most common types of health services offered as outreach services. These services result in a large amount of infectious waste and plastic waste in the form of needles and syringes. In this context of outreach sites, it is hard to manage the generated BMW. Informal healthcare providers also provide home-based services through their home visits. People perform various healthcare procedures at their homes, resulting in healthcare waste generation, like blood-stained cotton, pads, insulin syringes, discarded medicine, etc. Healthcare waste generated due to the activities mentioned above is often mixed in general waste due to the unavailability of requisite infrastructure for the safe management of BMW.

> "If I talk about my health facility, the quantity of healthcare waste generated is not the same daily. Sometimes there are patients with minor injuries, and at times, there are accidental cases. The waste generation is more where treatment is complex and lengthy, which does not happen in routine. During peak seasons of malaria and dengue, there is an increased number of patients, and the interventions used for them are more than the other seasons. It is prevalent for informal healthcare providers to use excessive IV fluids at those times" (MPHW of an SC).

> "As a PHC, we do not have much quantity of healthcare waste daily. Mostly, primary patient care, pregnancy-related procedures, and immunization of infants are done here. Patients visiting this PHC throw used swabs, bandages, and other things here and there even we instruct them to use the bins" (MPHW of a PHC).

> "There could be many factors responsible for the generation of a varied quantity of BMW. Larger hospitals are generating a huge amount of BMW. Facilities with a smaller number of beds will generate a lower amount of healthcare waste. However, the number of such bedded facilities is lesser than the overall number of informal health workers or smaller clinics in a district. Such practitioners provide more than 50 percent of the services in the field setting. There are more than 600 villages in district Hisar, and each village has around 8-10 informal health practitioners practicing medicine in their respective areas. You can imagine the quantum of BMW which is generated daily. We do not consider such practitioners usually while talking about the management of BMW. But the hard reality is that they exist and practice and generate BMW in community settings" (MPHW, Hisar).

> "As I mentioned, there are 12-15 informal healthcare workers in each ward or area. Additionally, pharmacists practice medicine and deliver over-the-counter drugs without any prescription. It is a common practice in villages too. These health workers are not a part of the formal healthcare system. So they do not feel or understand any legal boundation for them. Apart from these factors, private nursing homes, clinics, and bigger hospitals generate a significant amount of medical waste" (LHV of a PHC).

Apart from the categories mentioned above, there are certainly other types of healthcare activities that result in a small amount of BMW, but this small amount of BMW can be detrimental to the environment and may pose serious challenges. Smaller laboratories in rural or semi-urban areas act as a collection center for their parental facilities/ laboratories, chemists, dental clinics, Ayurvedic and Homeopathic facilities, school health activities, and local herbal medicine manufacturing activities units resulting in BMW generation.

> "Most of the waste generated is due to products used during dental procedures like teeth restorations, RCTs, dental surgeries, scaling, etc. Some of the chemicals used during these procedures are toxic, like mercury, when kept open or exposed to the environment, may cause mercury toxicity. Dental files used in Root Canal Treatments may break during the procedure, which must be handled carefully due to their small size, and there may be chances of blood contamination" (Dental Practitioner, Barwala).

> "In dental practice, a large amount of waste is generated as a result of routine procedures. A major portion of the healthcare waste generated is due to used gloves, syringes, restorative materials. It may be said that a single dental facility may not be responsible for the high amount of BMW generation as compared to the large health facilities with a large number of

OPD where more surgeries are performed than individual health facilities. These can be large government hospitals like AIIMS, district hospitals, major private hospitals like Max, Fortis, Apollo, etc. Other factors contributing to this are unregistered medical and dental practitioners, laboratories, animal research centers, forensic labs, clinical research centers, etc." (Dental Practitioner, Hisar).

"As I mentioned, Allopathic medicine is over-focused on the curative aspect of human health. In contrast, Ayurvedic medicine's primary focus is to maintain the healthy status of the individuals with a preventive and promotive approach. Ayurvedic medicine focuses on averting diseased conditions by maintaining a healthy lifestyle. This fundamental difference leads to variations in the quantity of waste generation in both medicines. Diagnostic services and pharmaceutical developments in Allopathic medicine involve technology and complex processes where BMW generation is inevitable" (AMO, Hisar).

"See, it depends upon the extent of your reliance on diagnostic services and the ayurvedic formulation type you are using. Some of the ayurvedic medicine contains traces of heavy metals, too, including mercury. We do not prepare such compounds in our pharmaceutical industry unit. Some of the industries in Hisar are preparing those compounds too. For that, they need to obtain environmental clearances from the environmental authorities. They are liable to install effluent treatment plants and manage liquid waste generated from those industries" (AMO, Hisar).

4.3 BMW MANAGEMENT IN THE VETERINARY SECTOR

There is not much difference in the type of healthcare waste generated due to healthcare activities for humans and animals. Sometimes, healthcare waste quantity generated from veterinary health facilities may be huge, e.g., due to surgical procedures for an animal. The amount of discarded pharmaceutical products may be substantial due to the quantum of pharma compounds used to treat animals. However, veterinary services provisioning has a major impact on BMW management in the case of veterinary healthcare services. Veterinary medicine contributes about an estimated 48 percent to the total healthcare waste generated by the healthcare delivery system. Much of the services are provided on an outreach mode basis. Additionally, veterinary service consumption is much higher in rural areas as compared to urban areas. Requisite infrastructure for adequate management of BMW is not sufficient in rural areas. Also, most of the veterinary services are provided by the state. Private players are not that much active in the field of veterinary medicine.

"As discussed, various healthcare waste is generated from veterinary activities like plastic waste, needles and syringes, blood and other byproducts, placentas, and much more. If not appropriately managed, these waste products may result in environmental degradation, hamper natural biodegradation processes, and contaminate the food chain. Therefore, it may affect both animals and humans indirectly. Also, as mentioned earlier, there was the direct effect of unmanaged or mismanaged healthcare waste on the health of humans and animals" (Senior Veterinary Surgeon, LUVAS).

"These activities result in the generation of a variety of waste such as pathological waste, radiological waste, infectious waste such as needles and syringes, and other plastic waste along with blood and blood products. Also, healthcare waste is generated from laboratories

> and research activities. However, health facilities to animals may not be accessible on the same line as they are accessible to animals where doses of medicines and fluids are very much higher than a human, which contributes to the BMW" (Senior Veterinary Practitioner, LUVAS).

> "Surgical procedures result in maximum waste generation. Apart from surgery, the obs and gynae department produces a large amount of health care waste. Liquid waste is generated more by the pathology department. Infield settings, needles, and syringes constitute the most significant proportion of the BMW generated by general veterinary medicine practiced mostly by VLDAs" (VLDA of a Government Veterinary Dispensary).

> "In larger veterinary settings, the quantity of healthcare waste generated is higher than in village hospitals. However, if we see effectively, the quantum of healthcare waste generated at the village level in total may exceed the quantum of healthcare waste generated here because the number of health facilities and infrastructure is huge. Needles, syringes, bandages, and plastic waste, and medicines are the major healthcare waste generated at a lower level of health facilities. Pathological waste generated by the pathology department may be infectious or non-infectious" (Senior Veterinary Administrator, LUVAS).

There is a huge difference between per capita waste generation as an individual veterinary healthcare worker generates almost ten times BMW compared to informal health workers of human medicine. A veterinary practitioner generates an estimated 5305 grams (Table 4.6) of BMW per day compared to 444 gms generated by informal health workers of human medicine.

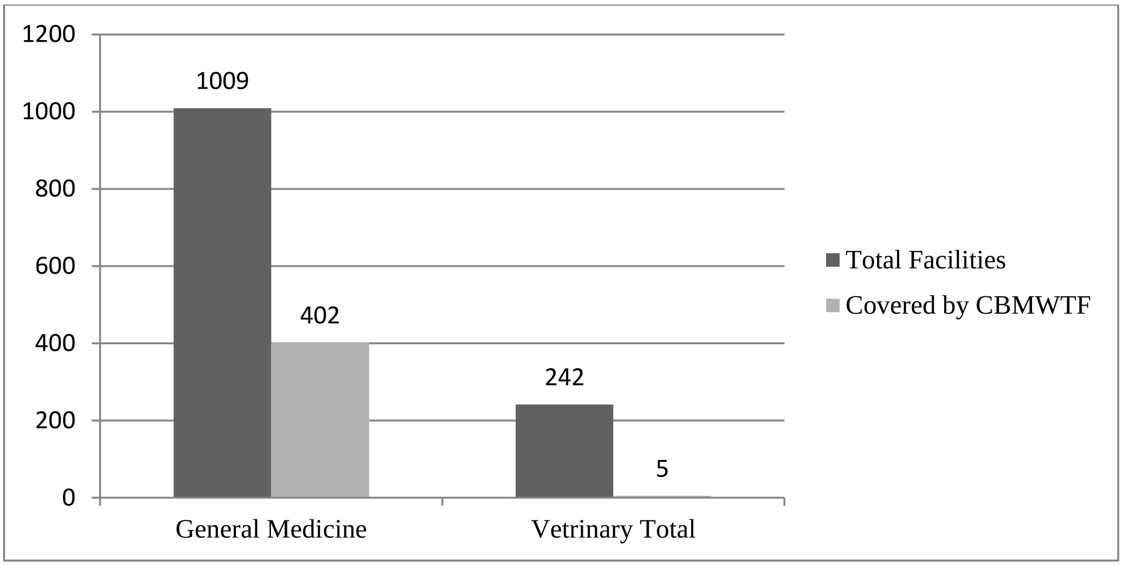
Table 4.6: BMW Generated by Individual Veterinary Worker/Practitioner on a Daily Basis

Items used by Vet Dispensary workers on an average daily basis in grams				
Serial	**Items**	**Weight**	**Number**	**Total Weight**
1	Needles	3 gms	15	45
2	Bandages	500 gms	2	1000
3	Placenta	3 Kg	1	3000
4	Ampules 20 ml	30 gms	2	60
5	Cotton roll	1 Kg	1	1000
6	Betadine/Dettol	200 ml	1	200
	Total			**5305**

Source: *estimation based on primary data*

The number of veterinary healthcare facilities covered by CBMWTF is negligible as only five veterinary healthcare facilities (Table 4.4) are covered by CBMWTF in the Hisar district. However, veterinary may contribute around 48 percent of total healthcare waste generated by the healthcare delivery system, but most of it usually gets mixed with municipal waste. Informal health providers of both veterinary and human medicine constitute as biggest providers in the private sector. However, even facility-level coverage by CBMWTF is deficient (Figure 4.2) for BMW treatment.

Figure 4.2: Facilities covered by CBMWTF for BMW treatment



Plant; The agriculture sector uses many chemicals and pharma compounds. Residues of one of such pesticides were consumed by birds which led to mass mortality of peacocks. The concentration of that poison might have been higher, which lead to the worst situation.

However, many pesticides and pharma products are present in the environment (air, water, and soil), which remain there for longer durations. These chemicals get accumulated in crops, food grains, drinking water, and animals, followed by other animals, organisms, and humans, who drive their food from those crops and animal products. It affects the ecosystem gradually. Many unnoticeable changes in the environment might be happening continuously.

4.3.1 BMW; as a Byproduct of Modern Medicine

Healthcare waste generation is compounding and ever-increasing since ongoing developments in modern allopathic medicine and diagnostic technologies. These transformations and developments have led to a significant increase in BMW generation. It is not justified that modern allopathic medicine could be accused as the sole responsible factor for an increased quantity of BMW. However, practitioners, providers, administrators, and users of modern medicine and those diagnostic procedures could be accused of unethical or unjustified use of modern medicine. Generation of some quantity of BMW is an inevitable phenomenon, but unnecessary interventions could lead to increased generation of BMW. In a certain context, sometimes ethical and justified use of medical interventions could lead to increased BMW due to the lack of requisite infrastructure for the management of this waste.

> "The problem of healthcare waste generation is a byproduct of modern veterinary practices, also. But the extent of unethical practices is very much limited in veterinary medicine, barring some examples such as the use of antibiotics in poultry industries and hormonal drugs in animals. Therefore, the direct effects of healthcare waste are very much limited. However, it is also an accepted fact that it is mismanaged in field settings. Impacts of healthcare waste due to the veterinary sector are lesser evident due to the shortage of evidence. However, like general medicine, waste and byproducts of pharmaceutical compounds may affect human and animal health indirectly through many pathways" (Senior Administrator, LUVAS).

> "The harm done by modern veterinary practices depends more on the environmental consciousness of practitioners and policymakers. The generation of BMW is an unavoidable phenomenon. All the problems lie with its mismanagement. Also, the extent of unnecessary interventions in veterinary medicine is very much limited as compared to general human medicine. In veterinary medicine, a major chunk of services are provided by the state" (Veterinary Surgeon, LUVAS).

4.3.2 Pharmaceutical Industry and Environment

The process of industrialization accompanies development processes. The industrialization process is always associated with environmental pollution. Some of the industries are highly polluting in nature. The pharmaceutical industry also is considered to be one of the most polluting industries. Large-scale developments have happened in the pharmaceutical industry. It is also imperative that the majority of highly polluting industries are located in developing countries for various reasons. India is a hub of generic medicine manufacturing and one of the largest exporters of generic medicines. The bulk of pharmaceutical industries could be found in many special economic zones or industrial towns.

The consumption pattern of drugs or antibiotics by a population affects the natural environment directly or indirectly. Additionally, these compounds are used on a large scale in animal husbandry, the poultry industry, and large animal farms. Partially metabolized pharmaceutical compounds are released into the natural environment through different channels. The residue of many pesticides and insecticides remains in crops and animal feed for longer durations. Then it passes on to humans through crops or food grains, meat, and milk products. Similarly, pharmaceutical compounds, especially antibiotics, remain in the environment for a longer duration as pharma compounds are one of the most slowly degradable products in the environment. Some of the APIs may stay in the environment for decades. These active ingredients persist in water bodies or drinking water, food, and air also. These processes are part of a very complex cycle. Therefore, slow exposure is there. Therefore, this is a very complex phenomenon, and the number of pathways is innumerable.

> "I am not aware of many channels of environmental contamination, but yes, as I am concerned with pharmaceuticals, I must say that these are very harmful chemicals. People use the bulk of antibiotics in the poultry industry, animal husbandry, and various medicines in human treatment. Additionally, the agriculture sector uses a variety of chemicals to treat multiple plant diseases. We, human beings, are exposed to such chemicals in many ways, directly or indirectly. Even pharmacists like me, who work in dispensaries, face many challenges with respect to discard of medicines. Therefore, it is a very challenging situation for us" (HI of a CHC).

> "As I mentioned, excessive and irrational use of antibiotics both in humans and animals lead to slow and persistent exposure in animals and humans. Hormonal drugs and pharmaceutical products, in general, are one of the slowest degradable products. They remain in the natural environment for longer durations. This slow exposure may lead to various adverse impacts to the whole ecosystem, which goes undetectable or unnoticed" (SMO of a CHC).

The products from pharmaceutical industries result in the release of APIs in the environment through different channels, especially wastewater release. This wastewater is often mixed with freshwater streams or directly to sewage waste lines without any treatment. Environmental monitoring of industrial processes is a huge concern. Without frequent environmental monitoring and an inadequate implementation framework of environmental legislation, it becomes easier for industries to violate the rules. It is evident from the literature that industrial ETPs cannot remove the dissolved APIs from pharmaceutical industrial wastewater. Therefore, environmental monitoring of such ETPs is imperative to pollution control strategies.

> "Yes, some of the industries have installed ETPs in their units, but their efficiency is always questionable. It is not clear whether they can perform the intended function. Also,

> environmental monitoring of such ETPs is necessary from time to time. I am not sure whether such monitoring is happening or not" (Ayurvedic Manufacturing Unit, Hisar).

> "See, it depends upon the extent of your reliance on diagnostic services and the ayurvedic formulation type you are using. Some Ayurvedic medicines contain traces of heavy metals, too, including mercury. We do not prepare such compounds in our pharmaceutical industry unit. Some of the industries in Hisar are preparing those compounds too. For that, they need to obtain environmental clearances from the environmental authorities. They are liable to install effluent treatment plants to manage liquid waste generated from those industries" (Ayurvedic Manufacturing Unit, Hisar).

4.4 HEALTHCARE WASTE MANAGEMENT IN THE PRIVATE SECTOR

4.4.1 Problem of BMW Management

Healthcare waste generation and mismanagement have been a compounding phenomenon ever since healthcare delivery has transformed itself under the influence of technological and infrastructural development. This transformation is ongoing as newer and newer technologies are coming into the field of healthcare. Under the overall context of development, advancements in healthcare and shifts in healthcare delivery have triggered the process of medical consumerism. All these processes have led to the increase in the generation of BMW. BMW generation and management are different processes. Different factors influence both processes. First and foremost is the delivery of healthcare and health services. It's a huge problem in current times where healthcare is being delivered as institutional care with many hospital/clinic-based interventions. This institution-based care is not only restricted to larger nursing homes or hospitals. There are various institutions viz. medical college hospitals, corporate hospitals, multispecialty hospitals, nursing homes, district hospitals, and other lower-level government health facilities, and smaller clinics run by both formal and informal health workers. Only 8 percent of the private providers are covered under services of CBMWTF (figure 4.1). Various activities at all these facilities result in the generation of healthcare waste.

> "Healthcare waste is being generated at various levels by various activities. Management of healthcare waste is also a huge concern a healthcare delivery system is very much fractured in India. Barring a few higher health institutions in the public and private sector, healthcare waste is hardly managed as per the set rules and regulations" (MO of a CHC).

> "Yes, healthcare waste is a major public health concern in today's context. We often hear that healthcare providers violate the rules and throw their healthcare waste in the open or mix it with general municipal waste. This is a huge environmental concern. It affects the health of human beings and other organisms. Though recent development in the effective management of healthcare waste has happened, very little change or improvements came in rural or small towns" (Homeopathic Medical Officer).

> "I am well aware of the problem of healthcare waste generation and management in healthcare facilities. This waste is generated due to many healthcare activities carried out in larger hospitals, smaller nursing homes, clinics, and smaller clinics of registered medical practitioners. Additionally, there are several quacks or unregistered medical practitioners in rural and urban areas who practice in smaller pockets of the population informally in their clinics or through home visits. Many medical treatment activities are carried out by them in the field and generate a variety of healthcare waste. Often, this waste is not collected and segregated the way it should be done. Therefore, it contaminates the environment, which is a big problem in India" (Radiographer, Barwala).

Healthcare waste is a significant environmental issue in our country as not all the waste is managed properly. Health providers tend to throw the waste openly or mix it with general waste. If not managed properly, healthcare waste could lead to huge adverse environmental impacts and long-term adverse impacts on human health. Our health system is very fragmented. We do not have clear boundaries about the provision of health services according to needs or levels. It's a mix of systems, and everybody is present everywhere to provide services. This means to say there is no clear hierarchy in terms of service provisioning. Various healthcare providers offer healthcare services in the private sector, both in veterinary medicine and general human medicine (Table 4.7). In addition to these providers, there are laboratories and medical stores which generate a small amount but hazardous and potentially infectious waste.

Table 4.7 Private Health Establishments and Services of CBMWTF

Type of Facility	Level of Facility	Number of Facilities	Covered by CBMWTF
General Medicine Private	Multispecialty Hospitals	75	70
	Clinics/Nursing Homes	412	249
	AYUSH Clinics	94 (estimated)	12
	Dental Facilities	100 (estimated)	7
	Individual Practitioners/RMPs	3500 (estimated)	0
	Pharmacies/Medical Store	950 estimated	0
	Laboratories	325 estimated	102
Veterinary Private	Veterinary Hospitals/Clinics	8	0
	Individual Practitioners	550 (estimated)	0

Source: CBMWTF*

The generation of BMW is unavoidable following healthcare activities, mainly curative health services/ activities. The extent of such activities has increased with the increasing proportion of institution-based care. Private healthcare infrastructure has grown exponentially in the last few decades. Developing countries like India are also facing the brunt of environmental problems due to lack of necessary infrastructure or lack of implementation of environmental protection laws. The regulatory framework seems inadequate, making it easier for violators to pollute the environment.

> "It is a big problem in current times. Over the last few years, health facilities, especially private health facilities, have grown exponentially. Most of the facilities do not follow the rules or norms with respect to BMW management. It is a common observation or news that health facilities are throwing their BMW in the open or mixing it with general waste. Though the proportion of infectious waste is not too much in overall BMW, lack of standard procedure or mixing it with general waste lead to an overall increase in infectious or hazardous waste" (Senior Administrator, Hisar).

There is also the rural-urban difference in terms of allocation of healthcare services. Most of the bigger hospitals and larger healthcare facilities lie in urban areas. Rural areas are mostly served by smaller clinics usually run by informal health providers. Mismanagement of healthcare waste is a commonly observed phenomenon in urban areas where requisite infrastructure for scientific management and disposal of BMW management exists to some extent. In contrast to it, such infrastructure is not present in rural areas. Smaller clinics and informal healthcare practitioners also generate some amount of BMW. The problem lies with the wide distribution of BMW as these healthcare workers are widely distributed. Also, such healthcare workers are not directly related to the health services system of the state; instead, they are often termed as quacks by authorities. Therefore, they are also not part of the implementation framework designed for the scientific management of BMW. Additionally, waste management infrastructure for general solid waste is also not developed in rural areas and many urban areas.

> "It's a big problem in the whole of the country. I must not deny that situation is not very well in urban health facilities also! Forget about the smaller healthcare facilities in smaller towns or villages. The problem is worse at lower levels in villages or clinics being run by informal health workers. Most medical practitioners, including practitioners in some bigger hospitals, throw their BMW in the open only or mix it with general municipal waste. Last week only, a report published in a local Hindi daily newspaper revealed complex realities. Bigger hospitals, even the same famous hospitals of Hisar, indulge in malpractices related to BMW mismanagement" (Senior Administrator, District Hospital).

> "This problem can be seen in the whole district. We are field workers, and we know the realities in field settings. Although some hospitals violate the rules and mismanage their BMW, the major problem lies with quacks and informal health workers. The city of Hisar has

around 350-400 informal health workers, and their number in 600 villages is huge. They generate a huge amount of waste and throw it in the open or mix it with general waste. This happens because they are not part of the formal health services system. All of them throw their harmful BMW openly. There is no doubt that 100 percent of them are indulged in the mismanagement of healthcare waste" (MPHW of District Hospital).

"Yes, I have long experience working in the field at different levels of health facilities. I am going to be retired soon. I have worked in various PHCs, CHCs district hospitals, and also at multiple sub-centers. In my opinion, the smaller is the facility more is the problem that exists with respect to BMW management. However, these facilities generate a lower level of BMW as compared to larger facilities. Earlier, most of the bigger facilities used to throw their medical waste in the open or burn it. However, things have been changing for the last few years, but problems still exist in the field" (HI of a CHC).

One of the major factors that directly affect BMW management practices is the type of facility. The private healthcare system is largely unregulated or uncontrolled. In addition to private clinics, nursing homes, and large hospitals, various healthcare establishments are responsible for generating BMW, viz. laboratories, pharmacies, health camps, and associated industries. In the wake of weak environmental protection laws or inadequate implementation, it becomes easier for private health facilities to violate the law. Multiple stakeholders are responsible for proper waste management practices. Many times, BMW is disposed of in municipal dustbins. Such practices are evident from various media reports and experiences of municipal workers.

"Yes! I am aware of the issues about healthcare waste. For the last few months, it has been in the news as National Green Tribunal has directed the Municipal Corporation of Hisar and Civil Surgeon of Hisar to ensure proper disposal and treatment of waste, especially BM waste. There is a problem with the private hospitals, which dispose of their BMW in the open or bins of municipal corporations. Similarly, at the field or village level, it is disposed of with general waste. Healthcare facilities which ensure proper management of BMW from generation to final disposal are minimal" (MPHW of District Hospital).

"I have been practicing as a lab attendant for years. I am aware of the problem of healthcare waste. A variety of BMW is generated from healthcare facilities, including laboratories that need to be managed based on standard guidelines. However, people generally do not follow the rules or guidelines, which leads to environmental contamination" (LT of a PHC).

Bigger healthcare facilities generate a large quantity of BMW. Healthcare facilities with more beds and specialized curative services generate more BMW. However, smaller facilities or field-level facilities deliver healthcare services in communities as institutional care or outreach services. Although the quantity of BMW generated may not be significant at that level, the requisite infrastructure for adequate management of that much BMW is usually not available. Outreach services are provided in the communities for various services like immunization or slide formation, which may result in the generation of sharps and infectious waste. In such a given context, it is not easier to manage BMW scientifically.

> "As healthcare workers, we generate different types of waste material at the sub-center and as well as in the field. It includes syringes, needles, blood-stained cotton, etc. these things can affect human health and the environment. It may be a huge problem for bigger hospitals if they do not handle or manage waste produced by them. Sometimes we also read such news on mismanagement or open throwing of BMW by healthcare establishments" (MPHW of a CHC).

> "Yes. It's a big problem in the field of healthcare. Many practitioners and hospitals throw their medical waste in the open. In the area of laboratories, a variety of healthcare waste is generated like sharps, syringes, soiled cotton, reagents, blood and other samples, etc. Sometimes we are assigned the responsibilities of mass sampling in the community settings. It leads to the generation of a huge BMW. All these waste products are infectious waste and could lead to various types of infections and injuries in laboratory workers and waste handlers, and community members. Additionally, sharp inflicted injuries can happen through this BMW" (LT of a PHC).

4.4.2 Laboratories

> "It depends upon the level of exposure; as lab attendants or practitioners, we are more exposed to various infections. Although we take extra precautions while handling a confirmed patient of a severe condition like HIV/AIDS, we are still at a higher risk of exposure to such conditions in routine. We can directly be contaminated from such infections while carrying out our duties like handling samples, drawing or taking blood samples, and performing diagnostic tests" (LT, Civil Hospital).

> "Healthcare waste is harmful to human health in many ways. It can cause direct injuries, infections, and other effects. In labs, we are exposed to a variety of conditions and injuries. We also test for HIV/AIDS and Hepatitis. We are constantly exposed to such infections as only patients visit laboratories. We do not know in advance about the kind of infection the patient is suffering from. Blood and other types of samples are potential BMW within themselves as they are highly infective. Constant exposure makes us more vulnerable to such harmful effects" (LT of a CHC).

> "Sample taking and handling samples that are usually infected pose serious challenges for us. Therefore, we always work in the context of challenging conditions. Apart from the infection, healthcare waste could lead to severe injuries to the person handling or generating it. Smaller labs functioning in the field do not take all the required precautions for handling BMW. It is often thrown in open or mixed with general municipal waste poses serious challenges to the environment" (LT of a PHC).

Healthcare waste could affect human health and the health of other organisms. There are many direct and indirect ways in which BMW could deteriorate the environment and human health. Ways or channels of infection could be numerous. Laboratory or blood bank workers are continuously exposed to severe infections through needle pricks injuries and infections. People working in pharmacies or pharma industries may be exposed to various chemicals with a slow exposure. Sanitary workers in a hospital or municipal workers are prone to such adverse effects through many different channels.

> "Healthcare waste contains many pharmaceutical chemicals, infected human tissues, glass, syringes or plastic waste, stained blood dressings, etc. In x-ray diagnostic facilities, we also have radio waste. This type of waste could affect human health directly or indirectly. Humans or scavengers may be contaminated, and they may get injured while carrying out their responsibilities. Sanitary workers also could get infected and injured. Human beings may catch a variety of infections due to healthcare waste" (Paramedic of a CHC).

4.4.3 Different Practices of Healthcare Waste Management

As discussed earlier, a variety of healthcare providers provide health services in India. The majority of the service providers are from the private sector. These providers extend their services to the population at various levels ranging from small individual clinics to high-end corporate hospitals. Therefore, the extent of the problem of healthcare waste management is different at different levels. Facilities located in urban areas might not face difficulties if they want to manage or dispose of their BMW scientifically in contrast to a rural facility where requisite infrastructure for effective and scientific disposal might not be adequate. Despite the availability of infrastructure for scientific management of healthcare waste, healthcare facilities might get involved in unethical and inappropriate practices with respect to BMW management viz. throwing of BMW in municipal dustbins or on roads, water bodies like ponds, water streams, or open sewage. Also, they may throw their waste directly at landfill sites or might end burning this waste. The burial or burning of BMW is a common phenomenon. Such practices lead to harmful emissions of various environmental pollutants, which affect the health of humans and other organisms of the ecosystem.

> "I am aware of healthcare waste and its management issues, which is a major challenge in the health department. Many hospitals and practitioners throw their medical waste in the open or with normal municipal waste, which harms the environment and human health. Many such issues are published in various newspapers from time to time. Reports regarding the openly throwing of BMW by many private healthcare providers are common practice" (LT of a CHC).

It is imperative to have the requisite infrastructure available for better waste management capabilities so that the stakeholders may adopt effective waste management practices. General waste management practices in both rural and urban areas are inadequate in India. Segregation of general municipal waste at the household level still seems a distant dream. Segregation of any waste is the first and foremost step for effective management of waste. Open disposing of solid waste at landfill sites is a common practice in India. Sewage connectivity is not adequate in most semi-urban and urban areas. Even for the areas connected to the sewerage system, most of it is left untreated and degrade openly in waste streams. Rural areas are largely devoid of such infrastructure. Such a given context might influence the behavior or practices related to waste management of consumers or polluters.

> "I am aware of the problem of healthcare waste. I have been practicing as a lab attendant for years. A variety of BMW is generated from healthcare facilities, including laboratories that need to be managed based on standard guidelines. Laboratories of urban areas directly put their liquid waste in sewerage without treating it. In contrast to it, there is no sewerage system in villages. In such scenarios, liquid waste from laboratories is disposed of openly in waste streams. However, people generally do not follow the rules or guidelines, which leads to environmental contamination" (LT of a PHC).

> "I know it is a big problem for our country. People throw BMW in the open or mix it with general waste. Also, they are used to burning it or throwing it in the river. Not only smaller clinics but also bigger hospitals used to do such practices. It is very problematic for the environment" (MPHW of a SC).

> "At this level of CHC, hardly there is no problem with respect to BMW management. However, in some other CHCs that are not connected to the sewage system or located in rural areas and the PHC laboratory, things are hard to manage. Sometimes we visit the field for mass sample collection. We face challenges in those situations also" (LHV of a PHC).

> "BMW includes needle syringes and medicine. If we throw the healthcare waste in the open, it can become a problem, but I don't do so. I dig a pit and bury my medical waste in that pit. Sometimes, it is not feasible to throw such waste in isolated places away from the community. Yes! Many practitioners do that. See, many practitioners have started practicing medicine without having the necessary experience for practicing medicine. They are not aware of the standard procedures to be adopted. Such practitioners throw their medical waste in the open or mix it with general municipal waste. Sometimes they burn it also. But I am not involved in such unethical practices" (Informal Health Practitioner, Barwala).

For better management of any waste, segregation is a must at the point of generation. The same applies to BMW as well. Mixing of dry and wet waste makes it harder to manage. Segregation of mixed waste is generally done after municipal collection in India, as it is very uncommon that people segregate their waste at the point of generation. It affects the calorific value of general waste. However, such segregation practices, i.e., after waste collection, will not help in the case of BMW because the mixing of infectious waste with non-infectious waste makes the whole of the waste infectious and hazardous. Therefore, segregation is a crucial step in the BMW management process.

> "Proper segregation at source and adequate storage facility are available in the largest veterinary hospital. Earlier, practitioners adopted practices for the safe disposal of waste, such as burial or burning waste. Nowadays, burning BMW is banned and not practiced as far as I know" (Field Veterinary Practitioner, Hisar).

> "We segregate it at the point of generation and store it properly in designated bins. We have contracted out the collection and disposal services to a third party which then takes care of healthcare waste according to prescribed rules and regulations. However, in the field settings, it is hard to manage BMW properly" (Senior Administrator, LUVAS).

4.4.4 Knowledge Awareness and Practices Related to Healthcare Waste Management

As discussed earlier, healthcare waste management largely depends upon the environmental consciousness of administrators, practitioners, and policymakers. This ecological consciousness of stakeholders is shaped by the knowledge and awareness of these stakeholders. Additionally, the implementation framework of environmental legislation and the extent of environmental monitoring could be triggering factors for enhancing the environmental consciousness of the stakeholders.

Primarily, the follow-up for management of BMW is not robust yet. There is a lack of awareness among the common man about what healthcare waste is and how to dispose of it. In addition to this, there are implementation challenges of the rules and regulations.

> "Field staff is hardly aware of such legislations and their dynamics. In the absence of such framework of implementation, filed staff or veterinary personnel is left with little choice and try to manage the generated BMW based on their consciousness, current knowledge, and existing practices carried out by their colleagues" (Field Veterinary Practitioner, Hisar).

4.5 OTHER SECTORS GENERATING BIOMEDICAL WASTE

Waste/ bio-waste is generated at multiple points, and this waste has similar characteristics as of healthcare waste, e.g., the meat industry and poultry industries generate a huge amount of anatomical waste in the form of animal and bird carcasses, leftover body parts after yielding of meat, such as wings, feathers, bones, skin, body fat, intestines, head of animals and body fluids, etc. Moreover, these industries consume a huge amount of antibiotics as around 73 percent of antibiotics are used in the animal sector only. Partially metabolized antibiotics are dispersed in the environment through different channels e.g. through feces and urines of animals. Although these things might not constitute the typical healthcare waste, a few categories of waste, such as anatomical waste, must be considered healthcare waste. It is similar to BMW and may pose serious environmental and health risks.

Human beings live close to domestic animals as they fulfill the food-related demands of human beings. Additionally, they are considered household assets. A livestock census conducted by the government of Haryana registered the total number of domestic animals present as 657532 (Table 4.8). These animals might be consuming different pharmaceutical compounds like hormonal drugs such as Oxytocin. Many deliveries happen daily. In the form of the placenta, BMW is usually hung on the tree or buried in a pit. According to the annual report of DAHD, GoH, 2018-19, 16200 deliveries of domestic cow and buffaloes in 2018-19 in Hisar district. Placenta weighs an average of 3 Kg for cows and buffaloes, which led to the generation of 48600 Kg of BMW alone in 2018-19.

Table 4.8 Livestock Census, Hisar, 2019 (DAHD, Govt. of Haryana)

Serial	Animal	Number of Domestic Animals
1	Cattles	170440
2	Buffalo	426486
3	Sheep	33689
4	Goat	18864
5	Horse	570
6	Pony	43
7	Mule	106
8	Donkey	70
9	Pig	4157
10	Camel	341
11	Dog	2727
12	Rabbit	39
	Total	**657532**

Source: Livestock Census, Hisar, 2019 (DAHD, Govt. of Haryana)*

According to the livestock census, there is around 71.26 Lac livestock population 2018-19 in Haryana. Also, there were 462.95 Lac poultry birds in 2018-19. This year, 117 Lac metric tons of milk production was recorded in the state, which comes to about 1142 gm per capita. In the state, 66153 Lac eggs were produced in 2018-19. The state recorded 553.87 Lac Kg meat productions in 2019-20 (DAHD, GOH). All these activities involve processes that could lead to BMW or waste having typical characteristics of BMW. According to the annual report of DAHD, GoH, 2018-19, more than 30000 sheep and goats were killed or died in addition to more than 5000 pigs (Table 4.9). More than 50 million chickens were killed or died in this duration. Extrapolating these numbers lead to more than 3 million Kg of anatomical waste, which in another sense is a BMW. If we consider this sector as an industry, it could contribute around 20 percent to overall BMW generation.

Table 4.9: Estimation of anatomical waste produced by meat/Poultry industry in 2018-19

Estimated Anatomical waste produced in state based on Numbers of Animal/Chicken Dead/killed in 2018-19 (DAHD report, Haryana 2018-19)				
Sr.	**Name of Animal**	**Numbers Dead/Killed**	**Average bio-waste in Kg (from secondary sources)**	**Total bio-waste produced**
1	Sheep	16695	9 Kg	150255
2	Goat	15616	12 Kg	187392
3	Pig	5234	28 Kg	146552
4	Chickens	50932163	0.6 Kg	30559297
	Total			3104396

*Source**: *Number of animals and birds killed/dead taken from annual report DAHD, GoH, 2018-19.*

4.5.1 Poultry

A variety of waste is generated from poultry farms which are a huge environmental concern. The solid waste generated from poultry includes litter, dead birds, anatomical parts of birds, avian carcasses, and spilled feed. Liquid waste includes wash water, wastewater, and water that come in contact with poultry operations. Air emission includes gasses and dust. Unscientific upkeeps of poultry farms cause soil, water, and air pollution and may have detrimental effects on the ecosystem. Recognizing its potential environmental hazards and keeping in view Article 48A, CPCB has issued environmental guidelines under Section 5 of the environmental protection act 1986 for poultry farms to promote hygienic production of poultry products with lesser environmental externalities. Some of the key guidelines are as follows;

- Poultry farms should be located far (at least 500 meters) from the residential areas and at least 1000 meters away from any major drinking water reservoir. Poultry shed should be located at least 200 meters away from the public roads. There are further norms for the location, height, and dimensions of the poultry. They are also expected to raise the two layers of green belt around farms. There must not be any indiscriminate dumping of birds' carcasses and solid waste within and outside the farms. Additionally, there should be a proper collection and discharge facility of poultry wastewaters.

- CPCB guidelines promote the usage of poultry waste as manure as it has prescribed the storage facility and process for converting poultry waste into manure. It should be collected and processed in a storage dump located at least 25 meters above the water table.

- To minimize gaseous pollution and emission, poultry farms must maintain proper ventilation and airflow with an appropriate storage facility for poultry waste. Birds' carcasses should be disposed of in an environmentally sound manner. It should not attract flies and insects.

- Deep burial is the method of choice for birds’ carcasses, anatomical parts, and dead birds and should be separated from live birds. It should be a 3 to 4 meter deep pit with at least 3 meters above the water table. The distance between two burial pits should not be less than 1 meter. Additionally, using standard processes, birds’ carcasses and parts could also be used as manure by composting it. Such waste should not attract stray dogs and other animals.

- Incineration is another method of choice to safely dispose dead birds, carcasses, and anatomical waste generated from the poultry. Norms for incineration should be followed as mentioned in BMWM rules, 1998.

- Wastewaters generated from poultry farms should be collected in appropriate tanks. It should not be spilled freely on the soil or in sewage water. Hot water and steams should be preferred for cleaning operations.

- The use of pesticides should be limited, and its potential environmental externalities should be considered.

- All poultry operations should be maintained with biosecurity norms to prevent the spread of diseases among birds, humans, and other animals due to flies, rodents, and other organisms.

4.5.1.1 Observations from Poultry farms and Backyard Poultry/Unorganized Poultry vendors

Poultry Farms: Two poultry farms at Barwala-Jind highway in district Hisar were visited in March 2021 to explore the poultry operations. Both poultry farms did not have a green belt around them and were located near public roads. However, according to respondents, these poultry farms were established much earlier than CPCB guidelines for poultry in place.

> "My father established this farm in 1994 with just 100 birds. Now we have around 1000 birds. I heard of some guidelines issued by the government, but I do not know what those guidelines or rules are. All the farms in this area are around ten years old or more" (Worker, Farm A).

When asked about the poultry waste management practices and challenges they face in day-to-day poultry operations, it was revealed that challenges are not much as their farms are not big. They keep birds as per demand from local markets only. They are not big suppliers like other farms which export their products to different states.

> "As our farm is very small, very little poultry waste is generated in the form of fecal matter and dust. Sometimes it may include bird feed which is spilled during daily operation. This waste remains in high demand as local farmers prefer to use this waste in their farms. Nowadays, some of the fisheries units also demand this waste for their operations. Dead birds and their parts are buried under a deep pit so that it does not smell. Liquid waste is discharged out freely as no sewage line is present here" (Owner, Farm B).

> "We should not term it as a waste as its demand is huge. Earlier, we used to through this openly, but nowadays, it is used in fish ponds and agriculture. However, liquid waste poses challenges to us as there is no sewer line here. Previously we used to throw bird carcasses and anatomical waste openly, which dogs like, but we have stopped this practice nowadays as dogs used to gather here all the time. Now we dispose of such waste in deep burial pits" (Owner, Farm B).

4.5.1.2 Backyard Poultry

Backyard poultry is a source of income generation for many rural households in India. Such practices can be observed in most villages and in the most disadvantaged sections of society. Two villages in the sub-center area were visited to observe the backyard poultry practices. It was observed that households kept these birds as a source of income as they produced eggs (*desi anda*) and yielded meat as well. The cost of such meat and eggs is comparatively higher in the market as per respondents due to their quality products due to nutritious feed and physical activities. Such chickens are perceived to be healthier than those produced or raised in a controlled environment of poultry farms. However, environmental conditions in backyard poultry were also not very promising due to obnoxious odor due to a mixture of poultry waste in the immediate environment of birds and human beings/owners of birds.

4.5.2 Unorganized Poultry Market, Barwala (Hisar)

Poultry meat and egg seller markets were visited in block Barwala, located at the outskirts of the town. This market constituted five temporary shops without any connectivity of sewerage any waste management system. However, such small-scale chicken sellers are not just located at this market only. There are more than 20 such sellers located at different locations within this town. These poultry sellers procure their birds/chickens from nearby poultry farms and sell them here to the locals by removing the un-eatables or wastes (head and intestine of the chicken and Bones), usually thrown at nearby corners. Environmental guidelines are rarely followed in such markets due to a lack of awareness or the necessary infrastructure to process such waste.

> “We are all selling chicken here in this market procure our chicken from nearby poultry farms. We do not sell indigenous chicken (desi murga) that grows slowly and does not yield much. These chickens have a higher growth rate than the desi ones. There is not much challenge in managing this waste generated while producing chicken meat because the quantity of waste generated is very low. Additionally, we need not throw or mix this waste in municipal waste as it is like my dogs very much. See, they are always here to grab this opportunity. However, sometimes we used to bury this waste in a deep pit to avoid increased gathering of such dogs nearby” (Chicken seller, Barwala).

There are many shops located in the outskirts of villages and towns in the district Hisar, which produce huge anatomical and other waste that is detrimental to the environment in many ways. Chickens are made to consume a huge amount of antibiotics for their faster growth and to prevent diseases prophylactically. These wastes are often either consumed by stray dogs or thrown in municipality waste for disposal. Average chicken meat yielding also results in the generation of around 600 gms of anatomical waste (Table 4.9). It can disperse in the environment and food chain through different sources.

4.5.2.1 Meat Industry

There are few meat seller shops within this market and at isolated places. Pork and mutton are usually sold in these markets. As evident in table 4.9, meat yield from a goat can result in 12 Kg of bio-waste or anatomical waste generation. Similarly, meat yield from pigs could result in the generation of up to 28 Kg of anatomical or bio-waste, leading to environmental contamination through different sources. When asked about disposal practices of meat sellers in one of the meat shops in Barwala;

> "There is a high demand for good quality meat and pork in this region. Mutton is thought to provide power and more energy than chicken. I sell around two goats and one pig on an average daily basis. Some of the wastes like bigger bones are disposed of in dustbins only. Skin is given to a nearby collector who is selling this skin somewhere. Few parts which are not consumed are given to dogs that are liked by them very much. Sometimes this waste is buried under the pit in isolated places. Like blood and other fluid, liquid waste is swept away with water while cleaning" (Meat Seller, Barwala).

Such waste from the meat and poultry industry must be contributing to the macroprocess of AMR throughout the world. However, attributable impacts of such practices in meat or poultry industries are hard to quantify and methodologically challenging.

Further, the annual report of DAHD, Government of Haryana, 2018-19 reveals that various animals and birds were sampled (blood, urine, and feces, etc.) for outbreak or disease investigation at different sources (Table 4.10). Similarly, more than 20 Lac vaccines were administered to animals for vaccine-preventable diseases (Table 4.11). The majority of these vaccination activities and samples are taken at the field level. BMW must be produced at different points while sampling. However, primary data from CBMWTF reveals that only five veterinary facilities are covered with CBMWTF.

Table 4.10 Diagnostic Services of Laboratories for 2018-19

Diagnostic Services of Laboratories for 2018-19 (DAHD Haryana, Annual Report 2018-19)										
Type of Sample	**Blood Samples**		**Urine Samples**		**Fecal Samples**		**Milk Samples**		**Skin Samples**	
Result +/-	Posit ive	Nega tive	Posit ive	Nega tive	Posit ive	Nega tive	Posit ive	Nega tive	Posit ive	Nega tive
Numbers	1073	252	518	200	8185	4599	2452	1400	526	178

Source: DAHD, Government of Haryana, Annual Report 2018-19*

Table 4.11 Vaccination among Animals, DAHD, Government of Haryana, 2018-19

Vaccination among Animals (DAHD, Govt. of Haryana, 2019-20)		
Serial	**Name of Vaccine**	**Number of vaccines administered in 2018-19**
1	Galghotu	12.6 Lac
2	Mouth and foot disease	6.03 Lac
3	Sheep Pox	0.49 Lac
4	Swine Fever	0.9 Lac
5	B.q	O.46 Lac
6	PPR	0.21 Lac
	Total	**20.6 Lac**

4.6 BMW MANAGEMENT AT CBMWTF, HISAR

Synergy Waste Management Pvt. Limited manages the CBMWTF plant. It is located in sectors 27-28 in Hisar, which is an industrial area. This plant has the capacity of treating or incinerating 9900 Kg of BMW per day. However, only about 1500 Kg of BMW is being treated here daily, according to the annual report of CBMWTF of 2019. 19 Kg of recyclable waste is handed over to recyclers after necessary treatment. 412 healthcare facilities are covered by this plant including only five veterinary facilities, which are a very small number. This facility covers more than 5000 beds for

BMW treatment. This translates into 0.29 Kg of BMW per bed per day treated at CBMWTF, which is a very small figure. Multiple studies have demonstrated that BMW generation may vary from 200 gm per bed per day to 3000 gm per day, depending on the services. The majority of the facilities covered by CBMWTF are above the level of clinics in the private sector and PHC and above for the public sector, which may reflect mismanagement of BMW at the level of production. Additionally, veterinary facilities which generate about 48 percent of the total BMW of healthcare delivery systems are not sending their waste for safety management in an environmentally sound manner to CBMWTF. Table 4.12 demonstrates the different categories of BMW managed at CBMWTF on a daily basis. 10.8 tons per annum ash is generated and handed over to the GEPIL industry. 1.08 tons of chemical sludge is generated. The type of fuel is diesel.

Table 4.12 Amount of Different Category of Waste Treated at CBMWTF Hisar

Serial number	**Category of Waste**	**Per Day Waste Treatment in (Kg)**
1	Yellow Category	1059.1
2	Red Category	231.8
3	White Category	0.45
4	Blue Category	213.3

Source: Report available at CBMWTF Hisar*

Currently, only parts of waste generated by the healthcare delivery system (human medicine and veterinary medicine) from the public sector and only from human medicine in the private sector are treated or managed at CBMWTF in Hisar. Estimations based on primary data and secondary data sources reflect that only about 15 percent of the total BMW generated by the healthcare delivery system is being managed at CBMWTF. Only a fraction of waste generated at veterinary health institutions is treated at CBMWTF. Another reason for such a low rate of treatment is that a huge amount of BMW is being generated by informal health workers, which are often mixed with municipal waste. Additionally, 20 percent of overall waste is generated by meat/poultry industries in the form of anatomical waste, which is not considered BMW but has all the characteristics of BMW.

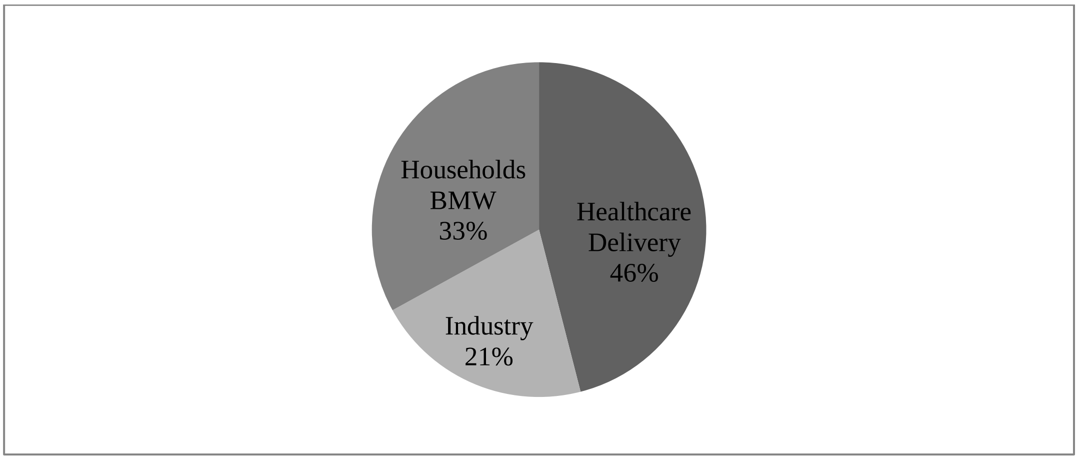
Estimates point out that out of the entire BMW household could contribute up to 33 percent. Different studies have demonstrated that domestic waste could have 2 to 10 percent of BMW mixed in it in the form of discarded medicines, needles and syringes, sanitary pads, and other items. Even if we assume 2 gm per capita per day generation of BMW in any form, it could translate to a huge amount of BMW. More importantly, it is getting mixed with domestic waste. Recent pandemics and policies like universal mass masking must have contributed to an overall increase in BMW.

4.7 KEY FINDINGS OF BMWM ECONOMETRIC MODEL

Although the present study is predominantly a qualitative study, an attempt was still made to understand the gravity of the research problem by developing an econometric model. Data from primary as well as secondary sources were fed into the model. Following were some key observations demonstrated by this econometric model;

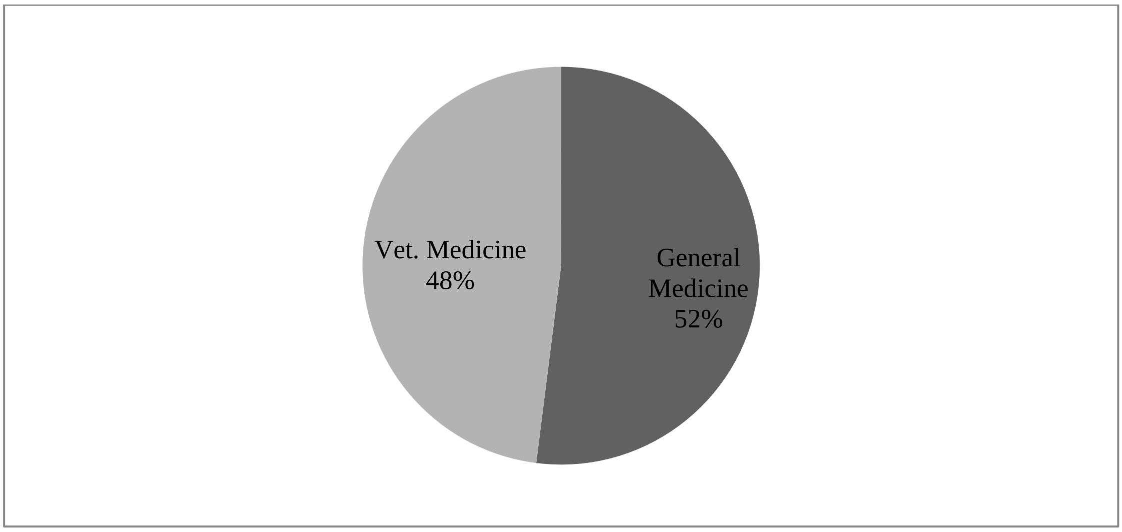
Considering the available data from various sources and making all the assumptions to the most realistic level, it was estimated that a total of 7829070 Kg of BMW is being generated annually by all the sectors putting together. It translates into the daily generation of 21540 Kg of BMW in Hisar district by all the contributors. Sector-wise bifurcation is shown in Figure 4.3, which clearly indicates that HCDS (General medicine and Veterinary) is responsible for about 46 percent of total BMW generation in Hisar district. Assuming 10 percent of the proportion of BMW in total domestic waste, households generate about 33 percent of total BMW.

Figure 4.3 Estimated Proportion of BMW



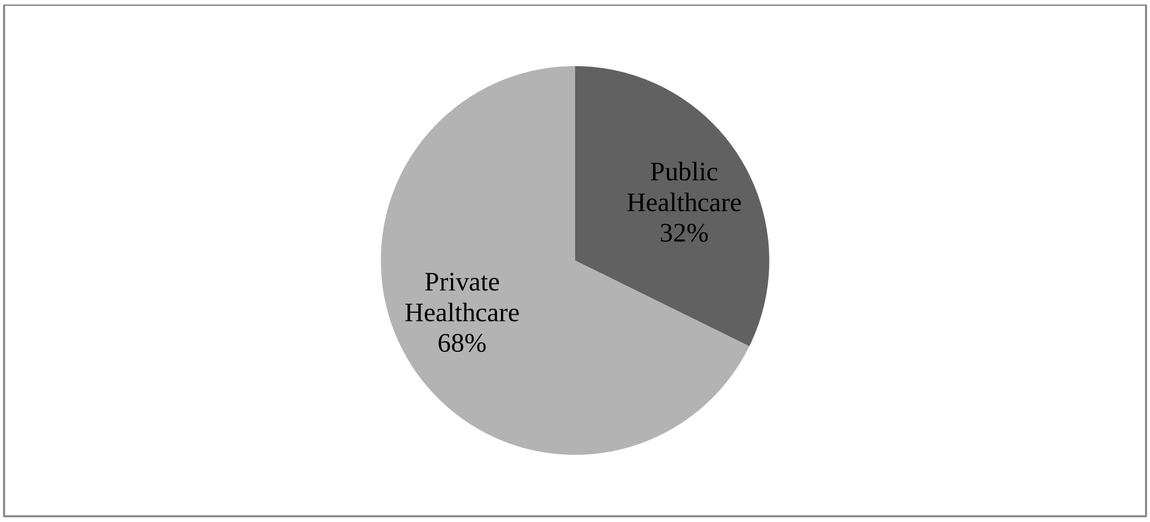
Out of the total waste generated by HCDS, 52 percent is generated by general human medicine, which reflects that veterinary medicine also generates almost an equal amount of BMW in district Hisar (figure 4.4).

Figure 4.4 Proportion of BMW of Health Delivery



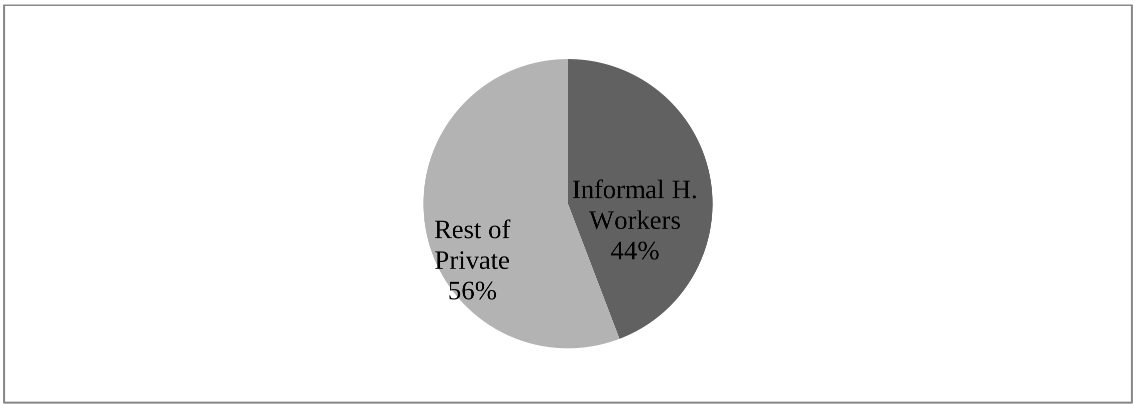
The econometric model demonstrated that general human medicine is responsible for generating around 52 percent of the total BMW of HCDS in district Hisar. Within this proportion, the private healthcare sector has emerged as a larger contributor, which generates about 68 percent of total BMW generated by HCDS (figure 4.5).

Figure 4.5 Proportion of BMW in General Medicine



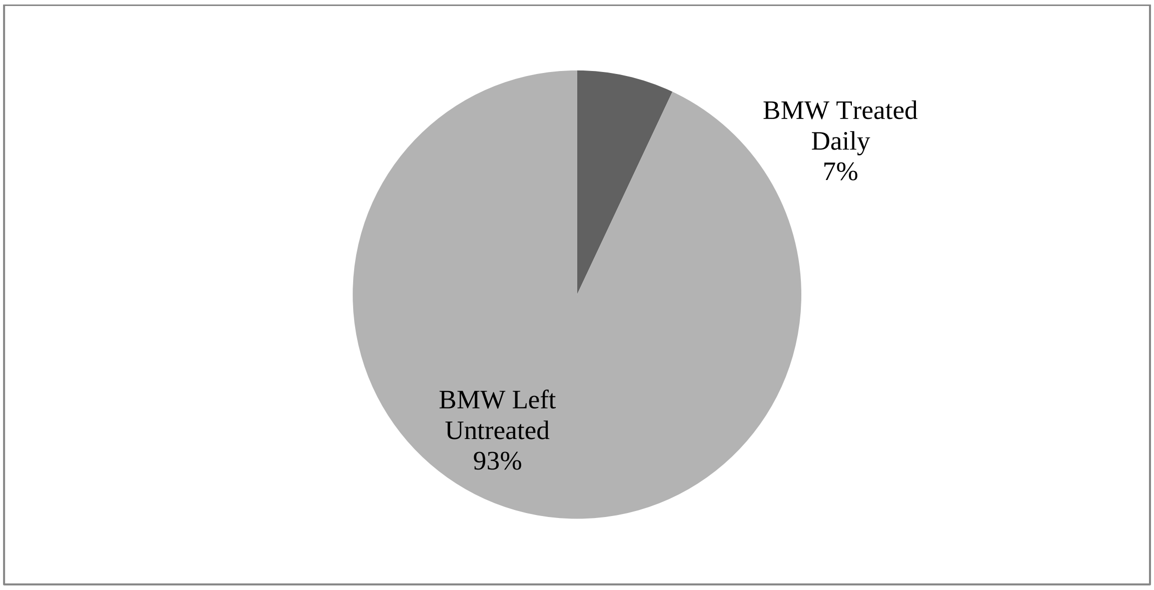
The private sector in general human medicine has emerged as the largest contributing sector in total BMW generation by human medicine. There are a variety of providers in this sector. There are around 3500 informal health workers in district Hisar who contribute approximately 44 percent of total BMW generated by the private sector (figure 4.6). Their BMW amount might be small, but their presence is huge and contributes as the largest provider in the private sector.

Figure 4.6 BMW Generation by Informal Health Workers



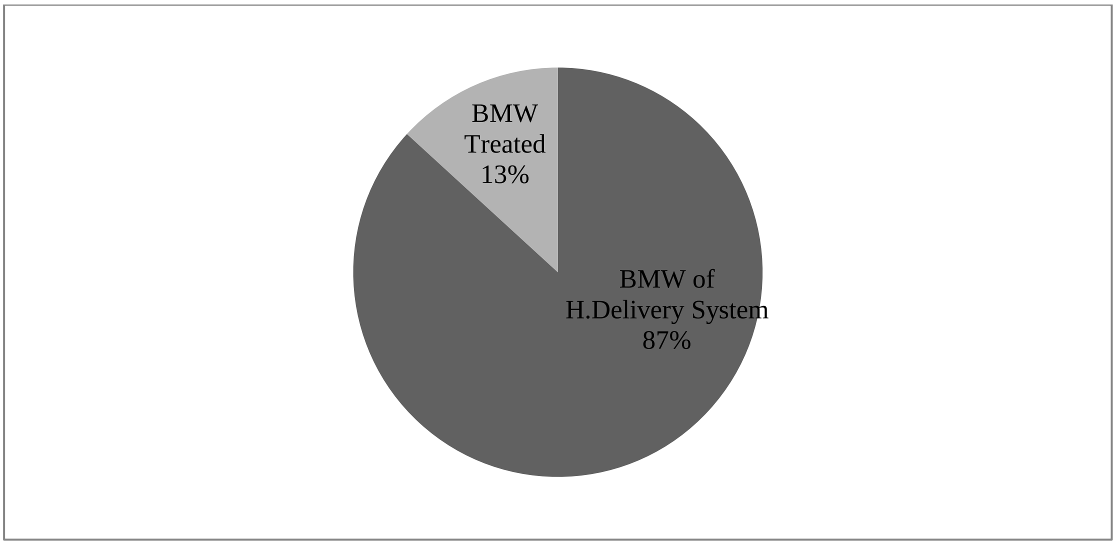
CBMWTF is treating and disposing of around 1500 Kg of healthcare waste per day compared to the total BMW of 21540 Kg which demonstrates the gravity of the problem. 93 percent of the total healthcare waste does not even reach the CBMWTF (figure 4.7).

Figure 4.7 Proportion of BMW Treatment



The majority of the stakeholders consider waste generated by humans and veterinary medicine as BMW and neglect the other kind of waste having similar characteristics as BMW which is generated by other sectors. Figure 4.8 demonstrates that even if we consider the waste of HCDS only as BMW, then also we are just able to process only 13 percent of total waste generated by HCDS.

Figure 4.8 Proportion of BMW Treated (out of BMW of HCDS)



In addition to these estimations, an attempt was also made to quantify the probable impact of total BMW (both treated and untreated BMW) in district Hisar. Following were the key observations/ results;

- Considering the NCD contribution of untreated waste as 2 Particulate Per Million (PPM), which is minimum as per assumption, untreated waste could contribute to 2202 cases of NCDs in district Hisar on an annual basis.
- Considering the untreated waste as mixed waste and every gram of mixed waste as a potentially infectious agent, it was estimated that untreated waste could cause 11559 to 117789 cases of infectious disease in Hisar on an annual basis. The attributed impact was calculated using secondary information with respect to Hepatitis B and HIV infections due to contaminated syringes.
- Considering the treatment methods at CBMWTF as the most efficient method of treatment of BMW and assuming that NCD contribution of treated waste as

1 PPM, which is the minimum, it was estimated that treated waste could contribute to 74 cases of NCDs in district Hisar on an annual basis.

4.8 ADVERSE ENVIRONMENT EFFECTS AND IMPACTS OF HEALTHCARE WASTE

4.8.1 Environmental Contamination

Human beings survive on natural resources of the physical environment. Day-to-day human activities and decision-making negatively affect the environment in most instances. Healthcare activities and decision-making also involve consuming certain types of products and services, which results in various byproducts in different forms. These byproducts contaminate our natural environment through different channels. Through environmental contamination, these processes may ultimately lead to multiple long-term environmental impacts.

> "Antibiotic resistance and outbreaks are very common examples. If not appropriately managed, these waste products may result in environmental contamination and degradation, hampering natural biodegradation processes, and contaminating the food chain. Published literature exists on antibiotics and pesticide residue in milk and milk products and meat products. This is a very complex cycle and the least observed phenomenon. The general public may have notions about contamination of milk and food grains due to excessive use of pesticides, but there are other pathways also which are least known by them. Untreated sewage and open defecation lead to slow environmental contamination, which may enter into the food chain of animals and humans. This may lead to antibiotic resistance and API exposure. These issues need to be explored further through the development of innovative research methodologies" (Veterinary Epidemiologist, Hisar).

It is not just the healthcare activities performed in healthcare institutions that result in environmental contamination, but healthcare activities and decision-making at homes contaminate the environment in various ways. Pharmaceutical compounds degrade slowly in the environment. They persist in the environment for longer durations. A lot of medicines are consumed by patients in their homes, which metabolizes partially in the human body. Additionally, sanitary pads, insulin syringes, blood-stained cotton, etc., are a few other byproducts that adversely contaminate the environment.

> "Open defecation is a common phenomenon in our country. Even if it is not open defecation, how much sewerage waste is being treated in our country? Stray animals could consume this open defecated matter. Additionally, untreated sewage and open defecation lead to slow environmental contamination, which may enter into the food chain of animals and humans. Also, human excreta may contain partially degraded active pharmaceutical ingredients. This may lead to antibiotic resistance and API exposure. These issues need to be explored further" (Senior Veterinary Practitioner, LUVAS).

> "There is not much difference in categories of healthcare waste generated due to veterinary activities and human medicine, but the quantity-wise type of production may vary, e.g., the placenta is a common byproduct of veterinary activities or toxic dead animals, especially stray animals which are not appropriately buried or not buried at all may lead to various type of environmental contamination and ultimately may lead to various health problems directly or indirectly" (Field Veterinary Practitioner, Hisar).

As mentioned above, day-to-day human decisions and activities result in some externalities to the environment. These externalities are mostly negative, i.e., daily human decisions negatively affect the natural environment. Healthcare activities, both at the institution level and household level result in healthcare waste generation. Healthcare waste, when not appropriately managed, impacts our environment through negative externalities.

> "BMW, when disposed of unscientifically through open disposal or burn, results in harmful and toxic emissions. The air we breathe contains chemical residues as airborne particles, which further affect our health. Also, BMW alters the quality of surface and groundwater. There are increased levels of chemicals that, when consumed, lead to health hazards. Gradually, the environment around us changes and may make living unbearable" (Private Medical Officer, Barwala).

> "As said earlier, the disposal of healthcare waste poses health risks, and these risks are increased by direct and indirect contact of toxic pollutants into the environment. The liquid and solid BMW may get mixed with water and soil, leading to more disease-causing bacteria and viruses. The burning of healthcare waste increases gaseous levels like carbon dioxide, which can add to processes like climate change" (Private Practitioner, Barwala).

> "Negative environmental externalities as a result of human activities ultimately negatively affect human beings. There are multiple ways in which healthcare waste may lead to harmful effects on human health. These effects could be directly through direct contacts or exposure to healthcare waste or could be indirect through environmental contamination and then may affect the food chain, contamination of drinking water, soil and air. Pharmaceutical compounds in sewage water may lead to alteration of natural decomposition and biodegradation of waste and wastewater. Negative environmental externalities could lead to severe and deadly infections like Hepatitis" (SMO of a CHC).

Development in general and veterinary medicine have to lead to expansion of available choices in both the medicine stream. However, these issues are not discussed frequently due to their nature of slow and constant effects and largely due to involved conflict of interest of various stakeholders. Additionally, many chemical compounds are available for various plant diseases and problems in the agriculture sector. Unmindful usage of such pharma compounds and procedures due to multiple conflicts of interest leads to increased environmental contamination and exposure.

> "We neglect many environmental health issues in day-to-day life, e.g., pollution level now a day is on the rise. Pollution will be talked about in much detail in the media for the coming few days. Again, we will ignore this issue. Similarly, we neglect many exposures daily, e.g., we consume pesticides and traces of pharma compounds in small quantities daily, but we neither discuss it nor try to establish any association between health issues and such exposures" (Senior Veterinary Practitioner, LUVAS).

> “You must have discussed this question with veterinary medicine specialists. If I may add, epidemiologically speaking, various activities in animal husbandry and veterinary medicines produce a large quantity of healthcare waste that gets unnoticed and un-researched due to its nature. Uses of Oxytocin drugs in larger animal farms, use of antibiotics in the poultry industry, and residues of other pharmaceutical drugs in animal products such as meat and milk due to their higher use in animal husbandry and agriculture sector may lead to various environmental problems which may affect human and animal health through many channels e.g., food chain, direct ingestions of animal products and close contact with animals” (Senior Veterinary Officer, LUVAS).

4.8.2 Effects on Environment and Ecology

Various kind of healthcare waste is generated in multiple medicinal systems, viz. general medicine, veterinary medicine, and plant medicine or agriculture sector, which may affect the environment, human health, animal health, and whole ecology. Ecological and environmental changes are slow and not observed directly over a short span. Therefore, they get easily ignored. Direct injuries and infections are short-term effects of mismanaged healthcare waste. However, environmental deterioration and ecological changes are gradual and persistent.

> “It may lead to various short-term and long-term impacts on environmental health. Short-term deterioration may include air quality degradation or environmental pollution affecting the quality of the air we breathe. Also, it affects the water sources in the ecosystem. It may contribute to various long-term impacts like antibiotic resistance or various unknown effects of constant exposure to rare chemicals, especially pharmaceutical compounds” (Senior Administrative Officer, District Hospital).

> “Most of the literature or studies focus on the direct effects of unscientifically managed BMW on human health. In addition to human beings, BMW can impact the whole ecosystem and other organisms in many direct or indirect ways. Constant and slow exposure may lead to certain long-term impacts, which are lesser-known by us. Also, there is a lack of studies or methodologies which can establish some association between adverse impacts on ecology and pollution due to BMW” (Senior Administrator, District Hospital).

Healthcare waste may affect human health directly or indirectly. It may cause direct injuries or infections, or burn. However, the indirect effects of healthcare waste are many. It may adversely affect the whole of the ecosystem. Many chemical substances or medicines, such as antibiotics, may get into the soil, water, and air. It may then enter into the food chain in the ecosystem. Therefore, may be fatal for certain organisms and harmful for human beings. It may also be causing certain ecological changes. Plastic pollution is a huge concern to humankind. A lot of literature exists on the impacts of plastic pollution worldwide, especially in developing countries. Plastic degrades very slowly in the environment and pollutes surfaces and the sea. Such pollution affects the aquatic ecosystem and terrestrial ecosystem in many ways. The presence of microplastic in many aquatic organisms reveals these phenomena. It involves the other animals also due to the dynamics of the food chain.

> "Also, it may lead to slower environmental changes, which exposes human beings to persistent exposures of the environmental pollutants from BMW. These changes are hard to be identified and difficult to associate with healthcare waste. Antibiotic resistance, exposure to radiation or heavy metals, and Active Pharmaceutical Ingredients are some of the pollutants from healthcare waste. These slower environmental changes and exposures may lead to changes in the ecosystem that are hard to notice. It may lead to behavior changes in organisms, alteration in breeding processes of various organisms, and also extinction of certain species of organisms in the ecosystem. Therefore, it can ultimately lead to ecosystem imbalances" (SMO of a CHC).

> "Indirect effects could be observed due to environmental contamination due to healthcare waste. Slow and persistent exposure could lead to various environmental and ecological changes that may go unnoticed by the state or authorities. The extinction of vultures and fishes, and other aquatic organisms near the pharmaceutical industrial units are example of adverse impacts of healthcare waste mismanagement" (Senior Administrator, LUVAS).

Knowingly or unknowingly, human beings are involved in many activities that are harmful to the environment and ecology, e.g., plastic, is the commonest problem for animals. Apart from these obvious pollutants, there is certainly excessive use of pesticides in agriculture, antibiotics, and other hormonal drugs in animals. This is done to increase the production of animal products that may prove harmful to animals. These hormonal compounds and chemical compounds metabolize very slowly in the environment and contaminate the environment slowly. Apart from these direct impacts, humans harm animals unknowingly through activities pollution.

> "A lot of chemicals/ pharma compounds are used in the agriculture sector. Residues of one of such pesticides were consumed by birds that led to mass mortality of peacocks. The concentration of that poison might have been higher, which lead to the worst situation. However, a lot of pesticides and pharma products are present in the environment (air, water, and soil), which remain there for longer durations. It gets accumulated in crops and drinking water, then accumulated in food grains and animals followed by other animals, organisms, and humans, which drive their food from those crops and animal products. It affects the ecosystem slowly and slowly. Many unnoticeable changes in the environment might be happening continuously" (Veterinary Epidemiologist, Hisar).

4.8.3 Effects on Human Beings and animals

Healthcare activities involve the usage of various polluting substances/ chemicals/ products/ services or procedures which ultimately impact our natural environment. Human beings and other animals survive in the natural environment and are affected by any deterioration in the natural environment. This deterioration occurs due to environmental contamination due to pollutants like sharps (needles and blades), infected or uninfected plastic waste like syringes, vials, canula, IV set, packaging material, empty bottles, and other variety of plastic waste, etc. Pathological waste such as stained cotton and gauze pieces, blood-stained linens, blood-inflicted sanitary napkins, and blood products contaminate the environment. Additionally, anatomical waste and cytotoxic waste such as pharmaceutical waste and other hazardous waste contaminate the environment and deteriorate the quality of the natural environment. This deterioration affects human health and the health of other organisms in the ecosystem in many ways. There could be direct effects on the health of human beings, such as injuries and infection, which are immediate effects and short-term in nature. However, there are certain long-term environmental impacts on human beings and other organisms of the ecosystem due to deterioration of the quality of the environment.

> "Healthcare waste, if not managed properly, can cause serious infections like Hepatitis or HIV/AIDS. Also, sharp inflicted injuries are common in healthcare settings and to handlers of BMW. Slow exposure or prompt exposure of many pharmaceutical compounds and other chemicals used in healthcare activities or procedures can affect health adversely" (MPHW, Hisar).

> "Healthcare waste is harmful to human beings in many ways. Mismanaged healthcare waste may lead to infections like hepatitis, Tuberculosis, HIV and other blood-borne infections. Also, this waste may cause various injuries to humans and animals. A lot of chemicals are present in healthcare waste. These adverse effects are not known to the human population in general, but they are harmful to human health. Expired medicine thrown openly may also be harmful to human health. Healthcare waste may also contaminate the human environment, affecting various organisms indirectly or directly" (MPHW of District Hospital).

Urban-rural dynamics are associated with the problem of healthcare waste. The majority of the population lives in rural areas. There are facility-based services provided to the beneficiaries through Primary Health Center and Sub-Centers. Additionally, outreach services in the communities are provided by the health workers of the public health services system. Various programatic activities are carried out in the communities involving certain procedures and drugs and equipment use. Therefore, healthcare waste generated in the field setting poses different challenges to the environment and human health.

> "In the malaria control programme, we sometimes have to discard our expired medicines and needles and syringes used for making slides and sampling procedures. This leads to the generation of a huge amount of BMW. Due to inadequate infrastructure and clearer guidelines for such situations, some health workers throw this waste in water bodies or the open. Such practices may lead to various adverse consequences. The problem here is not concerned with the quantity of BMW generated, but it is the widespread distribution of such activities and hence widespread generation of harmful healthcare waste" (HI of a CHC).

4.8.4 Virulence

Inappropriate dumping of healthcare waste into open spaces, dustbins, and water sources, etc. pose serious environmental and ecosystem challenges. The process poses serious health hazards directly or indirectly. Some of the diseases like swine flu are highly infectious. The virulence of causative organisms of such diseases is very high. Also, sometimes, virulence may be magnified by the concentration or load of microorganisms in particular spaces. Mismanaged healthcare waste may increase the quantity of infectious waste, which otherwise is proportionately lesser i.e., around 15 percent according to WHO.

> "If infectious waste is mixed with general waste, it may increase the overall quantity of infectious waste and lead to greater chances of spreading infections. If healthcare waste is mismanaged, the chances of infections, the transmission of various diseases like cholera, typhoid, and hepatitis are increased many folds. The emission from this waste may further lead to alterations in the virulence of various bacteria. These bacteria may get evolved and become drug-resistance, posing life-threatening conditions for human beings and animals. Exposure to drugs, chemicals, and other BMW is altogether another problem. In short, mishandling of healthcare waste is a big threat to healthcare workers, the general public, and animals and birds" (MO of a PHC).

4.8.5 Outbreak Occurrence

A variety of waste is generated both in general medicine and veterinary medicine due to various therapeutic procedures. There are very common and hidden harmful effects of this waste, e.g., direct injuries to rag pickers, waste collectors, and animals are very common. It may lead to various infections and outbreaks also. As discussed, certain diseases are highly contagious, like cholera and swine flu. In such instances, if generated BMW is not managed correctly, it may further spread the epidemic. In current times of the Covid-19 pandemic, such phenomena are observable. Pollution control authorities have come up with newer and fresh guidelines to effectively manage the healthcare waste generated from Covid-19 related processes, i.e., diagnosis, treatment and immunization. Many countries across the globe have come up with innovative approaches to manage their Covid-19 related healthcare waste, which has increased exponentially. Such efforts are directed to minimize the chances of spread through healthcare waste.

> "I have been part of many outbreak investigation teams to investigate diseases like Diarrhea, Cholera, Hepatitis, and Swine flu. These are highly contagious diseases. Stained cotton, tissue papers, handkerchiefs, stool, or masks may add to the quantum of such epidemics if not disposed of properly. Though it is difficult to quantify the proportionate contribution of

> healthcare waste to the overall quantum of a disease outbreak, there is a definite contribution I must say” (Senior Administrator, Hisar).

> “Veterinary therapeutic procedures result in various categories of waste generation, which is almost similar to general medicine healthcare waste. This waste, if mismanaged my lead to various infections, outbreaks, or injuries both in humans and animals. In addition to these commonly observed adverse impacts, there are several ways in which BMW affect human and animals, and even aquatic organisms. Bird flu is a very common example that could pose serious challenges if generated healthcare waste in infected dead birds is not managed scientifically” (Field Veterinary Practitioner, Hisar).

> “Direct impacts are very much obvious such as infections, injuries, and outbreaks. Apart from the direct effects of veterinary medicine, there are various indirect effects of animal husbandry and infections carried by animals that may affect humans, JE is a classic example, and recent outbreaks in the Gorakhpur region could be linked somewhere” (Senior Veterinary Practitioner, Barwala).

4.8.6 Long-Term Implications on Human-Environment-Animal interface

It has been discussed that there are numerous pathways for environmental contamination, resulting in the deterioration of the quality of the natural environment. Every human activity negatively affects our natural environment in most instances. Healthcare activities result in various persistent and slow exposures of certain pollutants like APIs. The environment gets deteriorated due to the continuous release of hospital wastewater into the sewerage system or water bodies, burning healthcare waste, the unmindful burial of such waste, and mixing infectious waste with general municipal waste. This deterioration of the natural environment may lead to certain long-term impacts on the environment and human health. The development of ABR or MDR is one such example. There are also other examples in the literature which are results of mismanagement of healthcare waste.

> “The use of many pharmaceutical products such as antibiotics and hormonal drugs is very common in both humans and animals. Residues of these drugs may enter the food chain and ecosystem and may sustain for very long. This may lead to environmental contamination, which ultimately affects various organisms through a number of pathways” (Medical Officer, Hisar).

> “There are other categories of waste, e.g., waste generated in the poultry industry may contain a very high quantity of antibiotics and other pharmaceutical ingredients, which may lead to various adverse impacts on human and animal health. Apart from these, large animal farms where the use of hormonal and antibiotic drugs is common, waste generated from these activities may be harmful to the environment, humans, and animals. Such processes may contribute to the development of antibiotic resistance and may alter the behavior of various organisms” (Senior Administrator, Hisar).

Residues of pharmaceutical products ultimately may lead to various changes in the terrestrial and aquatic food chain and life cycle of various organisms. ABR is another example. But these changes and environmental impacts are so slow and least researched upon due to various reasons.

4.8.7 Effects on Animal

There are various kinds of wastes generated due to healthcare activities that may cause infections and injuries to animals. Additionally, there are various long-term effects on animals and birds due to the adverse consequences of mismanaged healthcare waste. Stray animals are commonly affected. Since domestic animals live commonly with humans, therefore, level of environmental exposure is not very much different. The human may live in slightly better environmental conditions, but it's difficult for animals to make choices. Most of their choices are made by humans only. There are many hidden issues and impacts on animals due to healthcare activities in general medicine or even in the agriculture sector. Large animal farms and poultry industries use many pharmaceutical products which infect the environment and human and animal health directly or indirectly. But there is a shortage of studies exploring or assessing these impacts, especially in the developing world.

> "These wastes are commonly thrown in the open or get mixed with general wastes. Stray animals such as cattle do not selectively feed in the open. They may ingest these wastes, which may cause infection or injuries to them. Also, slow environmental exposure may lead to various undetected negative impacts both on humans and animals" (Field Veterinary Practitioner, Hisar).

> "It may affect animals by infectious diseases, and external and internal injuries are very common to stray animals. We get a lot of animals to treat who inflict such injuries. Also, cases of plastic ingestion by the animal are very much common. We conduct a lot of surgeries on such animals to extract out ingested plastic and needles. The environmental and direct impacts on human and animal health are many, e.g., needle injuries in animals, mass morbidity, and mortality in animals may happen. There may be behavioral changes in animals due to pharmaceutical waste, but direct linkages are still needed to be explored" (Senior Veterinary Surgeon, Hisar).

A lot of insecticides and chemicals used in the agriculture sector affect animals in direct and indirect ways. Such chemicals and insecticides pose serious challenges to animal health as animals feed on such crops and plants. Environmental monitoring related to the exact quantity and quality of such substances is not a regular phenomenon. Additionally, the use of antibiotics and other pharma compounds in poultry industries and large animal farms put animals at risk of harmful exposure and ingestions. These processes may contribute to the various adverse consequences to the animals and birds.

> “The most common adverse impacts of mismanaged healthcare waste are outbreaks and infections, which may lead to mass mortality and morbidity in animals. It can be observed commonly as such news comes regularly. An outbreak of bird flu is one of the examples. Similarly, last month, mass mortality of the peacocks was noticed, which resulted from the ingestion of insecticide residue by peacocks in Delhi NCR. This is a clear-cut case of mismanagement of healthcare waste and adverse impact on birds. Also, sometimes birds and animals with multi-organ failure come into notice as a result of toxicity caused by various human activities” (Senior Administrator, LUVAS, Hisar).

Patencheru's study about the pharma industry revealed that environmental deterioration might lead to adverse impacts on various organisms in the ecosystem directly or indirectly. Nephrotoxicity caused by Diclofenac Sodium is leading to the extinction of vultures, which is an example of the adverse impacts of environmental toxicity. Similarly, there may be numerous examples of mismanagement of healthcare waste harming human and animal health. These need to be explored and researched further.

> “As mentioned earlier in the example of vulture extinction, many hidden negative impacts result from infectious and pharmaceutical waste. It is disturbing the whole ecology. Many species of fish are endangered as a result of exposure to such wastes. I mean, these are known examples, but there must be many examples that are not known or lesser-known. Mycobacterium tuberculi is now infecting animals or had been infecting in the past, but now it is accepted. Similarly, ABR or MDR issues in animals also. We must conduct researches with the idea of one health or in linkages. It must not happen in isolation” (Senior Veterinary Epidemiologist, Hisar).

4.8.8 Cross Infection

Generation of healthcare waste on both sides affects self and each other. Direct infections, outbreaks, and injuries are very common examples and are known to everybody. But certain issues are ignored easily. Much of the emphasis has been paid on zoonotic infections, but the least of the efforts are directed towards studying phenomena like reverse zoonosis. Animals may get affected adversely by the healthcare activities or decision-making of human beings.

> “Tuberculosis is a common disease both in humans and animals. Mycobacterium tuberculin is now traced in animals also. This is a case of reverse zoonosis. Similarly, antibiotic resistance or MDR is prevalent in animals, and humans also live in close contact with animals. Both may be contributing to MDR or antibiotic resistance in each other as drugs used in animals and humans are almost the same. Results of immunization with the BCG vaccine are still debatable. Therefore, there are numerous examples of adverse impacts as cross infections” (Senior Veterinary Practitioner, Hisar).

> "In the case of reverse zoonosis, animals may get TB from humans as they live nearby. Earlier, it was not accepted by the scientific community, but it's a well-known phenomenon nowadays. However, neither in animals nor in humans do we identify the same strain of bacteria. Therefore, this process of cross infections got neglected easily. However, there are screening programmes for both human and animals but both works separately. The least of the efforts are directed towards the establishment of linkages. BCG vaccine has been given to humans for decades, but an effective vaccine has not been developed yet for animals" (Field Veterinary Physician, Hisar).

Since there is no linkage between general medicine and veterinary medicine, it is tough to depict the proportion of cross infections. The prevalence of TB in animals and humans is almost similar, but like in Revised National Tuberculosis Control Programme (RNTCP) in general medicine, some animals go undetected. Whatever extent of bovine TB is known, most of it is derived or detected from domestic animals. The extent of TB on stray animals could be greater as they are also exposed to filthy conditions of waste sites. There is a shortage of studies to establish the proportion of cross infections of TB in humans and animals. Therefore, newer echelons like 'One Health' are emerging in the field of medicine, which focuses on integrated efforts.

4.8.9 Effects on Vulnerable Population

It is very evident that, burnt of environmental pollution and deterioration faced by minorities and vulnerable population subgroups. Literature reflects that globally deteriorated environmental conditions adversely affected the socioeconomically weaker section of the population. The population of workers and their families are most affected due to the adverse environmental impacts of industrialization. Waste disposal sites are often located near socially disadvantaged communities. Waste collectors, rag pickers, and sanitary workers in hospitals are the most vulnerable group of the population who are at constant risk of getting injuries and infections due to mismanaged healthcare waste. Moreover, there are higher possibilities that healthcare waste is composed of hazardous materials such as needles, blood-stained products, and sharps. Therefore, there are higher chances of adverse effects due to such waste while doing their job.

> "Healthcare waste can cause direct effects on human health through injuries and infections. Health care workers and sanitary workers are a vulnerable population. They are at constant risk of direct injuries and infections. Additionally, it deteriorates the quality of our natural environment through pollution of air, water, and soil. Therefore, it can lead to many indirect effects of healthcare waste" (Senior Administrator, District Hospital).

> "We are around 15 people working here as a sanitary staff. On the one hand, we are hired through contractors and paid very little as compared to regular sanitary workers, and on the other hand, being posted in such a setting, we are at constant risk of getting infected or injured. We are always exposed to injuries. Most of us get injured regularly while carrying out our job or day-to-day activity. Not everyone is provided with gloves and masks, which puts us at higher risks of getting affected" (Sanitary Worker, District Hospital).

In addition to the healthcare activities carried out at the health institutions, many healthcare activities occur at household levels, resulting in some healthcare waste generation, e.g., discarded insulin syringes, blood-stained pads or cotton, and discarded medicine, etc. Such healthcare waste is often mixed with general municipal waste or thrown openly. This poses severe challenges to vulnerable populations like waste collectors and rag pickers.

> "Yes, I have been injured many times. There are needles from injections that are thrown in the bins and not visible under the pile of garbage. So, I have been pricked many times. Once, it was a very deep prick, and I had to go to a government hospital to get it removed from my thumb. They applied a liquid, gave me an injection, and sent me home. I could not use that thumb at all for the next 3-4 days" (Municipal Waste Collector, Hisar).

In addition to the vulnerable population mentioned above, other groups are at constant risk of getting infected or injured due to mismanagement of healthcare waste. This population is mainly composed of various health workers like doctors, nurses, paramedics, and frontline health workers. These workers work in different settings like institutional settings and field settings. In both types of environments, healthcare workers are at constant risk of getting adversely affected by healthcare waste.

4.9 GROWTH IN HEALTH CARE INDUSTRY AND HEALTHCARE WASTE

4.9.1 Developments in Pharmaceuticals and Healthcare Industry

APIs are the most non-biodegradable products in the environment, which metabolize very slow. More than 4000 pharmaceuticals are used worldwide for medical and veterinary purposes (Arnold et al, 2014). With the growing industrialization, pharmaceutical is one such industry which experienced huge growth in the last few decades. Pharmaceutical is one of the most hazardous industries which if dispose their waste directly to the environment result in causing a different health hazard to humans and other organisms. Most of these industries do not follow the norms and dispose of their effluents directly into the rivers and landfill sites. Also, environmental monitoring of APIs in STPs and ETPs is very limited in low and middle-income countries (Kookana et al, 2014). Therefore, it poses serious threats to human health, which need exploration.

In the absence of adequate public healthcare infrastructure, most of the curative healthcare services are provided by private healthcare facilities, ranging from small clinics to big corporate hospitals. The focus of these facilities is secondary or curative care only. Hospitals with surgical and maternity services produce more waste than hospitals with eye and dental services (Banstola et al, 2017). The nature of healthcare waste may vary from needles, syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices, and radioactive materials. Apart from these facilities, healthcare services are also provided by RMPs and informal practitioners both in rural and urban areas. Healthcare waste generated from their practice is dumped in the open.

Home management of illness is very common in developing countries like India without adequate healthcare infrastructure. Therefore a variety of medical waste is generated from households too. This waste may not find its way to the treatment facilities in the manner that hospital waste could find.

4.9.2 Healthcare Waste Management in Ayurvedic Health Facilities

Historically, *Charak Samhita* in Ayurveda mentioned *Vikrat Vayu* (polluted air), *Vikrat Jal* (polluted water), and *Vikrat Desh* (polluted land) as major determinants of diseases. These factors were labeled as evitable reasons for *Janpadodwamsa* (disease outbreaks). Humans could control these factors. Therefore, BMW management is an integral part of the traditional and contemporary system of healthcare. BMW Management and Handling Rules 2016 are supposed to be followed and complied with by all healthcare facilities, including Ayurvedic hospitals. Earlier, Ayurvedic practitioners constitute a large workforce in the Indian health care system. National Accreditation Board for Hospitals and Healthcare Providers (NABH) has formulated accreditation standards for *Panchkarma* clinics under the infection control section in 2017. Poor BMW management may lead to nosocomial infections. The concept of *Aupsargic roga* (communicable diseases) in Ayurveda looks pretty similar to nosocomial infections. Under BMW Management and Handling Rules 2016, it has been made compulsory for all Ayurvedic clinics to get authorization/ renewal of authorization from the respective pollution control board of the state. Also, they are supposed to fill and send annual reporting performa to the pollution control board (Ranjan et al, 2018).

4.9.2.1 Ayurvedic Healthcare Infrastructure

Ministry of AYUSH collects data on an annual basis related to various aspects viz. infrastructure and human resources etc. Out of a total of 3632 AYUSH hospitals in the country, 2833 are Ayurveda hospitals as of 01.04.205. Hospitals related to Ayurveda have grown at a rate of 1.3 percent per annum. Out of 58020 AYUSH beds, 43454 beds are confined to Ayurveda only. Apart from hospitals, there exist 15555 Ayurveda dispensaries in the country as of 1stApril 2015. There was 744563 number of AYUSH practitioners in the country, including 402079 practitioners registered under the Ayurveda system. Out of 544 AYUSH colleges in the country, there were 279 undergraduate Ayurvedic colleges with an annual admission capacity of 15117 students. There are 9282 AYUSH drug manufacturing units in the country, including 7995 Ayurvedic drug manufacturing units. Therefore, a huge infrastructure under the Ayurvedic system exists in the country, which is also accountable for the safe management and handling of healthcare waste (MoAYUSH, 2016).

4.9.2.2 Classification of Healthcare Waste Generated from Ayurvedic Facilities

Ayurvedic clinics and hospitals produce a variety of healthcare waste. This may include any substance or byproduct that can be spilled, leaked, emitted, pumped, poured, and dumped onto the land, into the water, or in the ambient air. This waste in the environment can directly impact health and dent the ecosystem, including flora and fauna. A broad range of healthcare waste is generated from Ayurvedic treatment processes. These processes are *Kizhi* (material used for fomentation process), discarded medicated oils, blood products as a result of *Raktmokshan* (bloodletting) procedure, waste from *Panchkarma* (purification therapy) procedure, etc. Other waste includes body fluids generated from various procedures, plaster casts, bandages, cotton swabs, etc. pharmaceutical waste generated from Ayurvedic pharmacies is a matter of concern. A lot of heavy metals like Mercury are used in Ayurvedic formulations. These metals are potential pollutants to the environment. The amount of waste generated depends upon the type and size of health facilities. A study conducted by Ranjan et al (2018) titled “BMW management in Ayurvedic Hospitals in Kerala” revealed that 100-200 ml/bed of blood as a result of *Raktmokshan*, 3-4 liters of oil, 20 liters of pharmacy waste, 100 gms of infectious waste and other general waste is produced per day. Data had been collected from 3 Ayurvedic colleges, 10 government hospitals, 20 major private hospitals, and 35 clinics. Further, this study also made an effort to classify the variety of waste according to BMW Management and Handling Rules 2016.

Table 4.13 Categorization of BMW Generated from Ayurvedic Healthcare Facilities

Category	Type of waste	Type of bag/ container	Treatment /disposal option
Yellow	Items contaminated with blood, body fluids like dressings, cotton swabs, plaster casts and bags Containing residual or discarded blood and blood components. Wastes of *Panchakarma* (purificatory therapy), *Raktamoksha* (bloodletting)	Yellow colored non-chlorinated plastic bags or containers.	Incineration or deep burial or plasma pyrolysis or In absence of above facilities, autoclaving or hydro calving or micro-waving, treated waste to be sent for energy recovery.
	Expired or Discarded Medicines. Wastes after the preparation of medicines, wastes of raw materials, discarded medicines, used oils, powders, wastes after various fomentation procedures like *Kizhi, dhara, avagaha* etc.	Non-chlorinated yellow plastic bags or suitable packing material.	Expired medicines shall be either sent back to manufacturer or disposed of by incineration.
	Cytotoxic e Heavy metals like Mercury and arsenic etc. from Herbomineral preparations. Chemical Liquid Waste	Separate collection system leading to effluent treatment system Non-chlorinated yellow plastic bags or suitable packing material	The chemical liquid waste should be pretreated before mixing with other wastewater
	Discarded linen, mattresses, beddings contaminated with blood or body fluid.	Autoclave safe plastic bags or containers	Non-chlorinated chemical disinfection then incineration or plasma pyrolysis.

	Microbiology, Biotechnology, and other clinical laboratory waste:		Pre-treat to sterilize with non-chlorinated chemicals on-site as per National AIDS Control Organization or WHO guidelines thereafter for Incineration
Red	Contaminated Waste (Recyclable) Wastes generated from disposable items such as tubing, intravenous tubes, and sets, bottles, catheters, Urine bags, syringes (without needles and fixed needle syringes), and gloves. Disposable *vastinetras* or plastic glycerine syringes	Red colored non-chlorinated plastic bags or containers	Autoclaving or micro-waving/ hydroclaving followed by shredding or mutilation or combination of shredding and sterilization. Treated waste to be sent to authorized recyclers or for energy recovery or Plastics to diesel or fuel oil or for road making, whichever is possible. Plastic waste should not be sent to landfill sites.
White	Waste sharps including Metals: Needles, needles from needle tip cutter, syringes with fixed needles, blades, burner, scalpels, or any other contaminated sharp object which may cause puncture and cuts. This includes Discarded, used, and contaminated metal sharps. Sharp instruments for *Raktamoksha* (bloodletting), *Vastiyantras* (metallic instruments for administering medicated enema), *Shalaka* (probe),	Puncture proof, Leak proof, tamper proof containers	Autoclaving or Dry Heat Sterilization followed By mutilation or shredding or encapsulation in metal container or cement concrete; combination of autoclaving cum shredding; and sent for final disposal to iron foundries (having consent to operate from the State Pollution Control Boards) or sanitary landfill or designated Concrete

			waste sharp pit. *Vastiyantras* and *shalaka* should be reused after proper sterilization
Blue	Glassware: Broken or discarded and contaminated glass including medicine vials and ampoules except those contaminated with Cytotoxic wastes	Cardboard boxes with blue colored marking	Disinfection (by soaking the washed glass waste after treating with Sodium Hypochlorite) or through microwaving or autoclaving or hydroclaving and then sent for recycling

Source: Ranjan et al, 2018*

Regular training and awareness programmes could be helpful in sensitization of practitioners as the level of awareness was found to be inadequate (Ranjan et al, 2018). Only a small number of hospitals are conducting awareness programmes for their staff. These programmes should focus on making health practitioners responsible and aware of their social and ethical responsibilities of controlling infections as well as safeguarding the environment.

4.10 CONTEXTUALIZING MANAGEMENT OF HEALTHCARE WASTE

Several variables determine the extent of BMW management scientifically. One of the critical variables is the location of the healthcare facilities, with respect to their rural or urban location. Most of the larger and bedded facilities are located in urban areas. In contrast, rural areas are served chiefly by non-bedded healthcare facilities such as smaller clinics run by unqualified informal health providers. Such facilities and providers exist in large numbers both in rural and urban areas, as revealed by primary data. District Hisar has more than 300 such practitioners practicing medicine in different urban and suburban areas. Block Barwala has more than 50 such practitioners. In addition to it, most medium-sized villages with a population of around 4000 to 5000 have 10-12 such practitioners each. Therefore, these practitioners are widely distributed both in rural and urban areas. Another important factor discussed earlier is that these facilities are not a direct part of health system services, making it impossible for them to get authorization from pollution control authorities. Also, they lack information/ awareness/ training regarding standard practices about BMW management. The quantity of BMW generated by such facilities may not be large as compared to bigger healthcare facilities, but these facilities also generate BMW (like needles, syringes, etc.), which is infectious. In a context where requisite infrastructure for scientific and proper waste management is not there, such infectious waste easily gets mixed with general solid waste making the whole of the waste infectious.

Similarly, such practitioners exist in urban areas and semi-urban areas also. The variables discussed above affect overall waste management practices in these areas also. It is also a reality that bedded hospitals and bigger healthcare facilities also indulge in malpractices related to BMW management practices due to various reasons. One of the factors is the lack of internal and external environmental monitoring framework, which exposes the weaknesses of the implementation framework of environmental protection laws. In the absence of regular environmental monitoring and the absence of strong punitive actions on the violators, it becomes easier for the polluters of the health sector to pollute the natural environment.

> "I don't have much to reflect upon, but I believe there would be differences according to the level of facilities, urban or rural areas. I think health facilities in rural areas must be facing difficulties in BMW management. Also, there is a lot of quackery in the case of general human medicine. Unqualified or less qualified practitioners are there in both urban and rural areas. I don't think they are following BMW management rules" (Veterinary Surgeon, Hisar).

> "The field situation is very different from institutions located in the field. Some veterinarians even perform home visits in an emergency. So it is not always possible to manage the healthcare waste properly in the field settings. However, certain standard procedures should be adopted by the practitioners in the field while managing the waste, which too is questionable at ground level. Also, very limited infrastructure and resources are available for the proper management of BMW according to the rules" (HI of a CHC).

> "As discussed, waste management is a big issue in general. Many a time, healthcare waste is thrown in the open or dustbins meant for general waste. It may infect general waste and turn general waste into infectious waste. If not treated, it leads to environmental contamination and may affect both humans and animals in many ways. Facility level waste may get treated, but in rural areas, it might be challenging to manage the healthcare waste on the lines of BMW management rules" (Senior Veterinary Administrator, Hisar).

4.10.1 Mismanagement of Healthcare Waste in Rural Areas

As discussed, informal health providers are the major health service providers in rural areas. These providers are not authorized by health authorities and pollution control authorities of the state. Additionally, infrastructure and resources are very much inadequate for the effective management of BMW in the case of rural healthcare facilities. Administrative efforts are also lacking to effectively implement a framework for the management of BMW and monitoring it. A similar pattern may be observed in veterinary healthcare infrastructure. Many of such services are provided as home-based or home visits by the providers. During their home visits, a variety of BMW is generated, viz. needles, syringes, vials, glass, cotton stained with blood, and other pathological waste. Delivery of animals results in the generation of infectious waste such as the placenta, which is usually buried or hanged on trees in villages. Such waste is usually thrown openly and mixed with general household waste. This waste could be detrimental to the environment.

> "Resources are very much inadequate for the effective management of BMW in the case of rural healthcare facilities. There are certain customs and cultures of burial of certain products like the placenta. These social traditions hamper the proper management of healthcare waste. As informal health workers are not part of the formal health services system, they have no fixed liabilities. All of them tend to throw their harmful BMW openly. There is no doubt that 100 percent of them are indulged in the mismanagement of healthcare waste" (Field Veterinary Practitioner, Hisar).

> "Not very good, I must say! Infrastructure at village level facilities is very limited. Though field staff tries their best to manage the healthcare waste best with available resources, it is not enough to tackle the problem of healthcare waste. There are certain customs and cultures of the burial of certain products. Things are changing and will take a little longer in the field. But yes, positive changes are happening with increasing awareness" (Senior Veterinary Surgeon, Hisar).

> "As much as I have experienced, I don't think field-level facilities or smaller clinics are equipped with facilities or infrastructure required for the safe management of BMW generated in those facilities. Many veterinary practices or treatment procedures are done at the household level; therefore, it is very hard to manage the healthcare waste following standard methods. Also, support from the state or higher-level authorities is not adequate to enable them to adopt standard procedures for the management of BMW" (Senior Administrator, Hisar).

> "I have work experience in both public and private health facilities. Currently, I am working in Govt. veterinary hospital at the regional level. The implementation level of BMW management rules is limited in the field-level facilities. Also, blaming HSPCB and institutions at the village level is unfair as both have limited capacity for active implementation of those at this time. There are certain cultural practices, such as hanging placenta on the tree after delivery of animals which is improper. We cannot deny the mismanagement of plastic waste and needles or syringes in field settings" (Veterinary Epidemiologist, Hisar).

There is a specific and essential aspect of veterinary medicine in Haryana state. Animal husbandry as a profession is largely restricted to rural areas. Most of the community members engaged in the agriculture profession directly or indirectly are also engaged with animal husbandry to a large extent. Veterinary medicine is, therefore, practiced mainly in rural areas of the state. Animals also suffer from various infectious diseases and face morbidity and mortality, the same as humans.

Sometimes, dead animals are thrown openly can contaminate environments. Also, sometimes, they are buried near water bodies. Such practices pollute the environment in many different ways. Apart from these practices, veterinary medicine generates some quantity of BMW that gets mixed with general household waste.

> "As I mentioned, there are instances of mismanagement of healthcare waste in some villages. This may lead to unnecessary infection and injury to both humans and animals. However, unless such cases happen, no one is bothered to take action. In most cases, adverse impacts of such practices go unnoticed. The contamination of the environment due to BMW mismanagement is a slow process. Direct linkage or association between adverse effects due to mismanagement of waste is very hard to establish. For example, the burial of any toxic waste or dead animal (poison death) near water bodies in villages may contaminate drinking water, leading to infections or outbreaks in humans and animals. Such associations may go unnoticed due to the slow rate of impacts. Lack of awareness both in general public and field-level practitioners further complicates the situation" (Veterinary Scientist, Hisar).

> "I have not practiced much in the field settings, but we cannot deny the mismanagement of healthcare waste at the village level. My work encounter with the dead animal is very common. There are practices of improper burial of animals or stray animals. Sometimes, they are not even buried. This may create huge problems such as disease outbreaks or so. Monitoring activities are also very much limited" (Field Veterinary Practitioner, Hisar).

> "Field situations are very different as I have experience of working in a field setting for a long. Mismanagement of waste generated as a result of health care activities is very common. Although there have been improvements in the last decade, a lot of work is yet to be done to properly implement BMW Management and Handling Rules 2016. Inadequate sanitary conditions may lead to increased infections and outbreaks in animals along with similar conditions in humans" (Field Veterinary Practitioner, Hisar).

Mismanagement of healthcare waste in rural areas is a common phenomenon. As discussed, rural healthcare facilities run by informal health workers are recognized as unauthorized practices or quackery. It makes them devoid of becoming part of the implementation framework of environmental legislation. In the absence of requisite infrastructure or framework, such practitioners indulge in malpractices or unethical practices of throwing their medical waste in open or burning it, contaminating the environment. However, many of them might be following other counterparts for mismanaging their BMW without knowing or perceiving its negative externalities. Enabling the environment for better waste management practices in the form of the workforce, infrastructure, environmental monitoring, authorization process, and training is largely lacking in rural areas. Therefore, environmental consciousness is hard to be expected in such a context.

> "There are limited infrastructure and resources available in the field to manage healthcare waste which may often lead to epidemics and outbreaks. Active implementation and compliance of BMW Management and Handling Rules are very much limited in the field villages. Awareness among the practitioners may not be adequate, and we cannot deny a

certain level of carelessness. Authorization and reporting of BMW management are limited" (Senior Administrator, District Hospital).

"I have been working in this village as a multi-purpose health worker for the last 10 years. In this village of about 5000 population, around 12-15 informal health workers are practicing medicine. Most of them either throw their waste openly or burn it. I don't think any of them even bury their BMW" (MPHW of a SC).

"At this level of CHC, hardly there is any problem with respect toBMW management. However, in some other CHCs that are not connected to the sewage system or located in rural areas and the PHC laboratory, things are hard to manage. Sometimes we visit the field for mass sample collection. We face challenges in those situations also" (MPHW of a CHC).

"As such, we don't face major issues as a very small amount of BMW is produced in our facility. Most of it is needles and syringes. Mostly we tend to bury whatever waste we are generating. Higher authorities hardly provide different color-coded dustbins and poly bags. Most of the sub-centers have one dustbin for collection. Sometimes we face challenges with respect to BMW management while doing outreach sessions" (MPHW of a SC).

"I always throw my medical waste, such as needles, syringes, cotton, and plastic, etc., in dustbins only. I never throw them in the open. Therefore, I dispose of my waste very safely" (Informal Health Practitioner, Barwala).

"I do not throw my waste in any dustbin or in the open. Sometimes, I bury my BMW when it is in large quantities or some wet waste is mixed with it. In such a case, it is not possible to burn it. This is how I manage my waste of my own. However, sometimes, when we are on home visits and some injection is to be administered, it is not possible to manage BMW generated there. We try to put such waste in the dustbins of visited households only not to harm animals" (Informal Health Practitioner, Khedar).

"If we talk about challenges with respect to management of BMW, I would say challenges are more in rural areas, and smaller facilities as little infrastructure or resources are available to manage the BMW scientifically. The private health sector has grown tremendously. Violations of the law are a common practice in the private sector. We do not have adequate power or control over the private sector. Therefore, there are a variety of challenges with respect to BMW management in the field" (HI of a PHC).

4.10.2 Liquid Waste Management

Management of liquid waste or hospital wastewater is a grey area in this field. This aspect of BMW management is one of the least researched areas, especially in the Indian context. Hospital liquid waste or wastewater from laboratories and pharmaceutical units, and pharma manufacturing industries poses severe challenges to the environment as it contains a variety of harmful pollutants. Different departments of a hospital discharge a variety of wastewater in sewage waste streams. Samples are often discarded in waste sinks that are directly connected to sewage or waste streams. These samples are usually infectious. Discharge from operation theatre or delivery rooms constitutes a large proportion of hospital wastewater. Sanitary activities, which are regularly done in a hospital environment as a measure of infection control, often result in the generation of a huge amount of hospital wastewater and may contain harmful microorganisms and chemicals. This wastewater should be discharged in sewage waste lines after pre-treatment. However, this process is hardly followed even in major hospitals.

The situation worsens when such issues are faced in a country like India, where necessary infrastructure for the management of household wastewater is largely inadequate. The majority of the population lives in rural areas, and updated sewage systems cater to only a small proportion. Even if cities are connected to a functional sewage system, sewage wastewater treatment still seems a distant dream for most cities. There are a large proportion of healthcare facilities that are not connected to the sewerage system. Most of the CHCs and PHCs in district Hisar are not connected to a functional sewerage system. Similarly, many laboratories operating in rural or semi-urban areas are not connected to the sewage system. It is hard to imagine the fate of liquid BMW from these facilities in such a context.

Environmental monitoring of liquid wastewater is another grey area in the Indian context. With the lack of such monitoring frameworks, it is nearly impossible to establish the proportion of water pollution created by healthcare facilities. There are instances where the municipal corporation of Hisar did the environmental assessment of a few healthcare institutions in the past, but it was restricted only to solid hospital waste. Monitoring frameworks for hospital wastewater and its effect on overall sewerage wastewater are largely lacking.

> "There could be many unknown ways of contamination of the environment through pollution created by the health care sector e.g., we always talk about healthcare waste which is supposed to collect in different color-coded dustbins. Nobody talks about liquid medical waste mixed in drainage or sewage system untreated from various kinds of health facilities and laboratories" (HI of a CHC).

> "Around 15-20 laboratories are operating in the city of Barwala. Most of them are not authorized by pollution control authorities. Therefore, they usually throw or mix their BMW with general municipal waste. Moreover, most samples are discarded in sinks directly, which goes into wastewater streams or sewage waste. It must be impacting the wastewater ecosystem in some way" (LT of a CHC).

4.10.3 Generation of BMW at the Household Level

In addition to BMW generation at the institutional level and during outreach sites, households are also responsible for generating BMW to some extent. One may think that quantity of BMW generated from houses must be very small as compared to healthcare facilities, but it is also essential to consider the fate of that whatever amount of BMW. The proportion of BMW may be very small compared to general municipal waste. Still, when this least proportion of biomedical or infectious waste is mixed with general household waste, it may increase the quantity of overall infectious waste.

Blood-stained sanitary pads and cotton swabs, diapers, soiled waste, discarded or expired medicines, needles, and syringes, especially syringes used for insulin injections, are a few of the common BMW items generated at the level of households. Self-prescription is a common practice in a country like India. The over-the-counter availability of pharmaceutical products makes it easier for people to practice medicine. Additionally, informal healthcare workers visit households of the diseased and administer treatments there only. Such practices lead to the generation of BMW at the level of the household.

The current pandemic of Covid-19 has posed severe challenges to the environment in many ways. A huge number of asymptomatic patients and the high infective nature of the virus put the health system under pressure. Home isolation and home quarantine strategies, and universal mass masking policies have led to an increase in infectious trash in the form of used PPE kits, especially used facemasks, empty bottles of hand sanitizer, and other disposable items used by infected individuals. These processes have led to an increase in overall BMW generation at household levels and at public places.

Waste collection and management have been an issue in many states, especially in rural areas. The desired infrastructure for sound waste management is not in place in rural areas. Even in cities, municipal waste is often dumped at common landfill sites. This dumped waste is inadequately segregated, making it more challenging to manage.

> “There is general household waste like vegetables (raw and cooked), fruit peels, batteries, milk cartons and packets, blood-soaked pads, and since the current pandemic, there have been masks and sanitizer bottles in a large amount. If there is a child in the house, then used nappies, baby formulas can also be seen. People dump anything without giving another thought” (Sanitation Worker, Hisar).

> “Waste collected from houses is sometimes dry and sometimes wet. They both are mixed and difficult to separate. As a part of healthcare waste, I have found syringes with small needles, expired medicines, masks, blood swabs, dressing, and band-aids, etc. regularly” (Municipal Waste Collector, Barwala).

CHAPTER 5

ENVIRONMENTAL LAW AND ITS IMPLEMENTATION: PROVIDER'S PERSPECTIVES

5.1 ENVIRONMENTAL LEGISLATION AND ENVIRONMENTAL POLLUTION

Bhopal gas tragedy triggered the enactment of the Environment Protection Act, 1986, in India. However, specific rules for managing and handling BMW came much later in 1998. BMW management was a grey area before these rules were placed. It was ubiquitous for healthcare facilities and practitioners to dispose of their BMW openly or mix it with municipal or general waste. Deep burial was considered a sound method for the disposal of BMW. After the inception of the BMWM Act, an improvement has been made by the public and private health sectors in terms of BMW management and handling. However, with the growing number of private health facilities, especially smaller clinics, and quacks, BMW management is still a concern. The process of authorization and reporting, along with promising practices of BMW management, is only limited to a higher level of healthcare facilities or health facilities in urban areas. Healthcare provisioning in India is very much fractured, where most of the health services are provided by the private sector. In the private sector, too, a large chunk of the providers are unregistered medical practitioners, both in urban and rural areas. BMW generated from these practitioners is not disposed of or managed as per rules and regulations. The quantum of these practitioners is huge in India. Also, registered practitioners and institutions in urban areas, especially the private sector, hardly follow these rules. Many of the practitioners would not have registration/ authorization from the Pollution Control Board. Many of them dispose of their BMW with general waste. Surveillance and monitoring activities are minimal.

> "Comparing the era before BMW Management Act, which came in 1998, with the period after it, many changes have come in the management of BMW. Healthcare practitioners became aware over time. Before the BMW Management Act, the practitioners had adopted health practices to safely dispose of waste, such as burial or burning the waste. Nowadays, the burning of BMW is banned and not practiced, as far as I know. Awareness among the general public also has been increased with respect to plastic and sharp waste. BMW Management and Handling Rules have helped in transforming the ways it was handled previously. But we should also accept the fact that a lot of improvement is still needed. BMW management practices in the field-level facilities need active support from the state and authorities regarding training, awareness, and financial resources" (Senior Veterinary Surgeon, Hisar).

> "Earlier, the situation used to be tricky and relatively unmanaged. If we talk about pharmacies or dispensaries, people used to bury medicine in the pits in public health facilities. Sometimes they burnt it or threw it openly. Such malpractices were very widespread in dispensaries. Even now, this is very common in private sector dispensaries. Flushing medicines in the toilet are also a common phenomenon. More prominent private hospitals may manage their

pharmaceutical waste effectively as they have the necessary infrastructure to do that" (Pharmacist of a CHC).

"There has been quite a good improvement in management practices of BMW, generated as a result of veterinary activities. Awareness level among practitioners regarding the adverse impact of mismanagement of BMW has also improved. Burning practices have been almost abandoned. Earlier, the burning of BMW was a widespread phenomenon in the field. However, in rural areas, it depends primarily on the consciousness of field staff as few activities are carried out for monitoring such practices" (Field Veterinary Practitioner, Hisar).

"It's been more than 30 years since I have been working with the public health system. I have seen and experienced this activity on a varied scale in different health facilities. Also, I have seen practices followed in private health facilities with respect to medical waste. Earlier, most health facilities used to throw their medical waste in the open or dump it with municipal waste. Only a few health facilities were used to set up the framework of the burial method or so. Burning of healthcare waste was a very common practice in most healthcare facilities, irrespective of the type of facility. However, a lot of changes have happened with respect to BMW in the past 10 to 15 years. There are rules now to safeguard the environment. Although, in current times also, there are private health facilities and healthcare providers in rural areas who throw their healthcare waste in open or with general waste. A lot of unregistered medical practitioners who practice medicine in rural areas throw their garbage in the open only. Therefore, changes have taken place, but these changes are limited to a few healthcare facilities in the urban area only" (Radiographer of a CHC).

"In my opinion, a lot of changes have happened when we compare with last decades. Earlier, hospitals and clinics used to throw their medical waste openly or in the dustbins of general waste. Now it is not so common. Open disposal has diminished very much, but disposal in general municipal waste is still common. Lower facilities such as PHCs practiced open disposal of BMW earlier, which is not seen nowadays. Even field staff like us are strongly ordered not to dispose of needles and syringes in the open or with general waste. But minor changes are observed with respect to lower-level private health facilities such as smaller clinics and unregistered medical practitioners. They are still throwing their BMW in open or municipal dustbins" (MPHW, Civil Hospital).

To some extent, improvements with respect to BMW management are observed after the enactment of Environment Protection Law, 1986, especially since the formulation of BMW Management and Handling Rules, 1998. However, the quantum of these improvements is very limited and mainly restricted to urban areas. In urban areas, it is restricted to few higher-level facilities or bedded facilities. After the Environment Protection Act, 1986 came in place, the private healthcare sector proliferated at the same time. Informal healthcare workers practicing in villages and urban areas are also massive in numbers. They are not part of the formal healthcare services system. Ensuring implementation of the Environment Protection Act or BMW Management and Handling Rules is still a considerable challenge.

"I must say that there has been a lot of change in general BMW management practices in the field. Earlier, most practitioners or hospitals used to throw their BMW in the open only. But nowadays, such open throwing and burning of BMW are not so common. People do indulge in such activities, but they try not to reveal such practices to others. However, this change is limited only to urban areas. Rural practitioners do not tend to manage such waste scientifically as they have no knowledge of such legislation or law, which could bind them and restrict them from not throwing BMW openly" (MPHW, Hisar).

> “I have been in service for the past few years. Nowadays some improvements could be observed in the overall scenario. However, this improvement is limited to urban areas and a few higher healthcare facilities only. Many unlawful activities or practices are still going on in the field in towns and smaller healthcare facilities such as clinics and nursing homes. These providers often throw their healthcare waste in general municipal bins. Some of the providers used to burn or bury their BMW. Due to a lack in the implementation of BMWM Rules, these healthcare providers follow the convenience and burn or throw the medical waste. Additionally, we have a lot of informal, unregistered healthcare providers in our country. They are a big challenge for the system regarding the generation and management of BMW” (Homeopathic Medical Officer of a PHC).

> “I must say that these rules have impacted, to some extent, the overall situation with respect to BMW management in the field, especially in urban areas. However, this impact is only limited to a particular level of health facilities. As I mentioned earlier, most health services are provided by smaller health facilities or informal healthcare workers in field-level settings. How would you ensure proper implementation of rules at that level? The problem will remain big until we cover all the medical practitioners and healthcare facilities and fix liabilities at all levels” (Senior Administrator, Hisar).

Though legal provisions under Environment Protection Act, 1986 and BMW Management and Handling Rules, 1998 triggered some improvements with respect to BMW management but it is not the sole factor. There are other variables too, viz. general waste management practices and infrastructure, sanitation, environmental consciousness of stakeholders, environmental monitoring, training of stakeholders, and overall context of health provisioning, which impacts the extent of BMW management in a particular context. The majority of the population lives in villages and is largely devoid of adequate infrastructure for sound management of solid and liquid waste. Inadequate infrastructure for general waste management indirectly affects BMW management also. Without regular environmental monitoring, it is nearly impossible to ensure adequate management and disposal of BMW.

> “I have been working in the laboratory setting for years, both in the public and private sectors. I have worked at various levels of laboratory facilities. Different facilities have different types of service provisions. In district-level facilities, infrastructure is quite well for effective BMW management. However, in smaller facilities like CHCs and PHCs, facilities lack proper infrastructure for adequate BMW treatment. Some CHCs are connected with sewage systems where liquid waste could be pretreated and mixed with it. However, the majority of PHCs and few CHCs lack connectivity with sewage systems and hence face challenges for the safe discharge of liquid waste generated from these facilities. Smaller facilities like small laboratories in the private sector are not aware of such rules and throw their medical waste openly in municipal dustbins or burn it. The situation is even worse at the lowest level of healthcare providers” (LT of a CHC).

5.2 EVOLUTION OF ENVIRONMENTAL REGULATORY FRAMEWORK

Regulatory legislation around the world has come up due to different international conventions, conferences, protocols, and treaties. Many policies are present to protect the environment, prevent pollution of all kinds and deal with environmental crimes resulting in compensatory policies from the international efforts. Environmental movements in different countries and environmental jurisprudence also played key roles in shaping these laws and regulations.

The existence of an adequate regulatory framework and its implementation is the key determinant of ecological stability and environmental sustainability. Historically, various environmental movements and international imperatives shaped the development of an environmental regulatory framework. The role of environmental jurisprudence and environmental activism is also crucial in catalyzing these developments. 42^{nd} Constitutional Amendment Act, 1972, introduced the principles of environmental protection in the constitution through Articles 48A and 51A. The courts have made several decisions to safeguard the environment in light of these articles. India has various environment protection rules and Acts in place. BMWM rules were first formulated in 1998 (amended in 2000, 2003, and 2016). Apart from these Acts and rules, organizations like NGT, CPCB, SPCB, and Environmental courts are there in place to protect the environment.

5.2.1 History and Evolution of Environmental Legislation

Historical context

European countries were undergoing massive industrialization in the early 19^{th} century. People were deprived of all the means of cleanliness as the water of polluted rivers was useless. The filth and stagnant pools of the working people quarters in great cities had worse effects on the people's health. Friedrich Engels analyzed the features of the workplace and environment that caused disability and early death for the British working class. Large-scale mortality and morbidity were happening due to 'Miasma' (Pollution) as per Miasma Theory which was widely accepted at that time. Though the view was technically wrong and undermined after Germ Theory, it laid the basis for large-scale improvements in public health. Edwin Chadwick was a crucial figure in the sanitary reform movement in Britain, and his report on "The Sanitary Condition of the Laboring Population of Britain" in 1842 was instrumental in forcing a fuller acceptance of government responsibility for public health and sanitation in Britain. Therefore, it enhanced the rules, which played a crucial role in mitigating environmental risk factors.

5.2.2 International Imperatives

Following are some important international imperatives that laid the basis of framing of laws and policies around the world;

1. Stockholm Declaration (1972): UN international conference on Human Environment held in Stockholm having considered the need for a common outlook and common principles to inspire and guide the people of the world in the preservation and enhancement of the human environment, was probably the first global effort to discuss global environmental issues. The meeting agreed upon a declaration of 26 principles concerning the environment and development. There was an action plan with 109 recommendations and a resolution.

2. Brundtland Report (Our Common Future): UN General Assembly realized that there was a huge deterioration of the human environment and natural resources. In order to unite countries together to pursue sustainable development, the UN General Assembly established World Commission on Environment and Development (WCED), also known as Brundtland Commission, in 1983. It published its report naming *"Our Common Future"* in October 1987. It defined sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*. The report highlights the three fundamental components of sustainable growth;

    a. Environmental Protection

    b. Economic Growth

    c. Social Equity

3. World Charter for Nature: Sponsored by 34 developing nations, a multinational task force began in 1975 to draft the world charter for nature as a guide to regulate international environmental development. It explicitly states that the governments have a duty to pass on their natural heritage to future generations.

4. Rio Declaration (Earth Summit): A short document was produced at the 1992 UNCED. It consisted of 27 principles aiming to guide the countries for sustainable development.

5. Basel Convention on hazardous waste, which was focused on movements of hazardous waste, especially transboundary movements and its disposal, was adopted on 22nd March 1989 by the Conference of Plenipotentiaries in Basel, Switzerland. It was in response to deposits of toxic waste in Africa and other developing nations, which were imported from abroad, leading to transboundary pollution in these regions of the world. Basel Convention is considered the most inclusive convention on hazardous waste, with 170 member countries. Its aim is to protect the environment and human health from hazardous waste generated from various industrial activities like BMW generation from clinical operations (Datta et al, 2018).

   Increasing environmental awareness and ongoing developments, and tightening of environmental legislation in developed countries in the 1970s and 1980s led to syndrome like "Not in my Backyard" in the developed world. Additionally, the rising cost of disposal of such hazardous waste in these parts of the world made them find an easier and convenient way to dispose of their hazardous and toxic waste in developing countries where environmental regulations were not so developed. This phenomenon was termed as "Toxic trade," which laid the basis for the Basel convention in the late 1980s. Convention entered into force in 1992 (UNEP, 1992). Following were the principal aims of the Basel Convention;

   - The reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal;

   - The restriction of transboundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management; and a regulatory system applies to cases where transboundary movements are permissible.

6. The Conference of Plenipotentiaries on 22nd May 2001 in Stockholm, Sweden, also adopted the Stockholm Convention on Persistent Organic Pollutants (POPs). It is a global treaty to protect the environment, human health, and other organisms of the ecosystem from chemicals that remain in the environment for longer durations. They get widely distributed on geographies and accumulate in fatty tissues of organisms. This accumulation could lead to harmful effects such as cancers, birth defects, adverse impacts on immune, nervous and reproductive systems, and greater susceptibility to various diseases. Given the context of their long-range transport, no single party or government can protect its environment and citizens from the harmful effects of POPs. Therefore, the Stockholm Convention requires its parties and signatories to strategize and implement measures to reduce the POPs released into the environment (UNEP, 2004). These measures are focused on;

- Prohibition and eliminate the production, import, and use of POPs listed in Annex A of the convention.

- Reduction and elimination of the release of unintentionally produced POPs.

- Ensure the safe management of waste containing or contaminated with POPs.

  The guidelines for best available practices to ensure the safe management of such harmful POPs were released in 2006.

6. Approval of Minamata Convention

Mercury is considered one of the most toxic metals, which keeps the environment contaminated for a very long period once released. It biomagnifies and bioaccumulates in the food chain. It impacts the human nervous system and affects other terrestrial and aquatic lives. Minamata convention was a treaty to protect the environment and humans from the adverse effects of Mercury. Union Cabinet of India approved the ratification of the Minamata Convention in February 2018. This convention is a global treaty to protect human health and the environment from the adverse effects of Mercury. This ratification entails India for continued use of

Mercury-based products and processes up to 2025. India will also be entitled to get financial and technological assistance to address issues related to Mercury. The convention is supposed to urge the industry to move towards Mercury-free products and processes, ultimately driving research into non-Mercury technologies. The basic context of implementing this convention is related to sustainable development, which aims to protect human health and the environment from anthropogenic emissions.

5.2.3 Legal Provisions in Constitution

Constitutional Factors

1. 42^{nd} Amendment in Constitution: Considering the mandate of the Stockholm Declaration of 1972, the Indian Parliament passed a historic amendment (42^{nd} Constitution Amendment Act, 1976). This amendment introduced the principles of environmental protection in the constitution through articles 48A and 51A (g).

   Article 48A obligated the state to protect and improve the environment, safeguard the forest, including wildlife, and impose a pollution-free environment for good health. Under Directive Principles of State Policy, the state needs to enact legislation to realize these rights. Article 51A obligated the citizens to protect and improve the environment.

2. Right to health and the right to life were given space in the constitution. Articles 38, 39(E), 41, 42, 47, and 48(A) impose liabilities on the state by different provisions. The constitutional mandate is unequivocal to protect the environment.

3. On the subject of Public Health and Sanitation; hospitals, and dispensaries, the state legislature has legislative competence under Article 246 (3) to enact legislation in matters enumerated in List II (State List) in the 7^{th} Schedule of the Constitution of India, including management of BMW generated from any establishment within its territorial limits.

5.3 PROVIDER'S PERSPECTIVES ON ENVIRONMENTAL LEGISLATION AND REGULATORY FRAMEWORK

5.3.1 Evolution of Environmental Legislation

Ever since their existence, human beings are surviving on natural resources. However, in previous times, where humans lived as hunters and gatherers, the extent of consumption of natural resources was the least. Processes of industrialization, the rise of the middle class, and increasing consumerism have put enormous pressure on the environment. The quality of the natural environment has deteriorated. Having recognized this situation, international governments have tried to balance the extent of consumption of natural resources and level of environmental pollution through different strategies, viz. reduction in carbon emission, shifting to renewable resources for energy, and implementation of environmental legislation in various forms to curtail the environmental pollution. Environmental Protection Law is imperative to govern the polluting behaviors of polluters or stakeholders.

> "Having legislation to curtail the pollution caused by BMW mismanagement is necessary as people abide only by law. Though the law is there, only its existence is not enough to control the pollution due to BMW fully. This situation is arising due to poor implementation of the law. Without legislation, there is no boundation for the producer of BMW for its proper disposal. Therefore, having such legislation is important to protect the human environment. You can see, nowadays, stubble burning and environmental pollution is hot news. There are provisions of fine and imprisonment on stubble burning. This has enabled the authorities to curtail the extent of stubble burning and pollution caused by it. If there had been no such legislation, the situation of pollution caused by it would have been worse" (MPHW, Hisar).

> "Legislation is essential to fix the liabilities of the stakeholders. Without law or legislation, it is hard to control the behavior of polluters. However, in my opinion, it is crucial to have a well-established implementation framework for better implementation of the law. In current times, the majority of the private sector facilities are unaware of the existence of such rules, especially smaller level facilities. Therefore, it is hard to fix liabilities in such a context" (Senior Administrator, Hisar).

Merely having legislation or rule does not guarantee the control of a situation, as in the case of stubble burning. Having a regulatory framework is a necessary and prime thing to control pollution. Implementing rules following the regulatory framework is the next major thing to curtail the pollution due to BMW. The regulatory framework also needs to be context-specific.

5.3.2. BMW Management and Handling Rules in India

As discussed, environmental legislation is the key to protecting the environment. Through strong environmental protection laws, many developed countries have been able to safeguard their natural environment. However, merely enacting the laws is not sufficient; implementing those laws makes the difference. Without the adequate implementation of these legislations, the environment can be partially protected only. Under the Environmental Protection Act, 1986, BMW management rules are being implemented by implementing agencies, i.e., HSPCB. There is a regional office of this authority in district Hisar. HSPCB has the power to authorize healthcare establishments for generating BMW. Also, it seeks annual reports from these establishments on the extent of BMW generation and management. HSPCB is also responsible for carrying out environmental monitoring activities to have a check on environmental pollution caused by healthcare providers. Implementation of BMW Management and Handling Rules is done by involving multiple stakeholders, viz. health departments, administrative authorities, municipal corporations, and waste management authorities. A proper implementation framework for any rule is an important tool to get desired results. Healthcare infrastructure and provisioning in the state make it difficult to implement these rules/laws in the state properly.

> "Authorities of HSPCB are responsible for implementing BMW Management and Handling Rules, 2016 in all the medical institutions of the state. Also, there is a process of getting authorization as occupier of the health facility. There are certain issues in getting an authority certificate from HPSCB (off the record- *kai baar monetary demand bhi hoti hai, to jhanjhat kaafi h*). *Unki website bhi zyada time kaam nahi karti h.*, so it isn't easy to download and send reports. The pollution control authorities extend very little administrative support or monitoring support on this issue" (Senior Veterinary Administrator, Hisar).

> "HSPCB is an implementing agency for the BMW management rules and monitoring healthcare activities. Active involvement of the board personnel could reduce the outbreak incidences which occur due to BMW mismanagement. Outreach of board activities is minimal. There may be human and other financial resources issues, but it's good to observe that the Pollution Control Board is doing something" (Senior Administrator, Hisar).

> "The Pollution Control Board is the prime agency responsible for implementing BMW management rules in the state and district. The authorization process should be more straightforward, which will enable smaller facilities in the village setting to get authorized easily, and compliance with the rules could be made easier. Inevitable outbreaks and infections occur as a result of mismanagement of BMW in the villages, which could be prevented with the active implementation of rules which is not the current scenario" (Senior Administrator, Hisar).

> "As I mentioned, without having legislation, we cannot imagine safeguarding our environment from polluters. But we can only accomplish this role of environmental protection with a proper implementation framework" (Senior Administrator, Hisar).

5.3.3 Legal Provisions in Constitution and Extent of Implementation

The environmental consciousness of all the stakeholders like population, politicians, practitioners, professionals, and policymakers is imperative to establish a better and functional framework for the scientific management of BMW. A certain level of this consciousness is required to enable the people/ citizens to make choices that are not harmful to the environment. However, environmental consciousness itself is shaped in a particular context of environmental legislation or legal frameworks. The behavior of people is bound by certain laws and regulations. BMW Management and Handling Rules under the aegis of the Environmental Protection Act are the keys to protecting the environment from BMW mismanagement. Legal provisions enable implementing authorities to carry out environmental monitoring and to take legal actions wherever necessary. HSPCB is the implementing agency for implementing BMW Management and Handling Rules in the healthcare establishments of Haryana. Additionally, it is also responsible for disseminating updated guidelines, extending technical support to the stakeholders. However, implementing these rules at the ground level is not very far-reaching and the stakeholders carry inadequate information about these legal provisions.

> "As such, there is no direct support exclusively for BMW management. We get guidelines and circulars from the state or HSPCB regarding the management of healthcare waste. The state government provides financial support. However, this support is limited to facilities located in urban areas. Rural facilities are devoid of such support. Also, there is a lack of administrative support, which should also be extended to rural veterinary facilities to effectively manage BMW" (Senior Veterinary Surgeon, Hisar).

> "There are various laws and rules to protect the human-natural environment, such as BMW Management and Handling Rules. Similarly, there are rules to protect air, water, and soil. I don't know these rules in detail. Also, there are rules for the disposal of general waste generated from households. Additionally, the legislation also exists for the management of chemical or industrial waste. All these laws are enacted to protect the environment from human activities" (MPHW, Hisar).

> "They are responsible for the implementation of BMW Management and Handling Rules 2016 in all medical institutions. Earlier, it was not so clear and in the limelight, but nowadays BMW management rules are followed due to the active coordination of HPSCB. Though there are certain issues in implementation, these things will get resolved slowly" (Senior Administrator, Hisar).

> "HPSCB is responsible for implementing BMW Management and Handling Rules in all the veterinary and medical institutions, but these things are hardly known in the field settings or villages. Active implementation of the BMW rules is lacking. Merely creating reporting formats is not going to solve the problem. Unless there are monitoring activities in the field villages or training is conducted, there will always remain problems" (Veterinary Epidemiologist, Hisar).

5.3.4 Awareness about Recent Changes

BMW Management and Handling Rules first came into the picture in 1998. Since then, it has been revised or modified several times. Recently, these rules were amended in 2018. WHO blue book is the primary reference text for authorities worldwide to amend, add or formulate rules and regulations for BMW management and handling. To assess the knowledge and awareness of stakeholders, especially healthcare providers, the researcher asked a few stakeholders about many recent changes or advancements in the BMW Management and Handling Rules. There were mixed responses, and only a few of them could point out recent changes or advancements made in existing BMW Management and Handling Rules.

> "Yes, some modifications have been made in terms of the types of health facilities covered under these rules. All the health facilities, including health camps and AYUSH facilities, are now covered as they are liable to manage their BMW according to the laid provisions or standards. Also, a few modifications are done in the color codes of the bins used to store BMW" (Senior Administrator, Hisar).

> "I have not referred to the document yet, but yes! I have heard about some changes in these rules with respect to the color codes of the bins. Also, we are planning to phase out plastic bags in the coming future. Additionally, we have added more facilities like AYUSH facilities or camps under the purview of these rules" (SMO of a CHC).

> "I have heard some amendments were done in these rules some time back, but I am not sure how all components are modified or changed in the BMW management rules" (MPHW of a CHC).

> "There has been a slight change in the categories of waste collection bins and their color codes. The government is also planning to implement the GPS/GIS-based collection of healthcare waste from healthcare facilities. In addition to the healthcare facilities, many other establishments like healthcare camps or schools (provision of first aid box) are also included in the categories of health care providers. They also generate some amount of BMW. Ayurvedic and Homeopathic healthcare facilities are also included in recent changes" (Homeopathic Medical Officer of a PHC).

> "There are changes in the color codes of bins designated for the storage of BMW. Also, some other categories of facilities were added recently. We have conducted training for our staff in district hospitals for segregating, handling, storing, and adequate and scientific disposal of BMW. Also, we are planning to conduct further training in the coming days to communicate recent advancements or changes in BMW management rules to our stakeholders" (Health Officer, Hisar).

> "Earlier, there were three categories of bins used for the collection of BMW. Now, these categories have been changed to four. I have not read these rules in detail as we work in the field, and we hardly generate any BMW. Also, monitoring activities from the higher authorities are getting intense in more extensive public health facilities such as district hospitals and CHCs" (HI of a CHC).

5.3.5 Adequacy of Existing Framework of Implementation for Legislation

5.3.5.1 Issues of Infrastructure and Manpower

Though the regulatory framework is the primary factor for safeguarding the human environment, it is not sufficient to protect the environment. We have had environment protection laws and BMW Management and Handling Rules for years. Laws do not guarantee environmental protection and sustainability as many other factors influence the implementation of these laws and the health of the natural environment. Moreover, the regulatory framework needs to be inclusive to safeguard the environment from every kind of pollution and polluters. Additionally, such frameworks must be flexible enough to cater to each level of processes that ultimately pollute the natural environment. But the question still remains; are we successful in protecting the environment while having these laws in place? No!

> "I think we do not have adequate infrastructure and human resources to implement these laws. Monitoring activities are minimal. Law is not inclusive of all the stakeholders who generate BMW. These rules are confined only to institutions or health facilities. There needs to be a flexible regulatory framework for their inclusion. In addition, research work/ studies are very much limited in this area to guide the policies. Greater control or regulation on the private sector is required to effectively implement the law" (SMO of a CHC).

> "I do not have much experience working in the private sector or lower level of health provisioning. Changes have been happening over the years in ways we are handling our BMW, but as I hear from my colleagues and friends, these changes are limited to a specific section of facilities. Lower level facilities or small clinics in the private sector have not demonstrated any changes in this regard. So, there is space for a lot of improvements in this regard. In a health system like India, where we have a variety of practitioners and the sector is dominated by private players, it is hard to imagine the dynamics of such provisioning. We don't have control over the private sector and much of it is unregulated. Growth in the private sector has been enormous in recent years. Informal practitioners are practicing medicine in huge numbers. They do not feel abiding by any legislation. Also, there is least awareness among them about such rules. Moreover, environmental monitoring is very much limited. Public health authorities have limited power to control such practitioners. How would you ensure the adequate implementation of law in such a scenario?" (Health Officer, Hisar).

5.3.5.2 Framework of Implementation; Urban and Private Dynamics

HSPCB/ CPCB is the implementing agency for environmental protection laws and BMW management rules in Haryana. Board is responsible for regular ecological monitoring of healthcare establishments located in urban and rural areas. However, in-depth discussion with various stakeholders revealed that the extent of such environmental monitoring is not adequate and cannot cover every level of the healthcare facility. Environmental monitoring of healthcare facilities is a rare phenomenon and restricted only to facilities of urban areas. Rural areas hardly observe such processes which aim at the safeguarding environment. Therefore, healthcare practitioners practicing in the field or villages are least aware of such monitoring frameworks. This situation is the same for general human medicine and veterinary medicine. Additionally, Pollution Control Authorities/ HSPCB/ CPCB is responsible for providing technical support to healthcare facilities for effective implementation of the law, which also is very limited. Authorization from HSPCB is a must for every kind of health provider, but the recent report of NGT has pointed out huge gaps in this regard. Moreover, the healthcare market is dominated by private providers in India, which is highly unregulated. This makes implementation much difficult to execute in an adequate manner.

> "HSPCB and higher authorities/ senior officials in the livestock department are responsible for framing guidelines and implementing such legislative framework in the state. Effective implementation requires the execution of administrative action and other activities like monitoring, training and reporting mechanisms, and technical support. Such activities are evident in urban areas, but rural areas are completely devoid of such frameworks. Field staff is hardly aware of such legislations and their dynamics. In this context, veterinary healthcare personnel practicing at the field level tend to manage the BMW at their convenience" (Field Veterinary Practitioner, Hisar).

> "I don't think that the present regulatory framework is adequate to safeguard the environment from polluters. We have different laws for everything. But merely having law does not serve the purpose unless it is well implemented. As I told you, the present framework has changed or improved things in a few healthcare facilities located in urban areas only. But the majority of the Indian population lives in villages. A variety of practitioners provide healthcare facilities there. How does the present framework fit into that scenario? Every village would have at least ten practitioners in Barwala block. And we have around or more than 50 villages in this block. Imagine the number of practitioners working there and the amount of waste they would be generating. So, the present framework is insufficient to safeguard the environment" (Radiographer of a CHC).

> "If I talk about the overall scenario, I would say it is insufficient as the law does not cater to every stakeholder in this field. A vast number of informal practitioners serve rural areas. There is very little knowledge, or no knowledge at all, among those practitioners about BMW management rules. Even we don't have any framework for the implementation of such regulations in rural areas. And our rural population and informal health workers providing services in those areas are enormous. It is tough to imagine the aggregate amount of BMW that our rural practitioners would be generating" (HI of a CHC).

> "However, progress in BMW management in rural areas facilities is very much negligible. Apart from the improvement in rural areas, coordinated efforts are not being taken. Pollution control authorities conduct meetings of different stakeholders once or twice a year. Field level health staff is not aware of such meetings also. Therefore, it is hard to imagine their awareness level for the effective management of BMW generated in rural veterinary facilities" (MPHW of a SC).

> "If we talk about the implementation, it is the pollution control authorities and the higher authorities in the veterinary department responsible for implementing such rules in the urban and rural veterinary facilities. Some level of implementation of BMW management rules 2016 could be observed in urban areas, but if we talk about rural areas, not much of the work has been done in the field. Though we have rules and Act to protect the environment from healthcare waste generated as a result of various healthcare activities, the existing framework

> of implementation is very much inadequate. We have to be more attentive to effectively implement the BMW management rules, especially in rural areas" (Senior Veterinary Administrator, Hisar).

5.3.5.3 Limited Punitive Action

The present framework of regulation with respect to BMW management seems insufficient for environmental protection. There are limited punitive actions for the violators of the rules. Moreover, whatever little punitive actions are taken, are only restricted to comparatively larger or bedded facilities of urban areas. Informal healthcare workers or smaller health facilities located in urban and rural areas are unaware of such rules or punitive actions/ provisions. Whatever action is taken can only be taken by implementing agencies like HSPCB. Public health authorities of the district feel helpless as they have no control or power over private health facilities in this regard.

> "Environmental monitoring under environmental protection laws is an infrequent phenomenon and restricted only to a few healthcare facilities in urban areas. Therefore, punitive actions are only limited to a few bedded healthcare establishments located in urban areas. Smaller clinics and informal healthcare workers present in large numbers are not aware of or afraid of any such rules or laws. To make the law more effective, we have to cover all the stakeholders under the regulatory framework" (MPHW, Hisar).

> "The legislation is the key to controlling the polluting behavior of health practitioners. People feel bound by law or morality if it exists in some way or other. You can take the examples of other legislation or frameworks; it is tough to imagine a situation without legislation or rule. Without adequate legislation, we do not have control over the private sector, a business-driven institution. We do not have the power even to generate challans or fines if violations occur at their level. Such activities and the process could be carried out by HSPCB officials only. Therefore, legislation is must to govern people's behavior" (Senior Administrator, Hisar).

> "A lot of changes have been there in this particular area. Even we at public health facilities did not have any guiding document for adequate management of BMW generated by us in the 1990s. In earlier times, we used to bury most of the BMW. SOPs were developed later on, and many changes were observed in this regard in public health facilities. However, the situation has not changed much for the lower level of health facilities that need to be looked upon. Private health facilities located in urban areas are liable for the management of their BMW. Still, often, they violate the rules in the absence of strong administrative or legal actions by implementing agencies. They are overburdened with the monitoring of other highly polluting industries. The situation has not changed much for smaller health facilities and quacks" (Senior Administrator, Hisar).

5.3.5.4 Lack of Awareness/Guiding Document/Infra/ Monitoring

Environment protection law or BMWM rules have dented to some extent in urban areas only, and this dent is only limited to a certain level of health care facilities. The majority of the health facilities, significantly smaller healthcare facilities in semi-urban or rural areas, do not care about such rules due to inadequate implementation of legislation at their level. Informal health care workers are not aware of such laws and regulations. But their existence in the healthcare system is a reality of the Indian healthcare system. Legislations must be framed or implemented in a way that includes all types of healthcare providers. Monitoring activities are the major part of the implementation framework. It should not be restricted to larger/ bedded facilities in urban areas only and needs to be expanded at all levels with increased frequency.

> "I have work experience working in both the public and private sectors, and I have never encountered any environmental monitoring or supervisory activity exclusive to BMW management. Though as part of supervisory visits for other programmes, such activities are monitored internally, smaller facilities or the private sector do not generally face such monitoring" (LHV of a CHC).

> "The current implementation framework is not adequate to solve the problem of healthcare waste. It cannot cater to the lower level of healthcare facilities such as smaller clinics and informal health workers. A lot of health workers practice in rural areas. They are least concerned with even the existence of such a law. Most of them are not aware of such legislation. They produce a huge amount of BMW in the field. This is why the present regulatory framework is not sufficient to tackle the problem of healthcare waste" (MPHW of a SC).

> "I would say that present legislation or its implementation is not sufficient to protect the environment. We need to expand its coverage and fix liabilities even at the level of communities and lowest of the levels. Every type of health facility and informal health worker needs to be assigned some duties and responsibilities with respect to BMW management. Communities must be strengthened so that people could be made aware of such mismanagement of BMW by a variety of healthcare workers in their communities" (LHV of a CHC).

> "The present implementation framework hardly caters to a smaller level of health facilities like clinics, especially those run by unregistered medical practitioners. The numbers of such practitioners are huge. That's why it is a considerable concern in this area. Unless law caters to that level of health provisioning, it is hard to safeguard the environment from the polluters in the health sector" (Senior Administrator, Hisar).

> "State pollution control boards are responsible for the implementation of such a framework in the state. However, to what extent they can devise or implement such a framework is very much questionable. We can observe some activities or strategies at our hospital, the largest veterinary hospital in Haryana state, but there is also a limitation here. Existing knowledge regarding legislative framework is inadequate in most of the staff, especially in rural areas. They may be aware that there is a law related to BMW management, but they would not certainly be sure about the framework of implementation. So there is a lack of training and monitoring activities, which could contribute to the implementation of such frameworks" (Senior Veterinary Surgeon, Hisar).

HSPCB and central level authorities are responsible for implementing such a framework in the state (both in urban and rural areas). Still, the effective implementation seems to be less evident, especially in rural areas where little infrastructure and resources exist to effectively manage BMW generated as a result of various veterinary healthcare activities. People are not aware of the existence of the law. The pollution control board is involved in different other activities as well; there must be different other sectors to look after. But the contribution to pollution by the health sector received very little attention from pollution control authorities.

> "HPSCB is responsible for implementing BMW Management and Handling Rules 2016 in all the veterinary and medical institutions, but these rules are hardly known in the field villages. Active implementation of the BMW rules is lacking. Merely creating reporting formats is not going to solve the problem. Unless there are monitoring activities in the field villages or training activities, problems will remain there" (Field Veterinary Practitioner, Hisar).

> "As I said, merely having legislation or rule does not guarantee the control of a situation like in case of stubble burning. Having a regulatory framework is a necessary and prime thing to control pollution. Implementation of the rules according to the regulatory framework, is the next major thing to curtail the pollution due to BMW. Also, the regulatory framework should be context-specific. BMW management rules talk about the occupier of the health facilities, but in the Indian situation, many practitioners practice medicine out of such facilities. They must not be aware of such rules. The regulatory framework should answer such questions, and it must be able to accommodate such practitioners, or the practice of such practitioners should be halted if they are not accommodated" (MPHW, Hisar).

> "No, medicines are used in bulk in some industries and hospitals. Even in the village, a variety of healthcare workers are present. They use medicines in bulk to treat patients. Many of those medicines are used unnecessarily. This law does not cover such informal practitioners and industries. How would you ensure the implementation of this law to that level? Also, a lot of medicines and other products like insulin syringes are used by patients at home. How would you ensure or cover such practice-generated waste under this law?" (Pharmacist of a CHC).

> "As I said, the law should be inclusive of all practitioners. Much of the BMW is generated by the quacks or unregistered medical practitioners. Either you curb their practices or provide them with the required infrastructure to be able to manage the BMW properly. Also, other clinics and hospitals are there do not manage their BMW properly. In such a scenario, monitoring activities are required to be upgraded. They should be liable to fine or imprisonment for the violation of the law. Regular training and workshop is another tool to keep the practitioners and hospital updated on BMW Management and Handling Rules" (MPHW of a SC).

5.3.4.6 Implementation and Practices with Respect to Legislation

Veterinary: Administrative efforts are also lacking for the effective implementation of a framework for managing BMW and monitoring it. In the absence of such a framework of implementation, field staff or veterinary personnel are left with little choice and they try to manage the generated BMW based on their consciousness, current knowledge, and the existing practices carried out by their colleagues.

5.4 ENVIRONMENTAL MONITORING

5.4.1 Importance of Environmental Monitoring

As discussed earlier, day-to-day activities and decision-making affect the environment in a way or other. Therefore, there is a need to continuously monitor the effects and impacts of these activities and decision-making on the environment, especially in industrial processes. This process of environmental monitoring is institutionalized through a number of establishments. Pollution control authorities are one of them. This type of monitoring is external in nature. However, it is imperative to internalize the monitoring activities at the institutional or organizational level to streamline the monitoring process. Therefore, monitoring activities are necessary to keep a regular check on the management of healthcare waste.

> "At our level, we have constituted a committee of various stakeholders for regular monitoring activities. Monitoring is done from time to time. A meeting of the committee members is also organized. In our scheduled meetings also, we discuss this issue with our field staff. However, such activities and frameworks are limited only to urban areas" (Health Officer, Hisar).

It is evident that industrial processes and the day-to-day decision-making of humans lead to environmental pollution. However, the major issue lies with the proportion of environmental effects and ecological impacts due to healthcare waste generation. There have been some instances where efforts are directed in this direction. Some European countries studied the extent of carbon emission due to healthcare activities through modeling studies. However, standard methodologies for studying such effects and impacts are largely absent. Additionally, efforts like 'One Health' with an integrated approach are being extended to study environmental effects and impacts on health. One health is a perspective of looking at the problems of humans and animals collectively. Many human diseases occur as a result of an interface between humans and animals and other organisms. Rather than working in silos, it provides a shared outlook for a better understanding of problems.

5.4.2 Environmental Consciousness

Every human activity or day-to-day decision-making negatively affects the environment most of the time. Environmental consciousness refers to the general behavior, attitude, and concern of the people towards the environment while carrying out certain activities or making a decision. This consciousness becomes a great concern when we talk about the consciousness of policymakers or decision-makers. The environmental consciousness of key decision-makers could have huge environmental consequences which affect a large number of people. As discussed, human beings carry the behavior of consumers who consume or survive on natural resources. Therefore, it is the concern or attitude of the consumer towards the environment that affects the environment positively or negatively.

Healthcare activities right from their inception, planning, procurement, consumption, and procedures involve decision-making at different levels. These key decisions ultimately result in the generation of some kind of BMW. Similarly, the adoption of strategies or practices to dispose of this BMW involves some key decision-making from administrators or practitioners. They may decide to dispose of this waste in the open or mix it with general municipal waste or burn it or bury it or send it to a CBMWTF for proper disposal. These decisions are affected by the level of their environmental consciousness. This ecological consciousness also depends upon available resources and facilities available around decision-making.

Environmental consciousness is shaped by the context and macroprocesses, like the overall organization and provisioning of health services and waste management facilities in a particular place or country. A variety of providers in India provides health services. Private healthcare providers offer the majority of the services. Out of these private providers, a major chunk is constituted by informal health providers. They are not a direct part of the health services system.

5.4.3 Frequency and Extent of Environmental Monitoring by Pollution Control Authorities

Environmental monitoring is an important aspect of the implementation of environmental protection laws by pollution control authorities. It is a part of the implementation framework of environment protection laws. Also, it can be a triggering factor for generating environmental consciousness among different stakeholders. The pollution control board is also responsible for establishing coordination among different stakeholders, viz. care providers, municipal corporations, and common BMW treatment facilities. Additionally, HSPCB is also expected to provide technical support to adopt better BMW treatment facilities. However, in the given context of the nature of health services provisioning by different providers, it is difficult to assess the extent of environmental monitoring carried out by pollution control authorities. An in-depth discussion with various healthcare providers indicates that ecological monitoring is a rare phenomenon, and most respondents have never encountered such a phenomenon in their lifetime. It becomes rarer in the case of smaller healthcare establishments and veterinary healthcare facilities.

> "Pollution control boards or authorities rarely conduct such activities. Although we manage it to do here, the situation in the field is very alarming. A coordinated effort would have helped the adequate management of healthcare waste. The pollution control authorities extend very little technical and managerial support in this regard" (Veterinary Surgeon, Hisar).

> "The Pollution Control Board is responsible for the implementation of such a framework in the state. Effective implementation requires the execution of planned activities, administrative action, and other activities like monitoring, training, and information dissemination, and establishing regular reporting mechanisms. Such activities are evident in urban areas, but in rural areas, the situation is entirely different. The implementation framework is not apparent in smaller healthcare/ veterinary establishments in urban areas and rural areas. Field staff is hardly aware of such legislations and their dynamics. In this overall context of inadequate implementation, field staff/ veterinary healthcare personnel tend to manage the generated BMW based on their consciousness, current knowledge, and existing practices carried out by their colleagues" (Senior Administrator, Hisar).

> "I have work experience in the public and private sectors, and I have never encountered any environmental monitoring or supervisory activity exclusive to BMW management. Though as part of supervisory visits for other programmes, such activities are monitored internally in smaller facilities or the private sector does not generally face such monitoring" (LHV of a CHC).

> "At our facility, we have constituted a committee to ensure the implementation of the BMW management system. We conduct regular meetings to discuss the issues of BMW management at our facility. However, there is a lack of efforts from pollution control authorities in terms of technical support or provision of some monitoring indicators" (Homeopathic Medical Officer of a PHC)

> "I have never encountered such monitoring by healthcare authorities or any authority related to pollution. I have not even heard about any such activity in any nearby health facility. There is no monitoring framework for monitoring such phenomena in practices. We are sometimes asked one or two questions in supervisory visits by senior officials, but BMW management monitoring has never happened in our facility or a nearby facility since the day I have been here" (MPHW of a SC).

> "I have not faced environmental monitoring in my carrier, but yes, I have heard such instances once or twice in the past. Environmental monitoring is not a routine activity in the field of BMW management. HSPCB is the implementing agency, and they have power for environmental monitoring with respect to BMW management" (MPHW of a SC).

> "Since I am a field worker, I do not know much about the monitoring framework, but some public health programmes are running for improved cleanliness in public health facilities. I have heard of it being carried out in our district hospital but never observed it myself. I have never heard of these monitoring activities carried out by authorities in lower-level facilities such as CHCs, PHCs, and sub-centers. Also, it is very much limited in private hospitals and clinics, almost nil I must say. I have never encountered any kind of environmental monitoring by the authorities of the health department or State Pollution Control Board" (MPHW of a SC).

Above mentioned responses indicate that environmental monitoring is the least observed phenomenon, and many of the respondents have not even heard about such processes. However, efforts are being taken at the institution level in some institutions to streamline the process through internalization.

5.4.4 Institutionalization of Monitoring

Monitoring and supervision are two important administrative activities for the implementation of any programme. These activities are continuous processes for achieving desired outcomes. Usually, these processes are carried out by internal actors. However, sometimes these activities could be carried out by external stakeholders. BMW generation, storage, handling, collection, treatment, and final disposal are regular and ongoing processes. Therefore, it is imperative to ensure regular environmental monitoring to streamline the proper disposal of BMW. Environmental monitoring by pollution control authorities is not a frequent phenomenon due to various reasons. Institutionalization of monitoring activities through multiple programmes and internal committee activity is a valuable mechanism. The majority of bedded public health institutions and few private healthcare establishments have constituted internal committees to regularly monitor the ongoing BMW management activities at the institutional level. Cleanliness programmes like Kayakalp are being run in public health facilities where the BMW management is an essential checklist component. This checklist is used to generate the score for the respective facilities. Through implementing the Kayakalp programme, the government is trying to institutionalize the monitoring activities in public health institutions.

> "There is an internal committee in every public health facility for regular deliberations and monitoring practices of BMW waste storage, handling, treatment, and final disposal. More extensive facilities have designated one nodal officer for the management of BM waste. Additionally, every district hospital has a quality cell to overlook quality control in public health facilities. Also, there is planning for GIS-based (along with QR code) waste collection and disposal, which will enable the authorities to monitor the movement of BM waste from the point of generation to its final disposal" (Health Officer, Hisar).

> "There are various programmes to regularly monitor the cleanliness activities in public health facilities. Kayakalp is such a dedicated programme for the improvement of public healthcare facilities. Regular institutional monitoring is being done even at the lowest level of the healthcare establishment. BMW management is one of the components of its checklist, where a particular score is assigned to healthcare facilities based on their performance. This is how monitoring activity is being institutionalized in public health facilities" (Senior Administrator, Hisar).

> "At our level, we have constituted a committee of various stakeholders for regular monitoring activities. Monitoring is done from time to time. A meeting of the committee members is also organized. In our scheduled meetings also, we discuss this issue with our field staff. However, such activities and framework are limited only to urban areas and bigger facilities" (Veterinary Surgeon, Hisar).

Although the Kayakalp programme has provided an opportunity to internalize the monitoring activities at the institutional level but barring a few larger institutions, exclusive monitoring for better BMW management practices is still missing from broader day-to-day administrative activities. It makes things difficult to manage for the smaller institutions where Kayakalp has not been implemented yet. Additionally, the nature of healthcare provisioning is such that not every healthcare service is provided through institutions.

> "After the internal monitoring under the Kayakalp programme in public health facilities, a score is assigned based on every checklist component. BMW management is one of the components. Monitoring activities are being carried out at different levels of health facilities based on this checklist. However, exclusive monitoring for BMW management is not conducted internally by the health department" (LHV of a CHC).

As observed, external environmental monitoring by HSPCB is not being conducted regularly. Though some institutions, especially public health institutions, have established systems of institutional monitoring, such mechanisms are not so commonly observed in smaller public healthcare institutions and private healthcare institutions. A bulk of private healthcare services is also provided on a non-institutional basis. There is no framework for environmental monitoring of such services.

> "There is a shortage of monitoring activities by the authorities. Even if some monitoring activities are happening in the private sector, that too must be limited to the institutions in urban areas. There is a vast private sector constituting smaller clinics and unregistered medical practitioners, which caters to a large population both in urban and rural areas. BMW Management and Handling Rules must be implemented at the level of these practitioners" (SMO of a CHC).

> "Yes! Some years back, our district hospital was visited by implementing agency, but regular monitoring is not conducted by these agencies which makes it easier for private health facilities to violate the rules. Another reason for such violations is that our private sector is highly uncontrolled and unregulated. They do not understand their duties and liabilities" (Senior Administrator, Hisar).

> "No, as I said, I am not an experienced guy. Whatever little experience I have, I did not encounter any such phenomena in my carrier personally. I came to know about such monitoring in the private sector through the newspaper, massive violations were reported. External monitoring is limited by pollution control authorities. However, we have developed an internal monitoring system at our institutional level" (Health Officer, Hisar).

Monitoring and supervision activities should be followed by corrective measures which could bring improvement in the services. Institutional monitoring does not involve legal actions. However, environmental monitoring by HSPCB could lead to legal action against the violators. The overall extent of environmental monitoring is not up to the desired level. Additionally, it does not involve all the types of healthcare facilities/ providers under its purview. Public health authorities do not have adequate power to question or monitor private healthcare providers. There are some instances where municipal corporations have undertaken environmental monitoring, and a fine was imposed on a few violators (mostly private hospitals in Hisar), but it hardly brings any change in the processes, and such monitoring activities are sporadic. Additionally, these activities are restricted to a few institutions of urban areas only.

> "I have been practicing medicine in the public health care system for the past 20 years. I had an encounter with pollution control board authorities only once in these 20 years when I was posted in Hansi Sub-divisional hospital. It was related to lower-level staff's mismanagement of healthcare waste and I must say this is one of the areas where maximum improvement is desired from the pollution control board which is the implementing agency for the BMW Management and Handling Rules in the state. In addition to this, the private sector is huge and very much fragmented in India. The team of the pollution control board visited some of these hospitals, but they took minimal action. Monitoring activities are very infrequent in this field, with limited action on violators. I have been posted to various levels of facilities in my carrier but it is very uncommon to hear that such a monitoring activity occurs in the field" (HI of a CHC).

5.5 DESIRED CHANGES IN ENVIRONMENT PROTECTION ACT/BMWM RULES

Above mentioned discussion points out some key areas for desired improvements or modifications in the implementation framework of BMW Management and Handling Rules. The implementation framework in the present time does not cater to informal health practitioners and smaller healthcare facilities like small clinics. The number of smaller healthcare establishments is huge, and more importantly, they are present everywhere. The implementation framework must be able to cover all the levels of facilities. Environmental monitoring is an important aspect of BMW management rules implementation. This activity should be scaled up to cover each level of healthcare provisioning.

> "In my opinion, two major things need to be done. Firstly, implementing the existing BMW Management and Handling Rules to all the facilities, including smaller clinics, needs to be ensured with an adequate monitoring and surveillance framework. The implementing agency, i.e., the Haryana State Pollution Control Board, needs to be more vigilant and active for adequate compliance with the law. Monitoring activities must be amplified to the lowest of the levels. Secondly, desirable improvements could be made to the existing laws to make them more inclusive of unregistered practitioners in the field. Similarly, the law should guide household BMW for the proper disposal and treatment" (SMO of a CHC).

> "For improved effectiveness of the law, the implementation framework must be scaled up to include all healthcare providers at each level. Monitoring activities should be more frequent and should be able to cover all the levels of health facilities. District health authorities should

be able to act as a monitoring agency for better implementation of the legislation in the private sector" (Senior Administrator, Hisar).

"Several things could be done to make the law more effective like we have to include every type of medical practitioner in the implementation framework. Some mechanisms should be evolved to include them in the overall management of healthcare waste as they serve most of the population. Also, measures must be taken to implement the rules or legislation at every level of healthcare like PHCs, sub-centers, and smaller private health facilities. There may be a lesser generation of healthcare waste at the level of these facilities, but they are generating this little amount of waste everywhere" (Radiographer of a CHC).

As evident, monitoring and supervision activities are of no use unless they suggest some corrective measures to achieve desired results. Monitoring and supervision activities should be frequent and continuous, and these activities must be institutionalized. Environmental monitoring should be carried out by multiple agencies like HSPCB and municipal corporations along with Panchayati Raj Institutions to monitor the rural areas as well. District's public health authorities should be provided with the power to monitor private healthcare institutions to ensure the implementation of rules. Legal actions for violators should follow monitoring activities.

"As I mentioned, we have to cover every level of health providers to implement the law correctly. Liabilities should be fixed. Communities must be involved in monitoring activities. Community awareness is a must phenomenon so that people can understand the dynamics of the issue and could demand better ways or solutions from health facilities located in their residential areas. Monitoring activities need to be conducted more frequently with various monitors or different stakeholders" (Senior Administrator, Hisar).

"A lot of things could be done to make the law more inclusive and effective. There should be more control over private practitioners, especially those practicing medicine in rural areas or in smaller health facilities. Monitoring activity should be scaled up to cover more and more health facilities and practitioners. The provision of stronger punishments could be one of the improvement strategies for better effectiveness of the legislation" (Pharmacist of a CHC).

"As I mentioned, we have expanded the coverage of the law. Every type of health practitioner and the facility must be assigned liabilities, and strong and frequent punitive actions are desirable to make the law more effective. Another aspect is regular monitoring. We need to devise mechanisms and strategize regular monitoring of this phenomenon in every level of health facilities. More and more stakeholders can be included to make it a regular activity" (Health Officer, Hisar).

"As I said, the law should be inclusive of all practitioners. Much of the BMW is generated by the quacks or unregistered medical practitioners. Either you curb their practices or provide them with the required infrastructure to be able to manage the BMW properly. There are clinics and hospitals that do not manage their BMW properly. In such a scenario, monitoring activities are needed to be upgraded. They should be liable to fine or imprisonment for the violation of the law. Regular training and workshop is another tool to keep the practitioners and hospital updated on BMW Management and Handling Rules" (MPHW, Hisar).

"As we discussed, the implementation of the law should be expanded to a larger horizon to cover a variety of practitioners as our health system is very much diverse. Smaller laboratories in villages or towns are unaware of such laws. Informal health practitioners must also be generating some healthcare waste. Those practitioners should be covered or trained, or monitored under the aegis of this law" (LHV of a PHC).

5.6 IMPACT ON HEALTH AND ENVIRONMENT

5.6.1 Antimicrobial Resistance

Pharmaceutical compound persists in the environment for a very long duration. APIs of many drugs and antibiotics are believed to persist in the environment for years. APIs are known for their slower metabolism in the environment.

Even in human bodies, pharmaceutical compounds metabolize partially. When ingested by human beings or animals, these pharma compounds are excreted out partially through open defecation results in the release of these APIs in the environment (air, water, and soil). Additionally, through hospital wastewater and sewerage system, pharmaceutical compounds are released into the natural environment as even sewage treatment technologies cannot remove these APIs from wastewater streams. Moreover, the irrational use of drugs or antibiotics in the poultry and agriculture sector makes APIs more obvious to get released into the natural environment. These processes contribute to environmental exposure and contamination at different levels.

Antibiotics are considered a revolutionary development of modern medicine. It has transformed the way surgical processes were and the way of treatment of many communicable diseases. However, in today‘s time, ABR is a burning issue across the globe. Excessive and irrational use of antibiotics is considered as a main underlying process of ABR. It is a common phenomenon in developing countries like India, where over-the-counter medicines are prescribed considerably. Additionally, antibiotics are prescribed by even informal health workers who are present in a large number. Moreover, there are other indirect processes like excessive usage of antibiotics in poultry industries and large animal farms. Hospital sewage and industrial wastewater of the pharmaceutical industry also contribute to ABR due to their continuous and slow exposure to the natural environment through different channels.

> "There is no doubt that antibiotics have transformed modern medicine. Surgical interventions became a successful mode of treatment after antibiotics. However, the irrational use of antibiotics has led to many environmental problems. Irrational use of antibiotics in the poultry

industry and by practitioners and self-medication have led to environmental contamination, leading to antibiotic resistance in humans and animals" (SMO of a CHC).

ABR is a much-debated phenomenon nowadays. Policymakers are discussing the issue, and efforts are taken to tackle the problem of ABR. Many states like Kerala have come up with newer guidelines and policy documents. ABR is posing severe challenges not only to humankind but to other organisms also. ABR and MDR are emerging as common phenomena in animals also. However, it is imperative that only human beings are responsible for such impacts on animals.

"Yes! ABR and MDR are very common phenomena observed in animals also. Animals may or may not get TB from humans, but they definitely get ABR or MDR from humans. Who is responsible for medicine consumption patterns in animals? Environmental exposure of traces of antibiotics and other pharma products is due to human activities and mismanagement of healthcare waste. All these cycles may contribute to MDR or ABR in animals. The prevalence of an actual number of ABR or MDR is not easily predictable in animals, but it is there for sure. Domestic animals still may get treatment for such problems, but stray animals are unable to get an opportunity to get cured; rather, they get sicker due to human activities" (Veterinary Epidemiologist, Hisar).

As discussed, human activities such as mismanagement of healthcare waste, open defecation, discharge of pharma industry into water streams, use of antibiotics in bulk in the poultry industry, and other activities may lead to slow contamination of the environment and persistent exposure to human and animals. Infectious waste and discarded or leftover medicines are thrown openly or mixed with general waste leading to the exaggeration of environmental problems. These factors contribute to ABR in humans and animals as they live in close proximity, especially in rural areas. Humans with MDR strain may infect animals. However, this phenomenon is very much complex which makes it difficult to pinpoint the actual process.

"ABR is a very common phenomenon both in humans and animals. Treatment of TB is almost the same in humans and animals. Although it is very hard to establish the linkages of ABR and MDR in humans and animals, it is very much definite that both affect each other as both live close. Animals are dependent on humans for regular intake of anti-tubercular drugs. Even humans are not able to follow the DOTS course strictly, whereas animals are entirely dependent. There are slow environmental exposures to these drugs both in humans and animals. If any of them is consuming anti-tubercular drugs, it affects the environment/ atmosphere of others, especially when they are living nearby. That is why research should focus on cross-linkages of diseases prevalence/ incidence and impact of treatments on each other. Efforts are being made with the projects like One Health, but they need to be escalated" (Senior Veterinary Surgeon, Hisar).

5.6.2 Slow/Long Term Environmental Impacts of BMW

Different dynamic pathways result in environmental contamination and exposure to humans and animals. It slowly accumulates in the whole ecosystem through the food chain and water bodies resulting in slow and unidentified changes. The challenge of exploring and assessing these changes is enormous as these changes are gradual and multifactorial and hence remain unidentified. Very little work has been done on different pathways of the development of ABR, the role of healthcare facilities and personnel. There is a need to explore the problem further with more quantitative data.

Institutions are doing a lot of work on antibiotics and pesticide residue in milk and milk products and meat products. This is a very complex cycle and the least observed phenomenon. The general public may have notions about contamination of milk and food grains due to excessive use of pesticides, but there are other pathways that are least known by them.

> "Our institute does conduct studies to assess the residue of pesticides and antibiotics in animal products. However, most of the studies are cross-sectional. Longitudinal studies for residue, environmental contamination, and impact on humans, animals, and ecosystems are need of the hour. Additionally, there is a lack of complex methodologies, which could establish an association /relationship between a particular exposure and effects" (Veterinary Epidemiologist, Hisar).

> "Humans are responsible for all environmental health problems. A lot of human activities result in environmental contamination and lead to health problems in humans and animals. Infectious diseases, outbreaks, injuries, ABR, or MDR are a few examples that resulted in environmental health issues. The problem with environmental health issues is that these exposures and impacts are slow; therefore, they go unnoticed. Some infectious diseases with known causes and sources have been identified, but efforts to control those infections are not well directed, e.g., Japanese Encephalitis outbreaks" (Senior Scientist, Hisar).

5.6.3 Monitoring of Environmental Exposure and Diseases

As discussed in the previous section, monitoring activities are imperative to check environmental contamination due to BMW. Healthcare activities and procedures both at the institutional level and outside the institutions result in BMW generation. This waste if not managed correctly may result in various environmental emissions and exposures. Environmental monitoring is a process to keep a check on such emissions. Therefore, it helps in safeguarding the environment. However, certain methodological issues lie with the environmental monitoring of such exposures. Different industrial processes may contribute to a particular type of exposure. There is a shortage of literature or methodologies associated with a specific type of exposure to specific healthcare activity. Drug resistance or MDR, or ABR development, is a result of various complex processes. It is hard to quantify how much of this phenomenon is contributed by mismanagement of healthcare waste or excessive usage in the poultry industry.

> "Issues like ABR or MDR are multi-factorial. ABR can happen due to many factors. It is hard to identify the proportionate contribution of healthcare waste. Moreover, these problems of environmental contamination and exposure are slow processes. It has been observed that there is behavior change in stray dogs near the poultry farm. It may be due to specific constant exposure, but it is hard to associate things without research. Similarly, there might be certain other changes happening in the ecosystem and going undetected. I think efforts should be made to identify these changes. More and more research should be directed towards these inquiries. The state should strengthen monitoring activities of the known associations and adverse impacts" (Field Veterinary Practitioner, Barwala).

> "Very inadequate efforts are being directed towards the development of research frameworks to understand such phenomena. These changes are gradual and very hard to monitor. Also, there is a lack of interest among research communities to understand such issues. Therefore, a lot of efforts, especially coordinated efforts, are required to understand such changes in the ecosystem. Methodologies for quantification of such effects on the environment are the need of the hour. And not only quantification but macroprocesses like underlying reasons/policies for such developments/ destruction of the ecosystem must also be understood through research studies" (Senior Veterinary Surgeon, Hisar).

Monitoring activities must not be restricted to supervision only. As discussed, largely, environmental contamination is a slow and persistent process. That is why it is hard to observe. It leads to slow and long-term changes in the ecosystem through environmental deterioration. Methodological frameworks for establishing direct association or quantification of proportionate exposures of different human activities are lacking. Not only for exposures but methodologies for establishing indirect effects of macroprocesses like socioeconomic development on overall environmental contamination, are also lacking. It hampers the processes of environmental monitoring, which should be a continuous phenomenon otherwise.

> "It is somewhat evident that changes are happening in the ecosystem, although they are slow and persistent. This nature of slow change is not triggering any active action to curb the situation. Also, there is a shortage of studies and efforts from the scientific community to establish the linkages. The establishment of such associations is not lucrative enough for the researchers. Complex methodologies are required to develop such frameworks which could answer these processes. Such changes result from different macroprocesses, e.g., overall social, economic, and developmental policies. Therefore, research frameworks must be able to establish such association within the overall process" (Senior Administrator, Hisar).

> "Some of the studies are ongoing projects, e.g., residue studies are being conducted on continuous mode. Longitudinal epidemiological studies are required to assess the slow environmental exposure of many contaminants. Mismanagement of healthcare waste may contribute" (Veterinary Epidemiologist, Hisar).

> "As discussed, there is a shortage of information on these issues, especially in the developing world. In the field veterinary settings, it has been observed that there have been behavior changes in stray animals due to the higher use of antibiotics and pharma compounds in the poultry industry. Again these are mere observations and need to be explored further. Residue studies of pesticides and antibiotics are being conducted here, which has reflected

> contamination of the environment. However, studies of persistent environmental changes and exposure in humans and animals and their impact need to be researched further” (Senior Administrator, LUVAS).

5.7 CHALLENGES WITH RESPECT TO BMWM/IMPLEMENTATION OF LAW

Challenges of BMW management in a scientific and proper manner are diverse and huge and depend upon various factors. These factors are distinct and typical for different healthcare facilities and providers. Rural healthcare facilities may face challenges in terms of infrastructure and resources for the effective management of BMW. In contrast, facilities in urban areas face different challenges with respect to BMW management, viz. storage, segregation, handling, training, and monitoring activities. There may be administrative challenges with respect to the authorization process or implementation of environmental protection laws. Additionally, challenges may be different from the point of view of stakeholders. There would be other challenges for administrators of health facilities, healthcare workers, and sanitary workers. Finally, working conditions or context where these stakeholders are situated would ultimately affect their decision-making or environmental consciousness.

> “Speaking from this position, there are not many challenges. In a public health facility, there is the ease of collaborating with pollution control board authorities. Authorization and reporting is not a very big issue. However, in lower-level facilities, things are harder to manage. Not much of the waste is generated at the level of a Primary Health Center or sub-center. Still, the management of whatsoever little waste is generated at these facilities may become a problem as a regular collection, especially in remote areas. We have contracted out our BMW management to a private organization up to the PHC level as not much of the waste is generated at the level of sub-center. Similarly, in the private sector, bigger hospitals and clinics might have made similar arrangements to manage BMW generated from their facilities, but smaller clinics or unregistered medical practitioners may find some other undesirable ways to dispose of their BMW” (SMO of a CHC).

> “It is not much complicated in the higher level of facilities, i.e., CHCs and above, as required resources and manpower are there. The third-party provider is identified and contracted out services with respect to the management of BMW. However, in smaller level facilities, challenges are sometimes enormous” (MO of a CHC).

There are different kinds of challenges faced by district health authorities when controlling or monitoring private sector establishments in the district. The private health sector dominates in health services provision, especially in curative services. However, the private sector is largely unregulated in India, so in district Hisar. District administrators of health services find themselves incapable of exercising any control over private health providers. Therefore, external environmental monitoring of the private sector by district health authorities is negligible.

> "As such, at the level of district health facilities, we do not face many challenges. We are also supposed to get authorization from pollution control authorities every year. A smaller level of health facilities under our districts faces some challenges with respect to segregation and storage of healthcare waste. Sometimes resources are not adequate to manage the healthcare waste scientifically. As a District Health Officer, challenges are colossal with respect to this issue for ensuring standard practices in private sector healthcare facilities as most of them run in an uncontrolled manner" (Health Officer, Hisar).

> "There are certain challenges concerning BMW management in many public health facilities. However, things and processes have been streamlined to some extent after the Kayakalp programme implementation, but there is still much to do. Private facilities often throw their BMW in the open. There is a landfill site nearby in Dandhoor Village, and you can visit and see every type of medical waste and hazardous waste burning there" (HI, Hisar).

5.7.1 Challenges of Field Settings

In addition to the facility-based health services, many health activities are carried out by healthcare workers in field settings. Many activities under the Malaria Control programme, TB Control Programme, and Maternal and Child Health programme are carried out in the field settings. Immunization is an everyday activity where outreach sessions are planned and executed in field settings. These activities result in the generation of a lot of BMW. In those settings, it becomes difficult for healthcare workers to manage their waste effectively. Veterinary healthcare practitioners face similar challenges as most of their healthcare activities are mostly executed in field settings or rural areas.

> "We are more associated with activities that are carried out in the field. Sometimes, we take samples in bulk as part of our routine activities. In those situations, it becomes hard for us to manage sharps and syringes. We try to carry those wastes with us most of the time, but sometimes our health workers tend to throw such waste at their convenience" (MPHW, Hisar).

> "We carry out different activities in our sub-center related to various health programmes like National Malaria Control Programme or TB Control Programme, or Immunization Programme. Apart from services or activities carried out at the facility, we carry out some of the activities in the form of outreach sessions in the community. In that particular context, we face various challenges for the safe management of healthcare waste. Sometimes we are forced to carry outreach-generated BMW with ourselves while returning" (ANM of a CHC).

> "Yes. As healthcare workers, we generate different types of waste material in the sub-center and the field also. It includes syringes, needles, and blood-stained cotton, etc. These things can affect human health and the environment. It may be a huge problem for bigger hospitals if they do not handle or manage the BMW produced by them. Sometimes, we also read such news about mismanagement or open throwing of BMW by healthcare establishments" (MPHW of a SC).

> "The quantity of waste generated by us is not that much. We face challenges in managing our waste while we are in the field and outreach sessions and it is not possible every time to manage this BMW properly" (ANM of a SC).

> "Frankly speaking, we work in a field situation where we do not generate much of the waste. Syringes, needles, cotton and slides (glass) is the most common waste generated by us. We have space in our field kit to keep the used needles and glass slides. We are supposed not to

throw this waste in the field. However, due to lack of monitoring, many field staff throw them openly or in general waste. Staff is not being provided with the training of management of whatever bio-waste is produced by us. Therefore, management and disposal of such waste depend upon the consciousness and ethical value of the field staff" (MPHW, Hisar).

Apart from the above-mentioned healthcare facilities, there are other types of healthcare establishments that generate some amount of BMW of different varieties. There are pharmacies or medical stores located in most of the villages. A huge amount of discarded or expired medicines that constitute hazardous waste is generated by them. These may be hormonal drugs, cytotoxic drugs, antibiotics, and other APIs. Some laboratories are now present in rural areas as well. Most of the laboratories are not connected to the sewerage system and are not authorized by pollution control authorities. Many of the smaller laboratories existing in the small town, like Barwala, or other rural areas serve as collection centers of bigger laboratories of Hisar. Those bigger laboratories may have the authorization process completed, but most of these smaller laboratories are not authorized. They generate a huge amount of BMW in the form of infectious samples, glass, needles and syringes, cotton, and other hazardous waste in the form of reagents, etc.

> "Pharmacies that are located outside government health facilities and bigger hospitals do not have or are not aware of such legislation, which makes them indulge in unscientific ways of BMW management practices" (Pharmacist of a CHC).

> "As our laboratory is a part of a government health facility, we do not face many such challenges concerning BMW generated in our lab, but sometimes, I feel that there should be greater emphasis on this issue. Regular training should be conducted for the effective management of BMW. Changes that happen from time to time should be communicated to each stakeholder. Challenges faced by smaller and private laboratories are huge as they lack the necessary infrastructure and resources for effective management of BMW management" (LT of a CHC).

> "Definitely, I am aware of the problem of healthcare waste. I have been practicing as a lab attendant for years. A variety of BMW is generated from healthcare facilities, including laboratories which need to be managed based on some standard guidelines. However, people generally do not follow the rules or guidelines, which leads to environmental contamination" (Private LT, Barwala).

Informal Health practitioners practicing in rural areas and urban areas have their challenges. These workers are not part of the monitoring, authorization, and training processes of the state. Lack of awareness for scientific management of BMW among such practitioners is a huge challenge as they constitute a large proportion of the healthcare providers.

> "We have many challenges concerning our practice in the field. Many interest groups do not want us to practice medicine. But we are experienced, and if the community is benefitting somehow, then there is no harm in practicing medicine. Higher authorities do not communicate us for guidelines like this. Otherwise, we would have followed them. We are ready to cooperate, but there is a lack of cooperation from government authorities" (Informal Healthcare Worker, Barwala).

5.7.2 Challenges in Veterinary

There are different types of challenges faced by practitioners of veterinary medicine, with respect to BMW generation and management. Unlike human medicine, the private sector is not so developed, and most of the services are provided by state veterinary healthcare workers. Additionally, most of the veterinary facilities or clinics are located in rural areas. There is a veterinary clinic in every 2-3 villages in the state of Haryana. Additionally, most of the veterinary services are provided by veterinary healthcare workers through home visits to tend to sick animals. Therefore, BMW is generated in a different context altogether as a result of veterinary procedures. Moreover, rural areas are devoid of the requisite infrastructure and resources for scientific BMW management. That is why there are different kinds of challenges in managing the BMW generated as a result of veterinary activities.

> "There is a large quantity of healthcare waste resulting from veterinary activities such as biological waste (placenta, blood products, needles, syringes, IV sets, and medicines, etc.). Since this is a tertiary care hospital, not many of the challenges are faced by us; sometimes, it is difficult to segregate the waste on the point of generation. Otherwise, healthcare waste generated here in this hospital is appropriately segregated, stored, and managed according to the protocol. BMW Management and Handling Rules also apply to veterinary institutions. Though there are guidelines, administrative support from authorities in this regard is lacking, especially in field settings" (Senior Veterinary Practitioner, Hisar).

> "Since this is a large hospital, we do not face many challenges in managing waste, but yes, the situation in the field-level facility is not that good. Field-level practitioners face various issues while managing healthcare waste. Dedicated resources are not extended for such facilities in the rural areas, which makes the field-level staff indulge in unlawful practices with respect to BMW management. Framework for monitoring such activities is not developed yet. Such management requires coordinated efforts of the field staff, higher-level authorities, pollution control authorities, etc. The stakeholders are making very little effort to develop the required coordination" (Senior Administrator, Hisar).

> "Challenges are not many at this level as proper segregation is being done in this facility. Sometimes coordination challenges are there due to inadequate support from stakeholders like the Haryana State Pollution Control Board. Apart from the reporting mechanism, little help is being extended by the state pollution control authorities to effectively implement BMW management rules in rural areas" (Veterinary Physician, Hisar).

Few veterinary practitioners practice veterinary medicine without taking formal training. Such activities also result in the generation of some quantity of BMW. Veterinary medicine is practiced in many diversified situations than human medicine.

Positivists tend to measure the quantity of BMW based on the number of beds in a kilogram unit, but there are no such beds in most veterinary facilities. Therefore, it is hard for even researchers with a positivist worldview to estimate the quantity of BMW generated due to veterinary activities.

> "We keep an account of some of the departments, but it is not possible to measure everything, such as pathological waste and fluids from different labs are hard to measure. It is a little more difficult to handle this BMW in field-level facilities as the collection facility is not adequate in villages. Also, the authorization process is complicated. Though we try to manage the generated waste to the best of our efforts and according to the prescribed rules, still there are many loopholes at the field level" (Veterinary Surgeon, Hisar).

> "Though higher authorities provide constant support and guidelines for the proper management of healthcare waste, sometimes that is not adequate for its proper management. We are often inclined to bury a variety of waste in the absence of facilities like regular collection by a CBMWTF. Field-level practitioners are not very aware and equipped to manage such waste according to the prescribed rules. Practices like the burial of waste are prevalent in the field. Also, sometimes it is thrown open, which cannot be denied" (Field Veterinary Practitioner, Hisar).

5.7.3 Challenges with respect to Infrastructure and Resources for BMW Management

Any management process would require resources as inputs, which are, man, material, and money. Infrastructure is related to the material. The processes like monitoring, implementation activities, and other inherent processes, along with an implementation framework imperative for better and proper waste management activities, require resources. Larger healthcare facilities located in urban areas may possess the requisite infrastructure for the scientific management of BMW. But there is a need for efficient use of resources for better outcomes. However, such an infrastructure and dedicated resources may not be available to facilities located in rural areas. In addition to the availability of infrastructure and resources, there should be intent and coordinated efforts from all the stakeholders such as administrators of health institutions, doctors, paramedics, waste handlers, municipal workers, pollution control authorities, and operators of BMW treatment facilities.

> "Not very good, I must say! Infrastructure at village level facilities is very limited. Field level facilities need active support from the state and authorities regarding training, awareness, and financial resources" (Senior Administrator, LUVAS).

> "Well, this is a state-run hospital, every kind of support is provided by the state in this regard, but BMW management-related support is not adequate such as vaccination of staff personnel/ waste handlers, training for them, and equipment for protection. We have constituted a committee at our level to look into this matter. This committee decides on different aspects of BMW like training, management, and monitoring framework. However, infrastructure and resources are very much inadequate for the effective management of BMW as in the case of

rural healthcare facilities. Administrative efforts are also lacking to effectively implement a framework for the management and monitoring of BMW" (Senior Veterinary Surgeon, Hisar).

"The quantity of waste is not fixed, but yes, it becomes significant in peak seasons. We segregate the waste at the source and store it properly. Then it is handed over to a third party for treatment which collects the healthcare waste for treatment every alternate day. This is how we manage our healthcare waste. However, smaller facilities may face problems with respect to BMW management due to different reasons. Due to their smaller size and lesser quantity of BMW, contracting out BMW management services to third-party is sometimes not possible. Regular collection of a very small amount of BMW from smaller and remote facilities might not be possible for third-party service providers as well" (Senior Administrator, Hisar).

CHAPTER 6

CONTEXTUALIZATION OF BMW GENERATION AND MANAGEMENT: A DISCUSSION

6.1 UNDERLYING PROCESSES AFFECTING HEALTHCARE WASTE GENERATION AND MANAGEMENT

Overall developmental processes in the various sectors, along with developments in the healthcare sector, have transformed the way people and practitioners perceive diseases and sickness. In earlier times when allopathic medicine was growing, physicians and surgeons used to conduct home visits for treating patients. There were trends of family physicians. However, with the advent of medical technologies and healthcare infrastructure, there are certain shifts in understanding of diseases and sicknesses. Other developmental processes like urbanization and industrialization have resulted in various shifts in the medical needs of the population. Different stakeholders had different opinions about this phenomenon. Traditional Indian medicine was practiced in earlier times in the Indian subcontinent that was focused on the preventive approach of medicine. The primary focus of those times was improving the existing health status and restoring health. However, later with the developments in allopathic medicine, this focus on prevention has shifted to a curative approach. This shift also affected people using health services.

In the context of overall development in health infrastructure, people tend to visit health facilities even for most minor of the ailments which otherwise would have self-cured. They tend to take medicines with increased frequencies. Additionally, over consciousness about simple sicknesses leads to labeling disease conditions. Processes like health insurance have catalytic effects on such a phenomenon.

There has been huge growth in private health infrastructure in recent years, may it be larger multispecialty hospitals, five-star corporate hospitals, smaller nursing homes, or smaller clinics. The presence of a health facility nearby also affects the behavior of consumers in many different ways. With the growing wealth of a few subgroups of the population, there is an increased tendency to visit high-end facilities. Sometimes, visiting five-star or high-end health facilities is associated with a matter of pride in Indian society. Such behavior influences the behavior of other users also.

In addition to the institutional-infrastructural developments in healthcare services, there is a huge growth of informal health providers in communities due to changing medical needs and the overall context of development in medical technology.

Nowadays, the existence of smaller clinics and unregistered medical practitioners is very common in every village. They are producing a huge amount of medical waste in the form of syringes and plastic waste. This is a mixed result of changing medical needs of the population in the era of technology. The respondents reiterated that the behavior of the general population was affected by the advent of medical technology. People have a general tendency towards getting treated by technological interventions like administering some injectables. It may be a simple injection or IV fluid. Such technological interventions enrapture the mind of consumers and affect their behavior. Therefore, these processes result in a huge amount of medical waste in the forms of sharp and plastic.

In addition to this phenomenon, advancements in technology have transformed diagnostic services in a number of ways. The huge growth in laboratory infrastructure can be observed everywhere. Additionally, with the developments in information technology and automation of laboratory services, household collection of samples at the mass level is a new phenomenon. Consumers can get information over search engines and can book laboratory tests for themselves while sitting at their homes. Such advancements have impacted the behavior of medical consumers, and corporate houses are investing in such developments. This process also results in the generation of BMW where the responsibilities of the producers or consumers are not fixed.

With the increasing awareness or consciousness and developments in information technology, there is a huge increase in home-based treatments or self-medication. However, this process was prevalent earlier also, but usage of smart phones has catalyzed this process. A number of procedures and interventions are being carried out at the household levels, e.g., administration of insulin injections, self-medication, and other procedures. If there is a child in the house, then used nappies, baby formulas can also be seen. People dump anything without giving it another thought. There are needles from injections that are thrown in the bins and not visible under the pile of garbage. Medical waste generated from healthcare facilities may find its way to a treatment facility, but it is difficult even to assume that household-generated medical waste is treated and disposed of safely.

6.1.1 Changes in Medical Practice

The development section discusses that developments in healthcare technology and healthcare infrastructure have transformed the way disease or sicknesses are perceived. Such developments ultimately impacted the culture of medical practice among practitioners. Earlier, there was a trend of home-based provision of care. Physicians used to visit households of diseased persons and treat them there. But with developments in technology and infrastructure, medical practice has shifted from home-based to institution-based. Hospitals were started coming along with other developments in the health sector and allopathic medicine.

These developments and changes transformed medical practice. Due to excessive usage of technology and drugs, there is an increase in the BMW generation. When asked about this relationship, the respondents reiterated that the first and foremost reason is an increase of intervention-based healthcare facilities, which results in the generation of a huge quantity of BMW. Earlier, a diagnosis was made using standard and straightforward methods like observation, palpation, and percussion. These methods are now considered secondary to the existing diagnostic technologies. Therefore, there has been a shift in the ways medicine is being practiced today.

In the context of the unregulated private sector, growing medical needs of people, advancements in technology in the forms of diagnostic services and treatment through medicines, especially antibiotics, informal health providers grew informally both in urban and rural areas. Their location in communities itself makes it easier for the people to access health services close to their homes. However, it has severely impacted the way medicine is practiced. Such shifts in health provisioning have impacted the process of generation of BMW.

Veterinary medicine has also developed enormously in the past century. There is improved health infrastructure for animals now. One major difference is that in general human medicine, many unnecessary procedures are performed, which lead to increased BMW, but it is not a common phenomenon in the case of veterinary medicine. There is a lot of quackery in the case of general human medicine. Unqualified or less qualified practitioners are there in urban and rural areas. There would be differences according to the level of facilities. Here in India, the state provides a major chunk of veterinary medical services. There are lesser developments in private healthcare infrastructure for animals.

6.1.2 Germ Theory- Growth of Hospitals Based Care

With the developments like germ theory and advancements in medical technology, more and more emphasis was laid upon the disease-causing agents or microorganisms. Undue focus on causative pathogens resulted in neglect of broader environmental and social determinants of diseases. Host and environmental aspects of an epidemiological triad are not being given much attention. In the wake of further technological advancements with respect to developments of newer pharmaceutical molecules and antibiotics and vaccines, the pursuance of diseases has entirely transformed. Alongside, developmental processes have led to shifts from home-based provisioning of care to the hospital or institution-based provisioning of healthcare services where diagnostic services are also available. Additionally, a number of biomarkers were developed, which aggravated the increase in the use of diagnostic technology. Modern medicine has over-relied on diagnostics and medical interventions/ surgical procedures; such phenomena have contributed to an increase in BMW generation. Therefore, germ theory was proved a game-changer in the field of medicine. It further pushed the technological advancements in other fields like pharmaceuticals and diagnostics, which in turn transformed the way medicine, is practiced and consumed by the consumers and beneficiaries.

6.1.3 Developments of the Pharmaceutical Industry

With the development and increasing beliefs in germ theory, huge advancements were observed in the pharmaceutical industry. Overemphasis was laid on developing newer antibiotics and newer molecules. Investments in the development of vaccines were increased manifolds. Identification of a newer causative organism on the basis of germ theory may create an opportunity for the pharma industry or investors of the pharmaceutical industry. There may be an indirect relationship between over-reliance on diagnostic technology and usage of pharmaceutical compounds. Developments in culture tests could answer such relationships. Developments in diagnostics such as the identification of newer biomarkers might have affected the extent of usage of newer and aggressive or irrational usage of pharmaceutical medicine.

The pharmaceutical industry adopts aggressive marketing strategies to increase sales. Such marketing strategies may aggravate or push physicians for overuse of medicines and technology. The irrational use of antibiotics has led to many environmental problems. The irrational use of medicines in poultry by practitioners and self-medication has led to environmental contamination, leading to ABR in humans and animals. Also, human excreta may contain partially degraded APIs, which may be consumed by many stray animals. Similarly, there are many exposures that are ignored by us in day-to-day life, e.g., we consume pesticides and traces of pharma compounds in small quantities daily, but neither do we neither discuss it nor do we try to establish any association between health issues and such exposures. Patencheru's study about the pharma industry revealed that environmental deterioration might lead to adverse impacts on various organisms in the ecosystem directly or indirectly.

The advancements in healthcare technology, i.e., diagnostics and pharmaceutical compounds like antibiotics, have changed the way a physician diagnoses and treats a patient. Therefore, these developments have impacted the overall culture of medical practice. Also, it may be one of the contributing factors for the provisioning of healthcare services by a huge number of informal health workers. There is a need to explore such associations.

6.2 DEVELOPMENTS IN THE HEALTH SECTOR (ENVIRONMENT VS. DEVELOPMENT)

6.2.1 Development, Urbanization, and Growing Medical Needs

Over the centuries, the process of development has positively or negatively affected various facets of human life. Processes like urbanization and globalization have major roles in the developmental process. There have been a lot of changes in the way demand and utilization of health services were seen previously and the way health services are envisaged in current times. Shifts in disease patterns, provision of care (institutional from non-institutional), policy changes over the years, and changing the culture of medical practices are a few of the factors which have impacted the nature of the developmental process in healthcare services or provisioning. Additionally, macro-processes like economic developmental activities, political scenarios, and development in technology have indirectly impacted the overall provisioning of health services. Technological development is one of the most important factors that have a major contribution to increasing healthcare waste generation. Developments in disposable items/equipment have manifolded the quantum of healthcare waste. These factors are discussed elsewhere in this thesis in detail.

Development in healthcare infrastructure and provisioning of healthcare involving technology in diagnosis and treatment has transformed the way health and healthcare services are envisaged today. Additionally, policy shifts have changed the nature of the provisioning of healthcare services. Underfunded public healthcare system and technological development created the space for the growth of the private sector in India. The private sector is more focused on curative provisioning of the services. Due to the overreliance on technological interventions/ methods involved in the provisioning of curative services, a huge amount of BMW is generated.

Atmospheric pollution is a byproduct of modern development, and it is a well-known phenomenon among policymakers, academic decision-makers, and most stakeholders. However, there is a dearth of research studies and methodologies which can establish a direct association between a particular exposure and industrial or developmental activities. ABR is a major issue in current times, but it is a lesser-known phenomenon that who is responsible to what extent. There are many exposures that are persistent, and their impacts are very slow, hence not much obvious. These changes are gradual and very hard to monitor. Such processes are least concerned of scientific communities or policymakers. It was emphasized by the respondents that there is a lack of interest among research communities to understand such issues. Methodologies for quantification of such effects on the environment are the need of the hour. And not only quantification but macroprocesses like underlying reasons/policies for such developments/ destruction of the ecosystem must also be understood through research studies.

It is not just institution-based healthcare that is responsible for the increase in the problem of healthcare waste, there are other types of developments in health provisioning in India which has a major role in the generation of healthcare waste. Indian private health sector has a huge presence of community-based informal practitioners who practice in communities. Inadequate regulations and lesser control over the private sector have led them to flourish over the years. They generate a huge amount of BMW. Additionally, outreach sessions are conducted by public health providers, especially for preventive services. These are some developments in the provisioning of healthcare in India which has a direct relation with the generation of BMW.

Economic growth-oriented development is mediated and catalyzed by urbanization and globalization. Additionally, demography has considerably changed in the wake of these processes. The rate of urbanization has increased across the globe in the past few decades. These processes, alongside developments in the form of industrialization, have changed the quality of the natural environment, not just through environmental pollution but through modified urban spaces like inadequate housing, sanitation, and drinking water supply. All these processes have impacted the disease burden in the communities. In addition to the existing burden of communicable diseases, modern environmental changes have negatively impacted the burden of NCDs. These epidemiological shifts impacted the medical needs of the communities. Hence, the demand for medical services has grown along with developments in healthcare technologies and services. These processes have complemented each other.

6.2.2 Technological Advancements in Healthcare

Technological developments have transformed our lives to a huge extent. The presence of technology and our dependence on it have impacted day-to-day life activities and processes. However, as discussed earlier, atmospheric pollution and different exposures (known and unknown) are byproducts of modern development. In addition to the developments in pharmaceutical, huge developments have been observed in diagnostic technologies. Technological advancements with newer and newer developments have transformed the way we diagnose disease. Alongside developments in information technology, the usage of smartphones has impacted the behaviors of consumers of such technology. A lot of biomarkers have been identified for the accurate diagnosis of diseases. With increasing infrastructural facilities with respect to diagnostic services, a lot of shifts are being observed in reaching a diagnosis by a physician. There is an over-reliance on diagnostic methods for reaching a particular diagnosis. Diagnostic services and pharmaceutical developments in allopathic medicine involve technology and complex processes, which result in many byproducts. BMW generation is one of the byproducts, and it is an inevitable phenomenon.

In addition to diagnostic services, a lot of development has happened in the field of medical equipment, which is now a part of the day-to-day and common medical procedure. Such technological advancements might have proven as a game-changer in modern medicine, but its excessive utilization or irrational usage may impact the changing culture of modern medicine. With the advances in medical technology with respect to diagnostic services and treatment procedures, huge growth is observed in private sector healthcare provisioning. These dynamics and processes have led to the increase in the generation of BMW.

6.2.3 Overreliance on Technological Solutions/ Interventions

Technological advancements have transformed the provisioning of healthcare services. In current times, more and more technologically oriented interventions are being planned and carried out in hospitals. Developments in the pharmaceutical sector, especially antibiotics, have a major impact on the nature of provisioning. Similarly, developments in technologically oriented diagnostics methods have changed the definition of diseases. Earlier, surgeons were known to be practicing medicine with the least of the intervention, and the diagnosis was primarily done by surgeons with their hands, eyes, and ability to relate signs with the asking questions. However, nowadays, it has become a fashion to get the various investigations done and performance of unnecessary interventions.

Therefore, such developments have transformed the culture of medical practice. Doctors/practitioners are over-dependent on technology for diagnosis and treatment. Also, treatment procedures involve too much technology nowadays. Every decision in our day-to-day life affects the environment in some way or another. Overuse of pharmaceutical products, especially antibiotics, has led to slow and persistent exposure to different organisms. Also, it gets accumulated in crops and drinking water, then accumulated in food grains and animals followed by other animals, organisms, and humans, which drive their food from those crops and animal products. It affects the ecosystem slowly and slowly. Like this, many unnoticeable changes in the environment might be happening continuously.

6.2.4 Disposable Materials/Single-Use Products or Items

Technological developments in the evolution of inventions of disposable or single-use products have been seen as a positive development in the healthcare sector. It has been envisaged that disposable or single-use items have a major role in infection control processes and in surgical interventions especially. However, volumes of debates are growing around the world about their environmental externalities and impacts. Additionally, there are few technologies like insulin syringes, which have a huge role in the control of diabetes mellitus, which leads to the generation of a large amount of BMW. The extent of the use of such technologies is huge as the prevalence of such diseases is much higher and continuously growing, especially in developing countries. Environmental impacts of such usage are very hard to imagine and quantify. The least emphasis has been paid till now on such issues.

A large proportion of disposable items is constituted of polyvinyl chloride or plastics, which is detrimental to the environment. Few studies have attempted to quantify and assess the impact of healthcare activities/services or the health sector's contribution to overall pollution in the developed world. It has been established that even the management processes like incineration of BMW, out of which a large proportion is of plastic, pose severe challenges to the environment and human health. Infectious waste may enhance exposure to pathogenic microorganisms and ARGs. Incineration of plastic waste (both infectious and infectious) may lead to harmful emissions like Dioxins and Furans, which are potential carcinogens.

6.2.5 Medical Consumerism

Race of economic development has impacted the quality of human life. With more developments and underlying processes like urbanization, globalization, and industrialization, we are putting huge stress on our natural environment. Every single decision of our day-to-day activity or process has some environmental outcomes or impacts associated with them. Such an outcome or impact may be obvious sometimes, or it is hard to monitor or observe most of the time.

Human beings carry consumerist nature with them. We survive on natural resources and are major polluters of this environment. Our consumerist behavior affects the environment naturally. Industrial activities or mining are the biggest examples.

Similarly, in the health sector, a lot of healthcare waste is generated. This waste generation is an evident and unavoidable phenomenon to some extent. However, excessive usage of technology and overreliance on technology with respect to diagnosis or treatment may result in the generation of excessive medical waste. Many respondents reiterated the fact that we are living in an era of medical consumerism where healthcare provision or activities would result in excessive generation of health care waste due to various factors such as excessive use of health technology, unnecessary intervention or treatments which are genuinely not required by patients.

There are processes that directly or indirectly have catalyzed the overall phenomena of medical consumerism. Growth in the private sector and health insurance has led to the medicalization of many simple ailments like general fever or headache. People visit medical institutions or physicians for minor ailments. Also, economic development empowers or enables people to visit health facilities more frequently. All these factors are linked with each other and are part of complex phenomena. These complex phenomena somehow impact the consumerist behavior of human beings. Therefore, like other facets of environmental externalities, this phenomenon of medical consumerism affects the human environment adversely. There is a difference in the way the complex phenomena of the development of medical consumerism are understood. Developments in modern allopathic medicine, which is focused more on intervention-based treatment and diagnostic procedures with the use of technology, have affected the behavior of the consumers and users. Practitioners of systems of medicine other than allopathic medicine attributed the excessive BMW generation to this technology-oriented modern medicine. Therefore, it seems obvious that excessive BMW waste generation is a byproduct of modern medicine.

In addition to medical consumerism, this consumerist approach of human beings impacts the environment in many different ways. One of the examples is the meat or poultry industry. Even the dairy industry is another mode of business process where animals are seen as assets. They are not considered living beings. In the race of over or excessive production of meat, chicken, and other dairy products, animals are subjected to various unnecessary and unethical interventions like the use of antibiotics and hormonal drugs like Oxytocin. Excessive use of such pharma compounds is very common in large animal farms and the poultry industry resulting in environmental contamination through different known and unknown channels. Therefore, such usage puts animals as well as other organisms at risk of continuous exposure to harmful contaminants.

One of the other sectors is the agricultural sector, which could be taken into account while discussing the consumerist behavior of human beings. Since the success of the green revolution, the agriculture sector has been relying on excessive usage of insecticides and pesticides for the overproduction of food grains and vegetables. It is also one of the most debated phenomena as it results in huge environmental contamination. Additionally, the agriculture sector uses a variety of chemicals to treat various plant diseases. We, human beings, are exposed to such chemicals in a number of ways, directly or indirectly. Ultimately, problems lie with the development of methodologies that could quantify or establish any association between a particular exposure and human interventions or activities.

Health Insurance is one of the key factors which affects the complex processes of privatization of health care, intervention-based health care, and increased usage of health services. Though the process of privatization and growth in the health insurance sector are complementary and sometimes go hand in hand, health insurance may lead to the phenomena like moral hazard both from the provider’s and consumer’s side. Unnecessary consumption of services takes place with respect to an insured person or an individual. Providers also tend to provide unnecessary services to the users on account of medical insurance. Therefore, in addition to catalyzing the growth of the private sector, health insurance also affects the consumer’s behaviors which ultimately impact the process of BMW generation.

6.2.6 Growth In Healthcare Waste

With advanced technologies, there are certain byproducts of technology that are generated as waste. The more we choose technological interventions, the more BMW will be produced. In the light of the econometric model devised in the present study, it is demonstrated that general human medicine produced 52 percent of the total waste of the healthcare delivery system, which is not significantly more than the BMW produced by veterinary medicine. However, whenever we talk about the problem of BMW, veterinary is almost neglected. BMW generated by veterinary healthcare institutions is not even represented in research studies focused on the BMW problem. Moreover, the categories of waste are almost similar in both the systems (general and veterinary). In veterinary medicine, healthcare waste comprises pathological waste, tissues, cotton, bandages, needles and syringes, plastic waste, blood and blood products, etc. Sometimes quantity may get very large, especially in peak seasons. A large quantity of healthcare waste is generated as a result of veterinary activities such as biological waste (placenta, blood products, needles, syringes, IV sets, and medicines, etc.) The type of BMW generated is not that much different from the BMW generated as a result of human medicine. The quantity of waste generated is much higher in the case of veterinary treatment per capita/patient/animal as compared to human medicine. One of the key aspects of veterinary medicine is that it is practiced in the field setting in most instances. Therefore, whatever waste is generated in the field settings, especially in rural areas, where it isn't easy to manage the BMW adequately.

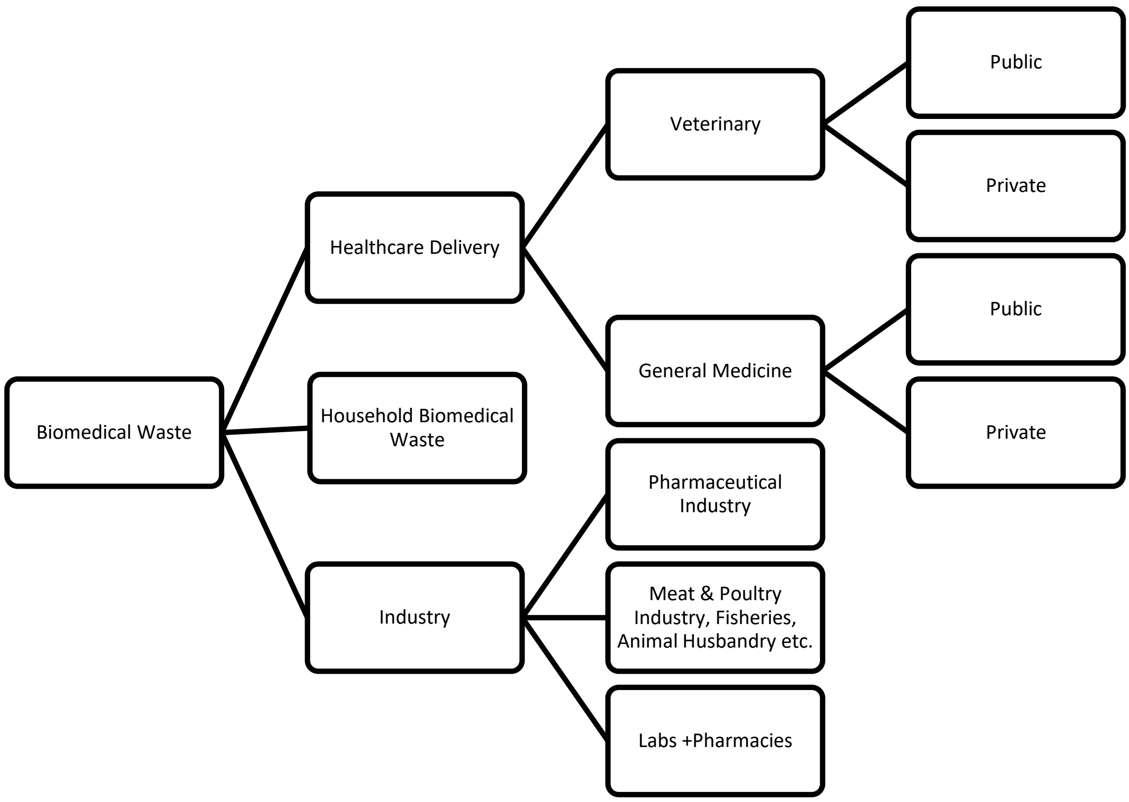
A major proportion of the total BMW waste is generated at the level of households which is also not adequately represented in the studies and least deliberated upon while discussing the problem of BMW management. The unregulated private sector is one of the major contributors to overall waste generation and contributes around 68 percent of the total waste generated by the general medicine of the private sector. In addition to households and healthcare delivery systems, a considerable amount of BMW is generated by the meat/poultry industry and animal husbandry in various forms. This waste, however, is not included under the category of BMW, but due to similar characteristics of the anatomical waste (bones, skin, intestines, head, and other leftover body parts), it was included under BMW in the present study.

6.2.7 Other Sectors Contributing to BMW (Poultry/Fisheries/Meat/Animal Husbandry)

The econometric model of the present study reflected that around 21 percent of total BMW generation in the Hisar district is generated by industrial processes, which include the meat industry, poultry industry, leather industry, animal husbandry, and fisheries. A lot of animal leftover body parts after the yield of meat like bones, skin, intestine, head, blood, and other parts carry similar characteristics as other BMW. They may carry harmful pathogenic microorganisms and may further harbor their growth if not disposed of adequately. Even the fecal material and urine of these organisms may harbor and be helpful in circulating pathogens and ARGs due to the wide dissemination of these wastes into the natural environment. There are a number of pathways through which these ARBs and ARGs may enter and circulate into the environment. A sheep and goat may result in the generation of 10 to 13 Kg of bio-waste after the meat yielding. Similarly, a chicken meat yield may produce around 600 grams of bio-waste and may be proved detrimental to the environment.

Few studies have attempted to associate infection and circulation of viruses like Coronavirus to its zoonotic origin, where some researchers believe that it came through the Wuhan meat market (through an intermediate host) from its original reservoir bats. However, this intermediate host is yet to be discovered. Additionally, some studies indicate that the flu virus could lead to the next pandemic due to large-scale chicken farming. Therefore, such processes and developments indicate that pathogens of zoonotic origin pose severe challenges to the human environment and the environment of other organisms. BMW could serve as one of the key carriers and reservoirs of such harmful pathogens.

Figure 6.1 Scheme of Healthcare/BMW Generation



6.3 HEALTHCARE WASTE MANAGEMENT AND GLOBAL PRACTICES

The results of the present study are pointing that BMW generation and management is a complex and multifactorial phenomenon. The first and foremost factor is the inclusion criteria of facilities that are producing BMW in Hisar district. Even if we consider waste generated by general medicine and veterinary medicine as BMW, we are able to treat just 13 percent of total BMW in the district Hisar. This is due to neglect of veterinary facilities as most of the veterinary medicine facilities are not covered under the services of CBMWTF for multiple reasons. Most veterinary activities /interventions only occur only in field settings. Therefore, waste generation takes place in a very scattered manner. Additionally, this may be attributed to a lack of interest or consideration of veterinary BMW for safe management among the stakeholders.

Econometric model points that around 21540 Kg of BMW is generated on a daily basis by healthcare delivery system (general and veterinary medicine), households, and industrial processes (meat/poultry/fisheries/animal husbandry) but CBMWTF processes and treats around 1500 Kg of BMW per day which translates to only 7 percent of total BMW generated on a daily basis. However, waste generated from households and industrial waste is not counted under the purview of BMW according to the definition of BMW. Though at other instances, governments and authorities have considered such waste as BMW, e.g., in the times of peak of Corona pandemic, CPCB issued guidelines for safe management of waste generated by asymptomatic and symptomatic patients under home isolation and quarantine facilities. Few waste substances were considered as BMW, and guidelines were issued for the management of such waste on the lines of BMW. In addition to it, guidelines by CPCB were issued for safe management of waste generated by poultry farms and animal slaughterhouses where it is reiterated that a few categories of waste such as animal carcasses and other anatomical waste must be treated and managed according to BMW management guidelines. However, this waste generated by households and industrial processes is not covered under BMW according to the definition.

Home management of illness is a very common phenomenon in developing countries like India. Even without any diseased conditions, a variety of waste like sanitary napkins, insulin syringes, is produced as waste that can be considered BMW.

Moreover, informal health workers practice medicine through home visits also in addition to practicing at their clinics. They also produce a considerable amount of waste, as reflected by the econometric model in this study. Most of this waste is mixed into general domestic waste. Moreover, anatomical waste (bones, skin, blood, intestine) and other leftover parts of animals or birds after meat yield are mixed with general waste or consumed by stray dogs adding to the problem of BMW and making it more complex. This may be attributed to the fragmented and unregulated meat industry in the district as the key stakeholders emphasized that meat/chicken sellers slaughter these birds and animals at their shops only. Slaughterhouses are not being utilized for the intended purpose of slaughtering animals. This whole industry is in a transition stage. Efforts are being made to shift these processes to a designated area. However, this transition is very slow and hard to observe in the wake of weak regulation and environmental monitoring.

Liquid BMW management is one of the grey areas of the whole BMW management process in district Hisar. Most hospitals or establishments do not follow the standard procedures of management of liquid BMW. Many of the facilities, especially rural healthcare establishments (in both general and veterinary medicine), are located in rural areas and, therefore, lack even a sewage line for disposal of liquid BMW. However, certain facilities which are covered with a sewage facility are not pre-treating their liquid BMW before mixing it with sewage wastewater. This particular type of waste is underrepresented even in the research studies. Environmental monitoring of such waste is completely lacking. A number of laboratories are functional in urban and semi-urban areas, which produce a large amount of unquantified liquid BMW, which is mixed with sewage waste or disposed of openly. It may pose serious challenges for the environment and human health.

6.3.1 Status of BMW Management in India

Although there is a dearth of studies focusing on comprehensive management of BMWM in India, there is no lack of evidence of BMW mismanagement from the bedded facilities of general medicine. In the study titled "Hospital waste management and environmental problems in India," Mohankumar and Kottaiveeran (2011) emphasized that with 6 Lac hospital beds in 23000 PHCs and 15000 small and private hospitals, India is facing huge challenge with respect to BMWM. This problem is thought to be aggravated by the mushroom growth of private health institutions (Manzoor & Sharma, 2019). International Clinical Epidemiology Network (INCLEN) (2014), in its study with respect to BMW management in India, explored the existing facilities, set-up, and framework for BMWM in 20 states revealed that around 82 percent of primary, 60 percent of secondary, and 54 percent of tertiary healthcare facilities in India are devoid of credible BMWM system. Further, it highlighted an urgent need to strengthen the existing system of BMWM (INCLEN). Another study conducted by Verma et al (2008) in Delhi revealed that a lot of health facilities disposed of their BMW in an unscientific manner. The 46.6 percent of the waste was being discarded in municipal sewers, 41.6 of BMW were buried in landfills, and the rest of it was being treated by autoclaving.

It has also been estimated that there are seasonal variations with respect to BMW generation, and hence capacities of common BMWTF could be capitalized on the basis of such information (Thakur & Anbanandan, 2015).

The effective and sustainable management of healthcare waste has become a profound challenge in today's world as hazardous and infectious waste is increasing as a result of a variety of healthcare and industrial activities. After ratifying the Stockholm convention on persistent organic pollutants, it has become even more challenging as it emphasizes sustainable management of healthcare waste. Stockholm convention calls to promote the use of the best available technology and best environmental practices for the safe disposal of healthcare waste.

Incineration has been the most effective and widely used method for healthcare waste management till now. Incineration neutralizes the infectious nature of medical waste, which is the most hazardous property of healthcare waste. Incineration is characterized by technical maturity, versatility in treating different types of waste, waste volume and weight reduction ability, health recovery potential, and availability of operating standards. However, if not operated properly, this method could lead to the release or emission of highly toxic substances in the environment causing secondary pollution. According to WHO, enforcement of emission standards has helped in reducing the emissions from incinerators in the past few years. The best technology and environmental practices guidelines of the Stockholm convention described the proper design and parameters for different types of incinerators (Yang C et al, 2009). Further, these guidelines emphasize on use of non-incinerator technology for newly built facilities such as sterilization through dry heat and steam, alkaline hydrolysis, microwave, biological treatment, and landfill disposal. It also highlights the importance of reduction in waste generation, segregation at the source, and recycling or reuse. WHO (2018) emphasizes the promotion of non-incinerator-based technologies for waste disposal to reduce the burden of diseases due to unsafe management of healthcare waste and risk from hazardous substances like Furans and Dioxins. The use of environmentally sound technology will prevent the risk to healthcare workers involved in the management of healthcare waste and communities from adverse effects.

Many countries lack an integrated system for authorization of appropriate technology for the safe disposal of healthcare waste. Capacities of air pollution control systems are inadequate. There is a lack of supervision and evaluation systems for the operations of the incinerator. Environmental protection departments lack capabilities to measure secondary pollution from such facilities.

6.3.2 International Practices Pertaining to Healthcare Waste Management

Different countries adopted a variety of healthcare waste management practices. The quantity and quality of healthcare waste generated by different countries also vary.

6.3.2.1 United Kingdom

The traditional approach of healthcare waste management used to be landfill or government-supported recycling. Environmental Protection Act in the UK was enacted in 1990. Prior to this Act, most of the hospital waste could be incinerated on site. It was very common in the 1980s for yellow bag waste to be incinerated by municipal plants run by local authorities. This Act had mandated the onsite segregation of hospital waste in the UK. As a result of the high cost involved in implementing new regulations, many of the incineration plants were shut down. Then the NHS started organizing and providing healthcare services in the UK. NHS had started monitoring and maintaining a record of hospital waste quantity and the cost of managing it. Following the loss of crown immunity, health facilities had to start segregating the medical waste onsite. With the introduction of the concept of ‘Duty of Care’ under the Environment Protection Act 1990, all the waste-producing organizations had an obligation to ensure the safe treatment, transportation, and final disposal of their waste. EU (European Union) landfill directive of 1999 mandated the reduction of the landfill by biodegradable waste and co-disposal of general waste along with the hazardous waste. Additionally, PPC (Pollution Prevention Control) regulations, the proximity principle, and producer responsibility are other regulations that govern the handling and disposal of waste (Tudor et al, 2005).

In order to achieve sustainable development, the government has brought up performance indicators and targets for all its departments. With the closure of many incineration plants following strict regulations, the cost of management of hospital waste has increased. The per ton cost of managing healthcare waste is about 300 Pounds which is 5-6 times higher than the cost of managing general waste. The NHS has employed risk assessment practices and achieved a reduction in waste generation by adopting waste minimization strategies. However, the NHS is facing challenges in long-term planning of waste minimization and management issues (Tudor et al, 2005).

6.3.2.2 China

The healthcare waste policy, regulation, and standard system of China were first defined in the 1990s. National hazardous waste and healthcare waste disposal facility construction plan was introduced in 2004 after the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003. A series of regulations and standards have been framed thereafter.

According to the people's republic of China state council, healthcare waste is defined as 'waste characterized by infectious, toxic and other hazardous properties driving directly or indirectly from medical treatment prevention, health protection and other healthcare-related activities in healthcare institutions'. Chinese legislation has classified healthcare waste as infectious, pathological, sharp objects, chemical and pharmaceutical waste based on its properties and source of production (Yang C et al, 2009). The amount of healthcare waste generated in China was projected to be 1870 tons/day or 680000 tons annually in 2010 by the people's republic of China state council. There were a total of 149 healthcare waste disposal facilities located across china. 147 of these 149 facilities are incinerator-based treatment facilities. China follows the emission standards for incinerators as 0.5 TEQng/Nm³ in contrast to standard emission levels for developed countries, which is 0.1 TEQng/Nm³. Several facilities/ incinerators have higher emission levels than standard emission levels. Most of the facilities are lacking in environmental monitoring equipment. Also, most of the facilities operate without a safe disposal plan (Yang C et al, 2009).

The 57 percent of total waste disposal facilities are located only in the east of China. Western parts of China face a huge lack of healthcare waste disposal facilities. Therefore, there are wide gaps between the requirement and existence of healthcare waste treatment facilities. China adopted the Stockholm convention from November 2014 onwards, aiming to promote the best available technology and environmental practices. National hazardous waste and healthcare waste disposal facility construction plan is aiming to construct 331 centralized new facilities for safe disposal of healthcare waste. This plan focuses on the rational distribution of centralized facilities and the use of advanced and reliable techniques to avoid secondary pollution. Existing infrastructure is believed to be inadequate and inefficient in the safe management of healthcare waste. The regulatory framework needs to be more robust, and technological innovation is low. Although China has adopted the Stockholm convention, it is still lacking in research and development capacities for establishing and employing context-specific technologies. Also, there need to be sound monitoring methods in place to keep a check on existing sources of secondary pollution. (Yang C et al. 2009).

6.3.2.3 USA

Concerns for medical waste management were first raised in the 1980s when medical wastes were observed washing up on several east coast beaches. This phenomenon has forced Congress to enact Medical Waste Tracking Act (MWTA) in 1988. State environmental and health departments regulate medical waste generated by health care establishments. Earlier it was governed by MWTA 1988, which got expired in 1991. Under MWTA, medical waste was regulated from the point of generation to the point of disposal. Requirements for segregation, handling, and labeling were detailed in MWTA. It was enacted in order to provide information in order to develop environmental laws in the US (Lee et al, 1991). USEPA (United States Environmental Protection Agency) and State Health Agency are the implementing agencies for environmental regulations. There are other federal agencies that have regulations with respect to medical waste viz. Centre of Disease Control (CDC), Occupational Safety and Health Administration (OSHA), US Food and Drug Administration (USFDA), and many others (USEPA, 2019). USFDA protects human health and the environment through the Federal Food, Drug, and Cosmetic Act and Prescription Drug Marketing Act by assuring the safety and efficacy, and security of veterinary and human drugs (Glassmeyer et al, 2009).

Incineration is the widely used method for the treatment of medical waste in the USA. However, earlier emission standards were not met by most of (90 percent) the incineration facilities. Newer regulations with respect to pollution control system in incinerators was proposed by the authorities. Emission standards are proposed to comply with the 'Clean Air Act' (CAA) of 1970. In 1997, USEPA promulgated regulations that set standards of emission in order to keep a check on pollutants/emissions from incinerators that were detrimental to human health and the environment. Air Quality Planning and Standards Office of USEPA continue to review and revise the Hospital Medical Infectious Waste Incinerator (HMIWI). USEPA has jurisdiction over medical waste treatment technology in the US (USEPA, 2019).

US is the largest market for pharmaceuticals in the world, with combined sales of 200 billion USD in 2007. With the increased use of pharmaceuticals, concerns about their fate in the environment are raised. Disposal of unused or expired medicines into sewage systems poses serious challenges for the ecosystem. Poison Control Centre in the US has advised disposal methods for disposing of pharmaceuticals. In 2007, the White House Office of National Drug Control Policy (ONDCP) issued federal guidance for consumer drug disposal (Glassmeyer et al, 2009).

6.3.2.4 Bangladesh

Medical waste generated from healthcare activities in Bangladesh is estimated to be 0.8 to 1.67 Kg/bed/day leading to a medical waste generation rate of around 93075 tons per year (Syed et al, 2012). Around 600 healthcare establishments of Dhaka city generate about 200 tons of waste per day. Apart from a few bigger healthcare establishments, most of the institutions dump their waste in the dustbins of Dhaka

City Corporation. Many times even amputated body parts are dumped in the streets. Liquid and laboratory waste is often disposed into municipal sewage or drains (Hassan et al, 2008). Medical waste is often stored in open buckets and bowls in healthcare establishments. Apart from the city dustbins, medical waste is disposed of in pits near hospitals, roadsides, or open fields. In Bangladesh, waste collectors called 'Tokai' collect recyclable waste like saline bags and syringes from hospitals and sell them for recycling. Many of the hospitals sell their recyclable waste (Syed et al, 2012). The practice of segregation of medical waste at the source point is inadequate. Medical waste poses a serious threat to the environment and human health in Bangladesh, as the country still lacks a comprehensive BMW management policy. Additionally, existing laws are outdated and characterized by very low and sometimes no penalty for the offenders. Many times, hazardous and infectious healthcare waste is dumped along with municipal waste in dustbins, which ultimately converts general waste into infectious waste. Studies have reported that it's a common phenomenon in Dhaka city that women and child scavengers collect parts of medical waste like syringes, needles, saline and blood bags, etc. to resell those items (Hassan et al, 2008).

6.3.2.5 South Korea

As per MoE (Ministry of Environment) Korea, 44478 health facilities generated 33980 tons of medical waste in 2002. There has been a sharp increase in the quantity of medical waste generation due to strong legislation and increased use of single-use products. Until recently, healthcare waste has been managed along with general waste through landfilling and incineration methods. Regulatory agencies have made many efforts in the recent past to manage hospital waste properly. Until 1999, medical waste management was regulated by medical law under the Ministry of Health and Welfare. Medical waste was often disposed of with general municipal waste, and no information and record was available on handling and final disposal of medical waste. Korea National Assembly modified the Waste Management Act in 1999 to improve the handling and disposal of medical waste. Korea MoE is responsible for the implementation of the Act. This Act imposes several regulations for definition, segregation, storage, transportation, and final disposal of medical waste (Jang et al, 2006).

The largest producers of medical waste in Korea are general hospitals, accounting for 60 percent of total waste production. The average amount of waste generated by general hospitals in 2002 was approximately 68.5 tons and the estimated generation of medical waste per bed per day was 0.48 Kg. The segregation of medical waste is done on-site in Korea. Waste is stored in color-coded bins. Korea has also developed monitoring protocols for medical waste treatment facilities and incinerators. In 2002, Korea introduced an online manifest system for real-time monitoring of treatment facilities. This has enabled the authorities to check the real-time status of medical waste along with the cost of treatment, time and energy usage by these facilities. 90 percent of the medical waste in Korea is being sent for offsite treatment. Incineration is the most common method employed for the treatment of medical waste in Korea. Since 2002, MoE Korea has set standards for emissions of Dioxins and mandated to measure the Dioxins more than once annually (Jang et al, 2006).

6.3.3 Relation between the Amount of BMW and Healthcare Infrastructure

A study conducted by Sharma et al (2017) in 6 hospitals (3 public and 3 private hospitals) in Himachal Pradesh demonstrates that the relationship between yellow category waste generated (anatomical and blood products etc.) and the number of beds is positive. As the number of beds is increasing, BMW of the yellow category will increase. Similarly, the relationship between the red and blue category of waste generation and the number of beds is positive. A regression analysis of the collected data shows that if only the bed is entered, it explains 94.2 percent of the variation. When bed and doctor are both entered jointly, they explain 94.9 percent of the variation in healthcare waste generation. A positive relation has been observed between the number of doctors, beds and staff and generation of BMW. Therefore, this amount of BMW will go on the increase. This increasing BMW will be proved detrimental to the environment and human health. Therefore, the author of this study made an attempt to predict the need for skilled employees who are trained on various fronts of BMW management skillfully.

However, the present study revealed a generation of 0.29 Kg of BMW per bed per day reaching CBMWTF for treatment, which is very less than the average per bed per day of BMW in other settings reported by other studies. Additionally, informal health workers who generate huge amounts of BMW do not possess any bed per se, but they constitute a huge health workforce. Additionally, the infrastructure of veterinary health facilities is not recognized in terms of beds. Therefore, it is hard to quantify or translate the amount of BMW in per bed per day terms. Veterinary healthcare services generate a huge amount of BMW, but most of them are not covered by CBMWTF. In addition to such waste, household generation of BMW is a compounding problem that may contribute to environmental contamination through different channels. Such waste also cannot be quantified in terms of beds. Also, a huge amount of anatomical waste (BMW) is generated in the poultry and meat industry which is not considered as BMW per se, but it has similar characteristics to BMW. It, too, cannot be quantified in terms of beds. Therefore, the problem of healthcare waste is multifaceted and standard methodologies for quantification of estimation cannot be applied to the Indian context.

6.3.4 Knowledge Awareness and Practices related to Healthcare Waste Management

Healthcare institutions generate a variety of the waste that may be hazardous, infectious, or non-infectious. Though the quantity of infectious waste within total medical waste is quite low as compared to non-infectious waste, if proper segregation is not done at the source of generation of medical waste, non-infectious waste could become infectious waste. It may pose serious threats to the environment and human health. BMW is a source of contamination of the natural environment (air, water, and soil). The severity of environmental threats to human health is compounded by the high sero-prevalence of Hepatitis B and C and HIV infections (Sharma et al, 2013). This consciousness of proper handling and disposal of BMW comes from knowledge and awareness regarding proper methods for handling and disposal. This consciousness, along with the implementation of BMW management rules and regulations, impact the practices of handling and final disposal of BMW. Primary data collected from the respondents revealed that most of the key stakeholders, barring informal health workers and sanitation workers, had considerable knowledge about the BMWM and handling rules. However, most of the respondents were not aware of the recent changes in these rules.

GoI issued the first draft rules of BMW disposal in June 1995. It mandated on-site incinerators for a hospital with a bed capacity of 50 beds. Further developments led to the issue of BMW Management and Handling Rules in 1998. It called for the scientific and effective management of BMW. It laid provisions for segregation, storage, handling, transportation, and final disposal of BMW. Further, amendments were made to these rules from time to time. There is a huge dearth of financial and human resources for the effective management of BMW (Mathur et al, 2011). However, in addition to the absence of common BMW treatment facilities, lack of awareness of BMW Management and Handling Rules pertaining to segregation, storage, transportation, and final disposal of the waste raises serious concerns for the health of healthcare workers, population, and other organisms in the ecosystem.

A study conducted by Rao (2008) in 121 health facilities with 138 private medical practitioners in three states (Andhra Pradesh, Maharashtra, and Uttar Pradesh) revealed that the awareness regarding BMW rules was marginally higher in urban areas than rural areas. Similarly, the status of training imparted was slightly higher for health facilities in urban areas than rural areas. About 70 percent of the health facilities used sharp cutter /destroyer for the sharp management. However, 31 percent admitted that they dispose of sharp waste along with other waste. Access to common BMW management facilities was as low as 35 percent. A 30 percent of the health facilities used specified spots in the premises of health facilities to dispose of their wastes. A 22 percent were dumping their waste on roads which is still a widespread practice. Monitoring and surveillance activities were found to be very low. Only 40 percent of the private medical practitioners were reported to be aware of BMW rules in rural areas. Only 41 percent of the private medical practitioners admitted that they employ segregation practices.

Another study conducted by Mathur et al (2011) in Ahmedabad, demonstrated that common private providers perform collection, transportation, and disposal of the healthcare waste both from public and private facilities. Knowledge and awareness regarding BMW rules were found to be better in technical staff than in class IV staff or sanitary staff. However, knowledge regarding color coding and waste segregation was found to be better among nurse and laboratory technicians. 37 percent of doctors and nurses reported the needle stick injury incident.

A study conducted by Sharma et al (2013) among the staff of Jaipur Dental College revealed that only 30 percent of the dentists had a fair knowledge of the BMW

Management and Handling Rules. Only 15 percent of class IV personnel were aware of these rules. 36 percent of the nurses had extremely poor knowledge regarding these rules. 65 percent of all the health care personnel agreed that BMW management requires teamwork. Very few of the health care personnel were aware of the risks associated with the needle stick injury. Apart from this study, most of the studies conducted in India to assess the knowledge, awareness, and practices pertaining to BMW management reveal that there is a lack of awareness and consciousness with respect to BMW management and handling among healthcare personnel.

A study conducted by Das and Biswas (2016) with 198 participants in 5 wards of North Bengal Medical College and Hospital revealed that there is a considerable lack of knowledge and standard practices among the staff. Only 1.5 percent had informal training in handling BMW. 41 percent of the subjects were aware that HIV/AIDS could be transmitted through BMW. Similarly, 37.9 percent were aware of Hepatitis B and C transmission, and 17.75 were aware of the chances of TB infection through BMW.

72 Observatory visits revealed that in 33.3 percent of observations, syringes were reused for the same patient. However, in 25 percent of the observations, syringes were reused for different patients also. The red-colored plastic bag was not found in any of the wards. No bins were found to be covered with the lid. Segregation at the site of waste generation is found nil in the study. There was no provision for maintenance of the record of BMW (Das & Biswas, 2016).

Another study conducted with 42 key informant interviews in 14 facilities with inpatient facilities in Pokhra sub-metropolitan city revealed that the municipality is involved in the final disposal of healthcare waste which disposes of the waste by land filling without performing any segregation. There is no separate mechanism as most of the institutions use their own color-coding system. Out of 14 facilities, only 14.3 percent separated their waste into two categories as sharps and general and infectious waste. Some institutes incinerate pharmaceutical products that are not working up to standards. Hazardous waste is not sterilized before burial, disposal, or incineration (Banstola et al, 2017).

A direct contribution of the health sector to environmental degradation is less analyzed, but it is clear that the scale of carbon reduction needed to limit the effects of global warming cannot be achieved without the health sector playing its part. Analysis of the carbon footprint of NHS shows that 59 percent of it is coming from procurements, including equipment and pharmaceuticals (Scally, 2009). Concern about injecting practices has led some countries to advocate a shift back to reusable glass syringes (Scally, 2009).).

6.4 LEGISLATION AND BMW MANAGEMENT

There have been various developmental processes behind the development of regulatory frameworks across the globe. International agreements have been reached on multiple underlying principles like ‘polluter pays principle,’ ‘precautionary principle,’ and ‘duty of care principle, which laid the basis for the enactment of various Acts and laws (WHO, 2018). Legal provisions establish legal control and permit the national authorities to apply pressure for effective implementation of the law.

The findings of present studies based on qualitative and econometric models demonstrated that extent of BMW generation is not quantified well by the stakeholders due to multiple reasons. Household generated BMW accounts for 33 percent of total BMW, and it is a neglected area. There were few efforts from the authorities in the peak times of the Covid-19 pandemic where BMW generated from the households were considered as BMW, and liabilities were assigned to different stakeholders by CPCB. Similarly, guidelines issued by CPCB on waste management from animal slaughterhouses or poultry industries reflect that such waste could be considered as BMW and must be treated and disposed of on the same lines as BMW treatment and disposal. Such consideration and neglect of a proportion of BMW also impact the legal dimension of this area.

India was among the forerunners who enacted and implemented the BMW management rules for the safe and sustainable management of BMW. Authorization of the facilities as a producer of BMW is one initial and important process of implementing BMW Management and Handling Rules. Environmental monitoring by pollution control authorities, municipal corporations, and health authorities is a key activity for implementing BMW Management and Handling Rules in the district. However, primary and secondary data reflect that such authorization and monitoring activities are restricted to larger or bedded facilities in general medicine and only a few higher establishments in veterinary medicine. It is evident that India's health service provisioning is very fragmented. Health services are provided by a variety of providers (codified and non-codified systems, public and private, formal and informal health workers) both in general and veterinary medicine. Informal health workers constitute a large fraction of private providers, which is a major sector of India's health services system. These workers provide their services at scattered places in urban and rural areas in a dual-mode (practice medicine by visiting patients' households and in their non-bedded and bedded clinics). These workers exist in large numbers in both general and veterinary medicine. They are not part of the system legally and hence not provided with authorization by CPCB. However, they generate a huge amount of BMW in the field settings. Additionally, environmental monitoring is restricted to bedded and larger facilities with limited punitive action against the polluters.

Qualitative information received from respondents revealed that it is very rare that pollution control boards or authorities conduct such activities, especially in rural areas and smaller facilities. A coordinated effort would have helped in the adequate management of healthcare waste. It was also reiterated that the pollution control authorities extend very little technical and managerial support for effective and sustainable management of BMW. The pollution control board is responsible for the implementation of such a framework in the state. Effective implementation requires the execution of planned activities, administrative action, and other activities like monitoring, training, and information dissemination, along with establishing regular reporting mechanisms. Such activities are evident to some extent in urban areas, but in rural areas, the situation is completely different. The implementation framework is not evident in smaller healthcare/ veterinary establishments in urban areas and rural areas. Field staff is hardly aware of such legislations and their dynamics. In this overall context of inadequate implementation, field staff/ veterinary healthcare personnel and informal health workers tend to manage the generated BMW based on their consciousness, current knowledge, and existing practices carried out by their colleagues.

Monitoring and supervision activities should be followed by corrective measures that could improve the overall processes of BMW management. Institutional monitoring at the internal level does not involve legal actions. However, internal environmental monitoring by institutions could bring considerable improvement and environmental consciousness among stakeholders. Monitoring by HSPCB could lead to legal action against the violators. It was observed that the overall extent of environmental monitoring is not up to the desired level. Additionally, it is not able to involve all the types of healthcare facilities/ providers under its purview. Public health authorities of the district do not have adequate power to question or monitor or impose challans on private healthcare providers for not abiding by the law. There are some instances where municipal corporations have undertaken environmental monitoring, and the fine was imposed on a few violators (mostly private hospitals in Hisar), but it hardly brings any change in the processes, and such monitoring activities are very rare. Additionally, these activities are restricted to a few institutions of urban areas only. Moreover, whatever monitoring is executed, all of it is restricted with respect to solid BMW only. Liquid BMW monitoring is a very rare phenomenon.

Having progressive environmental legislation in the constitution to protect the environment does not guarantee its full-fledged implementation. Many researchers highlighted the gaps between practices and legislation. There have been many international treaties and conventions that govern hazardous waste trade between countries. African countries with stringent environmental laws have been victims of international pollution until these international Acts are implemented, e.g., many developed countries used to dispose and recycle hazardous waste in the African region taking the opportunity of weak environmental legislation (Godfrey et al, 2019). Such an example exists for South Africa, which until signed international convention remained as an environmental and public health concern. The chemical plant (a Mercury processing and recycling plant) situated near Durban had its original plant in the UK, which was closed by authorities as it was causing pollution, then it got relocated to South Africa in 1986. This plant with inadequate technology resulted in environmental contamination and devastating health consequences for workers and nearby communities. Though the plant was shut down in 1994 due to adverse consequences, the long-term impact of Mercury pollution continues to show because the level of contamination remained high for nearly two decades.

6.5 DISEASE CIRCULATION AND TRANSMISSION IN THE ENVIRONMENT

As discussed, broader phenomena like urbanization and change in land use have impacted the human-animal-environment interface directly and indirectly. The human population has increased from 2.58 billion in 1951 to 6.1 billion in 2000 and to 7.8 billion in 2020. The urban population had increased from 46.7 percent in 2000 to 56.2 in 2020. Such an expansion has set the stage for emerging and re-emerging infectious diseases (Reddy & Mathur, 2021). With these changing landscapes, there is greater deforestation and consumption of natural resources in order to achieve economic desires.

Co-habitation of animals with humans is common, especially in rural areas, which are usually sanitation and hygiene deprived. This provides an opportunity for otherwise incapable microorganisms to flourish and may infect animals as well as human beings through environmental contamination. Additionally, the problem is compounded by the increased and irrational use of antibiotics in livestock (Bhatia, 2021). Shared environments act as channels for transmitting ARGs and pathogens from animal to human and vice versa. Antibiotic usage is estimated to be double from 2013 to 2030 in India (Boeckel et al, 2015).

Now people live in more proximity to each other with rising urbanization. It gives rise to different types of problems altogether. Additionally, there is increased demand for food, shelter, and infrastructure, which impact the environment adversely in the end. The developments in means of fast commute and their larger access make it easier for people as well as microbes to travel along with them (Reddy & Mathur, 2021). Travel and tourism have been characterized as major drivers of disease transmission. National and international boundaries have become more porous (Bedi et al, 2021). Also, these changes in the human-animal-environment interface affect human-animal relations and animal-environment relations, which ultimately affect their microbe reserve. Now there is a greater opportunity for microbes of the environment or microbes of humans and animals to intermingle or cross-over leading to alteration in their natural reservoir and transmission dynamics. Most of the disease agents that have caused pandemics in previous decades could be traced to their origins in animals and birds. The ever-changing human-animal-environment interface has altered their natural habitats and influenced their transmission dynamics. In addition to macro-processes like change in land use, urbanization, and globalization, this change in human-animal-environment interaction is compounded by microprocesses (day-to-day human activities) like waste management practices and day-to-day environmental decision-making.

6.5.1 Environment Exposure

A variety of infectious and non-infectious waste is generated from healthcare activities. Though, the quantity of infectious waste is much less than non-infectious waste, inappropriate practices like the non-segregation of healthcare waste increase the proportion of hazardous waste. Other inappropriate practices like mixed storage, dumping healthcare waste with general waste in municipal bins or in open spaces, burning healthcare waste, or disposing of it by burring untreated medical waste into pits contaminates the natural environment. The environmental effects of healthcare waste generated from a variety of healthcare activities have been widely described by various studies. Environmental contamination may result from various environmental pollutants like hydrocarbons, carbon monoxide, aero pathogens, pathogenic organisms, toxic chemicals, APIs, antibiotics, etc. (Patil & Shekdar, 2001). If not managed properly, healthcare waste may contaminate soil, water, and air and may enter the food chain of various organisms. The potential increase of heavy metals and pharmaceutical compounds in agricultural soil through uncontrolled and hazardous waste dumping may result in soil contamination and lead to the elevated concentration of these pollutants in crops and plants. The metal contamination of food may result in depletion of important nutrients from the human body, which may cause weakening of immunity, disability with malnutrition, and high frequency of upper gastrointestinal cancer (Patwary et al, 2011).

Liquid waste is discharged from various healthcare activities such as laboratory, blood bank, operation theatre, surgical ward, and labor rooms. This discharge contains various potent pollutants, including pharmaceutical residue, metabolized and unmetabolized antibiotics, heavy metals, radioactive waste, infectious discharge from the body, and other body fluids. This discharge is often mixed with sewage systems in most health facilities. The majority of health facilities do not even connect with a sewage system as sewage systems are present only in cities in developing countries like India. Healthcare facilities in developing countries do not have adequate infrastructure to treat this effluent on-site and then mix it with sewage water. Even if it is treated, effluent treatment plants are not fully capable of removing these harmful pollutants like antibiotics. After treatment, this treated water is often mixed with freshwater streams. These pollutants then contaminate air, soil, and water through various pathways. In the absence of treatment plants, discharge from healthcare facilities may directly contaminate the natural environment and pose a severe threat to the environment and human health.

As discussed, waste generated from healthcare facilities may pose serious environmental and human health challenges. Studies have suggested that residents, who live in proximity of healthcare institutions, have higher chances of getting ill. One such effort is made in the capital city of Dhaka in Bangladesh, where the Center for Diarrheal Disease and Research demonstrated that there is a higher incidence of Cholera, Typhoid, Infective Hepatitis, and Dysentery in Dhaka. Moreover, there is a direct correlation between the rate of incidence and locality near hospitals/ clinics/laboratories or diagnostic centers. Dhaka City Corporation has recognized such areas as the red zone (Patwary et al, 2011).

In most developing countries, general and medical waste is handled by waste pickers and municipal workers. Infectious waste poses serious challenges for informal sector workers dealing with recycling and handling medical waste, which may contribute to the transmission of infections (Patwary et al, 2011).

Many studies have tried to demonstrate the differential effect of environmental exposure on different socioeconomic groups. These studies have revealed that the effects of deteriorated environmental conditions pose more risk to disadvantaged communities than the privileged section of the population. Hazardous waste sites, industries, and dumping sites are found to be disproportionately higher in the localities of disadvantaged sections of the population, such as blacks, lower castes residential areas, and other vulnerable sections. These conditions reveal a case for environmental injustice (Martuzzi et al, 2010). Moreover, international policies and processes like globalization have resulted in the shifting of hazardous industries from developed countries to developing and poor countries with little or inadequate infrastructure for dealing with environmental exposure from such dangerous sites.

Such policies have benefitted developed countries and put developing countries at risk of hazardous exposures.

6.5.2 Occupational Exposure

Health care workers and pharmaceutical industrial workers are occupationally exposed to a variety of pollutants. API is a potential threat to human health and the environment. Many pollutants like APIs degrade very slowly in the natural environment leading to their long-term persistence in the natural environment. These phenomena lead to slow and continuous exposure of APIs to human beings. Apart from this, a continuous threat to the health of healthcare workers and workers of pharmaceutical industries encounter API exposure due to the nature of their occupation. Workers handling these drugs, such as pharmacists, pharmacy technicians, drug dispensers, and nurses involved in their preparation and administration, along with workers employed in the synthesis and production of these products, may face serious health risks. Occupational exposure to APIs may lead to cytostatic and cytotoxic effects due to mutagenic, carcinogenic, and teratogenic properties. Some epidemiological studies have demonstrated that the number of spontaneous abortions and offspring malformation in nurses are reported to be caused by occupational exposure to cytostatic drugs. Additionally, the association between menstrual dysfunction and the handling of cytostatic drugs has been found. Some of the epidemiological studies have also demonstrated the carcinogenicity of a few drugs that are used in the treatment of cancer and for other non-cancer purposes. Drugs used for treating primary tumors have resulted in secondary tumors. (Sessink & Bos, 1999).

In addition to the occupational exposure to the APIs, healthcare workers are exposed to a number of occupational exposures. Needle stick injuries that may be contaminated with a variety of infectious agents like HIV, broken ampules, exposure to nuclear waste, continuous exposure to the contaminated or partially sterilized hospital surfaces, contaminated vials and ampules are a potential source of occupational exposure. Also, the urine, fecal material, blood, vomit, sweat, laboratory waste, beddings, clothes, drapes, gloves, and patient clothes are other sources of exposure in a hospital setting. Many studies have suggested that inappropriate practice for disposal of BMW poses serious threats for healthcare workers, population, and flora and fauna in the ecosystem. Accidental injuries are reported by different categories of healthcare workers may result in infection as 67 percent of the healthcare workers in Japan reported accidental injuries as compared to 50 percent in Peru and 18 percent in the USA. Lack of PPE makes healthcare workers in developing countries more vulnerable to such accidental injuries, as 94 percent of healthcare workers in Dhaka reported such accidental injuries. In Dhaka, 78 percent admitted that they did not use any chemical or detergent during the cleaning of the equipment, 73 percent did not wear protective equipment, and only 7 percent were aware of any protective uniform and equipment for such hazardous work (Patwary et al, 2011).

Therefore, environmental and biological monitoring of APIs and emissions from incinerators, hospital emissions, effluent waste, laboratory waste, and other hospital waste is critical to keep a check on environmental exposures due to health care activities. Despite employing all the protective measures, it is necessary to check whether there is any exposure or not. Several techniques are available to monitor the exposure, dose, or effect. Environmental monitoring is used to measure environmental exposure, and biological monitoring is done to measure the uptake or dose.

6.5.3 Role of Healthcare Waste and Waste in Transmission Dynamics

6.5.3.1 Risk of Disease 'X': Unknown Threat

The increasing human population and increasing demand for food, safe habitation, and developing infrastructure give origin to the desire of achieving economic growth. The ongoing phenomenon of so-called economic development is affecting broader processes like globalization, urbanization, and deforestation. The emergence and re-emergence of diseases of the potential of epidemics and pandemics is a constant threat in this changing landscape of human-environment interaction. This changing interaction, in turn, affects the human-animal-environment interface and hence influences host-pathogen relation and complex dynamics of disease transmission. Covid-19 is the latest example of this process. In a given context of the evolutionary origin of most emerging and re-emerging diseases, infectious agents can be traced to an animal source. There are an estimated 1.67 million unknown viruses from 25 families, out of which around 50 percent can infect humans. Zoonotic diseases constitute 75 percent of newer infections and 60 percent of known infections (Reddy & Mathur, 2021). It is difficult for even the most sensitive surveillance systems to detect novel pathogens. In changing landscapes of the human-animal-environment interface, emerging pathogens continue to expand their host-tropism. The maximum proportion of zoonotic microbes comes from wildlife. Disease 'X' represents the currently unknown pathogen that may emerge from an unidentified pathogen spillover event. (Chatterjee et al, 2021). There is a constant risk of the emergence of disease 'X' with a higher probability of being from an animal source.

Pathogens that have been restricted to an environment or animal-environment-specific agent might have experienced transition and entered into human beings through the human-environment or animal-human interface. Further, there are diseases that further transitioned, leading to human infection.

6.5.3.2 Antimicrobial Resistance

Globally, annual deaths from antibiotic-resistant infections are projected to increase from 700000 in 2014 to 10 million by 2050. If it is estimated by translating in economic terms, it would cost around 100 trillion US Dollars by increasing cumulative healthcare costs and decreasing productivity (Neill, 2016). Also, it will lead to a decline in livestock production by 7.5 percent, thus a challenge for food security. In monetary terms, it will lead to a loss of 100 trillion USD with a 3.5 percent decline in global GDP, which will push nearly 28 million people into poverty in addition to other devastating impacts (Neill, 2016). A larger proportion of total antibiotic consumption can be attributed to animal husbandry as it was estimated that in 2013 a total of 131109 tons of antibiotics were consumed in the animal husbandry sector only and is projected to reach 200000 tons by 2030 (Boeckel et al, 2017)). Developing countries like China and India are one of the largest consumers of antibiotics. Substantial efforts are being made in these two countries for the reduction of antibiotic usage (Xiao & Li, 2016; GoI, 2017). This large-scale usage of antibiotics in animal husbandry opens many channels of dispersion of ARGs in the environment. Backyard animal farming is highly prevalent in developing countries like India. People and domestic animals live in close proximity to each other. This may enhance the exposure of both humans and animals to ARGs and may lead to the enhancement of susceptibility to antibiotic-resistant infections.

Antibiotics are used among animals and poultry birds to promote growth and prevent infectious diseases. These antibiotics are often detected in the gastrointestinal environment of animals to prevent the growth of susceptible bacterial populations (Zhu et al, 2017; Woolhouse & Ward, 2013). This non-therapeutic usage of antibiotics in animals and birds helps in maintaining the selective population of bacteria that are resistant to the antibiotic and hence ultimately promotes the circulation of ARGs in the environment through different pathways (Gulberg et al, 2011).

Various pharmaceutical products are dispersed in the natural environment at as low a concentration as part per billion, which requires advanced analytical techniques to detect them (Ruhoy & Dauhton, 2007). Due to their low concentration as environmental pollutants, the environmental impacts of pharmaceutical products were overlooked in the past (Kim & Aga, 2007). APIs can remain active and potent for very long in the environment. These APIs exert enormous adverse effects on the biosphere and human health. One of the major categories of pharmaceutical compounds which pollute the environment is antibiotics. These antibiotics and pharmaceutical compounds enter the natural environment through several pathways like human metabolites via excretion, animal excretion, direct disposal of leftover or expired drugs into the sewage system, trash or landfills, disposal of effluents from the pharmaceutical industry, poultry industry, and effluents from hospital and laboratory settings. Antibiotics used for humans and veterinary are introduced in the environment through a number of pathways. There is inadequate data on the types and quantity of APIs and antibiotics in the natural environment due to a number of reasons. Very few countries collect data on the use of antibiotics and other drugs, e.g., take-back programmes and coroner's office in the USA (Ruhoy & Daughton, 2007). These antibiotics and other APIs are partially metabolized by human and animal bodies and, therefore, enter the environment as partially metabolized products. These products then enter the sewage system along with drugs which were directly disposed into the sewage. There they are again partially removed or not removed by sewage treatment processes. Even developed countries like the USA do not have the technology to completely remove APIs and antibiotics from Waste Water Treatment Plants (WWTPs) (Ruhoy & Daughton, 2007). Further, these compounds enter freshwater bodies through treated sewage water which is mixed into freshwater streams. These APIs then enter the human food chain through a number of pathways which results in the slow exposure of APIs and antibiotics to humans and other organisms in the ecosystem.

Though antibiotic-resistant bacteria are found in the natural environment, a higher concentration of these bacteria is found in wastewater or even treated wastewater. Studies have suggested that WWTPs provide favorable conditions for antibiotic-resistant bacteria to proliferate. These bacteria transfer their resistance genes to non-resistant bacteria through; transformation when resistant plasmid DNA is transferred into the bacteria, conjugation, and transduction using the bacterial virus as a gene vehicle. Several other studies suggested that environmental conditions in WWTPs may enhance the likelihood of gene transfer. These bacteria carrying resistant genes enter the ecosystem and then the human body through various pathways (air, water, and food) and mechanisms (Kim & Aga, 2007). Additionally, irrational use of antibiotics and overuse may trigger the development of ABR. Drugs and antibiotics are available over the counter in developing countries like India. Also, health services infrastructure in rural parts is inadequate where unregistered medical practitioners or quacks provide services. ARGs are found in higher concentrations in hospital effluents. Therefore, hospital waste and effluent are potential sources of ABR development. If hospital waste and effluents are not managed or disposed of properly, antibiotic-resistant bacteria may proliferate rapidly. All the above conditions lead to the increased development of ABR.

Even the design of the WWTPs and their operating conditions affect the fate of resistant bacteria and resistant genes in the water. APIs and antibiotics are removed from wastewater through a number of ways employed in WWTPs, e.g., volatilization, photo degradation, chlorination or ultraviolet treatment, and biodegradation processes. These processes may lead to the disappearance of parent compounds of antibiotics and may transform them into different metabolites or compounds. These transformed products may also possess the properties which were possessed by their parent compound. Therefore, the elimination of the parent compound does not necessarily mean that the parent compound is eliminated from the wastewater. There are limited studies on the assessment of pharma byproducts of treated effluents or their potency (Kim & Aga, 2007).

Antibiotics are widely used in humans and for veterinary purposes. In veterinary, antibiotics are used to promote growth in livestock production, feed additives in fish farming, and coccidiostatic drugs in the poultry industry. The AHI (Animal Health Institute) of the USA estimated that 50 million pounds of antimicrobial drugs are used every year, including 17.8 million pounds used in the livestock industry (Kim & Aga, 2007). However, there is a huge lack of antibiotic consumption data across the globe, which makes it difficult to assess the environmental load of antibiotics. Considerable efforts are made by some European countries and the United States to measure the extent of antibiotics in the effluent of WWTPs. There are not many differences observed for antibiotics present in influent and treated effluent of WWTPs. It indicates that WWTPs are partially effective in removing antibiotics from wastewater. The mean removal efficiency of sewage treatment plants ranges from 34 percent to 72 percent (Li, 2014).

A study conducted by Guardabassi et al (1998) in Denmark demonstrated the emergence of resistance in *Acinetobacter spp*. It was isolated from sewage water which used to receive effluents from the hospital and the pharmaceutical industry. Samples were collected from upstream and downstream at different locations at different times. There was the gradual emergence of resistance to multiple antibiotics in *Acinetobacter* in a sample collected near the discharge point of the pharmaceutical industry, whereas gradual emergence of ABR from a single antibiotic was observed in a sample collected near the discharge site of the hospital. Therefore, discharge from healthcare establishments and the pharmaceutical industry is a potential source of the emergence of ABR.

Antimicrobial resistance is a systemic issue with wider implications for humans and animals. Origin and transmission of antimicrobial resistance is a complex issue worldwide (Chakraborty & Barbuddhe, 2021). It’s a classic example of an issue that has a human-animal-environment interface origin. Routes of emergence and expansion of AMR are complex phenomena and have wider determinants. The defined daily dose (DDD) of antimicrobial agents in 76 countries has increased by 65 percent from 21.1 billion in 2010 to 34.8 billion DDD in 2015. This increase was greater in emerging economies (Boeckel et al, 2015). The problem of AMR is associated with overconsumption, irrational use, self-medication, illegal access, and unwarranted use of antibiotics. However, all these modalities of antimicrobial use are dwarfed by the excessive and irrational usage of antibiotics in the meat industry (Boeckel et al, 2019). The meat production level has increased enormously, especially in emerging economies. The annual consumption of antibiotics is estimated to be around 131000 tons which are expected to increase to 200000 tons by 2030. Around 73 percent of the global consumption of antibiotics is done for livestock production (Boeckel et al, 2017).

The ecosystem or environment undoubtedly provides a route for the transmission and amplification of the process of ABR. However, this whole process of transmission and amplification has elements of human interventions. Human beings mediate the consumption of antibiotics in the meat industry with their economic interest at the center. Animals do not consume antibiotics themselves. As discussed, there are certain macroprocesses that influence microprocesses like meat production. Looking at the problem of irrational usage through systems thinking would conceptualize the issue altogether in a different way. The meat and poultry industry, along with animal husbandry, is perceived to generate revenues. The economic interest of people involved in these industries and sectors tends to produce more and more in the shortest of time span. This process is compounded or catalyzed by weak regulatory mechanisms and easier access to antibiotics over-the-counter at unregulated prices without prescription. Further, these partially metabolized compounds or APIs of antibiotics are released into the environment through a number of channels and routes;

1. Domestic animals/meat production industry and animal slaughterhouses release liquid and solid waste in the form of urine and fecal matter into the waste streams and sewage. Not all sewage is treated in our country. However, sewage treatment can only partially remove APIs from the sewage waste.

2. These industries, especially the meat and poultry industry, generate huge amounts of anatomical waste in the form of animal carcasses, the head and intestine, and other organs like skin and bones, along with blood and other bodily fluids. These wastes are not considered BMW but certainly have elements of antibiotics or resistant genes. These waste products are also discharged and disposed of in the sewage wastewater or mixed into municipal waste most of the time.

3. These industries do not operate in a structured manner in India as backyard farming, and backyard poultry is prevalent practice. This sector is highly unorganized in India. Small and individual traders trade in poultry and meat in rural and urban areas in isolated places. Standard operating procedures are not followed up for the management of animal carcasses, and other anatomical waste may contaminate the environment.

4. Rural households share space with domestic animals. These areas often lack sewage lines or municipal collection of waste. Therefore, fecal material and urine are discharged into the immediate environment through different channels.

5. Literature suggests that poultry waste is often used as manure in agriculture and to feed fish in aquaculture.

6. Drugs are often used in animal husbandry to enhance milk production. Household-generated animal wastes do not find their way to waste treatment facilities leading to the contamination of the immediate environment.

7. Household-level consumption of antibiotics with irrational use and easy access over the counter makes it detrimental for the environment.

8. Hospital wastewater is often discharged into sewage without treatment which may add to complex phenomena of ABR.

9. Informal healthcare workers prescribe and promote antibiotic usage in irrational ways that also contribute to the increased consumption of antibiotics.

All these sectors contribute to the release of APIs of antibiotics into the environment through different channels and routes. Therefore, the present problem of ABR is a systemic issue where different subsystems, viz. poultry, fisheries, and medicine, interact with each other to form a complex whole. Furthermore, ABR is part of the overall implications of healthcare waste mismanagement as a whole. This complex phenomenon of ABR is leading us to the post-antibiotics era where antibiotics will no more be effective. Therefore, there is a need for a comprehensive ecological and epidemiological surveillance framework at different levels (Chakraborty & Barbuddhe, 2021).

AMR is a broader process having its origin at the human-animal-environment interface. Bacteria produce endotoxins and lipopolysaccharides, leading to infections that hardly respond to any of the antibiotics (Kumar et al, 2021). Global AMR Surveillance System Report (2020) revealed that many bacteria with clinical relevance become resistant viz. *Acinetobacter spp., Escherichia Coli, Pseudomonas aeruginosa, Staphylococcus aureus, Clostridiodes difficile, Candida auris, Enterococcus spp., Shigella spp., Salmonella spp., Streptococcus pneumonia, and Neisseria gonorrhoeae.* It has been estimated that ABR will lead to millions of death along with devastating economic implications (Chakraborty & Barbuddhe, 2021). In addition to the ABR, large-scale usage of azole fungicides in agriculture has led to resistance among large group fungi, including *Aspergillus* posing a serious risk to the health of the ecosystem (Banerjee et al, 2021). Multiple organizations, including agricultural universities, FAO, USAID, and ICAR, collaborated to detect AMR in different production systems (Kumar et al, 2021).

6.5.3.3 Pathways of Transmission/Circulation of ARGs

Numerous channels in the environment harbor the circulation of ARGs and their transmission from livestock waste to human pathogens. Considerable literature is available on the fate and circulation of ARGs in the environment (He et al, 2020). ARBs and ARGs are released into the air, soil, and water from animal excretory products. Land application of manure, irrigation with wastewater, wastewater discharge and runoffs, and meat and poultry operations are a few of the ways through which these ARGs circulate in the environment and eventually reach the human gut. Further, their silent colonization can lead to an infection (Manaia, 2017). Manure application enhances their abundance and circulation to the environment. They may persist in the soil for months (Han et al, 2018). Additionally, environmental conditions may affect their persistence and abundance. Temperature variability, UV rays presence, moisture, oxygen level, and heavy metal substrate presence may contribute to the abundance of ARGs in the environment (Guo et al, 2015). There has been a positive correlation between the presence of heavy metals concentration and ARGs abundance. They may act as a driving factor for ARG maintenance (He et al, 2020). This observation is important and critical to the present study as BMW (both treated and untreated) carries a lot of heavy metals particulate and wide variety of pathogens. Their co presence may harbor the growth and persistence of ARGs in ARBs. Therefore, segregation at source is very critical and imperative to adequate BMWM.

The human gut serves as the main reservoir for ARGs (common to both human and non-human environments) and provides a favorable environment for their abundance (Pal et al, 2016). However, there is a dearth of data on exact pathways through which these ARGs reach the human gut, but it may include ingestion of food and water and occupational exposure to waste (Sanganyado & Gwenzi, 2019). Further, propagation and abundance of these ARGs depend upon a variety of factors such as host immunity, usage of antibiotics, microbiome structure of host, and dietary context (Wu et al, 2020). Ingestion of antibiotics disrupts the host-microbiome structure and may catalyze the proliferation of selective bacteria and hence affects the abundance of ARGs in the human gut (He et al, 2020).

6.5.3.4 Biodegradation/Ecological Effects

The most frequent contaminants in hospital wastewater are pathogens such as viruses and bacteria, unused and partially metabolized or not metabolized pharmaceuticals, organ halogen compounds, radionuclide, and other hazardous substances. The contact of hospital effluents with the aquatic ecosystem may pose a serious threat to aquatic life (Emmanuel et al, 2005). Natural and synthetic antibiotics were introduced in the 1930s, and their usage has increased rapidly since then. Antibiotics are considered 'pseudo persistent,' which means they enter the environment and may remain permanently (Li, 2014). The presence of APIs and antibiotics in the natural environment pose a serious risk to the human health and health of the other microorganisms and flora in the ecosystem. Therefore, there are concerns about the potential adverse environmental effects of antibiotics and APIs. It is a very common process that treated wastewater from WWTPs is discharged into freshwater streams, which is further used for agricultural activities or other purposes. It is one of the commonly employed processes to meet the drinking water need of metro cities. Persistent exposure to the residue of antibiotics and other pharma compounds has increased in the human population and organisms. Additionally, these resistant genes enter the food chains of different organisms in the ecosystem and affect them adversely. The presence of these resistant genes in drinking water resources may be transferred to other bacteria that later may infect humans, e.g., ARGs against Streptomycin, Ampicillin and Tetracycline are known to be transferable to other bacteria (Kim & Aga, 2007).

Apart from the above effects, persistent discharge of hospital and pharmaceutical effluents in the sewage system would favor the antibiotic-resistant bacteria and lead to their selected survival (Guardabassi et al, 2002). This may lead to the re-emergence of virulent strains of resistant bacteria, causing increased incidence and prevalence of infectious diseases. Also, there are APIs, including antibiotics which may inhibit the proliferation of human embryonic cells. Additionally, these compounds pose a serious threat to aquatic life. Studies have demonstrated that the presence of Ciprofloxacin in stream water affects the algal biomass production and hence impacts the shifts in the food web structure of the stream (Kim & Aga, 2007). Studies have demonstrated that the presence of some hormonal drugs in the environment may lead to feminization of male fish, alteration in DNA integrity of organisms, and other harmful effects to organisms. Fishes are one of the most vulnerable species to pharmaceutical compounds in the environment. Antiepileptic drugs are known to be transformed in different metabolites than parent compounds and remain active in the soil. This can further contaminate the groundwater. Hormonal drugs can cause serious ecological impacts on a variety of species and may lead to endocrine disruption in most mammals, birds, and fishes (Li, 2014).

Effect on natural biodegradation: studies have reported that a lower number of fecal bacteria such as E. coli in the hospital are due to the presence of antibiotics and disinfectants in hospital effluents (Emmanuel et al, 2005). The continuous presence of antibiotics in the wastewater adversely affects the natural biodegradation process, which degrades a large chunk of waste (solid and liquid). The biodegradation process is manifested by microorganisms that are naturally present in the environment. However, the continuous presence of antibiotics in wastewater hampers the growth of these microorganisms hence posing a serious threat to the process of natural biodegradation. Developing countries like India have inadequate infrastructure for the management of their solid and liquid waste. In this scenario, natural processes like photo degradation and biodegradation have their own importance. However, the presence of antibiotics in the wastewater environment limits the amount of waste treated naturally.

Different countries have enacted legislation for risk assessment due to hospital wastewater and laid down guidelines for the connection of treated hospital wastewater and freshwater. European Commission requires all member states to carry out ecological and sanitary risk assessments for substances such as drugs, disinfectants, and radioactive substances. Ecotoxicological risk assessment involves problem formulation where the hypothesis is generated and evaluated for the reasons of ecological effects on humans or animals. Further exposure and effects are analyzed for a particular hazard. Finally, risk characterization is done in qualitative and quantitative terms. Few studies have demonstrated that it is possible to carry out the ecotoxicological risk assessment of hospital wastewater using standard bioassay, global physiochemical parameters, and analysis of targeted pollutants (Emmanuel et al, 2005).

6.6 IMPACT OF TREATED AND UNTREATED WASTE ON ENVIRONMENT AND HUMAN HEALTH

BMW is considered a source of contamination for the natural environment if not rendered harmless before it is disposed of in water, air, or soil (Manzoor & Sharma, 2019). The stakeholders employ a variety of ways and methods for the treatment and disposal of BMW. It may be open dumping of medical waste without treating, mixing BMW with solid municipal waste, burning, treatment, and disposal of BMW at designated sites, pre-treatment of BMW, and sending it to certified waste management facilities. In addition to that, liquid BMW in the form of body fluids, microbiological waste in the form of blood or urine samples, and discharge of various hospital activities may be released directly into the waste stream or sewage system without any treatment. Moreover, there could be health facilities that are not connected with sewage streams that may directly discharge their liquid BMW in open fields or small street drains. Apart from the health facilities, various industrial activities such as meat industries, slaughterhouses, poultry farms, including fisheries and piggeries may adopt various ways to dispose of their waste such as animal carcasses, leftover animal parts such as intestine, head, skin, and bones after meat yield, liquid waste discharge in the form of blood or body fluids. Therefore, the level of environmental contamination would depend upon the ways adopted for managing such waste. Untreated municipal and BMW may contaminate the environment through various pathways. In addition to it, even treated waste could pose a serious challenge to the environment based on the method of treatment, e.g., incineration method, which is commonly used for the treatment of BMW in India, may lead to increased carcinogens in the environment. Therefore, both the treated waste and untreated waste pose enormous pressure on the various biospheres in multiple ways.

In addition to the direct impact on human health, BMW, through many indirect pathways, may affect the health of the environment and the health of the organisms, including human beings. Eckelman and Sherman (2016) made efforts to measure various emissions. They studied the harmful impacts of healthcare waste on public health through their economic input-output model and demonstrated that the healthcare sector is responsible for contributing to various adverse environmental consequences like it contributed to greenhouse gasses (10 percent), smog formation (10 percent), acid rains (12 percent), air pollutants (9 percent), ozone depletion (1 percent) and carcinogenic and non-carcinogenic air toxic emissions (1-2 percent). These pollutants are responsible for 47000 DALYs from pollution-related diseases. This sector is responsible for 8 percent of total carbon emissions of the USA (Chung & Meltzer, 2009).

WHO (2016) estimated that around 16000 million injections are administered across the globe each year, and not all the generated waste is discarded properly. Such waste and other medical waste are usually contaminated with microorganisms that may infect hospital patients, healthcare workers, attendants, and communities. This waste, if not managed properly, could lead to infections, injuries, infertility, hormonally triggered cancers, genital deformities, dermatitis, asthma, mutagenicity, and neurological disorders in vulnerable populations in addition to commonly transmitted infection through BMW (Hepatitis B and HIV) (Manzoor & Sharma, 2019).

6.6.1 Impact of Treated Waste

Burning or incineration of hospital waste was considered a method of choice for various reasons. The incineration of BMW is still a method of choice in most developing countries. Incineration of BMW may lead to the emission of various harmful contaminants, which further depend upon the composition of BMW. With the advancements in medical technology with respect to developments in disposable items, the proportion of plastic or items made up of Polyvinyl Chloride (PVC) has increased considerably. Hospital waste contains around four times more plastic than municipal solid waste. Hospital waste may contain up to 20 percent of plastic by weight. The burning of such materials may give rise to harmful contaminants such as Dioxins and Furans. Additionally, a variety of POPs, Carbon Monoxide, Ethane, Propane, Ethylene, Propylene, and Hydrochloric Acid are emitted (Allen et al, 1986).

A study conducted by Amfo-Otu et al (2015) in Ghana demonstrated that open-pit burning and medical waste treatment through incineration is a common phenomenon in the country. Both the practices lead to different types of emissions and environmental challenges. It was found that the concentration of heavy metals was higher in the ash of incineration treated BMW as compared to the ash of open pit. The concentration of heavy metals was in the decreasing order of Pb>Cr>Hg>Cd. Bottom ash comprises 90 percent of total ash, with the remaining 10 percent as fly ash. Bottom ash contains a significant amount of heavy metals, which may leach down through the soil surface if not managed properly. Mercury is a volatile compound and vaporizes in open burning. This is a hazardous emission and may mix with the air we inhale, leading to slow and long-term environmental changes affecting the health of the organisms. Similarly, other heavy metals may be retained in the bottom ash of incinerators due to its enclosed operation as compared to the open-pit burning of BMW. Another study conducted by Adama et al (2016) in Ghana around a hospital incinerator at various distance points from the incinerator revealed that there was a high concentration of heavy metals such as Hg, Pb, Cd, Cr, and Ag in the bottom ash of the incinerator. The concentration of these heavy metals was more than the allowed limits. Additionally, hospital waste incineration leads to the generation of POPs such as Polychlorinated Biphenyls, Polycyclic Hydrocarbons, and other cancer-causing pollutants (Adama et al, 2016). Studies have shown that population groups living in proximity (within 3 Km) of old incinerators carry a higher risk of cancer incidences (Acharya et al, 2014). Auta et al (2013) conducted a study in Ibadan city of southwest Nigeria on heavy metal concentrations around hospital incinerator and municipal waste dump site. The study revealed that the bottom ash of the incinerator had a high concentration of heavy metals such as Lead, Copper, Iron, Zinc, and Chromium, etc. The concentration of Zinc was higher in the bottom ash of the incinerator. The soil of dumpsite had a higher concentration of most of the heavy metals than the soil around the hospital incinerator site (Auta et al, 2013).

It has also been documented that such compounds of heavy metals are persistent and probably last for centuries. If not managed properly, incinerator ash may lead to the leaching of such compounds to the underground water table and impact the whole environment and the health of organisms adversely. Additionally, most of the treatment methods are not potent enough to remove these contaminants from the water. There have been studies on epidemiological linkages of such pollutants with adverse outcomes in pregnancy, newborn health, and the learning ability of children. Lead can result in a wide variety of biological effects as it may affect hemoglobin synthesis, sperm morphology, adverse pregnancy outcomes, and kidney functions. Chromium is associated with allergic responses such as asthma; Cadmium may accumulate in kidneys and affect renal functions. It has a half-life of 10 years to 35 years in human beings (Amfo-Otu et al, 2015).

Though, there is no specific method for removing these heavy metals from the environment. Most of the treatment methods can only partially remove these heavy metals from the environment (soil, water, and air). They are problematic for the environment because they remain persistent in the environment for years and degrade very slowly. Therefore, they pose a constant challenge for the environment and human health. These metal particulate cannot be completely eliminated from the soil environment. At best, their reduction in the environment could be achieved by locally redistributing in the ecosystem through a number of pathways or being removed from the circulation in the atmosphere by immobilization (Auta et al, 2013).

6.6.2 Impact of Untreated Waste

The waste management sector is considered one of the major sectors responsible for environmental pollution in Asia. This waste management problem is ever compounding and intense in a few developing countries like India, Malaysia, and Indonesia (Agamuthu & Fauziah, 2010). Evidence from across the globe reveals that waste generation is continuously increasing in most countries. Landfill or open dumping of waste is considered the most convenient option for waste disposal due to its economic viability. Landfill activities may result in the formation of gas and leachate. There are possibilities of dissipation of this leachate through the landfill layers to contaminate soil, surface water, and groundwater (Al Raisi et al, 2014). Different kinds of waste are dumped on such sites resulting in the release of various heavy metals on the soil as electronic waste, plastic waste, medical waste, and other potentially harmful waste.

Disposal of waste, especially general waste through open landfills and burning, is a common phenomenon in most developing nations. A study conducted by Ali et al (2014) in Islamabad, Pakistan, demonstrated that even general solid waste's open dumping might affect the quality of soil adversely in various ways. Higher content of contaminants such as heavy metals like Lead, Copper, Nickel, Zinc, and Chromium was found in waste disposal sites. Moreover, it has affected the diversity among the plant vegetation as fewer plant species were present on dumpsite as compared to normal soil. High solid soluble concentration at dumpsites decreases the water availability to plants as increased salt concentrations reduce the osmotic potential resulting in stunted plant growth. Moreover, Total Dissolved Solids (TDS) concentration was found considerably higher (40 to 450 PPM), and pH of around 8.3 to 9.1 was recorded at waste sites (Ali et al, 2014). A study conducted by Al Raisi et al (2014) in Oman revealed that landfill sites were contaminated with a high concentration of heavy metals such as Iron, Zinc, Chromium, Aluminum, Lead, and Copper, etc. the concentration of these heavy metals was way more than the recommended value of the region. The pH concentration was found to be 7.94 to 8.91, indicating metal solubility. Mean TDS was 18037.5 mg/liter. Another such study was conducted by Agamuthu and Fauziah (2010) in Malaysia about heavy metal concentration at two waste dump sites. The study demonstrated that there was a higher concentration of a few heavy metals, such as Lead, Mercury, Zinc, and Iron, etc., at the landfill sites, which may pose serious challenges for the environment. Metals like Lead had higher concentrations on the upper layers, whereas metals like Iron and Zinc were at higher concentrations in deeper layers of the soil as compared to more proximate layers of soil surface.

One of the major concerns is that most of the studies which tried to link the impact of BMW management epidemiologically are only concerned with the health of human beings. Such waste and a wide variety of waste treatment methods may affect human beings through multiple pathways directly or indirectly. These pathways employ the environment at the center. Therefore, these pathways operate through the environment. Therefore, it is not affecting human beings alone by affecting the environment. A wide variety of aquatic and terrestrial organisms is there in this ecosystem. These organisms share their environment with humans and animals. Therefore, these animals, organisms, and microorganisms are part of human ecology. Any change in the immediate environment of human beings also affects these microorganisms and organisms in an ecosystem. Moreover, any effect or impact of adverse environmental conditions on human beings inherently affects this broad array of relationships. Although studies have tried and demonstrated the impact of human activities especially waste management practices, on the environment, least attempts have been made to study the impacts of these interventions. ARGs are frequently detected in livestock waste (excreta and urine). This waste, when released into the environment, may get mixed and can be detected in wastewater of animal farms, solids used for manure, lagoon slurry, and sediments at a much higher level than background water (Mckinney et al. 2018; Han et al, 2018; Yuan et al, 2019). ARGs are abundantly found in cattle and fish waste, and their concentration is sometimes higher or comparable to the hospital and municipal wastewater. Wastewater from swine and poultry farms harbors a much higher magnitude of ARGs than hospital and municipal wastewater (Sim et al, 2011; Ekpeghree et al, 2017). Also, ARGs concentration is much higher in poultry and swine waste than cattle and fish waste (He et al, 2020). This study conducted by He et al (2020) demonstrated that livestock waste from China showed the highest concentration of ARGs (Boeckel et al, 2015).

Table 6.1: Types of Infections Caused by BMW

Infection Type	**Pathogen Agents**	**Transmission Path**
Gastrointestinal infections	Enterobacteria:Salmonell, Shigella *spp*. Vibrio cholera Helminths	Feces or/and vomiting liquid
Eye infections	Herpes virus	Eye secretions
Genital infections	Neisseria gonorrhea Herpes virus	Genital secretions
Respiratory infections	Mycobacterium tuberculosis Measles virus Streptococcus pneumonae	Respiratory secretions, saliva
Skin infections	Streptococcus spp.	Purulent secretions
Meningitis	Neisseria meningitidis	LCR
Anthrax	Bacillus anthracis	Secretions of skin
AIDS	HIV	Blood, semen, vaginal secretions
Viral Hepatitis type A	VHA	Feces
Haemorrhagic fever	Junin Viruses, Lassa, Ebola Marburg	Biological fluids
Viral Hepatitis type B and C	VHB, VHC	Blood, biological fluids
Septicemia	Staphylococcus ssp	Blood

Source: Mastorakis et al, 2011*

6.7 ENVIRONMENTAL MONITORING

Uncontrolled development and multiple human activities have resulted in adverse consequences for human health and the environment. The rise in living standards due to increased consumerism has led to an increase in environmental pollution with increased carbon emission, greenhouse gases, and other variety of pollutants like chemical, biological, radioactive, and other non-biodegradable pollutants (Gavrilescu et al. 2015). Healthcare facilities and industries generate a variety of hazardous waste, which poses a different environmental health risk to the communities. Various healthcare activities generate pollutants like pharmaceutical ingredients, toxins, nuclear waste, endocrine disruptors, hormones, bacteria, viruses, etc. There are considerable environmental and health risks associated with these pollutants (Gavrilescu et al, 2015). Hospitals or clinics are potent sources of nosocomial infections and other hazardous exposures. More than 3000 pharmaceuticals are used in European Union only (Aukidy et al, 2012). The human body does not fully metabolize these pharmaceutical compounds. They are partly metabolized and partly excreted through urine or feces. They get into the water cycle or natural environment through human metabolism. These compounds can remain active for years in the natural environment. WWTPs largely remain ineffective in removing these pharmaceutical ingredients from the hospital or sewage effluents. Therefore, they get mixed into natural freshwater streams when treated effluents are discharged into them. Human beings and other organisms are then exposed to these APIs through various sources. As these compounds remain bioactive for a longer duration, many non-target organisms are exposed to these compounds and face adverse consequences. Therefore, it leads to the alteration of ecosystem dynamics (Aukidy et al, 2012).

In recent times, pharmaceutical compounds, especially antibiotics, have become a major concern for human health and the environment. Many species of aquatic and terrestrial organisms are facing adverse consequences from this deteriorated environment. A hospital or any healthcare facility is a different microenvironment within itself. Hospital waste or waste (liquid or solid) generated from various healthcare activities is different from municipal solid or liquid waste in various terms. Usually, there is no distinction between hazardous hospital waste (hospital effluents) and municipal sewage waste. Hospital effluents with the potential of causing hazards are directly discharged in municipal sewage for common treatment at wastewater treatment facilities (Verlicchi et al, 2012). It is predicted and estimated that hospital effluent waste contains a higher concentration of various pharmaceutical compounds or antibiotics than municipal wastewater plant influent or effluent. Conventional methods of effluent treatment are ineffective in removing these pollutants from effluents. Hospitals as a microenvironment could become a potential source of nosocomial infections. Also, it could become a source of outbreaks. Usually, environmental monitoring of microbial pathogens concentration in a hospital setting is not a routine process. Usually, this process is followed after a disease outbreak. Microbial monitoring of microenvironments like hospitals serves the dual purpose of hygiene evaluation and the presence of specific nosocomial infections. The frequency and time of microbial monitoring could affect the result. It could also be helpful in detecting MDR pathogens that are responsible for disease outbreaks (Galvin et al, 2012).

A hospital may produce a different kind of medical waste depending upon the services it provides. A variety of hazardous substances are found in hospital effluents. This effluent may be comprised of waste discharged from various hospital services like pharmacy, operation theatre, microbiology department, surgical wards, maternity wards, transfusion center, laundry and kitchen, and so on. Therefore, effluent may contain radioactive, chemical, metabolic, organic compounds, heavy metals, sterilizers, pharmaceutical compounds, especially antibiotics, blood byproducts, and various other hazardous substances which possess environmental health risks to various organisms. Therefore, monitoring and evaluating these kinds of pollutants or markers in hospital and industrial effluents becomes necessary. Also, the concentration of these harmful pollutants should be compared with municipal wastewater to determine the proportionate contribution of different sources.

Various studies have examined the concentration of pharmaceutical compounds or antibiotics in wastewater and sewage water. However, studies focused on the concentration of such pollutants in hospital effluents are inadequate. Little data available generally rely on predicted concentrations rather than measured concentrations (Verlicchi et al, 2012). Antibiotics such as Sulfamethoxazole, Clarithromycin, and Azithromycin are a few of the most critical compounds for the environment (Aukidy et al, 2012).

A study was conducted by Verlicchi et al (2012) on hospital wastewater generated from two hospitals and a municipal wastewater treatment plant in Italy. It studied the concentration of 73 commonly used pharmaceutical compounds from 12 different therapeutic classes. Also, it studied the contribution of hospital effluent in the concentration of various pharmaceutical compounds in wastewater treatment plant influent and also estimated the ratio between the predicted and measured concentration of the pharmaceutical compound. The study revealed that many antibiotics like Ofloxacin, Azithromycin, Clarithromycin, and Metronidazole had a very high concentration in hospital effluent waste which is further responsible for the higher concentration of these substances in municipal wastewater treatment influent and effluent. This study also demonstrated that few pharmaceutical compounds possess a considerable ecotoxicological risk. Another study conducted by Aukidy et al (2012) in Italy demonstrated that though hospital effluents are a potential source of pharmaceutical concentration in municipal wastewater effluents, other non-hospital sources are still responsible for the discharge of pharmaceutical compounds in the fresh and surface water. Few studies also attempted to calculate the pharmaceutical compound load in municipal wastewater due to household consumption of those pharmaceuticals. There is a lack of such evidence in the case of developing countries like India.

Conventional treatment of wastewater or drinking water is certainly not able to remove hormonal, antibiotics, biological (bacteria and virus), and other toxins due to their chemical structural stability (Gavrilescu et al. 2015). As hospital effluents are more harmful due to higher concentrations of a variety of pollutants, these effluents must be managed effectively at the local level with suitable technology. Conventionally, pollutant data related to macro pollutants (Nitrogen, Phosphorus, and Carbon compounds, and Escherichia Coli) had been and still are being collected in various industrial waste and freshwater sources. However, data related to micropollutants like pharmaceutical ingredients and microbes remains inadequate. Along with effluent treatment, an ongoing systematic collection of data related to various pollutants in collective hospital effluent as well as in the discharge of different departments is necessary to process and use this information for effective management of hospital effluents. In addition to the affluent, monitoring of pollutant data of other solid healthcare waste, waste from pharmaceutical industries, emissions from hospital incinerators must be carried out at regular intervals.

6.7.1 Biomonitoring and Ecological Risk Assessment of Different Sectors

Chronic exposure to any pollutant and its effect on the ecosystem and biodiversity is not a very easy task to accomplish. With a rise in the number of detected and several undetected pollutants, it requires innovative approaches to study the environmental and health hazards of pollutants. It is evident that exclusive reliability on chemical data is not sufficient to evaluate the effect of pollutants on the environment and health. Additionally, studies focused on the impact and behavior of low-level persistent exposure to the environment and human health are also inadequate. An inventory of the available information in terms of persistence, fluxes, and toxic potential of individual compounds and mixed compounds is lacking. Analysis of the potential risk of a pollutant along with its biological and biochemical effects on human health is desirable. To completely understand the potential of contaminants, it is important to have reliable data on their concentration at emission sources, within environment compartments or various channels, and in living organisms. With the improvement in technology, there are various techniques available for biomonitoring (online monitoring, chip-based monitoring, biosensors, and biomonitoring) to monitor the concentration of various pollutants. Various technologies are also emerging for bioremediation of these emerging pollutants (Gavrilescu et al. 2015).

There are various ways employed for environmental risk assessment to estimate the potential health and ecological impacts of antibiotics in the environment. Few countries like the USA have employed processes like Expected Introductory Concentration (EIC) and modeling techniques (Kim & Aga, 2007).

6.7.2 Monitoring of Environmental Exposure and Diseases

6.7.2.1 Exposure Assessment

Environmental exposure can be defined as any contact between a pollutant present in the environmental medium (such as air, water, or food) and a surface of the human body (such as skin, gut, or respiratory tract epithelium) (Bertolini et al, 2007). A pollutant may be present in different concentrations in the environment, which is often expressed in quantitative terms. A pollution dose refers to the amount of pollution that actually crosses the border between the environment and the human body. Sometimes assessment of biological markers in the body has advantages over assessment or monitoring of pollutant concentration in the environment e.g., if we take Lead exposure case, it is easier to assess the Lead exposure through Lead concentration in the blood rather than measurement of Lead concentration all mediums.

It is a crucial component in the case of environmental observation. Assessment of exposure may include different techniques to measure the contamination, sources of exposure, the medium in the environment through which exposure may happen, the different transformations of the exposure, routes of entry into the body, intensity, frequency, and length of exposure. Continuous monitoring of these aspects may provide crucial information regarding various diseases that rigorously planned studies might not be able to provide. Direct measures of past human exposures are difficult to know but can be assessed with the help of models. Recent advances in environmental epidemiology focus on microenvironmental exposures to a relatively smaller population. This kind of exposure is different from exposure in the general environment. The microenvironment, where people spend their time, may be different for different individuals. This adds to the complexity in the assessment of exposure for a population. Two approaches are used to assess this kind of exposure; the development of a personal monitoring system and exposure models. Healthcare facilities, industries like pharmaceutical industries, and CBMWTF are one kind of microenvironment different from other microenvironments. Increased exposure in high concentrations is very likely in such microenvironments. Many pollutants are so widely dispersed in the environment that they can reach the human body through a variety of complex pathways e.g., pollutants like Cadmium, Lead, and Dioxins are a few of such pollutants. Measuring and modeling for the assessment of such exposures is a complex phenomenon. Therefore, the measurement of biological markers is the preferred strategy. However, it will not be able to tell about the pathways and source of exposure. In this case, multimedia measurement and modeling approaches would be of help.

In the present era of large-scale industrialization and urbanization, especially in developing countries where different exposures are increasing in the general environment, there is a need for the establishment of monitoring systems that focuses on systematic collection and processing of data on a regular basis which can be used for the larger cause of public health improvement. Also, these systems can be the only source that provides information to determine the contribution of environmental factors to diseases where few causal factors are known. Additionally, they may prove helpful in a way to determine the extent to which disease rates have changed as a result of contamination. CBMWTF and sewage and effluent treatment plants need to be monitored regularly for their emission levels. However, there may be various problems associated with these monitoring systems;

- Difficulty in the identification of exposure
- Follow up latency
- Size of the affected population

Therefore, monitoring systems have to be large, and they must cover a substantial population for a long continuous period of time. It should collect data in a standard fashion and systematically. It is also not possible to establish a special monitoring system for all the requirements. Hence existing data systems should be used efficiently for environmental observations.

6.7.2.2 Exposure and Disease

A variety of organic and inorganic compounds in various concentrations are found in our environment. A disease can be attributed to exposure to a particular pollutant or a group of pollutants or contamination in the environment. Numerous organic chemicals are found in our drinking water, often at a very low concentration. Many of them have been labeled as carcinogens also. Many of the byproducts of the disinfection process also are harmful in nature. Control of waterborne infections is attributed to the drinking water and wastewater treatment in industrial societies. The result of disease incidence depends upon the type, duration, strength, and sources of exposure. Healthcare activities, including healthcare interventions in clinical settings, pharmaceutical industries, laboratory activities, and immunization activities, result in different kinds of emissions, including antibiotics, chemicals, and gases in the environment (air, water, and soil). These emissions are responsible for long-term exposure to the general population. The extent of these exposures is greater if healthcare waste is not managed appropriately. This exposure may result in various situations of increased infectious and non-infectious diseases and increased AMR etc. These kinds of exposures that get unnoticed by the majority of people are harmful in nature. Also, a lot of complexities are attached to their emissions and management. This nature of these exposures makes it hard to seek attention towards them and eventually difficult to be monitored.

CHAPTER 7

POLICY IMPLICATIONS AND CONCLUSION

7.1 BMW MANAGEMENT AND ITS BOTTLENECKS

In its meeting at Geneva in 2007, WHO had emphasized the importance of sustainable BMWM practices and stressed that it would require the right resources and complete commitment of the stakeholders to avert the harmful effects of healthcare waste on communities and people. People and providers involved in provisioning and financing the healthcare services should share the cost of proper and adequate BMWM, which is generated from various healthcare activities. It is their moral and legal responsibility to do it. Further, WHO (2001) reinforced that government should focus and do the needful in this regard with the help of non-governmental organizations. WHO has also released a handbook ("The Blue Book") in 2014 that may serve as a guiding document for the stakeholders.

It has been widely discussed that best waste management practices would aim at reducing the generation of BMW. Most of the BMWM practices, according to their desirability, are to reduce, reuse, recycle, recover, treat and dispose of. Therefore, management at the source (reduction, segregation, treatment, and recycling) is the preferable choice. The principle of good waste management practice is based on the 3R approach i.e., Reduce, Recycle and Reuse (Datta et al, 2018).

Dioxins and Furans are produced through incineration activities which are widely used in India for BMWM. These organic pollutants are deposited in fatty tissues of the human body and cause damages. Incineration of disposable plastic waste contains a high amount of PVCs. The burning of PVCs leads to the generation of Dioxins and Furans, which are harmful POPs. Many of the countries are now moving away from the incineration method for treating BMW to other advanced methods. However, in developing countries like India, incineration is still a major choice for BMWM (Datta et al, 2018).

7.1.1 Bottlenecks to the BMWM

Various studies have highlighted the varied practices of BMWM in different countries. These practices, in turn, are influenced by the different contextual factors in different regions as there is a lack of resources and adequate regulation to ensure sustainable BMW management practices in many countries especially developing nations. Provisioning of the services, trained staff, level of sanitation, implementation of the existing law, and overall environmental consciousness may be among a few other factors which affect the overall practices of BMWM.

El-Salam (2010) concluded that inadequate segregation and handling during storage, transportation, treatment, disposal, and lack of resources (monitory and human) are the bottlenecks of sustainable BMWM in Damanhour city of EL-Beheira. Different levels of implementation agencies must effectively coordinate for the safe and sustainable management of BMW. There is a need for responsible planning for ensuring safe handling, transportation, treating, and disposing of both non-hazardous and hazardous waste generated from various healthcare activities (Mastorakis et al, 2011). Priyadarshini et al (2016) stressed that even inappropriate treatment methods for treating BMW might pose serious challenges to the environment and human health due to its hazardous nature. Irresponsible planning of BMWM with respect to the collection, storage, transportation, treatment, and disposal is problematic to environmental sustainability (Bulucea et al, 2009). Another study conducted by Hossain et al (2011) demonstrated that lack of awareness, lack of effective control measures, lack of specialized clinical staff, and lack of regulations are among few responsible factors for inadequate management of the BMW. Additionally, resource crunch in developing countries makes them devoid of appropriate technology for effective BMW treatment. Patil and Shekdar (2001) argued that different regions of the country failed to put an appropriate system in place for effective BMW management due to a lack of resources for the adoption of appropriate technology and the absence of trained staff. In addition to these factors, inadequate knowledge and unawareness are other contributing factors to the overall process. This is a common phenomenon in developing countries (Nguwuluka et al, 2009). Therefore, there are multiple factors that are responsible for the generation of overall environmental consciousness among the different stakeholders.

Careful consideration and assimilation of all the factors would indicate that lack of infrastructure due to inadequate resources is the underlying reason for inadequate and unsustainable BMWM practices in most developing nations. Due to this resource crunch, developing countries lag behind in the adoption of appropriate technologies for effective BMW management. Regulations with respect to BMW management across the globe came around the 90s. Incineration was the most accepted and appropriate method at those times. Following the enactment of BMW management rules and regulations, a boom was observed in the construction and establishment of incinerators for BMW management. Developing countries are still building and relying predominantly on incineration as a choice of method and trying to improve their BMW management. On the other hand, developed countries are moving away from incineration as they have other choices of methods (Datta et al, 2016). This transition of development patterns with respect to BMW management practices affects the choices, adequateness, and extent of the BMW management in different regions of the world.

7.2 TREATMENT METHODS FOR BMW MANAGEMENT

There are various ways of treating BMW. These processes can be grouped as; thermal, chemical, biological, and irradiative processes.

7.2.1 Thermal Methods

Treatment of waste is done through various thermal processes. Based on the temperature, these can be further grouped as low, medium, and high-temperature thermal processes;

7.2.1.1 Low Heat

The processes or technologies involving temperatures between 93 degrees Celcius to 17 degrees Celcius could be put under this category. It includes technologies such as microwave and autoclave. Steamed heat is used in the autoclave process. Evacuation through the air is considered more effective in the autoclave process. Air is passed through High-Efficiency Particulate Absolute (HEPA) for disinfection before releasing it into the environment. Every type of human waste, microbiological wastes like cultures, sharps, and medical equipment, could be sterilized through autoclaving. Chemical waste and hazardous waste cannot be treated due to the chances of harmful emissions (Emmanuel et al, 2001).

Microwaves also use moist heat where steam is generated by microwave energy for sterilization. Infectious waste like sharps, laboratory waste, anatomical waste, bandages, gowns, etc., is treated in the microwave. Volatile waste, organic compounds, and waste like Mercury cannot be treated in the microwave. The advantages of these methods are their minimal emissions, while the capital cost of establishing such mechanisms is difficult due to their high cost (Datta et al, 2018).

7.2.1.2 Medium Heat

Certain technologies like thermal depolarization and reverse polarization operate between 177 degrees Celcius to 540 degrees Celcius. It can lead to the breakdown of organic matter in BMW through the application of high microwave energy in the nitrogen atmosphere, which helps in the combustion-free treatment of BMW (Emmanuel et al, 2001).

7.2.1.3 High Heat

Technologies like Pyrolysis, Plasma Pyrolysis, Laser-based Pyrolysis, and Induction-based Pyrolysis may operate at a broad range of high temperatures (between 540 degrees Celcius to 8300 degrees Celcius). Vaporization of organic solid and liquid waste takes place in this process. Inert ash, glass, and metal particles are left behind in this process. Electric energy is converted into heat energy in plasma pyrolysis. Waste like infectious waste, hazardous waste, chemotherapy waste, sharps, and plastics can be treated by this method. The advantage of this method is low emission and sterile inert ash leading to 95 percent reductions in volume. Its disadvantages include high capital cost and operational cost and chances of harmful emissions if set up are not well designed (Nema & Ganeshprasad, 2002).

7.2.2 Chemical Methods

There are certain categories of waste in BMW which require pre-treatment with chemicals before disposing it of in the environment. Laboratory waste, chemical waste, human liquid, and solid waste are treated with this method. Semi-volatile and volatile waste like Mercury should not be treated with this method. Usually, this type of treatment takes place under negative pressure in closed systems. The aerosol formation is prevented by passing exhausted air through HEPA. Advantages of this technology include no formation of combustion byproducts and ease of discharge into sewage streams. However, the use of Chlorine-based products for chemical disinfectants makes it cumbersome for the environment due to the release of toxic byproducts in the environment. Sodium Hypochlorite was used initially to treat BMW, but its use is responsible for the release of some toxic emissions like Dioxins in the environment (Datta et al, 2018). Therefore, the scientific community is moving towards non-chlorinated products for chemical disinfection. These products may include dry chemicals, gas, and liquid for chemical treatment. Treatment with Peracetic Acid in the portable chamber, waste reduction by alkaline hydrolysis at high temperature, decontamination using ozone, ionizing radiations, and electron beam technology are among other methods of chemical treatment of BMW. An advantage of these technologies is that they do not lead to toxic emissions (Emmanuel et al, 2001).

7.2.3 Biological Methods

Biological methods for the disposal of BMW are being considered as potential methods due to their large-scale advantages, which help in preventing toxic emissions and reducing the quantum of waste. Research studies are focusing on biodegradable plastics, which have the potential to transform the process of waste generation and management. Technologies like "bioconverter" are being used as a biological method of BMW disposal. Decontamination of BMW is done using an enzyme-containing solution, and resultant sludge is divided into solid and liquid for disposal (Datta et al, 2018). However, these newer developments would take their time and resources to be fully utilized or for their large-scale usage (Bano et al, 2017).

BMW management rules in most of the countries started to come around the 90s following various rising international concerns of hazardous waste. Prior to these rules burning and deep burial were the methods of choice. With the formulation of such legislation and rules, newer methods like incineration of BMW have arrived. This technology is based on a higher temperature, which kills the pathogen and destroys the material that can harbor the growth of microorganisms (Mattiello et al, 2013). A boom was observed in the installation of incineration plants across the globe following such legislation. It was observed that many products of incomplete combustion like Dioxins and Furans are formed in this process of incineration, which can accumulate in human fatty tissues and can be of potential harm. Dioxins are a group of 75 chemicals produced during the incineration of materials containing PVC (Vilavert et al, 2015). They co-exist with other chemicals like Furans. The existence of metals in BMW catalyzes the whole process of Dioxin formation. These are very harmful chemicals that can adversely affect the immune, endocrine, and reproductive systems (Datta et al, 2018). Traces of Dioxins have been recovered from human breast milk in metro cities like Mumbai, Delhi, and Kolkata (Subramanian et al, 2007). Considering the harmful effects of incineration-based treatment of BMW, many countries are now shifting to newer alternatives for BMW management. Countries like the Philippines and Denmark have banned the operations of incinerators for BMW management (Datta et al, 2018).

7.3 MANAGEMENT MEASURES OF HEALTHCARE WASTE

BMW generation and management is a complex systemic problem that requires coordinated efforts from different stakeholders. Moreover, the mismanagement of BMW is not just detrimental to human health; it also poses a severe challenge to the environment and other organisms of the ecosystem. Therefore, it needs to be understood that the environment is at the center of the problem and solution. Suppose the environment is affected by any human activity. In that case, it will not affect humans only, it will also affect all the organisms those share their environment with human beings. Therefore, the whole human-animal-environment interface must be considered while conceptualizing such problems and devising solutions.

First and foremost, effort should be directed towards the clear definition of BMW. All the waste having similar characteristics as BMW must be considered BMW. Such wastes having similar characteristics is generated from various industries viz. animal slaughterhouses, meat and poultry industry, fisheries, piggeries, animal husbandry, and leather industries. These industries account for a large proportion of waste that could transmit ARBs and ARGs in the environment and may pose severe threats to human health and the health of other organisms. Household generated BMW waste is another grey area of the whole waste management process. Innovative approaches are the need of the hour for sustainable management of BMW generated from households. As mentioned earlier, sustainable management of healthcare waste with environmentally sound technology is a huge challenge for authorities, following aspects of healthcare waste management must be considered;

- In the first place, focused efforts must be devoted towards minimization of waste generation by promoting reuse and recycling. Promoting use or substituting a few products with products that lead to lower emission during its disposal could be more beneficial.

- Timely segregation is the key phenomenon for effective waste management where storage and transportation are two key aspects. Pre-treatment before final disposal has its own advantages. These processes could considerably reduce the amount of infectious waste, hence catalyzing the process of safe disposal of healthcare waste.

- Best and environmentally sound practices would consider the requirement of the context/ situation and should operate on a lifecycle approach for health care waste management.

- The holistic management approach aims at the adoption of the lifecycle of healthcare waste management and the application of technology that is authenticated and standards for operations and emission are devised by authorities.

- The standard for the operation of healthcare waste treatment facilities must be in place along with rules and guidelines for environmental monitoring, regular supervision, emission standards, treatment procedures, and other regulatory standards.

- Coordinated efforts must be extended towards exploring options for a green procurement system for healthcare facilities and activities, recycling programmes, the substitution of hazardous and infectious waste into non-hazardous and non-infectious waste whenever possible.

- Extensive research and development for non-incinerator-based and green technology for healthcare waste management. These efforts would be helpful for developing countries like India, which lacks the required resource-intensive mechanisms for the safe treatment and disposal of healthcare waste.

7.4 LEGISLATION; IMPLEMENTATION AND PRACTICES

A regulatory and legal framework is the key to monitoring and evaluating the appropriateness of practices and compliance related to BMW management because it sets the standards for application and gives operational definitions (Thakur & Katoch, 2017). Effective BMW management requires institutions that take decisions and implement a wide range of measures to reduce health risks. In this regard, legislation and guidelines have been enacted for the safe management of BMW. Compliance with this legislation and guidelines shape the environmental and economic consequences (Insa et al, 2010). There have been various developmental processes behind the development of regulatory frameworks across the globe. International agreements have been reached on various underlying principles like ‘polluter pays principle,’ ‘precautionary principle,’ and ‘duty of care principle, which laid the basis for the enactment of various Acts and laws (WHO, 2018). Legal provisions establish legal control and permit the national authorities to apply pressure for effective implementation of the law. According to WHO (2018), the law should include;

- A clear definition of hazardous healthcare waste and its various categories.
- A precise reflection of legal obligations of healthcare waste producers regarding safe handling and disposal.
- Specifications for record-keeping and reporting.
- Specifications for monitoring and implementation framework and inspection system to ensure the enforcement of the law and penalties that may be imposed.
- Designation of courts responsible for handling disputes arising from enforcement or non-compliance to the law.

The policy document should outline the rationale for enacting the law along with the national goals and essential steps to be taken to achieve the same. Similarly, technical guidelines associated with the legislation should be practical and applicable. WHO (2018) recommends that there should be the gradual implementation of the law, particularly where existing practices are not adequate.

Another aspect of legislation, which the study results have highlighted to an extent, is the implementation of the law. India was a forerunner among the nations which enacted and implemented the Environment Protection Law, especially BMW management rules, in 1998. However, as discussed earlier, the context is very important for enacting and implementing the law. India's health system provisioning is very much fragmented and highly unregulated. A variety of providers are present in the system who does not comply with the environmental legislation with respect to authorization process and other aspects due to various systemic problems. Environmental monitoring of such facilities is a huge challenge in front of authorities. Such practitioners are present in huge numbers both in urban and rural areas. They may generate a small amount of BMW, but consecutively, the amount of their BMW could be higher as it is generally mixed with the municipal waste.

Environmental monitoring of the waste generators is another key area of environmental legislation necessary to ensure compliance with the law. Many respondents reiterated that it is a rare phenomenon, especially for smaller facilities. Moreover, even if such monitoring happens in the field, it is restricted to solid BMW only. Liquid BMW management and environmental monitoring are completely neglected. Additionally, other points of BMW generation such as veterinary health facilities, meat/poultry industries, and animal husbandry completely lack such monitoring processes. Therefore, environmental legislation must be able to cover all the aspects of such pollution, where contextualization of legislation is an important phenomenon. Legislation/ BMW Management and Handling Rules must be customized according to the requirement of a particular context.

7.5 PANDEMIC AND ENVIRONMENT

Ecological context and processes provide opportunities for pathogen spillover and hence lay the foundations for a disease to become pandemic. Other macroprocesses like globalization, urbanization and faster movements of people catalyze this process. People who are living in close proximity to each other and other potential reservoirs of pathogens are at higher risks of getting infected. An outbreak of Covid-19 is a classic example of this process as the disease spread first to urban agglomerations and then transboundary. Later it entered rural communities across the globe. Having originated from bats, Coronavirus is thought to have entered humans from the Wuhan meat market in China. However, the intermediate host is yet to be recognized. If we had known this intermediate host, the control measure of the pandemic would have taken a different trajectory. In the past few decades, some of the zoonotic viruses have posed a serious threat to human existence, e.g., the Influenza pandemic of 1918-1920 (Reddy & Mathur, 2021). Outbreaks of the Ebola virus in Africa, Avian Influenza in different parts of the world, and Nipah virus in South Asia are some of the important infections of zoonotic origin. Therefore, to conceptualize such pandemics and their origin, a transdisciplinary approach like One Health is a must.

7.5.1 Pandemic and Healthcare Waste

The researcher and policymakers employ an ecological approach to understand disease prevalence and transmission. Human activities, viz. agriculture, deforestation, change in land use, consumption of natural resources and waste generation lead to the change in the natural environment. It has been well documented that the thirst for economic development has deteriorated the quality of the natural environment, which is now experienced in the forms of climate change, floods, natural calamities, and other disasters like epidemics and pandemics. Covid-19 is the latest example of such variations where it is thought to be originated from the Wuhan meat market of China.

Understanding the transmission dynamics of novel pathogens is imperative to the control of outbreaks and epidemics and sustainable solutions. Environment plays a critical role in the transmission dynamics of pathogens. Environmental variables add to the complexity of the transmission and pathogen spillover. Macroprocesses of urbanization, globalization, and deforestation have led to increased environmental stress. An increase in food demands, safe shelter, and changing consumption patterns of human beings put severe environmental challenges in the form of waste generation, carbon emission, and environmental pollution. In addition to these localized effects on the environment, macro impacts like climate change have put the whole ecosystem on a threat that is hard to conceptualize.

Waste generation as a result of various human activities is an inevitable phenomenon, but the scope of these human activities or interventions or the extent of these activities determines the extent of waste generation. Waste of various kinds, which is generated as a result of a wide variety of human activities, is detrimental to the environment and hence to human and animal health. This waste impacts the environment, human and animal health directly or indirectly through several unknown ways. Waste generation and its mismanagement may add to the layers of complexity of the issues generated at the human-animal-environment interface. Fresh experiences of pandemic Covid-19 have demonstrated that humans and other animals were secondary targets of the virus. Its presence in sewage and wastewaters, and frozen meat indicates that there could be numerous reservoirs of the virus (Xu et al, 2020).

Wastewater stream and sewage waste receive waste from (both solid and liquid form) hospitals, pharma industries, animal slaughterhouses, poultry, animal husbandry, and households and other industrial units, etc. Partially treated or untreated wastewater is drained into freshwater streams, which may reach households for common use and agriculture purposes. Given that pharmaceutical compounds which are partially metabolized in the human body may sustain in the environment for longer durations. These APIs may circulate in the environment through different channels and processes. Not only pharmaceutical compounds, human anatomical waste, and liquid waste in the form of bodily fluids also may impact the environment and health of organisms in a number of ways. The presence of Coronavirus in wastewater streams and sewage indicates that many such unknown pathogens of pandemic potential might be circulating in the environment and may reach humans and animals, leading to unimaginable devastation. Population-based wastewater surveillance has been employed at the community level to track infectious agents like Adenovirus, Hepatitis A, Rotavirus, Poliovirus, and Coronavirus (Bedi et al, 2021).

7.5.2 Issues of Biosafety and Biosecurity

Global Health Security Agenda (GHSA) is a convergence of multiple international organizations like the United Nations Security Council (UNSC), International Health Regulations, WHO, and OIE. GHSA is further strengthened with the “Kampala Declaration” 2017, which emphasized on more streamlined framework focusing on addressing post-Covid Lacunae. Many countries are using its resource material for the development of biosafety and biosecurity guidelines. Learning from Covid-19 experiences, international community has realized the importance of restoring the environment and mitigating emerging future risks of zoonotic origin. One health is fundamental and core of these efforts (Basu & Sandhu, 2021).

7.5.2.1 Fisheries

The fisheries sector as a whole has observed enormous growth in the past 60 years. Fishes are considered a safe and cheaper source of protein (Vergis et al, 2021). 179 million tons of fish worth 401 billion USD were produced in 2018. Fish consumption has also increased across the globe from 9.0 Kg/capita in 1961 to 20.50 Kg/capita in 2018 (FAO, 2021).

Microorganisms are often found in the different body parts of aquaculture. Also, pathogens of public health concern are found on the body surfaces of fish as well as in aquaculture sediments. The presence of the ARGs in these microorganisms is a huge environmental and public health concern. There are several pilferages in production, storage, transportation, processing, and supply chain which pose a challenge for biosafety and biosecurity (Vergis et al, 2021).

7.5.2.2 Food Contamination

Food of animal origin like milk, meat, eggs, and fish basically supports the growth of microorganisms and acts as a reservoir. Therefore, antibiotic usage is common in aquaculture to prevent infections and promote growth. Drug-resistant bacteria could transmit from aquaculture to humans through aquatic biota or consumption of meat and fish. Not only human beings, but other organisms of the aquatic food chain could also receive these ARGs through food chain. Usage of chemical additives in the form of preservatives and colorants is common in aquaculture. Chemicals, water conditioners, disinfectants, and antibiotics are commonly used to sustain production. Such practices not just affect fishes but also impact the whole of the aquatic ecosystem including non-target species (Vergis et al, 2021).

Chemical and pharmaceutical waste may enter aquaculture through different routes and channels. Liquid pharmaceutical waste and wastewater from hospitals and other chemical discharge into sewage waste may contaminate freshwater and seawater, posing a serious environmental threat to aquaculture. It has been documented that poultry waste (fecal matter and excreta) is used to feed fishes to promote growth in certain conditions. Such practices raise serious challenges for biosecurity and biosafety of the aquaculture and meat industry. Improper disposal and recycling facilities in food-producing industries could ultimately lead to food contamination through pets and insects. Waste generated from food-producing industries in the form of antibiotics, chemicals, heavy metals, and other organic pollutants may enter the food chain of aquatic and terrestrial organisms.

WHO has estimated that foodborne illnesses account for 600 million cases causing 420000 deaths. Such illnesses cost 33 million years of healthy life years. Food borne illnesses are rooted in the contamination of food with chemicals, microorganisms, and heavy metals like Mercury mediated by the broader process of environmental pollution, unsuitable farming practices, and sociocultural habits (Vergis et al, 2021).

7.5.2.3 Environmental Racism

Globally the burden of environmental pollution and hazards is disproportionally shared by different population subgroups. People from socially disadvantaged classes and vulnerable population subgroups face more environmental health risks due to toxic wastes, pollutants, hazardous waste, incinerators, and other environmental hazards. Non-white, less educated, and politically lesser powerful populations are more vulnerable to environmental racism. This is a global phenomenon and is widely documented as well.

It has been documented that in the 1920s, all of Houston's landfill sites were located in the areas occupied by blacks, while Houston was predominantly a city of non-black people. Also, commercial hazardous waste sites were located more in areas with minority communities as local residents. These environmental inequities are believed to be partly a result of environmental racism, which is manifested by poverty, lack of political say, lack of mobility, and inability to move away from hazardous sites. (Coughlin, 1996). The report on "Environmental Equity: Reducing risk for all communities released" (1992) demonstrated that blacks and Hispanics are more likely to live in urban areas that do not match the federal air quality standards.

7.5.2.4 Environmental Health Risk

There are differential health risks associated with different population subgroups. Identifying such population subgroups and assessing the extent of health risk associated is one of the key priorities in environmental epidemiology. One population subgroup is at higher health risk as compared to others if it is exposed above some health-related benchmark or more susceptible to adverse effects of exposure. There is mounting evidence that people of color and low-income groups tend to be more exposed and susceptible to environmental hazards (Sexton & Adgate, 1999). People living in the middle of cities (in the case of developed countries) and in suburban areas near industrial establishments (in the case of developing countries) are more vulnerable to environmental hazards.

The health of the individuals is affected by a number of variables. The extent of environmental exposure is one of the most important variables which determine health status. Defining environmental health risk due to a particular environmental hazard is one aspect of environmental health risk assessment. But describing differential proportional health risks associated with different environmental hazards is another aspect that needs to be looked at, e.g., various factors and pathways are responsible for ABR like mismanagement of healthcare waste or usage of antibiotics in the poultry industry. But there is a lack of scientific evidence which could describe the differential proportion of individual factors responsible. Similarly, mismanagement of healthcare waste may lead to various environmental health risks for population subgroups but determining the extent to which it put its proportion of pressure on the environment leading to environmental health risks, among other factors, remains an important question to be answered through scientific evidence. It is also evident that there is an inherent difficulty in demonstrating the existence of a causal relationship between exposure to hazardous environmental agents and subsequent disease or injury unless the relationship is very strong, e.g., Radon-induced lung cancer in Uranium miners (Sexton & Agtate, 1999). In contrast to this example, there are various other attributes where the relationship between susceptible population and exposure is yet to be determined. A health worker engaged with medical waste management is more susceptible to environmental health risks posed by medical waste as compared to other health workers. Also, the susceptibility to exposure is affected by various other factors like the duration of the contact with exposure. Also, other driving forces determine the susceptibility like technology employed to manage the healthcare waste, compliance to the BMW management rules, occupational safety measures followed, and so on. Similarly, emission from incinerators beyond the permissible level and proximity of a population subgroup to the BMW management site or common waste treatment facility affects the susceptibility of the population subgroups.

7.5.2.5 Research Issue in Environmental Health Risk Assessment

It has been observed that lack of scientific evidence leads to a built-in systematic bias in the risk assessment, which hinders the recognition of non-quantifiable variables as risk-based decisions tend to be biased towards or in favor of hard quantifiable data in comparison to non-quantifiable data. Therefore, more credence is inherently given to tangible or easily measurable variables (Sexton & Agtate, 1999). This phenomenon leads to a lack of scientific evidence, which could further be the basis of the characterization of particular hazards as environmental health risks to the population. Quantitative risk assessment and resolution to environmental justice encounter two common problems; Lack of adequate and appropriate data for estimation and omission (misidentification of relevant hazard or causal pathways) and inadequate scientific understanding causing errors in specification and extrapolation. Therefore, filling these data gaps by conducting exposure-related toxicological, epidemiological, or clinical studies will help in reducing omission and estimation errors. Ultimately, it will help in reducing uncertainties in health risk assessment attributable to various causal factors and mechanisms. Sufficient scientific evidence and understanding is the key to environmental justice and hence rational decision-making.

These processes demonstrate that healthcare waste generation, management, and impact is not linear process. BMW generation is not restricted to procedures employed in human and veterinary medicines only. Multiple stakeholders and sectors are involved in these processes. Moreover, BMW generation and mismanagement do not affect human beings only. The environment is at the center of this problem, and human beings share their environment with many other organisms and plants. Any alteration in the human-environment affects the whole of the human-animal-environment interface leading to a broad array of problems that are hard to conceptualize through reductionist approaches and linear methodologies. It requires complex methodologies to conceptualize such complex issues. Therefore, One Health could be a useful approach to understanding such problems effectively.

7.6 ONE HEALTH AS A SOLUTION

A large fraction of human infections is thought to be of zoonotic origin. There are 1407 pathogens known those can infect human beings (Woolhouse & Sequeria, 2005). Out of these, 61 percent have a zoonotic origin, and within these, 40 percent are viruses. 3/4th of the emerging infections also have a zoonotic origin. Around five new diseases appear every year in humans, out of which three have an animal origin (CDC, 2021). Around 7000 new signals of potential outbreaks are received by WHO, which need investigation on a monthly basis. Between 1980 and 2013, 44 million cases were investigated globally (Basu & Sandhu, 2021). It is estimated that a timeline of 36 hours is sufficient for the travel of an outbreak from a remote village to any major city of the world (Basu & Sandhu, 2021). A small outbreak could progress into a public health emergency of international concern and further into a pandemic (Bhatia, 2021). Emerging and re-emerging infectious diseases were considered a potential threat to all lives on earth at a global symposium held in New York in 2004. Results were disseminated in the form of “Manhatten Principles” for sustaining the ecosystem by controlling and preventing zoonotic diseases, which were accepted globally (Panda et al, 2021).

Having known that most of the emerging and re-emerging infectious diseases have a zoonotic origin and reductionist approach of conceptualization is not going to be enough to devise the solutions to such complex phenomena, international agencies have come together to look for sustainable solutions. Food and Agriculture Organization (FAO), UNICEF, WHO, OIE, World Bank, and United Nations System Influenza Coordination developed framework on “One Health” in 2008. This framework aims to provide solutions to complex issues arising at the human-animal-environment interface through collaboration and multidisciplinary approaches at different levels in the hierarchy. One health is also an integral part of the SDGs of the United Nations under mandates 3 and 5. It forms the core guiding principle of many developmental programmes of many nations where the risk of zoonotic infection is relatively higher (Basu & Sandhu, 2021).

Realizing the requirement of multidimensional efforts to identify the precursor, pathways, and dynamics of zoonotic infections, MoHFW, Ministry of Agriculture, and the Wildlife Institute of India launched Roadmap to Combat Zoonosis in India

(RCZI) in 2008. It emphasized the need to measure mortality, morbidity, and economic loss associated with zoonotic diseases in India and provided the rationale for the adoption of the One Health approach (Reddy & Mathur, 2021). RCZI developed a five-year Strategic Research Agenda (SRA) to promote zoonotic research to manage pathogen spillover. A zoonotic disease research database is also proposed. With the fresh experience of a pandemic like Covid-19, the increasing threat of zoonotic diseases is being perceived across the globe. Union budget of 2021 specifically provides allocation for One Health. The first center for One Health was approved in Nagpur as a satellite of the National Institute of Virology Pune. Centre for One Health has been established at the National Institute of Animal Biotechnology (NIAB), Hyderabad, with the motto of "Animal Health for Human Welfare." The Indian Council of Medical Research (ICMR) has been collaborating with agricultural universities, and laboratory capacities are also being strengthened (Reddy & Mathur, 2021).

7.6.1 Model of Proactive than Reactive Response (One Health)

The process of economic development is dynamic and will continue to influence the human-animal-environment interface. Therefore, this human-animal-environment interface is ever-evolving and leading to change in the dynamics and complexity of this interface. In the context of changing ecosystem, different animals and their different species continue to come into contact. These changing interaction patterns are not restricted to humans and animals only but also to plants. Developments in the agriculture sector may lead to the mixing of different plant patterns and their species and thus has a potential for new cross-over infection at this interface affecting both humans and animals. This macroprocess is compounded by the change in climate patterns which may have a larger impact on the ecosystem as a whole (Chatterjee et al, 2021). One health approach could help in conceptualizing complex issues arising at the human-animal-environment interface for better understanding and devise sustainable solutions to the problem. However, usage of such approaches has been a reactive response rather than a proactive one as such integration is usually seen after outbreaks and epidemics. Operational integration on a day-to-day basis or proactive usage of one health approach is still lacking in the country. The present study is an effort to demonstrate proactive response using one health as a key guiding approach for exploring healthcare waste issues.

The implementation of One Health strategies through committees or frameworks would require a willingness to cooperate for collective action, effective collaboration communication between stakeholders, continuous surveillance and reporting, critical reviewing, and management. It would further demand collaborations at higher levels, i.e., inter-ministerial collaboration with a common funding strategy. Further, these linkages would require institutionalization to sustain these linkages (Dasgupta et al, 2021).

7.6.2 Health System Preparedness

Preparedness of health system with respect to concurrent and future health threats are discussed in the literature in different landscapes. However, before talking about health system preparedness, one must know about the system. There is a difference between health delivery system, health services system, and health system, which is discussed in the conceptual framework of the study. The health system does not only include healthcare delivery and its component, but it's a larger whole of different subsystems. Healthcare delivery is one of the subsystems of a larger whole which is connected to different subsystems like legislations, regulations, policies, community, and governance. There is very little information on community participation-oriented health system preparedness (Sahoo et al, 2021). Therefore, when we talk about the preparedness of health systems, it should reflect the preparedness of a larger whole rather than the preparedness of just a healthcare delivery system. Covid-19 pandemic has demonstrated that health system preparedness has larger meanings. Health system preparedness for the emerging and re-emerging infectious diseases would include health delivery strengthening, enhanced community participation, collaborated or integrated surveillance, data management, risk communication through effective regulation and legislation. One health approach goes with systems thinking as both talk about interconnectedness.

Recent public health emergencies of the globalized world have exposed the vulnerability of nations and demand for expansion of capacities for emergency preparedness. Emergency preparedness is one of the components of health systems' preparedness that can tackle emerging threats like the current pandemic of Covid-19. Emergency preparedness should imply continuous surveillance, epidemiological disease modeling, and capacity building approach (Bedi et al, 2021). One health approach is integral to emergency preparedness as it is integral to health system preparedness. Such preparedness would need multisectoral collaboration to devise sustainable solutions. Epidemiological modeling is an essential tool for disease prediction; however, biological models are often complex and deprived of quality data to feed upon. As a famous British statistician stated, "all models are wrong, but some models are useful," which illustrates that epidemiological models need continuous refinement to be able to respond optimally to outbreaks (Bedi et al, 2021).

7.6.3 Cultural Context and Future Prospects of One Health in India

Human beings, animals, and other organisms of the environment coexist in a particular mutual state of interdependence. Therefore, the human-animal-environment interface has been and is influenced by human activities. Further, this interface will continue to be affected through changes in the built and natural environment mediated by human interventions. The importance of this interface is being understood through the One Health approach for the last few years. This interface must have been influenced by human activities in the past too. Careful consideration of historical traditions and lifestyles may throw light on this interdependence. Indigenous people are thought to be better attentive and sensitive to their immediate environment. Indigenous people or tribal societies are considered subsistence economies as food security was ensured through forest products, fisheries, and cereal production using primitive technology. They were never producers of food but an only collector of food. Therefore, there was never an issue of ownership of land or forest. Therefore, the concept of One Health was an integral component of tribal culture. Britishers claimed ownership of forests for their desires and economic activities (Mutatkar, 2021). India's ancient medical literature discussed men's relationship with the environment (Weiss et al, 2021). The ancient text of *Charak Samhita* described a fundamental relationship between human beings and the environment as microcosm and macrocosm, each identified and represented within the other (Meulenbeld, 2002). Further, this text explains that human being and the whole world and environment is constituted of five basic elements (*Panchmahabhootas*). Therefore, a human being is just a micro-representation of the larger macrocosm. Any alteration in the environment or this macrocosm would ultimately affect microcosm or animals and human beings. Exposure to animal excreta, teeth, and semen may be toxic to human beings. Further, it was discussed in other major texts of (*Susruta Samhita and Ashtanghridyam*) Ayurveda on account of Rabies (Weiss et al, 2021). *Charak Samhita* described the principle of "*Lok Purusha Sama Sidhanta*," which means that all that exists in the universe, also exists in humans. *Purusha* is the epitome of *Loka* (Sharma et al, 2018). Therefore, the conceptualization of many human problems was done keeping the human-animal-environment interface at the center.

Humankind used to live in harmony with others in the ecosystem much before the development of agrarian societies. One can understand such harmony through the glimpse of the lifestyle of tribal societies (Panda et al, 2021). Additionally, in the ancient human medicinal system, Ayurveda pharmaceutical compounds were drawn from plants and animals. It has described the appropriate ways, times, and seasons for taking these raw materials from the environment and animals. It reflects that inherently, this relationship of humans with animals and the environment was mutually beneficial, not being destructive to each other. Therefore, One Health approach was indirectly at the center of decision-making in those times.

The work of Rudolph Virchow with respect to Cholera and Typhus epidemics in the 1800s had reflected the importance of the relationship of human beings with their environment. His work reflected an interdisciplinary approach involving anthropology, politics, and medicine. Also, he discussed the relationship of the human being with animals while discussing Rabies, Glanders, and Anthrax using the term zoonosis. He had emphasized the need for collaborative efforts from general medicine and veterinary medicine. The need for the legislation was felt for quarantine to control the epidemics and transboundary spread of those epidemics. Therefore, Virchow's work conceptualized around the essence of one health (Virchow, 1985).

7.6.4 Future Threats and One Health

The constant threat of emerging and re-emerging infectious disease along with outbreaks of Ebola, SARS, and Avian Influenza had pushed WHO to modify IHR 1969 in 2005 to include any disease as notifiable, which is a public health emergency of international concern (Panda et al, 2021). There have been instances where international communities were warned of the spread of highly pathogenic microorganisms. All three Coronaviruses are epidemiologically linked to animals. These potential emerging and re-emerging infections not only pose serious challenges to humankind, but they pose serious challenges for animal and environmental health with wider potential impacts like bio-threat, food insecurity, and socioeconomic instability (Kotwal & Yadav, 2021). Fungal toxins, which are highly neglected among research communities, could be used as bio-weapon and may also impact global food security (Banerjee et al, 2021). Fresh experience of the pandemic of Covid-19 has strengthened the idea of environmental sustainability for the well-being of humans. Quantum and possibilities of such threats have been and shall continue to rise in the future as well. Therefore, there is a need for multisectoral, concrete, and systemic actions to prevent, control and minimize the impacts of emerging and re-emerging infections (Bhatia, 2021).

Human beings are closely interlinked with animals and the environment. This interconnectedness is influenced by the process of deforestation, urbanization, globalization, and change in land use. The current pandemic has demonstrated this interconnectedness and linkages of humans with their ecosystem. Pandemic has not just impacted the health of the population, but it has posed a severe threat to the socioeconomic well-being of the population across the globe. Therefore, pathogens have massive potential for devastation of humankind in many ways. Pathogen spillover of these potential microbes (deliberate or accidental) could lead to mass destruction. These pathogens of pandemic potential can be used as biological weapons in wars as well as for bio-terrorism. Around 80 percent of the pathogens having the potential of being used as bio-weapon have an animal origin (CDC, 2021). Development, storage, and transmission of these bio-weapons are cheaper than conventional weapons. Outbreak/epidemic investigation generated samples that are stored in different corners of the world could be used to develop bio-weapons. The important advantage associated with these kinds of weapons is that their impacts could be easily disguised as natural phenomena (Kotwal & Yadav, 2021). Therefore, in addition to challenges of natural or accidental pathogen spillover, these pathogens of pandemic potential could be misused as weapons and hence may lead to mass destruction in terms of lives of people and socioeconomic loss. Collaborative efforts with a multi-disciplinary approach are needed to combat such threats.

The intensification of agriculture and the use of chemicals have put enormous stress on the environment and insect population. Large dam's construction for agriculture intensification is altering the river ecosystem. It has created grounds and space for an increase in various species of mosquitoes. These may transport emerging pathogens to naïve species. Additionally, urban agglomeration mediated by industrialization contaminates the environment in newer ways. Sewage constituted of human feces, and urine has impacted the riverine and aquatic ecosystem leading to alterations in the food chain and changes in transmission dynamics of pathogens. (Nulkar et al, 2021). Preserving biodiversity, while making agriculture sustainable for future generations would require multisectoral collaboration aiming at human well-being and restoring ecosystem health.

Agriculture intensification and increased economic activities pose serious challenges for environmental sustainability and hence food security of future generations. One Health approach is inherently imperative to achieve SDG1 (No Poverty), SDG9 (Industry Innovation and Infrastructure and Environment), and SDG13 (Climate Action). Additionally, environmental sustainability is important for food security for achieving SDG2 of zero hunger. These non-linear public health challenges require multidisciplinary collaboration and understanding and coordination between them. While ecologists, conservationists, and veterinarians are increasingly engaging and employing the One Health approach, the majority of social scientists and medical professionals hardly reflected any engagement (Dasgupta et al, 2021).

7.6.5 Genome Sequencing Using One Health

Studies have indicated that the pandemic of Middle East Respiratory Syndrome (MERS) had begun two months earlier than the first case was reported. The virus was isolated in camels and transmitted to humans. Further, the genome sequence demonstrated that Ebola virus outbreaks between 2013-2016 were maintained due to human-to-human transmission rather than the repeated zoonotic origin (Chakraborty & Barbuddhe, 2021). Therefore, naïve disciplines like genome sequencing would benefit humankind only if it can consider and acknowledge the interdependence of human beings on animals and the environment. Usage of One Health approach is thereby imperative to understand the complex problems.

Our well-being and existence as a species require environmental sustainability. Protection of human life cannot be the sole objective of different disciplines. Therefore, different disciplines must collaborate to ensure environmental sustainability. Approaches like One Health must be at the center of these collaborations. Naïve disciplines like molecular medicine are also going to adopt one health approach as there are proposals of genome sequencing of nearly 1 million microbes in One Health context (The Million Vaibhav Project). It is focused on monitoring vaccine effectiveness by assessing the decline, increase, and replacement of specific lineages. Also, it is aimed to identify potential reservoirs, failure in control efforts, detect emerging strains and promote outbreak investigation (Chakraborty & Barbuddhe, 2021).

7.7 ROLE OF ENVIRONMENTAL EPIDEMIOLOGY AND MONITORING

Though the developments in the field of 'Environmental Epidemiology' have been considerably slow, the principles of this discipline are of great importance in understanding the relationship between changing conditions of the environment and health effects on a population. Therefore, it provides and strengthens the basis for rational decision-making. The assessment of any particular risk exposure to human health is often based on toxicological observations or studies. Epidemiological assessments to support these toxicological observations are lacking due to the complexity and cost involved in designing and executing an epidemiological study. For example, in the healthcare industry, most of the stakeholders are aware of the toxicological effects of Mercury, but population-based epidemiological studies due to specific industrial activity such as the healthcare industry are lacking. It may be due to the complexity of exposure pathways and the extent of exposure in a population. A large population may be affected by a greater and extensive exposure such as air pollution for a longer time period, or a section of the population may be exposed to specific exposure for a longer duration in a particular industry. Therefore, the type of exposure, duration of exposure, and sources of exposure are important factors to be considered for planning an epidemiological study. There is extensive literature available on the epidemiology of air pollution. At the same time, there is a small amount of body of knowledge available on airborne exposure from hazardous waste sites. This may happen due to the relatively smaller population affected by the exposure or may be due to the difficulty in the characterization of relevant exposure. However, there have been various landmark observations in the field of environmental epidemiology which successfully established the relationship between point source exposure and disease incidence.

The causes of many common chronic diseases are unknown. Though the role of genetic factors is found evident, the role of environmental factors still needs to be established with epidemiological data. For many diseases of potential interest, especially with high prevalence, routinely available data do not include the rate of occurrence in a defined population or anything which can be related to the incidence of disease. However, the availability of gradient of exposure does not require incidence data to be there in conditions where toxicological effects are known (Bertolini et al, 2009).

The discipline of environmental epidemiology faces various challenges in terms of resources required to study the population-level data, especially in cases of diseases of unknown etiologies. An attitude of lack of interest in studying this environmental exposure may generate from economic considerations (the source of possibly hazardous pollutants may have economic benefits attached to it). For example, environmental exposure and its health effects on the population in the case of a pharmaceutical industry may find it difficult to be planned and executed as an environmental study by the local government. Other issues may arise due to the length of the exposure as it may be too short to measure, and the outcome is poorly explained. Population subgroups may be too small to study. In contrast to it, the complexity and cost of the study may rise when the population is too large, or there are varied sources of exposure. In addition to these factors, the persistence of a particular pollutant in the environment or its differentiated ability to enter the human body through different channels adds to the complexity of the phenomena. It is also difficult to generate the meaningful gradients of exposure as it is very hard to get an unexposed population in the case of studies pertaining to environmental epidemiology. Conventionally, exposure may be classified as present or absent, but it's actually difficult to find such populations, especially completely unexposed populations, as there are multiple and unavoidable pathways for exposure.

7.7.1 Role of Environmental Epidemiology

Assessment of environmental health risks is an integral part of the environmental decision-making, development of environmental health policies, planning of research, and establishing environmental regulations. The strength of scientific evidence would determine the credibility of the environmental health risk assessment. Therefore, the process and methods to evaluate the evidence and assessment of environmental health risk should be explicit, transparent, and based on valid epidemiological theory and practice (WHO, 2000). Studying determinants of health and the interplay of other variables and these determinants is an inherent part of the discipline of epidemiology. The ethical and sociopolitical dimensions of epidemiology have been widely discussed and debated. Values of epidemiology and individual and communities can be correlated via the struggle for environmental justice. Epidemiology is a discipline that is the key to generating scientific evidence in order to achieve environmental justice.

Modern epidemiology has paid great emphasis on the risk-factor analysis approach. Its methodological and theoretical foundations for testing causal hypotheses are located to study individual behaviors. Though risk-factor analysis is important to answer certain public health questions, it has certainly failed to probe the complex fundamental (social and ecological) causes. Risk-factor analysis encounters limits at various levels. Also, the traditional epidemiological approach assumes independence of outcomes as causal links between exposure and disease are analyzed at the individual level. Also, it assumes that population is a mere aggregation of individuals, and interaction between them does not alter the pattern of risk. Population-level effects are not equal to the sum of individual-level effects. Recent advancements with a system-based approach review the causation across various levels of environment and interrelate at different scales (Eisenberg et al, 2007).

It is a well-known fact that minorities and other socially disadvantaged population subgroups are disproportionately facing the brunt of environmental hazards. This leads to environmental racism and environmental inequity. Therefore, there is a need felt for new research initiatives among epidemiologists on environmental hazards to different subgroups of the population. Further, this need has been linked with the ethics in epidemiology as epidemiology is perceived to be helpful in achieving environmental justice and environmental equity through the generation of scientific evidence. Therefore, it is believed that epidemiology could foster the aim of environmental justice.

Various disciplines like epidemiology, toxicology, clinical medicine, and environmental exposure assessment generate evidence for environmental health risk assessment. Epidemiological studies have a unique role in the generation of evidence for health risk assessment as epidemiology provides evidence-based studies of the human population under real-world conditions in contrast to disciplines like clinical medicine and toxicology, which are primarily based on laboratory experiments. Therefore, it does not depend upon the extrapolation of lab results across species that can create various uncertainties. Also, it has contributed to the detection of newer hazards and hence stimulated the new research and catalyzed public health action (WHO, 2000). Socially disadvantaged population subgroups and communities often face multiple and bigger problems in addition to environmental hazards. Therefore, environmental issues often are being neglected by community members. Also, there is a need to research further to understand differential environmental health risks better. Additionally, scientific evidence is desirable for separating and evaluating the effect owing to lifestyle factors, environmental conditions, and genetic factors (Coughlin, 1996). International health issues are complex and intertwined with other environmental and sociopolitical concerns like poverty, overpopulation, desertification, deforestation, nuclear testing, underdevelopment, financial inequities, and struggle for human rights (Coughlin, 1996).

In the light of this situation where the unfair industrial tradeoff between developed and developing nations like shifting of highly polluted manufacturing units to third-world countries and making underprivileged and socially disadvantaged population areas as landfill sites, epidemiologists need to revisit the moral underpinnings of the discipline of epidemiology and should plan to study and research environmental hazards and environmental health risks in relation to other factors. Epidemiologists could undertake the study of various environmental exposures and health risk assessments in relation to race, class, gender, income, and nationality. Epidemiology can help the decision-making process by analyzing national, international, regional patterns of exposure to environmental risks and also by evaluating the different corrective measures (Coughlin, 1996). Epidemiologists could facilitate the idea of environmental justice.

Epidemiology has its unique role in health hazard characterization and health risk assessment due to this hazard. Health hazard characterization comprises the identification of hazards and the elements of dose-response assessment stages of the risk assessment paradigm. A health hazard is recognized by systematic collection of data, evaluation, and interpretation of available data from epidemiology and other disciplines concerning environmental factors and human health. Health impact assessment due to environmental hazard involves quantifying the expected health burden due to environmental exposure in a population subgroup (WHO, 2000). However, various peculiarities are associated with hazard characterization and health impact assessment. A particular environmental health hazard may lead to various outcomes, and a particular outcome may be present as a result of exposure to a range of hazards. In such conditions, health outcomes and hazards should be studied and interpreted separately and in relation to all available evidence to generate clear and explicit evidence.

Apart from the hospitals, the Indian population, due to its poorly developed public health system, resorts to a variety of medical practitioners and quacks. Additionally, self-medication is also very much prevalent in India. Medicines are available over the counter. Therefore a variety of personal care products, drugs, and cosmetics are consumed by the Indian population. This has resulted in emerging a variety of micropollutants (like pharmaceuticals, especially antibiotics, endocrine disruptors, hormones, and other biotoxins) which are hazardous to the environment and subsequently harmful for communities. Conventional pollutants have a sufficient research base, but these emerging micropollutants and their environmental and health risks lack adequate scientific evidence. Epidemiological studies focused on the detection and characterization of pollutants with various sources and pathways, and their environmental and health risk assessment is the need of the hour. Pathways and sources of these pollutants continue to be the essential subject of research as information even on conventional pollutants is inadequate. Changing the demography and physiochemical properties of these compounds along with the complexity of environmental characteristics may determine the unexpected behavior of pollutants in the air, water, and soil (Gavrilescu et al, 2015). Purposefully planned epidemiological studies on the detection of pollutants, sources, pathways, and their environmental and health risks could assist the decision-makers encompassing the principle of environmental justice.

7.7.2 Environment Epidemiology of Healthcare Waste Considering One Health

The research design to answer research questions pertaining to healthcare waste management must be able to examine and integrate different processes (BMW generation from general and veterinary medicine, poultry/meat industry, animal husbandry, and other allied industries) at multiple levels using stratified data from the village, block, district, state, and national level. This data should be complemented with molecular-level data pertaining to various exposures. System-level models must be devised to integrate these data sets. Further, these epidemiological study designs must be complemented with sociological, toxicological, forensic medicine, hydrological and geological study designs, etc. to get reliable evidence.

The complexity of these processes must be kept in mind while conceptualizing the problem and devising the solutions because strategies for mitigating the environmental impacts would ultimately depend upon the conceptualization of the problem as BMW generation and its implications in the form of injuries or infection is not a linear process. The environment is at the center of problems and their solutions. Many environmental changes occur as a result of human interventions or activities. BMW generation is one of them which pose certain environmental externalities. These externalities, affecting the environment, do not only impact human beings as they share their environment with animals and other organisms. Any alteration in the natural environment impacts the interconnectedness or relationship. Similarly, these changes also affect a broad array of organisms, including animals and birds. Therefore, this human-animal-environment interface faces severe challenges as a result of these complex processes. One health and systems thinking provide a unique framework for a better conceptualization of such complex processes. Econometric models and prediction models are being conceptualized through these frameworks.

Therefore, these approaches could be useful for conceptualizing epidemiological models for such complex phenomena which impact the human-animal-environment interface.

Public health actions, e.g., eliminating or reducing the exposure of a suspecting hazard, must often proceed even when scientific evidence is insufficient. In such scenarios of inadequate scientific evidence and uncertainty, the precautionary principle should play the role of guiding public health action (WHO, 2000).

7.7.3 Wastewaters and Wastewater Epidemiology

Results of the present study indicate that liquid BMW is a complete grey area that is neglected even among research studies of healthcare waste. However, few environmental scientists from different disciplines have attempted to conceptualize the generation and impact of liquid BMW in addition to solid BMW. In the Indian context, where even solid BMW is not getting desired attention, liquid BMW generated from various healthcare and industrial activities (meat/poultry, animal husbandry, slaughterhouses, etc.) is unable to find its space even in the consciousness of various stakeholders. It may be due to the fragmented and highly unregulated health provisioning in India. Additionally, even meat/poultry industries are highly unregulated, and this may result in contamination of surface water, groundwater, and sewage water.

Many studies have ascertained that municipal wastewater contains a varied variety of viruses and microorganisms, which may pose serious risks for human health (Bosch et al, 2008). In addition to wastewater, such pathogenic organisms are found in sewage, sludge, and biosolid samples (Bofill-Mas et al, 2006). Most of the viruses which transmit through the fecal-oral route are highly resistant in the water environment, where they may persist at high levels despite the decontamination processes commonly used for drinking water and sewage treatment (Kim et al, 2012; Kotwal & Cannon, 2014). A study on the detection of pathogenic viruses in Sweden by Hellmer et al (2014) demonstrated that Norovirus, Astrovirus, Rotavirus, Adenovirus, Aichi virus, Hepatitis A and E viruses were present in wastewaters of wastewater treatment plants in varying concentrations. Some of the viruses are detected even before their manifestations or outbreak in the communities (Carter, 2005). Clinical observations of symptomatic and asymptomatic patients/infections imply that municipal wastewater of affected communities contains Coronaviruses (Sinclair et al, 2008). Wastewater-based epidemiology has yielded promising results earlier with respect to Norovirus, Hepatitis A virus, and Poliovirus (Hellmer et al, 2014). Moreover, the majority of studies have indicated that asymptomatic infections of Coronavirus constitute a major proportion of the overall infection burden. Therefore, wastewater-based epidemiology could be of enormous help for such diseases to generate early outbreak signals and inform the efficacy of public health signals (Ahmed et al, 2020). Many techniques have been developed to detect viruses in the wastewater, especially for Poliovirus surveillance (Levitt et al, 2014). Similar efforts have been made to detect Adenovirus (Rodriguez et al, 2013). Also, some studies have indicated that these viruses could be present in hospital wastewater even after wastewater treatment (Prado et al, 2011). In addition to the detection of such viruses, ARGs have also been detected by some studies (Prado et al, 2008).

Multiple studies have revealed the presence of Coronavirus in municipal wastewater in the Netherlands, USA, and Australia. Tracking, tracing, testing, and treatment strategy has been accepted and implied by many countries for effective control of Covid-19. However, asymptomatic infections and the cost of population-level testing may pose challenges to public health activities, especially in developing countries (Ahmed et al, 2020). In such a context, naval epidemiological approaches such as wastewater-based epidemiology for detection of the virus could be critical of health systems. The study by Ahmed et al. in Australia demonstrated that wastewater contains copies of Coronavirus, which indicates the proportion of infection in the communities. Additionally, the extent of infection/cases was quantitatively linked with the clinical reporting of the cases in a sample population. However, it is a big challenge to establish quantitative predictions from the viral RNA concentration to the actual number of cases in the community (Ahmed et al, 2020). Another study on computational analysis of SARS –Covid-19 surveillance by wastewater analysis by Hart and Halden (2020) demonstrated that wastewater-based epidemiology is a very economical surveillance method, like, for Coronavirus screening, it would cost from million to billion USD for nationwide screenings even for one time. It would be difficult for developing economies to run such screening programmes sustainably in such a context. Wastewater-based epidemiology would be a faster and cheaper alternative. Additionally, it could indicate the prevalence and circulation of microorganisms or viruses much before the development of symptoms in the community. However, there are certain limitations of wastewater-based epidemiology as it would not be possible for it to pinpoint the infected individuals and their specific locations (Hart & Halden, 2020).

A comparative analysis of wastewater-based epidemiology and countrywide testing of Covid-19 in Germany indicates that for a developed country like Germany, whose testing capacity is highest in Europe (can screen about 100000 clinical assays per day), it will take around three months to complete the nationwide screening once and will cost around 1.25 billion dollars for assay reagents only. In contrast, Germany's 9636 wastewater treatment plants could be tested within the time frame of 24 to 48 hours with a reagent cost of around 145000 USD. It constitutes only 0.014 percent of the total cost required for testing all the individuals in Germany. Therefore, it could serve as a very economical way of surveillance, especially for underdeveloped and developing countries. Many countries have made strategic investments in wastewater-based epidemiology at national levels (Hart & Halden, 2020). Moreover, such technologies and approaches could indicate the presence of potential microorganisms having different reservoirs. Additionally, it could serve as a potential method for detecting APIs, ARBs, and ARGs in wastewaters, which could guide the control strategies at an integrated platform. Therefore, wastewater-based epidemiology is not just an economical method but could transform the approaches we look at and solve the problems of the human-animal-environment interface.

7.8 SYSTEMS APPROACH TO BMWM

Analysis of primary and secondary data reflects that BMW generation and mismanagement are systemic problems. An in-depth literature review reflects a dearth of data with respect to BMWM planning employing systems thinking. However, few studies employed systems thinking while planning for a comprehensive and sustainable BMWM system. Jindal et al (2013) attempted to ascertain the views of health care establishments/ hospitals of armed forces on the current system in BMW management in-vogue; to assess the quantity and composition on the healthcare waste generated from service’s hospitals, to get an overview of necessary equipment held and requirements by the services and to explore the possibilities of outsourcing, feasibility, and its relevance. Basically, they reviewed the problem with systems thinking as they attempted to study all the aspects related to generation, handling, treatment of BMW considering in-house capacities, resources required for sustainable management of BMW, and feasibility of establishing those treatment systems in the purview of existing BMW regulations. Considering all these variables, they demonstrated that outsourcing the BMWM to specialized service providers is the most relevant and feasible solution for sustainable BMWM.

Systems doctrine is closely associated with the integrative approach, which believes in the principle of the irreducibility of the whole to its parts as the sum of parts is always less than the whole. Therefore, this complex whole is understood as more properties than the sum of all the properties of different subparts of the system. Therefore, under the systems approach, all the subparts of a system need careful consideration to ascertain whether the proposed solution will fit into the complex system and, in turn, affect an overall improvement in the system. Ultimately, the goal of systems thinking is to define and consider all the significant features of a problem while proposing solutions (Jindal et al, 2013).

The role of the environment in the transmission of ARBs and the circulation of ARGs is critical and well understood, but the exact pathways of transmission and circulation are less established quantitatively. The environment is at the center of this phenomenon, and human beings share their environment with other species and organisms in the ecosystem, including animals. Therefore, it is not only the question of irrational usage of antibiotics in livestock and human beings and the release and circulation of ARGs in the environment. These processes also pose a risk of exposure to every organism of the ecosystem because every organism has its own microbiome structure. Large-scale usage of antibiotics and the release of ARBs and ARGs in the environment affect the microbiome of a variety of organisms in the environment through numerous pathways. This change in the human-animal-environment interface ultimately affects the relationship of the environment with humans and animals. There is a shortage of data and a communication gap among the stakeholders about this phenomenon. Bridging this communication gap between environmental and clinical microbiologists is required to conceptualize the phenomena, which can be done through the development of validated models to quantitatively assess the impact of

ARGs disseminated into the environment (He et al, 2020). Therefore, it's a complex phenomenon and requires complex methodologies for developing understanding and devising informed actions.

The scientific community of developed nations is pressing for the need to improve the efficiencies of waste treatment technologies in terms of ARGs removal from the waste. Reasonable and feasible regulation and policy change are required to mitigate ARG risks in the environment (He et al, 2020). However, this feasibility and reasonability itself are affected by many contextual factors. Developing countries like India have a lot of underlying factors for the overall inadequate management of waste. Animal husbandry, meat and poultry industries are highly unregulated sectors in India. Backyard farming and poultry is a common phenomenon. Moreover, the majority of the rural population is devoid of any means for adequate management of their waste. This leads to the generation of livestock waste, excretory waste, and bio-waste from various sources at multiple points. These multiple points add to the complexity of disseminating ARBs and ARGs in the environment leading to the increased chances of occupational exposure. Additionally, this study reveals that there is a huge lack of implementation of environmental legislation in the country, which depends upon a lot of contextual factors. Largely, we are lacking in establishing and putting systems in place for adequate waste management. Therefore, keeping all these contextual factors in mind, it is imperative to first improve the basic underlying factors and then plan for suitable, reasonable, and feasible waste treatment technologies.

BMWM is a complex and systemic problem within itself. There are multiple stakeholders and multiple contributors to the generation and mismanagement of BMW. These different subsystems integrate to form a complex whole (problem of BMW generation and mismanagement) with multiple blurred linkages. One health approach which corresponds to and inherently entails systems thinking could be a potential tool to conceptualize these blurred linkages and understand the whole problem effectively so that sustainable solutions could be devised.

7.9 ENVIRONMENTAL ETHICS/JUSTICE

There has been much debate about "Environmental Justice" in recent times. It has been identified as one of the most important societal goals. Ironically, everyone agrees that it is an appropriate societal goal but not defined very well. The benefits and burden of environmental decisions and newer technologies are not equally distributed among different population subgroups. Environmental health risks are borne disproportionately by different subgroups of the population. It is an accepted truth that everyone does not have equal capabilities to protect themselves from various environmental hazards. Efficiency and equity are often conflicting policy goals (Sexton & Adgate, 1999). Efficiency aims to maximize the benefits based on input cost, and equity aims to achieve proportionate distribution of benefits and costs. The nature of the necessary tradeoff between the two determines the various outcomes of environmental decisions. Therefore, society finds itself in a dilemma to attain the objective of environmental justice. Environmental justice has been defined by various scholars and agencies;

"Environmental Justice is a societal goal, defined as the provision of adequate protection from environmental toxicants for all people regardless of age, gender, ethnicity, race, social class, and health status" (Sexton & Anderson, 1993).

"The principle of environmental justice stresses equal access to natural resources and the right to clean air, water, affordable shelter, adequate healthcare, and a safe workplace" (Sexton & Adgate, 1999).

Similarly, there are other definitions of environmental justice incorporating principles of equity, fairness and justice which are further based on various judgments like philosophical, ethical, moral, and political judgments.

Though environmental justice is perceived to be at the forefront of environmental policies of various nations, this objective has failed in finding its place at the time of implementation as it is a highly political topic. Environmental justice is a legitimate health issue. Therefore, environmental justice needs to be put in the context of risk-based decision-making (Sexton & Adgate, 1999).

7.10 CONCLUSION

Large-scale economic growth-oriented developmental processes have entered and impacted every facet of human life. Demographic shifts in the context of industrialization-led urbanization have led to the increased disease burden due to negative environmental externalities. The industrialization has put enormous pressure on the biosphere. Like every other human activity, healthcare activities or interventions have some negative impacts on the environment resulting in environmental contamination. Human beings are connected to their immediate environment inextricably. Due to this interconnectedness of human beings with their environment, any alteration in this natural environment impacts human beings. Human beings also share their environment with other organisms of the ecosystem. Hence, human beings are not the only living entities getting affected by the altered ecosystem, environmental alterations affect or impact all such entities who share their environment with the human beings. Hence, the whole of the human-animal-environment interface is impacted by such alterations. Therefore, the environment is at the center of problems and solutions.

Developments in the health sectors are compounded by various processes, technological advancements in pharmaceutical and diagnostic equipment, the establishment of healthcare institutions, developments in medical education, and health services organizations. Similar trends were observed in the veterinary medicine field. Gradually, the privatization of healthcare has affected the provisioning of health services. Processes like health insurance have also catalyzed the growth of the private sector. The private sector is the major provider of curative health services, which is highly unregulated. A number of providers, including informal healthcare workers, provide health services both in general medicine and veterinary medicine. Such providers generate a variety of BMW. In addition to healthcare activities at institutions or in the field settings, home management of illnesses is common in developing countries like India; this also accounts for the generation of some amount of BMW. Furthermore, the poultry/meat industry, animal husbandry, animal slaughterhouses, piggeries, fisheries, and leather industries also generate waste having similar characteristics to the BMW. Therefore, the BMW generation is a complex and multilayered systemic problem. One Health approach was employed for the better conceptualization of this complex research problem which corresponds to and inherently entails systems thinking and provided the framework for the conceptualization of this multilayered problem.

The study results demonstrated that BMW generation is not a linear process as it is an outcome of various underlying processes of different sectors. Developments in the healthcare sector and processes like medical consumerism have impacted the BMW generation. Practitioners nowadays are relying too much on technology for diagnosis and treatment. These developments are responsible for an increase in the amount of biomedical trash. Environmental monitoring of smaller and non-bedded and veterinary facilities was seen as a rare phenomenon. Inadequate implementation of legislation, especially BMW, has compounded the problem. There was a lack of institutionalization of monitoring activities. Authorization was restricted to larger and bedded facilities. Furthermore, only larger facilities of general medicine and a negligible number of veterinary facilities were covered by common BMW treatment facilities for BMW treatment and disposal. This was because only a small amount of BMW is generated by smaller facilities. However, a general understanding of BMW tends to associate it with healthcare activities carried out in hospitals of general medicine. Other aspects or contributors like veterinary medicine, households, and other industrial processes are largely ignored in conceptualization.

It was observed that BMW Management and Handling Rules under the Environmental Protection Act were inadequately implemented in the district Hisar. Environmental monitoring, which is imperative for better implementation of the legislation, was very much inadequate and restricted to a few bedded facilities of general medicine. Furthermore, it was understood that other accompanying underlying processes which influence the amount of waste generated in the district were ignored. Broadly, environmental legislation in the form of BMW Management and Handling Rules was not contextualized enough to be able to cover every aspect of BMW generation and management. A large proportion of healthcare activities, especially veterinary medicine activities, take place in field settings only. Informal health workers are major healthcare providers in rural settings where there is already a lack of infrastructure, even for solid waste management. Understanding these contextual factors viz. nature of provisioning and organization of health services, the role of medical technology and industrial processes, variety of providers, institutions, governance, and policy is imperative to better understanding and conceptualizing multilayered problems. Integrated approaches like One health and systems thinking could provide a requisite framework for the inclusion of these contextual factors and establish linkages.

With the help of the One Health approach, the present study envisaged and conceptualized the problem of healthcare waste generation as a complex and multilayered problem and attempted to establish blurred linkages of this complex phenomenon. It was understood that such integrative and transdisciplinary approaches provide a better framework for understanding complex systemic issues such as environmental health problems.

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