CHAPTER 1

INTRODUCTION

1.1 Prologue

Healthcare waste is a highly growing waste globally. Various pandemics and an increasing number of hospitals are increasing healthcare waste. The amount of generated waste is also a topic of concern. Proper management of healthcare waste requires economical routes with environmentally friendly procedures. Collection and segregation are the most critical part of healthcare waste management. Many healthcare wastes are nonhazardous, so proper segregation is necessary to avoid the unnecessary cost of their treatment. A significant chunk of the healthcare waste, ranging from seventy-five percent to ninety percent of the garbage, is considered non-risk, similar to household waste. It predominantly emanates from healthcare facilities' organizational and tidying-up responsibilities, although it may also include trash generated during facility maintenance. The leftover ten to twenty-five percent of healthcare waste is considered toxic, posing several health hazards. Developing and developed countries are facing issues related to healthcare waste. Recycling and reprocessing healthcare waste is also one of the methods to reduce the amount of healthcare waste.

Going through various literature, it is concluded that healthcare waste management is a crucial issue for all countries, and their disposal is challenging. It is difficult for healthcare organizations to handle waste because of various barriers. Healthcare waste has a worse impact on the environment and society. Different treatment technologies have been developed to treat healthcare waste (Aung *et al*., 2019). Several healthcare sectors worldwide need help with healthcare waste management.

The current scenario motivates me to perform this study.

- The latest report (WHO 2019) indicates that 1 in 3 healthcare facilities globally do not safely manage healthcare waste.

- Sudden increases in the volumes of healthcare waste from the Covid-19 response exposed cracks in waste management systems everywhere.
- Adequate placement of infectious waste is an essential concern for developing countries.
- India is one of the developing countries. There is inequality in access to healthcare services in India because of unbalanced resource allocation, inadequate healthcare infrastructure, and high cost of health services (Ashutosh *et al*., 2019).

A case study in Tehran was performed and found that healthcare waste management involves social, economic, and environmental factors. (Ghannadpour *et al*., 2021). These factors worked as a barrier to adequately implementing healthcare waste management. However, research on healthcare waste Management (HCWM) barriers is limited to developing countries like India. This thesis identifies various obstacles and challenges and proposes strategies for proper healthcare waste management.

Through this study, various questions will be answered.

Q1: What are healthcare organizations implementing healthcare waste management?

Q2: Out of the barriers, which are the most relevant, and are they driving other obstacles?

Q3: What are the Strategies to overcome these barriers?

Q4: What changes are possible in the conventional healthcare waste management system, and how will it be helpful?

Healthcare Waste Management in Various Countries:

Due to the lack of means to physically manage the waste and create a legal mechanism to ensure everyone is protected in economically developing countries obeying the regulations governing its safe management. The issues with the secure management of medical waste are most noticeable. There are currently risks to the population from the workplace, the environment, or public health. Dangers from substandard medical waste management health care of separating rag pickers' Intravenous bags and syringe bodies for sale on the

illegal market are not uncommon (Stringer, 2012). Injuries caused by needlesticks, aerosols directly from the waste, or crude treatments such as open burning or other treatment methods due to poor healthcare waste management. Unchecked incineration is significantly more frequent and dangerous (Stringer, 2012). Medical procedures' waste can contain hypodermic needles and pathogenic germs, rendering the entire waste stream difficult (Chartier et al., 2014).

According to the findings from the literature, low- and middle-income countries had lower Environmental Performance Index (EPI) scores than most wealthy nations. Therefore, rich nations have better-controlled waste management and the most effective medical waste generation rate. As a result, the created medical waste is disposed of properly. The findings demonstrate that low- and middle-income countries generate less medical waste than industrialized and high-income nations. The average trash generation rate per daily bed varies from 0.3 to 8.4 kg. The two countries that produce the most medical waste are the United States and Canada (8.4 and 8.2 kg/bed/day, respectively). Asia, Kazakhstan, and Iran produce the most medical waste (4.6 kg/bed/day), whereas Spain and Italy have the most in Europe (4.4 and 4.1 kg/bed/day, respectively). The countries with the lowest rates of medical waste production are Pakistan and Greece (each, 03 kg/bed/day).

The findings indicate that, on average, 40% of workers had suffered injuries from handling medical waste. In India, nearly 40% of workers reported injuries, including eye, skin, and musculoskeletal problems, while most workers in Brazil were hurt in some way while handling medical waste. The worker's understanding and awareness of the disposal of medical waste. The findings indicate that, on average, 45% of employees understood how medical waste should be handled and disposed of. Senegal had the most significant percentage of workers with knowledge and awareness of medical waste disposal. In contrast, Malaysia had the lowest rate at only 12%, placing it last among the countries analyzed. The findings demonstrate that, on average, 41% of the employees received in-service training; China has the greatest percentage of trained

workers among the surveyed nations, at an average of 80%. The lowest in-service training was found in Egypt and India, where each country's average was 20%. The findings indicate that, on average, 33% of the medical waste was separated at the point of generation. While Uganda and Ghana only sort about 7% and 17% of their total medical waste, respectively, China separates almost 75%.

The Need for Healthcare Waste Management

Massive improvements in medical research and life-saving treatments must coexist with the emergence of a highly developed healthcare management industry to handle the variety of wastes generated by these operations and the substantial amounts of household-type. Healthcare facilities generate exceedingly objectionable waste regarding look or odor or present a severe and dangerous risk threat to the environment or human health. Contaminants can consist of the biologically active components of pharmaceuticals; pathogenic microbes, some of which have cytotoxic, cytostatic, and genotoxic characteristics (Chartier et al., 2014); polluted or infected anatomical wastes; dangerous sharps, such as surgical tools or hypodermic needles mercury, radioactive materials, and even chemical waste. During treatment, the waste industry can produce harmful secondary emissions and new wastes with new hazards. At every level of the chain, from waste handling to transport, treatment, and disposal, healthcare waste needs careful management to keep the environment and people safe.

Health Risks

Microbes in healthcare waste can pass on a disease to hospital patients, healthcare workers, and the shared community. Another possible danger is posed by bacteria resistant to different drugs. Some of the adverse health outcomes linked to healthcare wastes and their by-products are given below:

• Chemical burns resulting from disinfection, sterilization, or waste management actions

• Toxic contact with pharmacological produces

• Air pollution caused using the discharge of particulate stuff in the course of the combustion of therapeutic leftover

• Thermal damages

• Radiation burns.

Impact on the Environment

• The filling of the land by dumping unprocessed health care wastes can contaminate the environment.

• Chemical disinfectants employed to treat healthcare wastes might release biochemical compounds into the environment if those materials are not managed, stored, and appropriately discarded.

• Burning of healthcare waste also can lead to environmental pollution.

• Only modern incinerators can meet international dioxin and furan emission regulations.

Reasons for Failure in Healthcare Waste Management

One of the important reasons for the loss in healthcare waste management is the need for more awareness of health-related dangers and insufficient training inappropriate management of healthcare waste. Appropriate regulations also need to be in place.

Fundamentals of Healthcare Waste Management

1. Supervision and management structures for HCW: Proper supervision from top authorities and Management is required to handle healthcare waste. Foremost sources give advice and suggestions that everyone has to follow.

2. Risks associated with HCW: Several risks are associated with healthcare waste if the treatment is not done adequately.

3. Definitions and classification of healthcare waste: Healthcare waste is the waste which is generated from healthcare facilities, and it is classified as biomedical and general waste. More than seventy percent of wastes are non-hazardous. Almost fifteen percent of generated Healthcare waste is considered Biomedical waste, and the rest of the waste is general waste similar to household waste, as shown in Figure 1.4

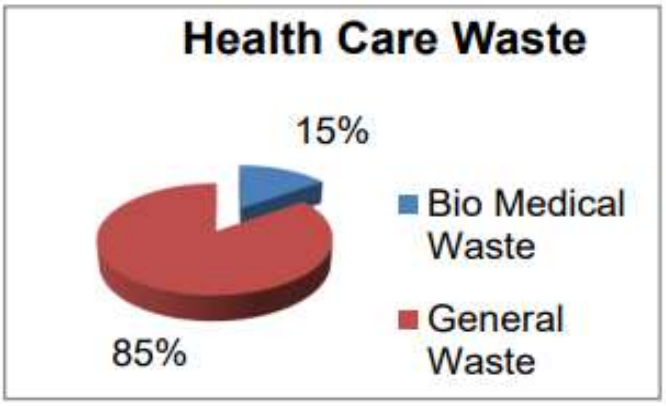

Figure 1.4 Health Care Waste (Biomedical Waste Management Rules, 2016)

Steps involved in Bio-medical Waste Management:

There are mainly five steps involved in the management of healthcare waste. These five steps are

1. Segregation 2. Collection 3. Pre-treatment 4. Intramural Transportation 5. Storage).

Classification of Healthcare Waste:

Health Care Facilities (HCFs) are primarily responsible for managing the healthcare waste generated within the facilities, including their activities in the community. While developing the waste, the healthcare facilities are responsible for segregation, collection, in-house transportation, pre-treatment of waste, and storage before such waste is collected by Common Bio-medical Waste Treatment Facility (CBWTF)

Operator. Thus, for proper waste management in healthcare facilities, the technical requirements of waste handling must be understood and practiced by each staff category following the Bio-Medical Waste Management Rules, 2016. Waste generated from the healthcare facility is classified as:

- Bio-Medical Waste
- General Waste
- Other Wastes

Bio-Medical Waste Segregation

Waste must be segregated at the source generation point and not in later stages. As defined earlier, “Point of Generation” means where wastes are initially generated, accumulated, controlled by doctors/nursing staff, etc.

In-House Transportation of Bio-Medical Waste:

In-house transportation of Bio-Medical Waste from the waste generation/ interim storage site to a central waste collection center within the hospital premises must be done in closed trolleys/containers, preferably fitted with wheels for easy maneuverability. Such trolleys or carts are designated for Bio Medical Waste Collection only.

Central Waste Collection Room for Bio-medical Waste:

Each Healthcare facility should ensure a designated central waste collection room within its premises for the storage of bio-medical waste till the waste is picked and transported for treatment and disposal at CBWTF.

Central Storage for HCF Having Captive Treatment and Disposal System:

The healthcare facilities which are having captive treatment facilities for the treatment and disposal of biomedical waste through incinerators, autoclaves/microwaves, shredders, etc., within their premises must ensure that waste generated from the HCF is stored in this central waste collection area till it is transported to the reception area of captive waste treatment facility within the premises.

1.2 Background and Motivation

As COVID-19 showed us, we are not ready to tackle this pandemic and fight pollution. Some recent research has proposed that performing bibliometric and text-mining analysis of several peer-reviewed journal articles in the Scopus citation database offered a detailed map of the WM research in the context of the COVID-19 pandemic. By examining and debating bibliometric performance indicators, such as (i) The geographic distribution of publications, (ii) The productivity and influence of authors, (iii) The major contributing journals and publications, and (iv) Keyword-based analysis to reveal research tendencies and hotspots, the performance of the COVID-related scientific production in the WM field was mapped (Ranjbari *et al*., 2022). India is witnessing strong economic growth in the last few decades, but the benefit of this growth is yet to reach the people at the bottom of the pyramid (Coale & Hoover,2015). This disparity between the rural and urban parts of the country grows with each passing day (Das & Pathak,2012). There are many motivations for people migrating from villages to cities, and the availability of better career opportunities, healthcare services, and educational institutions are to name a few. According to World Health Organization (WHO), more than half of the world's inhabitants live in urban areas. This phenomenon of rapid urbanization is more evident in the low- to middle-income countries of South-East Asia, where about 34% of the total population is urban. Moreover, over 40% of the urban population of South Asia lives in slums which makes them more susceptible to a wide range of diseases and health problems (WHO,2010). This exodus results in unplanned urbanization of the cities. Like other amenities, these cities don't have a designated area for opening healthcare facilities. The reason may be India's lack of

regulatory practices and the dependability of private players for ambulatory care (Phadke, 2016). Most of these hospitals have evolved from standalone clinics and are in the city's heart (Cheela et al.,2021). In March 2009, 240 people in the Indian state of Gujarat contracted hepatitis B following medical care delivered with previously used syringes later discovered to have been acquired through the black-market trade of unregulated health care waste (Solberg 2009). Thus, it is evident that careless and indiscriminate disposal of this waste by healthcare establishments and research institutions can contribute to the spread of serious diseases such as hepatitis and AIDS (HIV) among those who handle it and the public (Gupta & Booth, 2006). Based on the above discussion and extensive literature, healthcare waste management is one of the more challenging tasks. It is required to determine which barriers play a critical role and that they are working as a driving force for other barriers to understanding that weight allocation is needed. Barriers with higher weights are more prominent, and action against them is the top priority.

1.3 Objective of Research Work

The vital premise of this research is to propose a framework for providing guidelines for decision-makers and managers in policy formulation concerning proper healthcare waste management implementation. Succinctly, the research objective of this thesis is as follows:

- RO1: To Identify barriers and find the relationship among them for the healthcare waste management sector.
- RO2: Finding customers' Requirements and selecting essential activities for their fulfillment.

- RO3: Allocation of weight to HCWM barriers and policy recommendations to overcome barriers

- RO4: To deal with Hospital Waste Management Conundrum in an Unplanned City -A Case of Varanasi

1.4 Novelty of the Research Work

This study evaluates the perceived values of the hospitals from Varanasi, one of the tier II cities. Additionally, this research highlights the barriers that can uphold the contextual positioning approach and bolster competitive relationships between these barriers. In addition, it is crucial to be aware of the resources and associated obstacles to compete with hurdles to implementing a positioning strategy. This study is helpful to managers and decision-makers, who will be able to use it to carry out their plans.

1.5 Organization of Thesis

The thesis is divided into eight chapters and starts with a general introduction to the research work. Chapters 4 to 7 present the research related to mentioned objectives of the study. An overview of the thesis chapters is given in Figure 1.5, which shows the structure of the thesis organization.

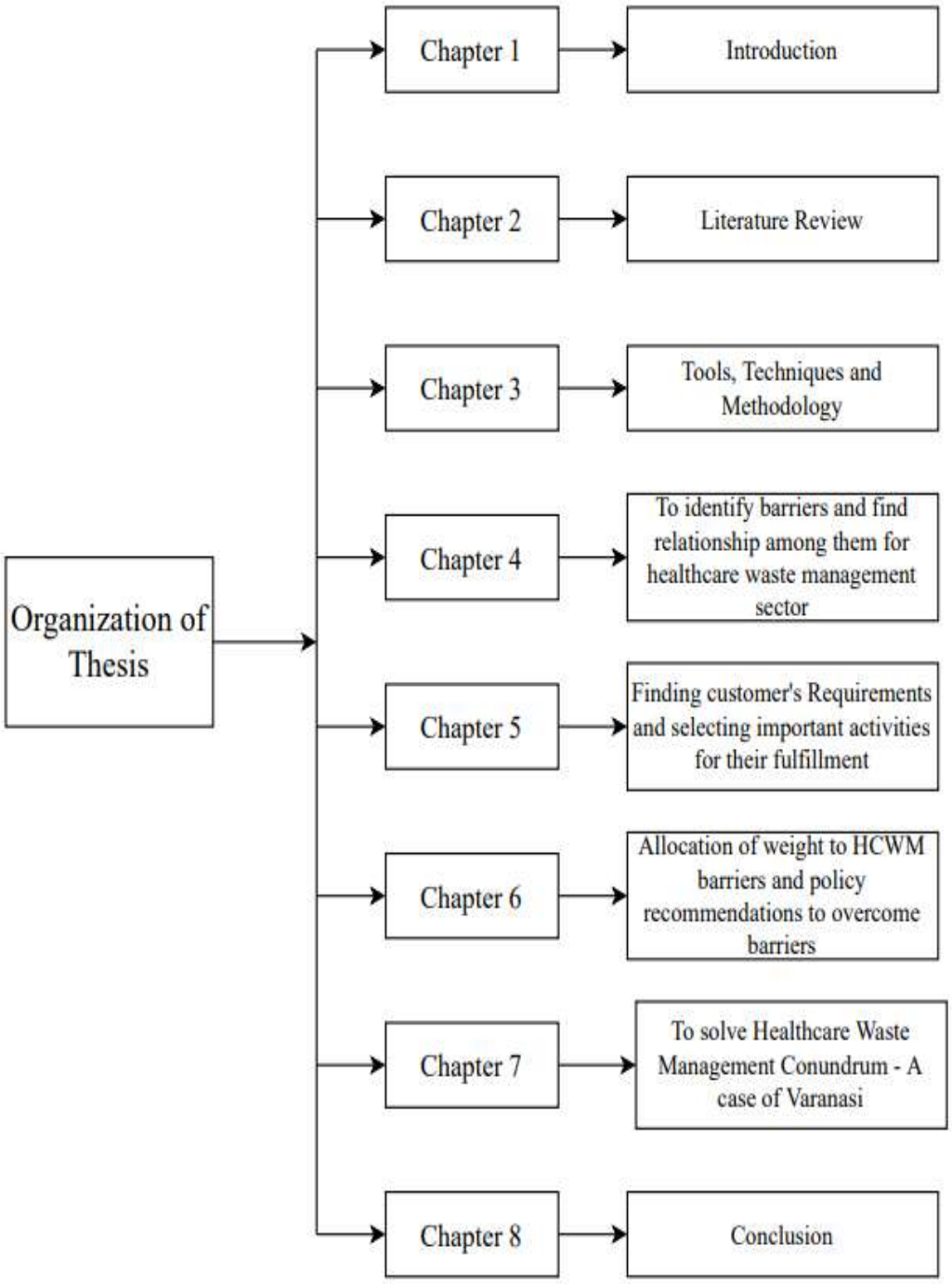

Figure 1.5 Structure of Thesis

CHAPTER 2. Literature Review:

The literature review in Chapter 2 emphasizes the careful examination of every component of Healthcare Waste Management to investigate the subject's notion. A review of the literature is done from 1996 to 2022. Using keywords like Healthcare, Barriers, hospitals India, etc., research papers were gathered for the literature review from the databases of reputable publishers, including Emerald, Taylor and Francis, Springer, Science Direct, Elsevier, and Inderscience. The literature review only included journal articles. Researchers also explore the internet, blogs, conference papers, and books in addition to journal articles, research publications, and scientific articles to gain a deeper understanding of the topic. There are many different definitions and dimensions. There are numerous examples of waste management in healthcare in the literature, many of which are examined and listed in this chapter. Finally, the gaps in the body of literature are noted, which encourages further investigation.

CHAPTER 3. Tools, Techniques, And Methodology:

This chapter explains each methodology that was used in the current dissertation. Many approaches are used in this thesis. In the first section, Total Interpretive structural modeling (TISM), Decision-making trial, and evaluation laboratory (DEMATEL) are used to create a hierarchy and determine links between HCWM barriers. TISM is a collaborative learning method that organizes closely related parts into a thorough, systematic model. The quality function deployment (QFD) method is used in the next section to plan services that systematically address customer requirements. In this part, the QFD tool and its use are discussed. A fuzzy logic approach is effective for judgments involving ambiguous and imprecise phenomena. The analytic Hierarchy Process (AHP) is employed as part of a multi-criteria decision-making (MCDM) process to assign weight to barriers. Making judgments in the context of several frequently competing criteria is the MCDM method. The last section shows a case study of a city with the help of a two-echelon location routing problem.

CHAPTER 4. To Identify Barriers and Find the Relationship Among Them for the Healthcare Waste Management Sector:

This chapter focuses on applying Total Interpretive Structural Modelling (TISM), MICMAC, and DEMATEL analysis to find the relationships among barriers and categorize them into four groups. Fifteen essential barriers to structural modeling have been identified in the literature.

CHAPTER 5 Finding customers' requirements and selecting essential activities for their fulfillment:

This chapter combines customer value perception and design requirements to construct a framework to determine the critical design needs for creating a competitive positioning strategy. By prioritizing the elements that require an immediate change to satisfy customers, this strategy aids managers. Using QFD, these design criteria are prioritized. Each section of this chapter has its heading. The consumer value perceptions are treated as demand-side items in the first part. The second section treats the strengthening factors as elements of the design specifications. The linkages between the demand side components are established in the third part. The relationships between the pieces of the design requirement are found in the fourth section. This paradigm establishes a connection between the supply and demand side items using this data. Further, key findings are discussed before the conclusion based on the analysis discussions in the earlier sections.

CHAPTER 6. Allocation of weight to HCWM barriers and policy recommendations to overcome the obstacles:

In Chapter 6, weights are assigned to HCWM Barriers (both locally and globally). The consequences are given using AHP. Decision makers must understand the rationale behind their decisions to evaluate the barriers. This foundation is known as the selection criteria. Priority ranking of Policies is done with the help of fuzzy TOPSIS**.**

CHAPTER 7. To Solve Healthcare Waste Management Conundrum -A Case of Varanasi:

This chapter performs a case study in one of India's unplanned, heavily dense cities (Varanasi). The problem is proposed as a two-echelon location routing problem. The prime minister's Constituency, Varanasi, prepares to become a smart city. The city's unplanned structure and plenty of recognized and unregistered hospitals make treating waste from these hospitals a complex undertaking, as we have described in our discussion of the state of healthcare waste management in Varanasi. A collecting site concept has been presented to address the problems associated with healthcare waste treatment since handling the waste is more expensive and time-consuming due to the large number of hospitals. As stated, big vehicles shouldn't go on tiny roads. Small vehicles must be available at the collection site to directly pick up waste from hospitals and transport it via large trucks to the processing plant for treatment. This way, the Varanasi hospital waste management issue can be approached as a two-layered challenge. A layer separates the processing facility from the collection sites, while other separates them from hospitals.

CHAPTER 8. Conclusion and Future Scope:

This chapter concludes the study's significant findings, recommendations, future scope, and limitations. It also discusses the specific contributions.

Finally, this thesis identifies the barriers to Healthcare Waste Management in Chapter 4. The 5th chapter deals with Finding Customers' Requirements and selecting essential activities for their fulfillment by combining the results of Chapter 4, the 6th chapter allocation of weight to HCWM barriers and policy recommendations to overcome the obstacles. The seventh chapter deals with the case study of Varanasi.