HEALTHCARE WASTE MANAGEMENT, QUANTIFICATION AND INTERVENTION IN ADDIS ABABA CITY ADMINISTRATION HEALTH BUREAU PUBLIC HEALTH FACILITIES

by

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submitted in accordance with the requirements

for the degree of

DOCTOR OF LITERATURE AND PHILOSOPHY

in the subject

HEALTH STUDIES

at the

UNIVERSITY OF SOUTH AFRICA

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November 2019

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DECLARATION

I declare that **HEALTHCARE WASTE MANAGEMENT, QUANTIFICATION AND INTERVENTION IN ADDIS ABABA CITY ADMINISTRATION HEALTH BUREAU PUBLIC HEALTH FACILITIES** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the dissertation to originality checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other education institution.

16 August 2019

SIGNATURE — **DATE**

Menelik Legesse Tadesse

HEALTHCARE WASTE MANAGEMENT, QUANTIFICATION AND INTERVENTION IN ADDIS ABABA CITY ADMINISTRATION HEALTH BUREAU PUBLIC HEALTH FACILITIES

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ABSTRACT

Healthcare waste management is very important due to its hazardous nature that can cause risk to human health and the environment. The study wished to determine the amount of healthcare waste generated in 15 public health centres and 3 hospitals and evaluate the healthcare waste management practices in Addis Ababa City Administration. The aim of the study was to develop a manual for healthcare facilities based on the findings on healthcare waste management practice, quantification and intervention. Data was obtained from questionnaires distributed to 636 randomly selected healthcare professionals, ancillary staff and managers and by means of surveying the facilities.

The mean HCW generation rate was 10.64 $\pm$ 5.79 kg/day, of which 37.26% (3.96 $\pm$ 2.017kg/day) was general waste and 62.74% (6.68 $\pm$ 4.293 kg/day) was hazardous waste from the surveyed health centres. HCW generation and quantification was not measured and documented in any of the HCFs. Quantifying HCW would help determine the type of waste as well as the HCFs that generate the highest and lowest HCW, which could have implications for resource allocation in managing HCW.

Segregation of different types of wastes was not regularly done. Some HCFs had separate storage areas for HCW and separate containers for hazardous and nonhazardous waste. In some instances, however, the containers were not clearly marked. Regarding storage, some of the HCFs had interim storage sites and HCW disposal sites. Several interim storage facilities lacked security and surveillance and were not cleaned after collection. In addition, HCW remained at the interim storage facilities for more than 48 hours before final disposal. The main forms of on-site treatment of HCW before disposal were burning, crushing sharps, sterilisation and chemical disinfection. The most common treatment method used for HCW was incineration. Most HCW handlers had not received adequate training; did not wear PPE, and did not take precautionary measures, such as washing their hands and heavy duty gloves after handling HCW. The researcher developed a manual for effective HCW management and training of HCW handlers. Based on the findings, the study makes recommendations for policy, education, HCW management, including generation, segregation, storage, transportation and disposal, and further research.

Keywords

Addis Ababa; case team; generation rate; health centre; healthcare waste; hospital; management; type of waste; visitors.

ACKNOWLEDGEMENTS

It seems like only yesterday that I began this journey and I cannot believe that I have come this far. My gratitude and praise to the Lord, without whose power and love neither I nor this study would have been conceived. No book or dissertation is the work of the author alone, therefore my sincere thanks and appreciation to the following for their contribution:

- Professor Bethabile Lovely Dolamo, my supervisor, for her guidance, support and encouragement and everything I learned from her
- The University of South Africa, for ethical clearance and permission to conduct the study
- Addis Ababa City Administration Health Bureau, for ethical clearance and permission to conduct the study at the public hospitals and health centres
- Menelik II Health Science Governing Board and College, for support to undertake the study
- The chief executive officers, medical directors, heads and staff of the hospitals and health centres, for their positive and enthusiastic support
- Alemnesh Mude Sorresa, my wife, for her unconditional love, support and understanding
- Bezawit Menelik and Hermala Menelik, my daughters, for being a constant source of joy and happiness
- My teachers, for stimulating my interest, sharing their knowledge and experience and being excellent role models
- The data collectors, for their assistance and distributing and collecting the questionnaires
- The participants, for sharing their time, knowledge and perceptions
- Rina Coetzer, for professionally formatting and finalising the manuscript
- Iauma Cooper, for critically and professionally editing the manuscript

Dedication

To my late father and mother, Legesse and Kiros Tadesse, the most remarkable man and woman I have ever known , for giving me vision and curiosity.

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LIST OF ABBREVIATIONS

AIDS	Acquired Immune-deficiency Syndrome
AOR	Adjusted Odds Ratio
BMW	Bio-Medical Waste
BMWM	Bio-Medical Waste Management
BSc	Bachelor of Science
CBWTF	Common Bio-Medical Waste Treatment Facility
CDC	US Centres for Disease Control and Prevention
COR	Crude Odds Ratio
EC	European Commission
EPA	Environmental Protection Agency
EPHLA	Ethiopian Public Health Laboratory Association
EU	European Union
EWC	European Waste Catalogue
FANC	Focus Antenatal Care
FDREMoH	Federal Democratic Republic of Ethiopia Ministry of Health Ethiopia
FMHACA	Ethiopian Food, Medicine and Healthcare Administration and Control Authority
HBV	Hepatitis B Virus
HCFs	Healthcare Facilities
HCV	Hepatitis C Virus
HCW	Healthcare Waste
HCWM	Healthcare Waste Management
HCWMT	Healthcare Waste Management Technologies
Hg	Mercury
HIV	Human Immunodeficiency Virus
HWD	Hazardous Waste Directive
HWL	Hazardous Waste List
MOE	Ministry of Environment
OPD	Out-Patient Department
PEP	Post Exposure Prophylaxis
POPs	Persistent Organic Pollutants
PPE	Personal Protective Equipment
PTS	Persistent Toxic Substances
SAMSO	Saudi Aramco Medical Services Organization
SHW	Solid Healthcare Waste
SOP	Standard Operating Procedure
SPSS	Statistical Package for the Social Sciences

UK	United Kingdom
UNEP	United Nations Environmental Programme
UNIDO	United Nations Industrial Development Organization
USA	United States of America
WDL	Waste Disposal Law
WHO	World Health Organization

CHAPTER 1

ORIENTATION TO THE STUDY

1.1 INTRODUCTION

Healthcare waste produced in the course of health care activities entails a higher risk of infection and injuries than municipal waste. Moreover, it poses serious threats to environmental health and requires specific treatment and management prior to its final disposal (Sorooshian, Teyfouri & Ali 2014:221). Different kinds of therapeutic procedures (surgery, delivery, resection of gangrenous organs, autopsy, biopsy, para-clinical tests, and injections) are carried out in healthcare facilities and result in the production of hazardous substances, including pathological and infectious wastes, sharp objects and chemical materials. These healthcare wastes may carry germs of disease such as hepatitis B and AIDS (Prüss-Ustün, Rapiti & Hutin 2005:482). In developing countries, healthcare waste has not received much attention and has been disposed of together with municipal waste (Pichtel 2014:549). In Ethiopia, improper healthcare waste management is alarming and poses a serious threat to public health (Tadesse & Kumie 2014:1221).

The risk of healthcare waste and its management has become a global cause of concern. The management of healthcare waste requires increased attention and diligence to avoid substantial disease burden associated with poor practice, including exposure to infectious agents and toxic substances (Chartier, Emmanuel, Pieper, Prüss, Rushbrook, Stringer, Townend, Wilburn & Zghondi, 2014; World Health Organization [WHO], 2018). According to the United Nations Environmental Program (UNEP 2005:18), healthcare waste is one of the most troublesome forms of waste and one of the most important environmental concerns for the global community. Healthcare waste production at hospitals and its management are important issues worldwide (Cheng, Sung, Yang, Chung and Li 2009:440). Since the mid-1990s the world has experienced a dramatic increase in the amount of hazardous waste generated. At the same time, a vigorous drive for sustainable development and increased environmental awareness and concern (Ketlogetswe, Oladirang & Foster 2004:67). The poor management of Healthcare Waste (HCW) is associated with a lack of adequate training of healthcare workers and disposal practices, including disposal with municipal waste together with some autoclave treatment and incinerator use.

Healthcare waste has done much damage to the environment and public health and been the cause of a high death toll from waste-related diseases (Kumar, 2006). A severe outbreak of acute respiratory syndrome in Taiwan led to serious steps in managing healthcare waste (Cheng, Li & Sung 2010:1690-1695). A comparison of waste classification between China and the EU, Japan, and the USA found that incinerator workers and people living near incinerators had significantly higher levels of dioxins, furans and hydrocarbon compound in their blood and urine (Wen, Luo, Hu, Wang, Chen, Jin, Hao, Xu, Li & Fang 2014:321-333).

Studies have been conducted on the generation rate and composition of healthcare waste in Africa. Longe (2012:562-571) examined the healthcare waste status in selected healthcare facilities in Lagos State, Nigeria. Azage and Kumie (2010:119-126) and Tadesse and Kumie (2014:1221) examined healthcare waste generation and management in Ethiopia.

The studies conducted in Ethiopia health centres and hospitals focused on healthcare waste generation and did not consider its management and intervention. This study wished to assess the generation rate and management system in order to use the information acquired to prepare a manual for healthcare waste handlers. The manual should improve healthcare workers' knowledge, skill and attitude towards healthcare waste management practice in general in Addis Ababa City Administration Health Bureau Health Facilities.

1.2 BACKGROUND TO THE RESEARCH PROBLEM

By achieving the goals of minimizing health problems and removing potential risks to human health, health services inevitably create waste that can pose a health hazard in itself (Chartier et al 2014:147). Healthcare waste (HCW) management is a worldwide issue. The majority of the problems are associated with an exponential growth in the health care sector together with low or non-compliance with guidelines and recommendations (Acton 2011:782). For example, in Mauritius, the percentage of healthcare waste has increased significantly since the 1990s due to population growth, increased number and size of healthcare facilities and the use of disposable medical products (Mohee 2005:575). Failure to control healthcare waste management directly affects healthcare workers in healthcare facilities, the public and the natural environment (Goddu, Duvvurik & Bakki 2007:134). Worldwide attention has been given to the risks associated with HCW and HCW management. In Korea, Jang, Lee, Yoon and Kim (2006:107) found that policy on healthcare waste management was inadequate and required strengthening.

There is growing public concern about HCW in Ethiopia, particularly in Addis Ababa (Ethiopian Public Health Laboratory Association [EPHLA], 2014). The concern is about the lack of appropriate HCW segregation, selection, handling, storage, transport, treatment and final disposal. A large proportion of HCW consists of solid and liquid waste, which cause health hazards and physical and natural environmental degradation. This motivated the researcher to conduct this study to assess the management and quantification of HCW in health facilities in Addis Ababa City Health Bureau. Between 2011 and 2016, the Addis Ababa City Administration Health Bureau built more than 60 health centres and one (1) referral hospital. In addition, the expansion of infrastructure and services to hospitals and health centres is also critical for the production of healthcare waste.

Ethiopia is a landlocked country in Eastern Africa with features that have been typical of a developing country with a rapidly growing economy since 2008. Addis Ababa, the capital city of Ethiopia and the social and political seat of the African Union and other diplomatic missions, is one of the major growing cities on the continent. In response to the population's health needs, the city administration allocates budget for the expansion of the existing health facilities and building new hospitals and health centres.

1.3 STATEMENT OF THE RESEARCH PROBLEM

Because of the expansion of manufacturing, tourism and business sectors, the development plan and the construction of healthcare facilities are necessary to accommodate population growth after economic change. The growth in the health sector has led to increased HCW generation. Protecting human health, the environment and natural resources must be a priority in the management of healthcare waste. In Addis Ababa, the health centres and hospitals produce a huge amount of solid healthcare waste per year. The high generation of healthcare waste is due to the increasing population and the use of healthcare facilities that exceeds the ability of the city administration to manage the increased amount of healthcare waste. The condition has been worsened by a lack of adequate technical, technological and human resources to deal with the problem. In addition, incinerators release different emissions of gases into the environment and cause air pollution. Frequently, placenta and surgical waste, and the remaining ashes from the incinerators are not properly disposed of.

Poor waste management practices at the level of healthcare facilities, including failure to segregation of waste and errors in the colour coding of waste disposal, can result in hazardous waste being disposed of not only improperly, but also accessible to community members (Mohan 2009:78). In Botswana, Mbongwe, Mmereki and Maqashula (2008:226) found that due to a lack of understanding of the importance of color coding and segregation in the management of healthcare waste, patients were given healthcare waste bags for their personal belongings and clothing after being discharged from the hospital. Sharp containers located in less secure storage facilities can also contribute to the scavenging and reuse of containers containing equipment. Tadesse and Kumie (2014:1221) found that handling of healthcare waste at some facilities in Addis Ababa was haphazard and unacceptable methods of transport were used. This indicated that the HCW management system in Addis Ababa required attention for effective and sustainable healthcare waste management. Incorrect HCW management practice presents risks to health centre and hospital staff, rag pickers, municipal workers, the community at large, and the environment. There is an urgent need for healthcare waste management guidelines for healthcare facilities, training for new employees of healthcare facilities, and regular refresher courses for all staff members in health care facilities. Infection prevention protocols developed for healthcare waste handlers, their supervisors and management must be followed. Waste from healthcare has the potential to damage the environment, especially soil, water and air, and wildlife. Consequently, HCW requires safe management, using suitable treatment and disposal methods.

1.4 THEORETICAL GROUNDING OF THE STUDY

A conceptual framework enhances understanding of the phenomenon being studied and is required for phenomenon awareness (LoBiondo-Wood & Haber 2014:84; Polit &

Beck 2012:264; Burns, Grove & Gray 2013:117). A theory explains a set of relationships that offer a phenomenon insight (Kitson, Rycroft-Malone, Harvey, McCormack, Seers & Titchen 2008:3:1). A conceptual framework is less formal than a theory. A theory is a collection of established and interrelated phenomenon concepts and is based on abstract thoughts, findings and lived experiences (Burns & Grove 2012:117; LoBiondo-Wood & Haber 2014:84-85).

This study was based on Tesfahun, Kumie, Legesse, Kloos and Beyene's (2014:215-220) assessment of the composition and generation rate of healthcare wastes in selected public and private hospitals of Ethiopia. Tesfahun et al (2014) found that the healthcare waste generation rate could be affected by the waste management practices of the hospitals. The hospitals' healthcare waste generation rates were affected directly by the number of patients (the number of patients was determined by the type of service, geographic location and the seasons of the year).

The study wished to determine the waste management practices of the Addis Ababa City Administration health facilities to restore patient and public safety. The aim was to determine the management practices of segregation, minimization, waste treatment, proper storage, quantification and proper waste disposal in the health facilities, including recycling and reusing to help maintain cleanliness of the environment.

Conceptual framework for this study focused for gathering the relevant data with a view to obtain answers to research questions. The conceptual framework illustrates the healthcare waste management practice in health centres and hospitals and discuss the independent and dependent variables of this research. The quantification of the amount of healthcare waste generated (quantities and compositions) in 15 health centres per patient. In this study during observation in the healthcare facilities to observe the health workers, managers and ancillary staffs' familiarity with health care waste management policies, procedures and implementation in their workplace and comply with healthcare waste management code of practice. After the empirical findings of research, the researcher believes to improve healthcare waste management practice to healthcare facilities in Addis Ababa City Administration Health Bureau public health facilities and the whole regions in Ethiopia. Therefore, it is critical need the development of a manual for effective management of healthcare waste. Figure 1.1 illustrates the relationship between factors affecting the healthcare waste generation rate.

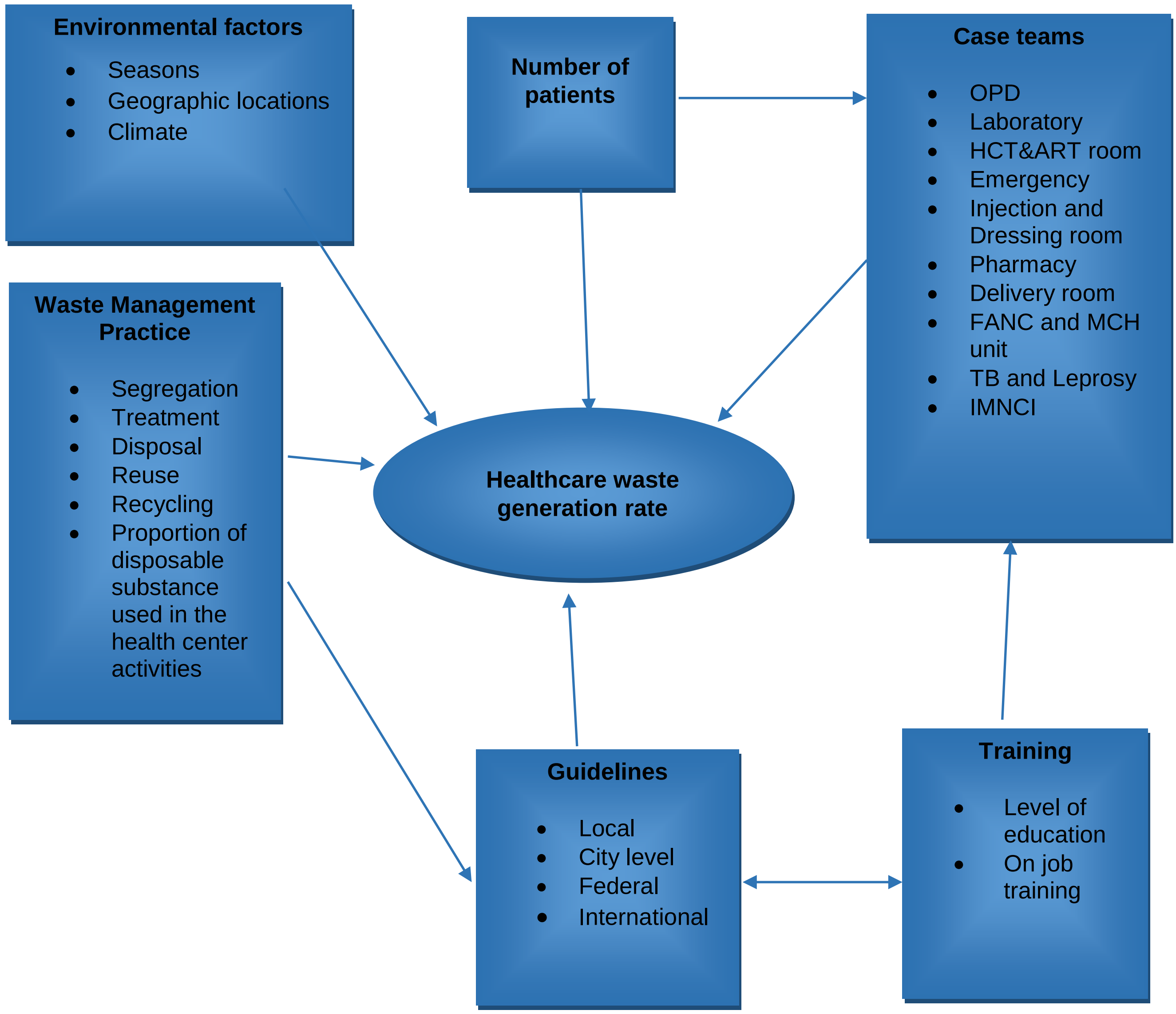


Figure 1.1 Conceptual framework showing the relationship between factors affecting healthcare waste generation rate

(Adapted from Tesfahun, Kumie & Beyene 2014:19)

1.5 PURPOSE AND OBJECTIVES OF THE STUDY

The purpose of the study indicates the objective of the study based on the problem statement (LoBiondo-Wood & Haber 2014:34-35; Burns, Grove & Gray 2013:93-94). This research aimed at developing a manual for the management of healthcare waste for health care facilities based on the findings for the Addis Ababa City Administration Health Bureau public health facilities in Ethiopia.

1.5.1 Objectives

The objectives are what a researcher wishes to achieve at the end of a study (Babbie 2014:88). Research objectives are brief statements expressed in the present tense and focus on one or more variables that clearly indicate whether the variables are to be defined or explained (Burns, Grove & Gray 2013:145). The research objectives are extracted from the problem statement and test intent and in a quantitative study explain the study variables and population (Burns, Grove & Gray 2013:93).

In order to achieve the purpose, the objectives of the study were to:

- Assess the current healthcare waste management practices in Addis Ababa City Administration Health Bureau public health facilities.
- Quantify the amount of healthcare waste generated in health centres in Addis Ababa City Administration Health Bureau public health facilities per patient utilization.
- Determine the level of knowledge and awareness of individuals involved in healthcare waste management in relation to waste management policies and procedures.
- Determine the extent to which the Addis Ababa City Administration Health Bureau implement and comply with healthcare waste management Code of Practice guidelines and all other related national waste management strategies.
- Develop a manual for the effective management of healthcare waste based on the findings in Addis Ababa City Administration Health Bureau public health facilities.

1.5.2 Research questions

A research question is a short query statement made up of one or more variable designed to fill a knowledge gap (Burns, Grove & Gray 2013:148; Rubin & Babbie 2010:41; LoBiondo-Wood & Haber 2014:26). Research questions help to define important study variables, relationships between variables and the study population in quantitative studies (Polit & Beck). This study wished to answer the following research questions:

- What are the different types and quantities of healthcare waste generated in Addis Ababa city administration health bureau public health facilities?
- How is healthcare waste management handled in Addis Ababa city administration health bureau public health facilities?
- To what extent are health workers familiar with healthcare waste management policies and procedures?
- To what extent do healthcare facilities implement and comply with the healthcare waste management code of practice?

1.6 SIGNIFICANCE OF THE STUDY

This study provides information about healthcare waste generation, quantification, and management practice and systems in healthcare facilities. The findings should assist policy makers the healthcare waste legislation in Addis Ababa City Administration Health Bureau Healthcare Facilities, Regional Health Bureaus and at Federal Level Healthcare Facilities. The study hoped that will provide valuable information for decision-makers, government organization like:

- Ethiopian Environmental Protection Agency.
- Educational institutions like universities and other teaching and training institutions.
- Non-governmental organizations like professional associations will gain more knowledge.
- Private healthcare facilities for designing policies, planning, promotional, supervisory activities and help to prepare the intervention strategy on the main components of healthcare waste management system.

1.7 DEFINITIONS OF KEY CONCEPTS

A concept describes and assigns an object/phenomenon name in abstract terms, giving it an identity and meaning (Burns, Grove & Gary 2012:117-118; LoBiondo-Wood & Haber 2014:84-85). A conceptual description replaces a dictionary definition and is firmly rooted in theoretical literature, helping to standardize the use of concepts in a discipline (Burns, Groves & Gary 2012:117-118). In this study the following terms were used as defined below.

Health bureau: In this study the health bureau referred to the government office that administers all health facilities in the Addis Ababa City Administration.

Healthcare waste management practice referred to when four indicators for healthcare waste management system are exercised; that is, always using PPE during handling of waste; segregating wastes with the available containers; treating infectious wastes, and always using the available waste bins for transportation to disposal.

Healthcare waste: The total healthcare waste stream from healthcare facilities, services and case teams constituting general waste and hazardous waste (sharps, infectious waste, and pharmaceutical waste). Healthcare waste includes several different waste streams, some of which require more stringent care and disposal.

Intervention: In this study an intervention referred to the strategy to mitigate the existing problem of healthcare waste management by developing manual.

Quantification referred to the act of counting and measuring waste.

Public health facilities referred to government owned hospitals and health centres.

Waste generation referred to the amount of wastes generated during the extraction of raw materials.

1.8 THE STRUCTURE OF THE DISSERTATION

Chapter 1 introduces the orientation to the study. An overview and introduction to the study is given.

Chapter 2 discusses the literature review conducted on the research topic in terms of sources consulted on the topic and research methods used.

Chapter 3 discusses the research design and method followed to conduct the study. The type of design, the population and sample, the sampling procedures, data collection and analysis and instrument used are discussed and justified.

Chapter 4 presents the process followed in data analysis, the sample realisation, data management and analysis, presentation and description of the research results, and an overview of the research findings.

Chapter 5 presents manual preparation for healthcare waste generation and management practice.

Chapter 6 details the summary and interpretation of the research findings, makes conclusions, contributions and recommendations from the findings and discusses the limitations of the study.

1.8 CONCLUSION

This chapter introduced healthcare waste (HCW), management practice and quantification at global and local level. The chapter also described the background to the research problem, the research problem statement, the theoretical basis of the study, the purpose and objective of the study, the research problem and the main concept definitions used in the study.

Chapter 2 discusses the literature review conducted for the study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discusses the literature review conducted for the study. A literature review involves researching, reading and understanding literature relevant to the study (Brink, Van der Walt & Van Rensburg 2006:55). In addition, it assists researchers to comprehend and extend their knowledge of the phenomenon under study (Polit & Beck 2012:105). The literature review addressed healthcare waste, regulations, policies and technologies for healthcare waste in developed and developing countries. The researcher reviewed books, journals, online resources and reports from healthcare organizations.

2.2 HEALTHCARE WASTE

Healthcare waste (HCW) refers to the total waste stream generated by healthcare facilities, hospitals, health centres, clinics, hospitals, centers of medical research, pharmaceutical factories, blood banks, animal health centres, home healthcare activities and research facilities related to health. (World Health Organization [WHO] 2018:1; Environmental Protection Agency [EPA] 2015).

Healthcare waste refers to all waste generated by healthcare facilities (in this study, health centres and hospitals) including biological and non-biological waste, hazardous and non-hazardous waste and chemicals that are not intended for further use and that will be discarded. These wastes consist of solid hazardous and non-hazardous waste, liquid hazardous and non-hazardous waste, and radioactive waste in small proportions (Pichtel 2014:549).

Healthcare waste generated from healthcare facilities can be broadly categorized as non-hazardous (general) and hazardous waste and is composed of general waste, the largest proportion of which is treated as domestic waste (Pichtel 2014:549). However, some waste generated in healthcare establishments is too hazardous to be treated negligently and carelessness in the management of this waste may spread infection and contaminate the surrounding environment (Rahman, Rahman & Patwary 2008:875). Healthcare waste (HCW) has become a global public health problem. The hazardous portion of HCW can present occupational health risks and its inappropriate disposal presents overall environmental hazards. An approximate 75% to 90% of the waste generated by health care facilities is non-hazardous waste comparable to domestic waste (Komilis, Fouki & Papadopoulos 2012:1434; Sharma, Kumar, Mathur, Singh, Bhatnagar & Sogani 2013:1). Moreover, 85% of hospital and healthcare facility wastes have no risk of contamination and pose no risk of infection (Kumar, Dhanapal, Ravi, Rao & Manavalan 2011:146). Of the total amount of waste generated by healthcare activities, 85% is general, non-hazardous waste and 15% is considered hazardous material that may be infectious, toxic or radioactive (WHO 2018; Komilis et al 2012:1434).

Hazardous waste contains hazardous substances that present a threat to human health and the environment. Budd and Baker (2013:45) found that between 10% and 25% of healthcare wastes were infectious and included biological (from human and animal body fluids), radioactive, chemical waste and pharmaceutical that can pose a variety of health and environmental hazards.

Hospital waste or healthcare facility waste includes healthcare waste, infectious waste, and regulated medical waste. In 1988, after medical wastes washed up on beaches in the United States, the Medical Waste Tracking Act of 1988 was introduced to address the healthcare waste handling and disposal in coastal areas (Pichtel 2014:549; EPA 2015). The Act defines healthcare waste as any solid waste produced by human or animal diagnosis, treatment or immunization, research related to it, or development or biological experimentation (Pichtel 2014:549; EPA 2015).

The terms “healthcare waste”. “infectious waste”, “hospital waste” and “medical waste” are used interchangeably. Furthermore, there is no consensus on a single definition of healthcare waste. The aim of this study was to develop a manual for healthcare waste management (HCWM) for healthcare facilities, based on the findings for the Addis Ababa City Administration Health Bureau public health facilities in Ethiopia on healthcare waste management practice and quantification. The results should provide insight into solution strategies for policy makers, healthcare facility managers, healthcare workers and the community at large. In addition, the findings should assist in training and education, monitoring and evaluation.

The literature review explored waste management in different countries and cultures and technologies that are used for the different types of wastes for the purpose of segregation, collection, treatment, disposal and comparison, as well as technologies for safe HCW management to minimise hazards and risks.

Healthcare waste is often called a "hospital waste" subcategory and refers to potentially infectious waste generated by healthcare facilities (Komilis & Katsafaros 2011:170; Komilis, Fouki & Papadopoulos 2012:1434). In healthcare facilities, especially in general and specialized hospital settings, including X-ray treatment and radiotherapy rooms, radioactive materials to avoid any health and environmental hazards caused by emissions should be properly stored, transported and treated. Hossain, Rahman, Balakrishnan, Puvanesuaran et al (2013:556) categorised waste generated in healthcare facilities as blood and blood products, body parts and contaminated animal carcasses, pharmaceutical wastes, medical and veterinary laboratory wastes, used sharps, contaminated materials and equipment, infectious agents and cultures and related biological waste, dialysis unit waste and surgical and autopsy waste.

2.3 CLASSIFICATION OF HEALTHCARE WASTE

Healthcare wastes are classified as non-hazardous and hazardous waste. Nonhazardous waste is generated in the patients' ward areas, out-patient departments, kitchens, offices, and patient waiting areas (Cheng, Sung, Yang, Chund & Li 2009:440). Non-hazardous waste includes kitchen waste, paper and wool and does not cause any particular human or environmental problems or health hazards (Mohan, Prasad & Kumar 2012:70).

In healthcare facilities, different areas such as the medical laboratory, pharmacy, delivery rooms, operating theatres, and emergency, injection and vaccination rooms produce healthcare waste. The amount and proportion of healthcare waste differs depending on the procedures, including pathological and chemical wastes and infectious sharps. Figure 2.1 depicts the World Health Organization (WHO) classification of healthcare waste, 1999.

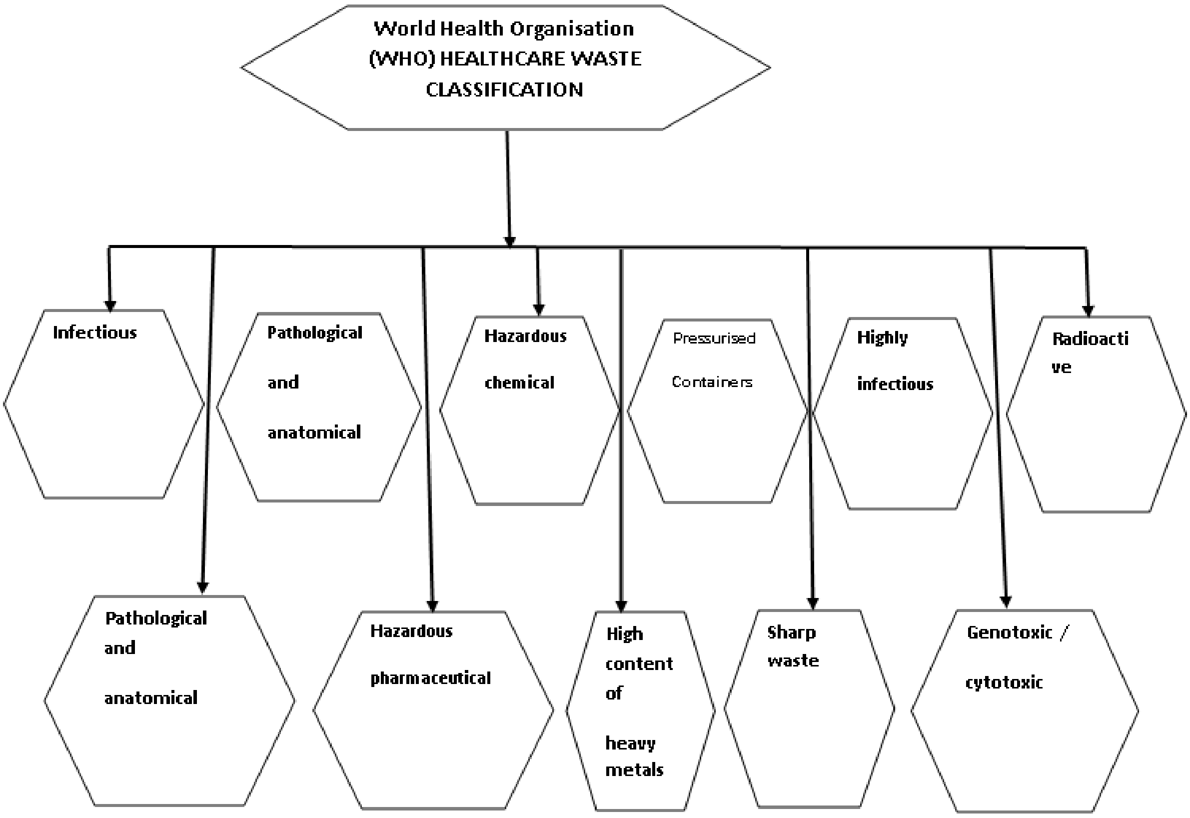


Figure 2.1 WHO healthcare waste classification, 1999

(Source: Prüss, Giroult & Rushbrook 1999:2)

2.3.1 Genotoxic/cytotoxic waste

Genotoxic/cytotoxic waste consisting of or containing substances with genotoxic properties, including cytotoxic and antineoplasic drugs; genotoxic chemicals. It can be found in vomit, urine, or faeces from patients treated with cytostatic drugs, chemicals, and radioactive material (Prüss et al 2013).

2.3.2 Hazardous chemical waste

Hazardous chemical waste consists of discarded solid, liquid, and gaseous, chemical that is ignitable, corrosive, reactive, toxic, or persistent, and is no longer useful or wanted. Chemical waste from healthcare may be hazardous or nonhazardous; in the context of protecting health (Lone Star College 2010).

2.3.3 Hazardous pharmaceutical waste

Hazardous pharmaceutical waste consists of or contains pharmaceuticals, including expired or no longer needed containers and/or packaging, contaminated pharmaceutical products, drugs and vaccines or containing pharmaceuticals (bottles, boxes) (Schwartz, Eng, Frieze, Gosselin et al 2010:S1).

2.3.4 Heavy metals waste

Heavy metals waste consists of materials and equipment with heavy metals and derivatives, including batteries, thermometers, and manometers (Fu & Wang 2011:407).

2.3.5 Highly infectious waste

Highly infectious waste includes cultures and stocks of highly infectious agents, waste from autopsies, animal bodies, and other waste items that have been inoculated, infected, or in contact with such agents (WHO 2014:2).

2.3.6 Infectious waste

Infectious waste consists of discarded materials from healthcare activities on humans or animals which have the potential of transmitting infectious agents to humans. These include discarded materials or equipment from the diagnosis, treatment and prevention of disease, assessment of health status or identification purposes, that have been in contact with blood and its derivatives, tissues, tissue fluids or excreta, or wastes from infection isolation wards (WHO 2014:4).

2.3.7 Pathological waste

Pathological waste consists of tissues, organs, body parts, human fetuses and animal carcasses, blood, and body fluids. Within this category, recognizable human or animal body parts are also called anatomical waste. This category should be considered as a subcategory of infectious waste, even though it may also include healthy body parts (Pichtel 2010 cited in Alhadlaq (2014:27)).

2.3.8 Pressurised container waste

Pressurised container waste consists of full or empty containers or aerosol containers containing pressure liquids, gas or powdered materials (Mathur 2014:81).

2.3.9 Radioactive waste

Radioactive waste includes unused liquids from radiotherapy or laboratory research; contaminated glassware, packages or absorbent paper; urine and excreta from patients treated or tested with unsealed radio nuclides and sealed sources (Demirbas 2011:1280).

2.3.10 Sharp waste

Sharps are items that could cause cuts or puncture wounds, including needles, hypodermic needles, scalpel and other blades, knives, infusion sets, saws, broken glass, and nails. Whether or not they are infected, such items are usually considered highly hazardous healthcare waste (Ananth, Prashanthini & Visvanathan 2010:154). Figure 2.2 presents the Environmental Protection Agency's hazardous healthcare waste classification, 2015.

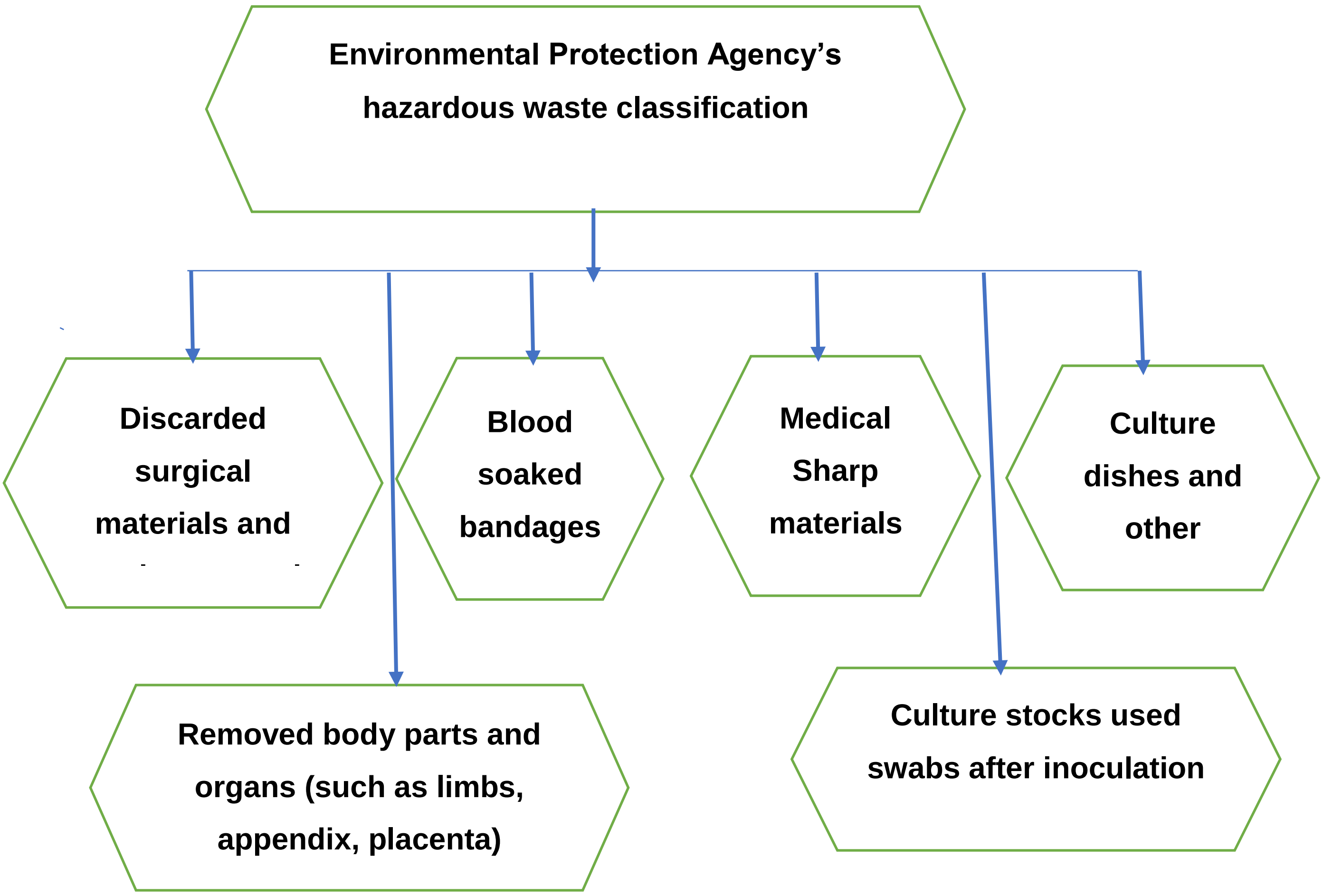


Figure 2.2 EPA's hazardous healthcare waste classification, 2015

(Source: Environmental Protection Agency (EPA) 2015:31)

Of the total waste in healthcare facilities, approximately 80% is non-infectious; 15% is infectious; 3% is chemical or pharmaceutical; 1% is pathological sharp, and less than 1% is pressurised cylinder or broken thermometer waste (Budd & Baker 2013:45-48; Cheng, Sung, Yang et al 2009:440-444; Lu, Chang & Liao 2013:1557).

2.4 HEALTHCARE WASTE CATEGORIES

For the purpose of risk assessment, the World Health Organization (WHO) established criteria and five categories of healthcare waste (Chaerul, Tanaka & Shekdar 2008:442). Table 2.1 lists the WHO healthcare waste categories, 2008.

Table 2.1 WHO healthcare waste categories, 2008

Category	Description
A	• Blood and blood products • Waste from the treatment of patients that are significantly soiled with blood, pus or serous fluids such as surgical dressings, swabs and other. • Tissues from human
B	• Used syringe needles discarded • Cartridges • Sharp such as broken glass and other contaminated disposable devices or objects
C	• Waste from departments of pathology (clinical laboratories and post-mortem rooms) and microbiological cultures
D	• Unused or expired pharmaceuticals • Cytotoxic wastes
E	• Low-risk products that usually occur and are also generated in community and home settings • Objects used for the disposal of faeces, urine and other body fluids or excretions assessed not known to fall under Group A • Used pans or bed pan liners, pads for incontinence, stoma bags and containers for urine • Products that are known to be healthcare waste only if they come from patients with dangerous etiological agents. They will be treated in the same way as Group A wastes

(Source: Chaerul, Tanaka & Shekdar 2008:442-449)

The portion of HCW capable of producing an infectious disease is considered infectious waste (Sehulster et al 2003:18). Five conditions are necessary for infection to occur for waste to be infectious, namely:

- a virulent pathogen
- sufficiently high dose
- portal of entry
- host resistance must be present.
- adequate number of pathogenic organisms (dose)

Infectious wastes are biological wastes: blood and blood products, cultures and stocks, sharps and pathological waste (Sehulster et al 2003:127). Some waste produced in health care facilities can be handled as normal, solid municipal waste, but special attention must be paid to a varying proportion of HCW including sharp needles, razors and scalpels; pharmaceutical waste; pathological waste; other potentially infectious waste; hazardous chemical waste and biological waste (Bartley, Olmsted & Haas 2010:S1; Babanyara 2013:757; Blenkharn 2009:860). These wastes are known as special healthcare waste (SHW). Isolation wards and microbiological laboratories need special attention because these services produce more biological and infectious waste.

In their study, Pandelova, Stanev, Henkelmann, Lenoir and Schramm (2009:685) found that many healthcare facility staff members involved in healthcare waste handling were exposed to health risks from chemical waste, biological waste and other special healthcare wastes. Inappropriate disposal of SHW, including open dumping and uncontrolled burning, increases the risk of spreading infections and of exposure to toxic emissions from incomplete combustion. Therefore, occupational health and safety should be included in healthcare waste management plans (Pandelova et al 2009:685).

In a case study of the City of Jakarta, Indonesia, Chaerul, Tanaka and Shekdar (2008:442) found that hospital waste generation was affected by various factors. To minimise the risk to public health, waste segregation as well as infectious waste treatment prior to disposal had to be conducted properly by hospital management, especially when scavenging took place in landfill sites in developing countries. Between 10% and 25% of infectious waste represented significant danger to staff, patients, visitors and the environment. Management thus involved collection, sorting, transport, storage, treatment and final elimination (Chaerul, Tanaka & Shekdar 2008:447). World health organization (2017:7) globally, in 2015, an estimated 257 million people were living with HBV infection and 71 million people with chronic HCV infection and 36.7

million persons living with HIV in 2015. Laboratory reagents, drugs and mercury thermometers face other toxic risks (Ho & Liao 2011: 2631). When disposing the biological waste, greater attention and care is needed as they are a special healthcare waste. In many countries including Ethiopia have different culture for disposal and burial of body parts. Cultural factors should be included in the biological waste disposal plans (Faisal, Khan & Farooqi 2010:154).

Improper disposal of wastes impacted directly and indirectly on the health of healthcare workers and communities and on the environment. Consequently, the collection, transportation and disposal of hospital waste were critical. Moreover, regarding the disposal and burial of body parts, it was important to consider cultural factors in planning for the disposal of biological waste (Faisal, Khan & Farooqi 2010:154).

Disease transmission is usually caused by contaminated sharp injuries. Human immunodeficiency virus (HIV), Hepatitis B Virus (HBV) and Hepatitis C Virus (HCV) needs particular concern. For example, HBV will remain contagious for a whole week if kept at room temperature even if dried, , the risk of getting a single needle stick would result in 0.3 percent of cases spreading the virus. The probability of single needle stick will result in zero conversion is 0.3 to 0.5 % and 2 to 5 % for HCV and HIV respectively (Tsakona, Anagnostopoulou & Gidarakos 2007:912).

Healthcare facilities should develop healthcare waste management plan and policies to ensure improvement and sustainable healthcare waste management practice. Community and stakeholder's participation in the preparation and implementation of healthcare waste management plan considered for sustainable disposal of healthcare waste. In the planning document the integration of regular or timely training for healthcare professionals, ancillary staffs and the community should be included. Monitoring and control processes for the system and personnel also critical. In the study area, healthcare facilities also facilitate the final disposal of genotoxic / cytotoxic waste as it is part of hazardous healthcare waste that poses disease to human health and the environment.

2.5 REGULATED HEALTHCARE WASTE (RHCW)

Though there is no universally accepted definition for Regulated Healthcare Waste RHCW, the definitions offered by regulatory agencies are similar. The Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO) and the Occupational Safety and Health Administration (OSHA) accept that "regulated healthcare waste" contains waste that has the potential to cause infection and for which special measures are prudent (Eker & Bilgili 2011:791). In addition to the inconsistency in definitions of healthcare waste and infectious waste, healthcare facilities have found ambiguities of regulations, protocols and standards in waste streams leading to confusion across hospitals, health centres, industry, and waste managers on proper management procedures. (Bartley, Olmsted & Haas 2010: S1).

The cost of managing healthcare waste affected by many definitions and the amount of waste generated that is identified as hazardous infectious healthcare waste. The CDC definitions describe 3% to 6% of total hospital waste as an infectious waste, while the wider definitions of the EPA describe 7% to 15% of hospital waste as an infectious waste. (Bai, Vanitha & Ariff 2013:1234). Since HCW disposal costs are estimated to be 6-20 times higher than solid waste disposal, healthcare facilities use as much as possible a narrow definition of HCW. It needs critical care to identify the waste stream components that are capable of transmitting disease. Because of lack of consensus of definitions, HCW per patient per day still varies.

2.6 NECESSITY OF HEALTHCARE WASTE MANAGEMENT

Healthcare waste policies are critical for safe, responsible programmes from generation to disposal of HCW (Tadesse & Kumie 2014:1221; Tesfahun, Kumie, Legesse, Kloos & Beyene 2014:215). The increasing number of infectious diseases focused public attention on HCW. The hazardous nature of HCW in Ethiopia has raised concerns about the risk posed by needles and other sharp injuries and the aesthetic degradation of the exposed environment (Habtetsion, Bock, Noel, Shanadi Bhat, Abebe & Van Roekel, 2009). In 2011, the Ethiopian Federal Ministry of Health introduced the *National Health Care Waste Management Strategic Plan, 2012-2016* to guide HCW disposal and management.

2.7 MONITORING AND CONTROL OF HEALTHCARE WASTE

The definition of “hazardous” and “waste” differs from country to country. In addition, policy and legislation on hazardous waste monitoring and control vary from country to country (Insa, Zamorano & López 2010:1048; Cheng, Li & Sung 2010:1690; Patwary, O’Hare & Sarker 2011:2900). Healthcare waste requires monitoring from the point of generation to the point of disposal. Monitoring facilities should be available in healthcare facilities to control healthcare waste programmes and reduce inappropriate handling of wastes or dumping (Zhao, Zhang, Chen, Liu & Wu 2010:181).

Today, reduce, reuse and recycle or 3R policies have become the basis of waste management and global warming countermeasures throughout the world. In 2011, Sakai, Yoshida, Hirai, Asari, Takigami, Takahashi, Tomoda, Peeler, Wejchert and Schmid-Unterseh conducted an international 3R and waste management policy comparative study in the EU, the USA, Korea, Japan and China. The study found that all the countries based their waste management on 3R policies by means of regulations to reduce greenhouse gas (GHG) emissions and other developments (Sakai, Yoshida, Hirai, Asari et al 2011:93). Draft guidelines on waste management were formulated in 2002 with respect to national laws, regulations and directives on healthcare waste (Sakai, Yoshida, Hirai, Asari et al 2011:94**)**.

Figure 2.3 presents a timeline of national legal and regulatory framework for healthcare waste management.

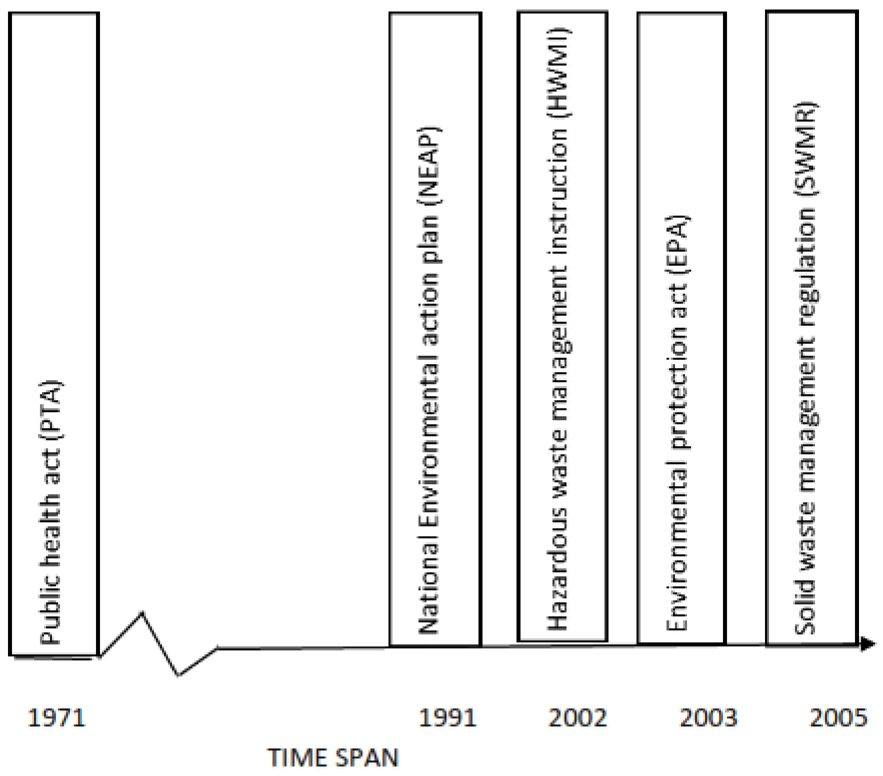


Figure 2.3 A timeline of national legal and regulatory framework for healthcare waste management

(Source: Sakai et al 2011:93-94)

Pichtel (2010 cited in Alhadlaq (2014:33)) indicated that countries and regions such as the European Union, Scandinavia, and North America focused on identifying municipal, hazardous, and industrial waste from other wastes and the incineration of hazardous wastes.

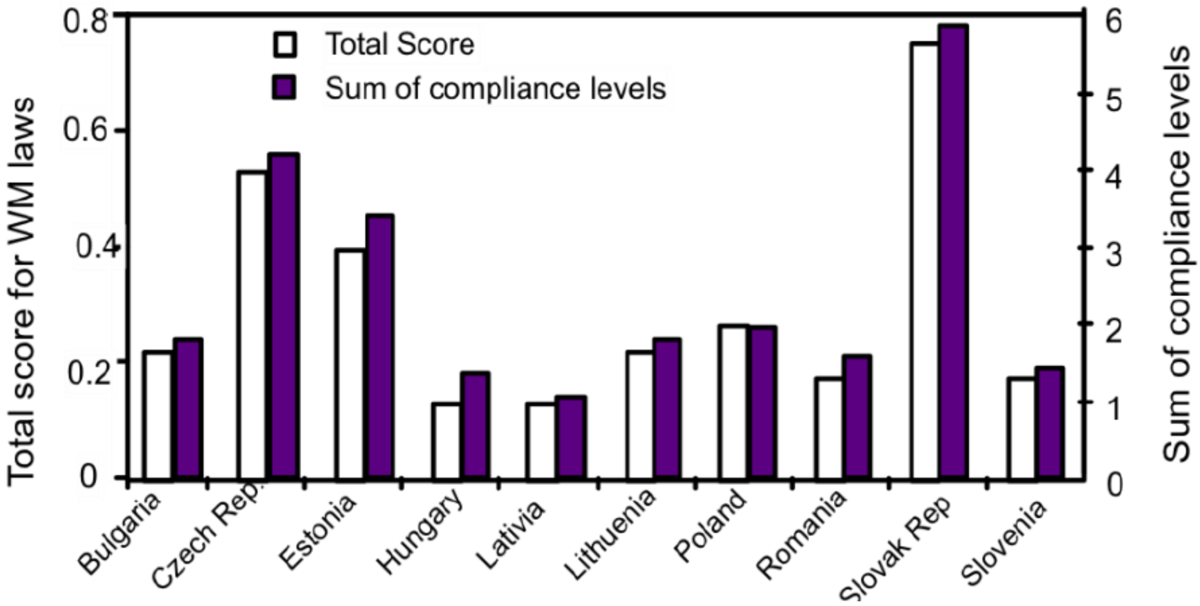


Figure 2.4 Comparison of the scores on compliance with and extent of environmental laws for the ten of the member countries in the European community, 2010

(Source: Alhadlaq 2014:34)

2.8 HEALTHCARE WASTE MANAGEMENT POLICIES IN DEVELOPED COUNTRIES

Using alternative technologies in developed countries helps the proper disposal of healthcare waste minimize risk to human**s** and the environment. Laws and good practice guidelines define healthcare waste and describe different ways of collecting, transporting, storing and disposing of such wastes (Patwary, O'Hare & Sarker 2011:1200). Waste classification differs between countries. In the United States of America, for example, about 15% of HCW is considered infectious waste, while in France 15% to 20% of HCW is considered infectious waste (Wen, Luo, Hu et al 2014:321-334; Sakai et al 2011:86). In the USA, specific rules and regulations were implemented to reduce regulated medical waste generated in operating rooms in both private and public medical institutions (Conrardy, Hillanbrand, Myers & Nussbaum 2010:711).

Healthcare waste is potentially dangerous because of the presence of pathogens. In addition, the segregation and pre-sorting of waste significantly reduced unrestrained emissions and the toxicity and quantity of ashes (Babanyara 2013:757; Demirbas 2011:1280).

2.8.1 Bulgaria

In the late 1990s Bulgaria introduced legislation on environmental health and waste management (Scheinberg & Mol 2010:18). The objective was to modernise the management of solid waste, waste resource facilities and waste conversion processes ecologically (Scheinberg & Mol 2010:18).

2.8.2 Croatia

Waste and its management were of grave concern in Croatia. Waste management was the single largest problem in the area of environmental protection in European private healthcare facilities (Botelho 2012:5). Healthcare waste management in Croatia is regulated by act, waste categorization regulations and healthcare waste management directives (Mühlich, Scherrer & Daschner 2003:260; Pires, Martinho & Chang 2011:1033). Croatia's waste management policy is based on the principle of sustainable development and outlines waste management concepts from the point of generation to the point of final disposal. Waste management education increased responsibility for waste organization and management. The population is constantly instructed on waste sorting, recycling, composting and ways of disposal (Pires et al 2011:1033; Botelho 2012:6).

2.8.3 Czech Republic

The waste management policy of the Czech Republic is outlined in the State Environmental Policy and Implementation Plan and the National Waste Management Strategy which are regularly updated and supplemented by regional waste management implementation (Czech Republic EPA 2014:31).

2.8.4 Japan

In Japan, the definition of HCW includes materials generated from healthcare facilities as a result of medical care and infectious disease research. The first regulation on healthcare facilities for human and animals was disseminated in 1992 (Pariatamby & Fauziah 2014:15). Healthcare facilities used intermediate treatment, such as sterilization or melting and incineration, to reduce non-infectious HCW. The management of HCW has become increasingly demanding and healthcare facilities in Japan employ strict measures to reduce HCW and to protect HCW handlers from infectious disease (Pariatamby & Fauziah 2014:15; Wen, Luo, Hu, Wang, Chen et al 2014:324).

2.8.5 Poland

Poland has introduced a national waste management strategy and implementation plan for the management and reduction of health waste in accordance with EU standards (Saner, Blumer, Lang & Koehler 2011:67). The legislation and strategies aimed to

- Set as a short-term priority national, regional and local land filling limits.
- Reduce waste generation and increase waste recycling
- Create a collection system and implement waste management plans.
- Achieve the successful removal of old landfills and reduce the amount of bio-degradable waste landfills.
- Implement specific legal instruments for hazardous, non-hazardous and municipal waste and waste water treatment sludge.

2.8.6 South Korea

In South Korea, healthcare facilities and animal clinics, medical laboratories and health research centres are the sources of HCW (Chung 2013:72). The amount of highly infectious and hazardous materials from HCW was small compared to the solid waste stream. Until 1999, HCW was regulated by the Ministry of Health and Welfare (Min & Rhee 2014:173-194). HCW was most often disposed of in municipal landfill sites without proper treatment facilities. The national assembly of South Korea amended the 1999 Waste Management Act to improve HCW control from the point of generation to the final disposal destination. The Korean Environment Ministry (MOE) has been responsible for the implementation of the Act (Richards & Haynes 2014:255).

The Act classified HCW as hazardous waste and incorporated the segregation, packaging, tracking, and disposal of HCW. HCW has been described as any solid waste generated by healthcare facilities and laboratories. The size of healthcare facilities and medical services result in the quantity and variety (Richards & Haynes 2014:255; Min & Rhee 2014:173). Healthcare facilities in South Korea had limited information about the handling and disposal of HCW. The problems associated with poor management of healthcare waste include harm to humans by sharp instruments, and toxic and hazardous chemicals (Gautam, Thapar & Sharma 2010:191).

2.8.7 The United Kingdom (UK) and European Union (EU)

The United Kingdom (UK) health sector was concerned about reducing HCW (Costa, Massard & Agarwal 2010:815). The National Health Services (NHS) endorsed a ten-year strategy for healthcare waste management, which involved a change in policies and practices. In order to develop a sustainable development environment, the NHS implemented community policies for improved health standards to waste management, power, transport, water and procurement, with waste management as a key principle (Tudor, Woolridge, Philips, Holliday et al 2010:432). The NHS has a legal responsibility to reduce environmental impacts and properly manage HCW waste production and disposal. The Environmental Protection Act of 1990 and the Environmental Protection regulations of 1991 imposed legal “duty of care” requirements on waste producers in order to ensure the appropriate safe handling, treatment and disposal of waste (Tudor et al 2010:432). UK waste regulation for public and private health facilities ensures that all waste sources operate more sustainably (Tudor 2011:307). This reflects the essence of the control over the transfer, storage and destruction of waste and the management of the waste treatment outcome.

Advances in HCW disposal standards in hospitals have allowed a major reduction in risk. Waste policy is built within the context of the European Union (EU) strategy (Pires, Martinho & Chang 2011:1033).

The EU also has a community waste management strategy that includes the following technical recommendations 2010:419):

- Reducing waste production and hazardous waste products should be a priority for mitigating and optmise waste disposal
- Introducing schemes for collection and recovery and supporting recycled products.
- Promoting the reuse, recycling, composting and conservation of energy to reduce the amount of waste to be disposed of and save natural resources.

The Hazardous Waste Directive (HWD) of the European Council sets out the framework for the regulation of the movement of hazardous waste in EU Member States (Bryant 2010:422).

The aim of the HWD is to ensure specific and consistent European definition of hazardous waste and proper waste management and regulation. The definition of hazardous waste includes all forms of waste on a list drawn up by the European Commission (EC) because it has one or more of the hazardous properties set out in the HWD (De Sadeleer 2013 cited in Alhadlaq 2014:39). In 1994, the Waste Framework Directive produced a comprehensive list of all wastes, hazardous or otherwise. This list is referred as the European Waste Catalog (EWC) of 1994. On the basis of the properties set out in the HWD, the EC then established which of the wastes on EWC, 1994, is considered hazardous. The resulting list of waste was called the Hazardous Waste List (HWL) and was the hazardous waste list of the HWD (Llatas 2011:1261). In the new EWC, adopted by member states and implemented on 1 January 2002, the EWC, 1994 and HWL were reviewed, merged and substantially expanded (Wen, Luo, Hu, Wang et al 2014:321).

In the 1990s waste production increased worldwide. The HWD impacted on waste regulations and affected aspects such as charging, monitoring and inspection. Most Central and Eastern European Countries (CEECs) disposed of waste as landfill which resembled the situation in the Organization for Economic Cooperation and Development (OECD) countries in the 1980s.

The following problems were analyzed for waste management in EU member states in the 1990s (Wen, Luo, Hu, Wang et al 2014:321):

- The waste generation rate in the European Union and European Free Trading Association increased by 10% in 1990s.
- Projections of future trends were hindered by limited data quality.
- Recycling and reuse systems were partially successful.
- Increasing volumes of waste have created new issues, such as rising levels of sewage sludge and residues from vent gas cleaning
- EU member countries' waste represented up to 15% of freight transport.

Preventing and reducing waste was necessary for two main reasons:

- Waste is a major health hazard and source of pollution.
- Waste contains a high volume of reusable and recyclable materials.

Minimising the risks and maximising the waste utilisation was the main objective of strategic waste planning. In its 1996 review of the community strategy for waste management, the European Commission stressed that the prevention of waste and the minimisation of hazardous substances in waste should be and remain the overall targets of a strategy for community waste management (Pires, Martinho & Chang 2011:1033). The management of waste generated within the community was a key task of the 1990s (Therivel 2012). In terms of quantities and environmental hazards / damage, the community waste management policy sought to waste minimisation. The program developed an EC waste minimisation target of 300 kg per capita on a country-by-country basis for the year 2000. Strategic planning regarding waste management in the EU countries would also be revised in accordance with further EU waste policies (Dale & Robinson 2011 cited in Alhadlaq 2014:40). Thematic strategies aimed at ensuring sustainable management of resources and waste through strategic planning and identifying which waste would get priority in recycling according to an appropriate set of criteria. Five policy directions were proposed while reuse, material recycling, energy extraction and final disposal followed the EU hierarchy of waste management (Dale & Robinson 2011 cited in Alhadlaq 2014:40). The directions were to:

- Facilitate the general public to play an active role in the environmental decision-making process.
- Planning and better management of land-use.

- Improve the implementation of current community environmental legislation.
- Enhance the use of market resources by involving businesses and consumers.
- Integrate the dimension of the environment into other policy areas.

In 1995, EU member states produced a total of 36 million tons of hazardous waste (De Sadeleer 2013 cited in Alhadlaq 2014:39). Between 1990 and 1995, there was a 21% reduction in the UK and Germany by recycling and reusing, by closing heavy duty industries, by moving parts of industrial production outside of the EU and by penetration of cleaner technologies before the introduction of the hazardous waste list (Wen, Luo, Hu, Wang, Chen et al 2014:321).

In 1995, CEECs produced high quantities of hazardous waste. Except in Hungary, the amounts of hazardous waste in most CEECs had decreased by 1999. (Pires, Martinho & Chang 2011:1033). Slovenia sent all hazardous waste (97%) mainly to Austria, France and Italy in 1995.

In a comparison of infectious waste management in European hospitals according to the EU classification factors, Mühlich, Scherrer and Daschner (2003:260) found that the difference between Austria, Denmark, Germany, Ireland and Spain varied from 27% to 71%. There were significant disparities in national hazardous waste classification, categorisation and management between EU countries (Selin & Van Deveer 2006:6).

2.8.8 United States of America (USA)

A research on waste disposal in USA healthcare showed that public and private hospitals accounted for about 15% of the total waste stream in hospitals (Berwick & Hackbarth 2012:1513). Berwick and Hackbarth (2012:1515) emphasised that there was an urgent need for systematic, comprehensive and cooperative medical waste reduction, management and disposal in US hospitals.

In the United States, the Occupational Safety and Health Administration (OSHA) sets worker safety standards throughout healthcare facilities and the handling of healthcare waste (Ramani Bai, Vanitha & Zainal Ariff 2013:1234; Berwick & Hackbarth 2012:1513; Bartley, Olmsted & Haas 2010: S1). The OSHA (2001) defines regulated waste as:

- Pathological and microbiological waste containing blood or other potentially infectious materials.
- Contaminated items which, if compressed, would release blood or other potentially infectious materials.
- Contaminated sharps.
- Items caked with dried blood or other potentially infectious materials that can be released during handling.

Although healthcare facilities have to abide by regulations regarding HCW management practice, HCW is not governed uniformly across the United States at state level. At the same time, federal laws have also limited alternatives to on-site treatment methods of healthcare waste. HCW has to be treated in many federal states before it is deposited in a landfill or is required to be segregated and labelled before moving to a commercial facility. (Ramani Bai et al 2013:1234; Berwick & Hackbarth 2012:1513).

2.8.9 Healthcare waste management in developing countries

The rapid growth and expansion of the healthcare sector in developing countries led to a tremendous increase in healthcare waste generation by hospitals, clinics and other establishments. The quantity of healthcare waste produced in developing countries depends on various factors (Zafar, 2018). For example, India generates up to 500 tons of biomedical waste every day while Saudi Arabia produces more than 80 tons of healthcare waste daily. Since most healthcare facilities in developing countries do not adequately segregate infectious or hazardous waste from ordinary domestic-type waste, the growing amount of medical wastes poses significant public health and environmental challenges. The situation is worsened by improper disposal methods, insufficient physical resources, and lack of research on healthcare waste management. Improper HCW disposal exposes waste transporters, landfill workers, waste pickers, scavengers, recyclers and children as well as the environment to risks (Zafar, 2018).

Public concern over incinerator emissions and federal regulations for medical waste incinerators caused many health care facilities to alter their medical waste treatment (Gautam, Thapar & Sharma 2010:191). Medical waste incinerators emit toxic air pollutants and toxic ash residues that are the major source of dioxins in the environment. Gautam, Thapar and Sharma (2010:191) emphasise that waste management policies, waste segregation and training programmes as well as attention to materials purchased are essential in minimising health and environmental risks. The release of persistent toxic substances (PTS) into the environment is frequently due to the improper use of older, inefficient incinerators with insufficient air emission controls, which produce dioxins and furans. Incinerators emit a variety of harmful pollutants, including particulate matter, mercury, dioxins and furans (Gautam et al 2010:191).

Waste pollutes the environment and threatens human health (Demirbas 2011:1280). Demirbas (2011:1287) found that tackling these problems required ongoing public health education; educating personnel; efficient waste management systems and HCW management guidelines for safe waste handling and management. There is a gradual but concerted effort to stop the use of incineration to treat HCW and to phase out HCW incineration in developing countries in the near future (Anastasiadou, Christopoulos, Mousios & Gidarakos 2012:165).

Patwary, O'Hare and Sarker (2011:1200) undertook a survey of medical waste management in Dhaka, the capital of Bangladesh. The study found that workers dealing with waste were largely untrained and did not understand the hazards involved; personal protective equipment was inadequate, leading to accidental injuries; health care facilities lacked secure hazardous waste storage facilities, and proper disposal, accountability and responsibility were lacking. Consequently, scavengers gained access to syringes, expired medicines and other items which they repackaged and resold. In many cases there was no proper segregation, waste was dumped in bins, and disposed of on general landfill sites. This exposed the waste to scavengers and could potentially contaminate ground water (Patwary, O'Hare & Sarker 2011:1202).

In Malabar, southwest India, Ahmed, Soni and Gupta (2013:76) examined the handling, management and disposal of biomedical waste. The biomedical waste generated from health care activities has a higher potential for infection and injury than any other waste. Ahmed, Soni and Gupta (2013:76) stressed that inappropriate handling of biomedical waste could have serious public health consequences and significantly impact on the environment. The study found that many health workers were unfamiliar with the potential risks associated with HCW and the impacts of the waste stream on human health and the natural environment (Ahmed, Soni & Gupta 2013:79).

2.8.9.1 Ethiopia

In Ethiopia the generation of healthcare waste from public and private health care facilities, health-related research centres, medical laboratories and home care facilities increased rapidly from 1990. Although HCW represents a small proportion of Ethiopia's total solid waste stream due to its potentially infectious and hazardous content it must be handled with care. Inappropriate disposal of waste from healthcare poses significant risks to human health and the environment. The management of healthcare waste is a major concern for regulatory bodies.

Ethiopia’s healthcare waste was regulated by the Ministry of Health from 1990. Most wastes were often improperly treated and disposed of in municipal landfill sites, low temperature incineration, and open air burning on the ground (Habtetsion, Bock, Noel, Shanadi Bhat, Abebe & Van Roekel 2009:87). Moreover, information on handling and disposal of HCW from health care facilities was limited and largely unknown. HCW's hazardous nature raised concerns about the risk posed by needles and other sharp injuries and the aesthetic degradation of the exposed environment (Habtetsion, Bock, Noel et al 2009:87).

To tackle the problem of healthcare waste management, the former Ethiopian Environment Protection Authority formulated the national environmental policy provisions in 1997 (Alem 2007:1-121). The provisions recognized the need to promote conditions for domestic solid waste disposal, community education on sustainable waste management, and partnership between the government, communities and NGOs for an integrated sanitation system (Alem 2007:1-121).

The Ethiopian Food, Medicine and Healthcare Administration and Control Authority (FMHACA), under the Ministry of Health of Ethiopia, is responsible for control of HCW from the point of generation to its final disposal. In 2005, FMHACA issued a directive for implementing the Healthcare Waste Act. The Act classifies HCW as designated (hazardous waste) and is subject to the Waste Management Act's hazardous waste regulations. FMHACA disseminated regulations on the definition, segregation, packaging, transporting and disposal of HCW. Single-use items like gloves, disposable syringes, medical kits, bedding, tubing, IV bags and containers increase the amount of HCW. The dominant method of HCW disposal in Ethiopia is incineration (Tadesse &

Kumie 2014; Azage & Kumie 2010:119-126). Tadesse and Kumie (2014:1221) found that HCW should be segregated at the point of generation; infectious waste should be pre-treated before disposal; healthcare workers and waste handlers should be trained; incinerators should be constructed that facilitated complete combustion, and placenta pits should be lined with water tight material.

2.8.9.2 Saudi Arabia

Saudi Arabia is a Muslim country, dead babies, human organs and parts of the body and human placenta buried under Islamic law. Human tissue and specimens, however, from autopsies or during surgery are incinerated (Alhadlaq 2014). This definition of HCW led to over-disposal of waste requiring incineration, although many hospitals in Saudi Arabia considered replacing single-use waste-generating disposable items with one that could be reusable and reprocessed (Almalki, Fitzgerald & Clark 2011:784). A survey of HCW generation in 27 hospitals in Saudi Arabia indicated that over-disposing of HCW was a problem in many hospitals (Alhadlaq 2014).

In January 2000, a policy was fully implemented in Saudi Arabia that included the definitions and the disposal method for each waste category. Reduction of waste and cost savings were essential to the introduction of the waste management plan to reduce the amount of waste being incinerated by the source reduction. In-service training on waste management was given to all staff for ease of identification and separation of HCW. Subsequently, the eastern region of Saudi Arabia reported a 65% decrease in HCW generation through education and a waste segregation facility (Almuneef & Memish 2003:188-192).

To reduce its HCW source, the Saudi Aramco Medical Service Organization (SAMSO) used HCW surveys; reduces the load of incineration; identify and remove specific items of concern from HCW bags and establish a more safe working environment for housekeepers (Hagen, Al-Humaidi & Blake 2001:198-202). This was the first report in the country to provide an extensive analysis of HCW. All housekeeping personnel were immunised against hepatitis B at the beginning of each contract. A SAMSO Medical Housekeeping Supervisor, together with a staff of inspectors and trainers, conducted intensive, task-oriented training at the beginning of new contracts on a weekly basis during the term of the contract. This was to ensure that SAMSO met the Saudi Arabian

Government and Joint Commission International (JCI) standards for infection control and environmental care. SAMSO has a well-defined medical waste management system incorporating colour-coded labels for waste containers and colour-coded plastic bags (Hagen, Al-Humaidi & Blake 2001:198-202).

2.9 HEALTHCARE WASTE MANAGEMENT PRACTICES AND TECHNOLOGIES

Healthcare waste management practices and technologies vary from country to country. This section briefly discusses commonly used HCW technologies and practices in order to understand how HCW is processed and contained, and to assess its safe management.

2.9.1 Waste management practices

The best practice for HCW management is to prevent and reduce waste generation (Hossain, Rahman, Balakrishnan, Puvanesuaran et al 2013:556-557). The point of generation or “cradle” to the point of disposal or “grave” must be consistent for the management of waste. Effective HCW management programmes need multi-sectoral cooperation and interaction at all levels. National policies and legal frameworks help to train healthcare workers; raise public awareness and provide for environmental security.

Waste management practices vary in specialisation, use of reusable items, and waste reduction technologies and apply to public and private healthcare institutions. Comprehensive surveys and periodic reviews of waste management practices at national level and healthcare facilities should improve and protect occupational and public health and enhance the cost effectiveness of waste disposal (Prüss, Giroult & Rushbrook 1999:167).

2.9.2 Healthcare waste minimisation (HCWM)

Health care waste minimisation (HCWM) is a method that helps healthcare facilities reduce the production of the bulk or amount of HCW, whilst cutting costs for running the waste management system and for final treatment/disposal (Prüss, Giroult & Rushbrook 1999:58). HCWM is achieved by means of segregation and containerisation; labelling for biohazardous waste; storage and transport, and treatment and final disposal.

2.9.2.1 Segregation and containerisation

Segregation is the process of separating different wastes at the point of generation/source and keeping them apart during handling, accumulation, intermediate storage and transportation (Dohare, Gare & Sarkar 2013:1107). In a review of the status of hospital waste management facilities in Medan, North Sumatra's capital, Dohare, Gare and Sarkar (2013:1107) found that waste segregation:

- Minimised the amount of waste that needed to be managed as infectious or hazardous waste (since mixing non-infectious waste with infectious or hazardous waste renders the combined amount as infectious or hazardous).
- Facilitated waste minimisation by generating a solid waste stream, which could be easily, safely and cost-effectively managed through recycling or composting.
- Reduced the amount of toxic substances released into the environment in the disposal of general waste (e.g., removing mercury from general waste).
- Made it easier to assess the quantity and composition of different waste streams, thereby allowing health care facilities to obtain baseline data, identify options, determine waste management costs and assess the effectiveness of waste minimization strategies.

In the WHO recommendations and guidelines the best way to identify types of healthcare waste is to sort waste based on colour code (Dohare, Garg & Sarkar 2013**:**1107). Figure 2.5 Shows proposed colour coding techniques and container types for the segregation and storage of different healthcare waste elements.

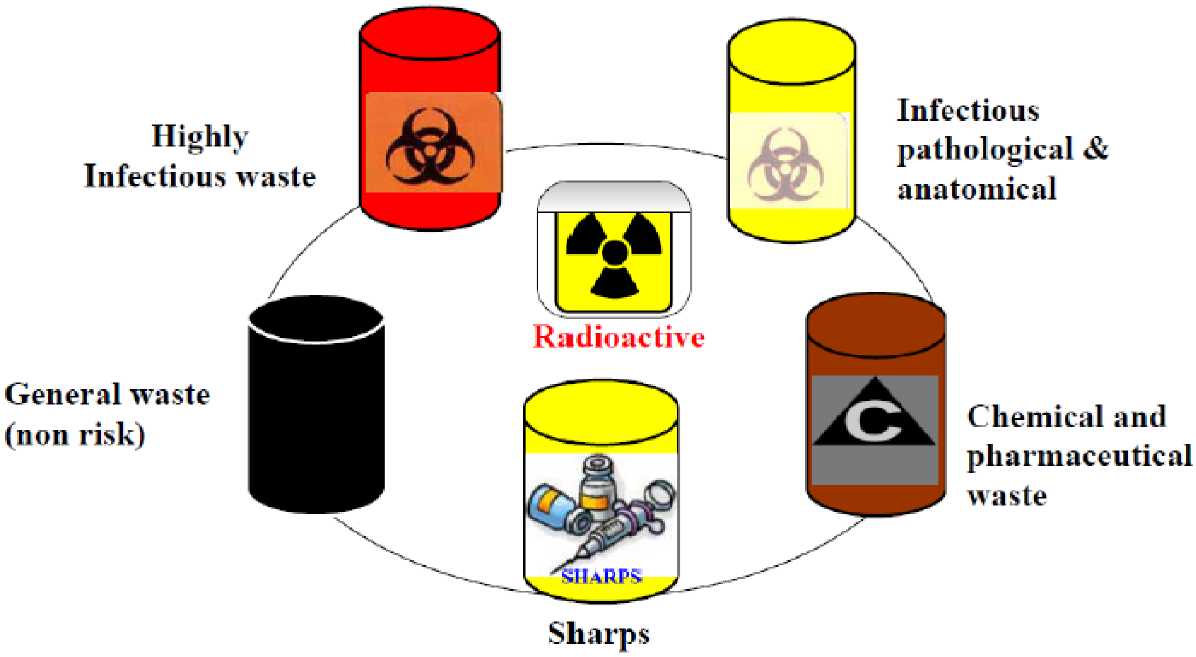


Figure 2.4 Containers with different colour coding and labelling for healthcare waste collection

(Source: Alhadlaq 2014:55)

The WHO recommends that waste from healthcare be segregated into suitable containers / bags at the point of generation. To encourage source segregation, reusable containers or baskets with liners of the appropriate size and thickness must be positioned as close to the point of generation as possible (Bala & Narwal 2013:1).

Separate labelled colour coded containers (yellow and red for infectious waste; brown for chemical and pharmaceutical waste, and black for general waste) and with the international infectious waste symbols clearly marked should be available for each medical area for each category of healthcare waste. When they are three-quarters full, the liners must be closed with plastic cable ties or string and placed in larger containers (Mathur 2014:81-89). Closed colour-coded labelled containers must be kept away from patients indoors for interim or short-term storage (depending upon the type of waste, this should not be not more than 12 hours) of healthcare waste in each medical room. According to Mathur (2014:81):

- Healthcare waste containers for sharp must be tightly sealed when no more than 2/3 full
- Healthcare waste bags must be tightly sealed when no more than 2/3 full

- Identify the area from which the waste was generated and healthcare waste bags for HCW must be marked with a code.
- Healthcare waste containers for sharps must be tagged with a code to identify the area from which the waste was generated.

2.9.2.2 Labelling requirements for HCW containers

Healthcare waste contained in a red biohazard bag must be labelled with the words “Biohazardous Waste” or with the international biohazard symbol and the word “BIOHAZARD” (Bala & Narwal 2013:3).

According to Bala and Narwal (2013:3),

- Biohazard bags must be tied to prevent leakage or expulsion of contents during future storage, handling, or transport
- Red biohazard bags must be placed for storage, handling, or transport in a rigid secondary container.
- Rigid secondary containers must be leak resistant, have tight fitting covers and be kept clean and in good repair.
- Containers can be any color and marked with the words "Biohazardous Waste" or the international biohazard symbol and the word "BIOHAZARD" on the lid and sides to be visible from any side.

2.9.2.3 Storage and transportation

Storage and transportation of HCW is very important. In order to prevent both the accumulation and decomposition of waste, it must be regularly collected and transported on a regular basis to the area where the larger containers are stored before being removed to the central storage facility (Almuneef & Memish 2003:188).

Wheelie bins or trolleys should be used for transportation to the central storage area. Wheelie bins or trolleys should be easy to load and unload, have no sharp edges that could damage waste bags or containers, and should be easy to clean. Ideally, they should be marked with the corresponding coding colour (Bala & Narwal 2013:3).

The amount or volume of waste generated as well as the frequency of collection should be considered in relation to the size of the central storage area. The central storage area for HCW should be located within the health care facility and situated so as to minimize the risk of contamination to other operations in the area, such as medicines, foodstuffs, textiles, employees, patients and visitors. The facility's waste management plan should indicate the times and routes for the collection of HCW from each temporary waste storage area. Collection frequency should be determined relative to the waste streams generated the quantity thereof and recommended storage times. The storage area should be checked on a daily basis to ensure it is secure, always limited to authorised personnel, clean and organized, i.e. waste receptacles/containers are not overflowing or leaking. In countries with warm and humid climate the storage time should not exceed 24-48 hours (Pichtel 2010 cited in Alhadlaq (2014:57)).

The HCW generator is responsible for the safe packaging and correct labelling of waste to be transported off-site for treatment and disposal. Packaging and labelling should comply with the national regulations governing the transport of special wastes and must present no danger to the public during transportation. Furthermore, waste generators are ultimately responsible for ensuring that their wastes are properly treated and disposed of in an approved and fully compliant treatment/disposal facility. Off-site transportation should be carried out by dedicated vehicles and local or regional authorities must ensure that the contractor has a valid certificate (Alhadlaq 2014:57).

2.9.2.4 Treatment and final disposal

Health care waste management can be achieved by handling, recovery of valuable materials and modifying the properties of the waste, making exposed less harmful and enhancing the protection of the environment (Ahmed, Soni & Gupta 2013:76). Toxic and infectious waste treatment refers to any method, procedure or process for modifying the biological character or composition of the waste to make it non-toxic or non-infectious. Because landfill operations can result in loss of containment integrity and dispersal of infectious waste, all infectious waste should be treated before disposal (Alhadlaq 2014:58).

There are a number of approaches and treatment options for HCW including incineration, steam sterilization (sanitation), microwave sanitation, chemical disinfection, dry heat disinfection, steam disinfection and overheated (Demirbas 2011:1280). Figure 2.6 depicts steps for HCW treatment.

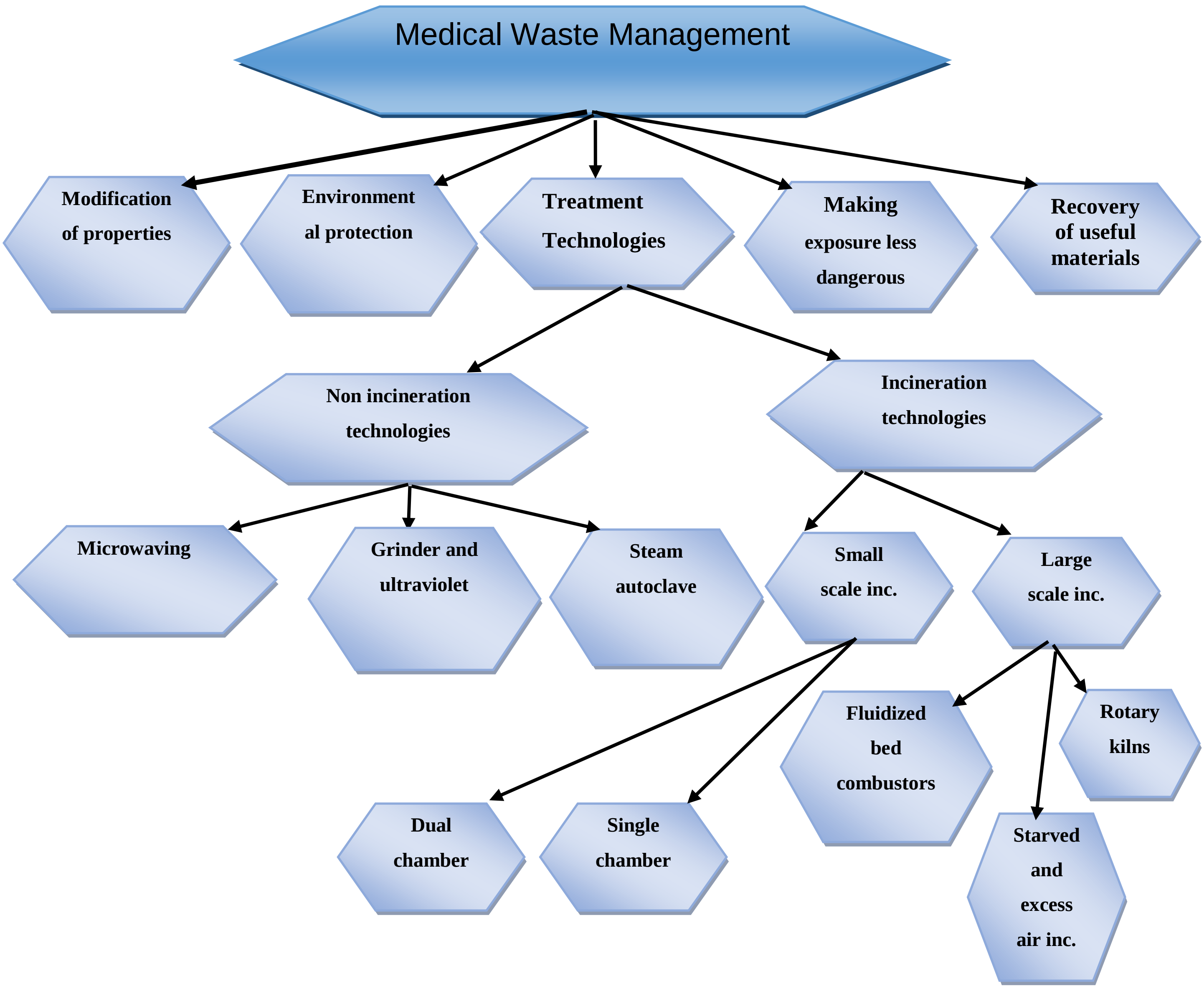


Figure 2.5 Steps for HCW treatment

(Adopted from Demirbas 2011:1280)

Treatment and disposal involve several factors and costs (Assamoi & Lawryshyn 2012:1019). The highest is the capital cost of incineration. Moreover, due to the running costs of pollution control and waste preparation equipment, operating costs are high. Certain cost considerations include running costs, quality of sterilization, repairs and improved operator skills. It is also necessary to consider air pollution, water emissions and the characteristics of the treated waste. Nevertheless, incineration is still the best technology to date, although it cannot remove radioactivity in the waste generated by X-ray laboratories (Assamoi & Lawryshyn 2012:1019). Figure 2.7 presents a comparison of treatment technologies in terms of HCW volume reduction, operating charges and capital costs.

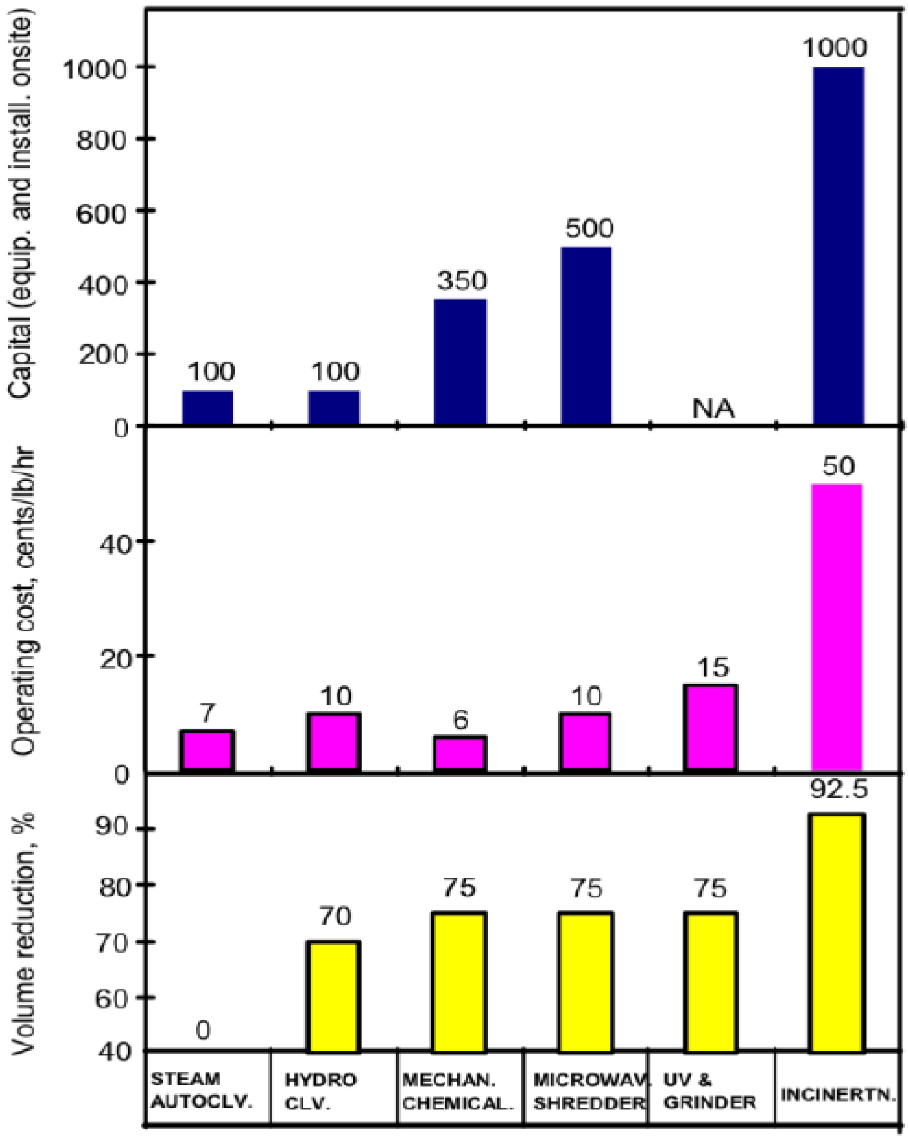


Figure 2.6 Comparison of treatment technologies in terms of HCW volume reduction, operating charges and capital costs

(Source: Alhadlaq 2014:59

When non-incineration methods are used for HCW treatment, further disposal problems must be solved because the volume is slightly reduced or almost constant (Assamoi & Lawryshyn 2012:1019). Non-incineration technologies achieve a less significant volume reduction of less than 90% of the HCW treated compared to incineration which reduces above 90% of HCW (see figure 2.7). The hydroclave, mechanical/chemical treatment, microwaving of shredded waste and irradiation of ground waste by ultraviolet rays give intermediate values for volume reduction, operating charges and capital cost (Assamoi & Lawryshyn 2012:1019).

It is important to use biological indicators to measure the efficacy of a treatment method. Upon assessment of the treatment process, biological indicators should be chosen to provide evidence of relative resistance to an inactivating agent as it relates to the conditions used during resistance. The degree of relative resistance of a microorganism to an inactivating agent can depend on various factors, particularly temperature (Ahmed, Soni & Gupta 2013:76). Conditions that demonstrate a relatively high degree of resistance of a specific microorganism that is substantially different from the conditions in a given treatment process.

Incineration and autoclaving are the most commonly used methods for treatment of healthcare waste. Incineration has several advantages and is an effective method of waste management that is used as the preferred means of treating and disposing of HCW (Almuneef & Memish 2003:188). Nevertheless, increasing air pollution issues have prompted many governments and agencies to adopt more stringent air quality requirements, among other drawbacks to its use in HCW treatments. Healthcare and other facilities that generate HCW have found that by retrofitting existing incinerators or buying new equipment, it would be prohibitive to meet such enhanced requirements (Almuneef & Memish 2003:188).

2.9.3 Healthcare waste treatment technologies

The HCW treatment technologies used in most healthcare facilities are autoclaves and thermal oxidation units. An alternative technology is plasma technology,

2.9.3.1 Autoclave

An autoclave is a pressure chamber used to carry out industrial processes requiring elevated temperatures and pressures different from ambient air pressure. Autoclaves are used in medical applications to perform sterilization and in the chemical industry to cure coatings and vulcanize rubber and for hydrothermal synthesis. Autoclaves are used to sterilize equipment and supplies by subjecting them to pressurized saturated steam at 121°C (249°F) for around 15 to 20 minutes depending on the size of the load and the contents (Republic of Namibia 2011:39).

2.9.3.2 Thermal oxidation unit

A thermal oxidizer (also known as thermal oxidiser or thermal incinerator) is a process unit for air pollution in many chemical plants that decomposes hazardous gases at a high temperature and releases them into the atmosphere (Sorrels, Baynham, Randall & Hanc 2017:2-10). Thermal oxidizers are typically used to destroy hazardous air pollutants (HAPs) like drugs, therapeutical chemicals liquid or solid therapeutic substances that are toxic corrosive, carcinogenic, mutagenic or genotoxic (cytotototoxic) waste and volatile organic compounds (VOCs) from industrial air streams. These pollutants are generally hydrocarbon based and when destroyed via thermal combustion are chemically oxidized to form CO_2 and H_2O. Three main factors in designing effective thermal oxidizers are temperature, residence time, and turbulence. The temperature needs to be high enough to ignite the waste gas. Most organic compounds ignite at a temperature between 590°C (1,094°F) and 650°C (1,202°F) (Sorrels et al 2017:2-11).

2.9.3.3 Alternative technologies to incineration for healthcare waste

Alternative technologies to incineration are an important move (Bosmans, Vanderreydt, Geysen & Helsen 2012:10; Kawai, Ikegami, Sato, Matsuda, Uchino & Kuzuya 2010:170). Several factors have contributed to considering and employing alternative technologies, namely:

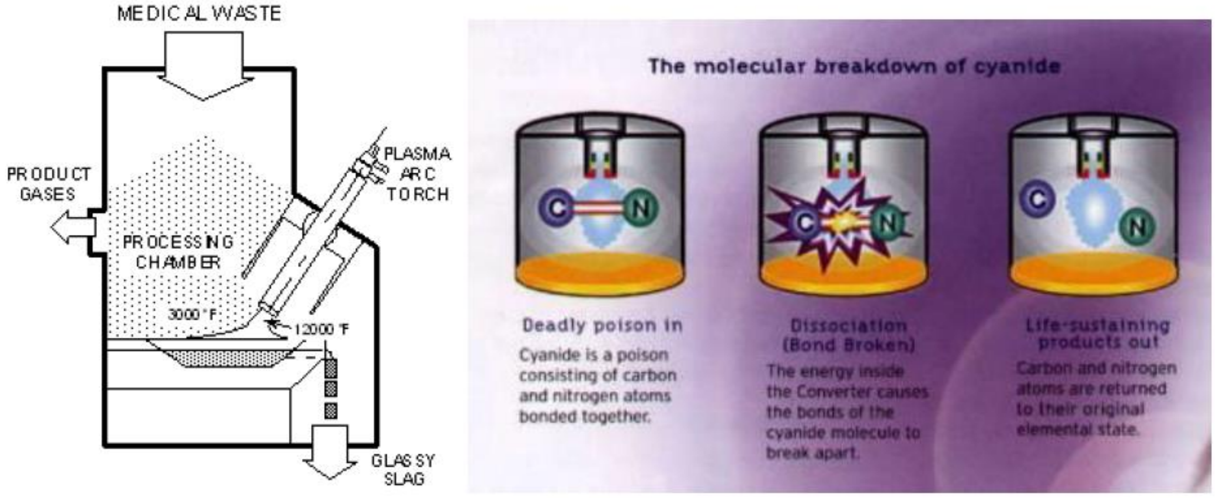
- The health and environmental impact of incinerators.
- The enforcement of new emission standards by regulatory authorities.
- Difficulty in obtaining new incineration sites.
- Non-incineration technologies accessibility

Plasma technology is an example of an alternative technology, which has not yet been widely implemented.

2.9.3.4 Plasma technology

Very hot plasma comprises of ionized gas (i.e. oxygen, under normal pressure) in a strong electrical arc with a power range of 2 to 20 Mega Watts. (Bosmans et al 2012:10). The temperature of such plasma is very high, ranging from 2 to 6 thousand degrees Celsius. In such high temperature**s**, all waste constituents, including metals, toxic materials, silicon, etc are totally melted to form nontoxic dross. Plastic, biological and chemical compounds, toxic gases yield complete dissociation (required minimal dissociation temperature is in the range of 1500 degrees Celsius) into simpler gases mainly H_2 and CO_2 (Kawai et al 2010:170). Simpler gases, mainly H_2, can be used as ecological fuel to generate heat energy and electrical energy decreasing significantly (even to zero) the cost of plasma formation and waste utilization (Bosmans et al 2012:12). It is possible to safely return recovered metals from the dissociation process to the metallurgical industry and use slag as an additive to road and construction materials. Using this approach to use municipal waste does not involve the release of foul odours and does not create a toxic ash, which is something that normally occurs in an incinerator.

The inert gas (steam) and metal (copper, tungsten, hafnium, zirconium, etc.) electrodes are used by a plasma torch. Passing between two electrodes, spaced apart, a relatively high voltage source with high current produces an electrical arc (See Figure 2.8 a.). When going through the arc, pressurized inert gas is ionized to produce plasma. The plasma torch temperature may be within the range (2204 to 3871 ° C). At these temperatures, molecules break down in a gaseous form into basic elementary components and complex molecules are divided into individual atoms (Kawai et al 2010:21). This cycle of plasma based molecular dissociation is called plasma pyrolysis. The reactor runs at a slightly negative pressure, which ensures that a gaseous removal system and later a solid removal system complement the feed system (see Figure 2.8 b).



(a) (b)

Figure 2.7 (a) Plasma based healthcare waste management system (b) Process of treatment

(Source: Kawai, Ikegami, Sato, Matsuda, U chino and Kuzuva 2010:26)

Depending on the input waste (plastics tend to be high in hydrogen and carbon), gas from the plasma containment can be removed as syngas and may be refined into various fuels at a later stage or fired on site to provide power. The process produces pure high-calorific syngas (CO, H_2, CH etc.). Syngas produced from organic materials using plasma gasification has a conversion rate of greater than 99%.

A correctly selected temperature of plasma reaction and structure plasma of forming gas generates minimal content ballast products of oxidation (CO_2, N, H_2O, etc.). Other non-flammable inorganic components in the waste stream that are not broken down but only go through a phase change (solid to liquid) add to the volume of slag (including various metals) with minimal energy recovery and increased cost for refining. The metals obtained through plasma pyrolysis can be recovered from slag and used as commodity products in various applications. Inert slag could be granulated and subsequently used in construction. For efficient operation of the plant, a portion of the syngas may be used to run on site turbines to power the plasma torches and feed system (Kawai et al 2010:21).

2.9.3.5 Plasma gasification for waste management

Gasification of plasma is a process for converting organic matter into syngas using plasma processing (Byun, Namkung, Cho, Chung, Kim, Lee, Lee & Hwang 2010:6680-6684). Technologies for plasma gasification use an electric arc gasifier (plasma torch) to create a high-temperature ionized gas that mainly separates organic matter into syngas and solid waste (slag) in a controlled vessel (plasma converter whether furnace or reactor) (Zhang, Dor, Fenigshtein, Yang & Blasiak 2012:106). Its main use is as a waste treatment technology as it allows full decomposition and disintegration of organic components. However, it is also tested for the biomass and solid hydrocarbons, such as coal, oil sands, and oil shale gasification. The process (see Figure 2.9) is intended to be a net generator of electricity, depending on the composition of input wastes, and to reduce the volumes of waste being sent to landfill sites.

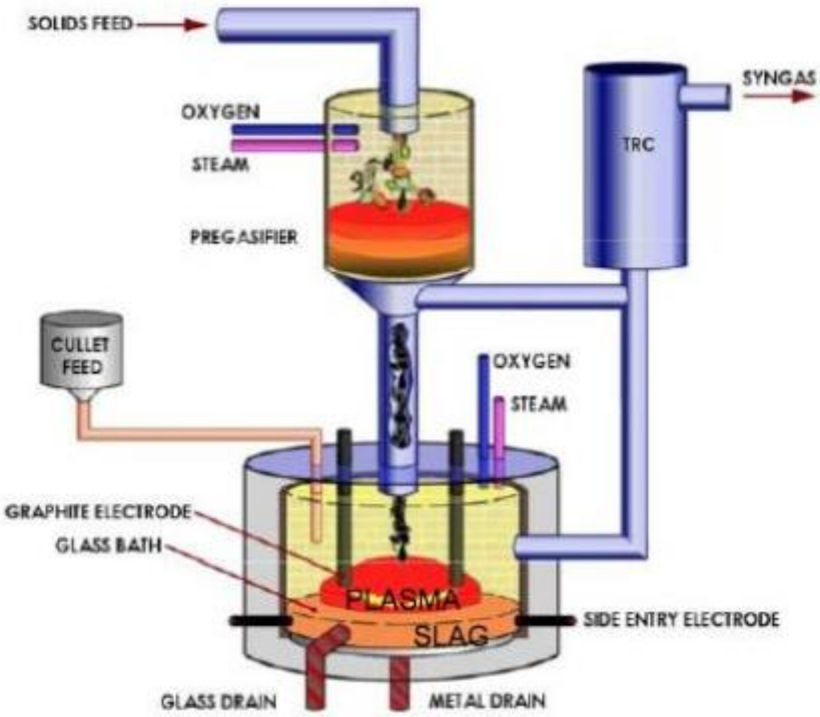
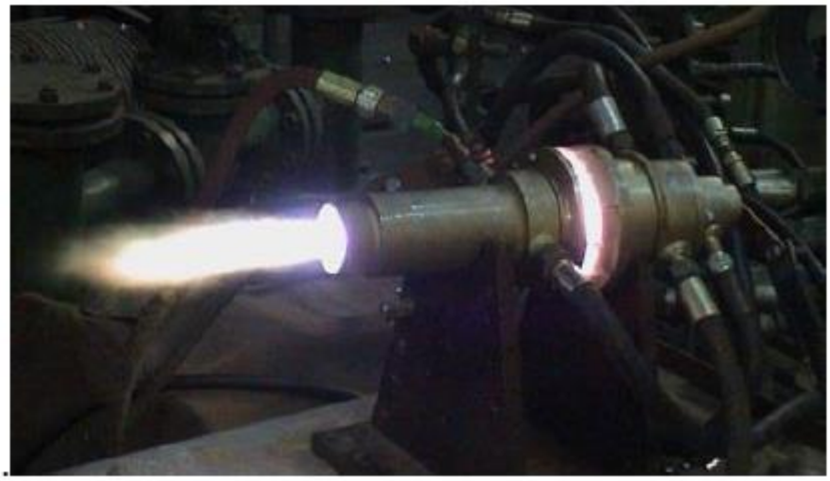


Figure 2.8 Use of plasma for toxic municipal waste

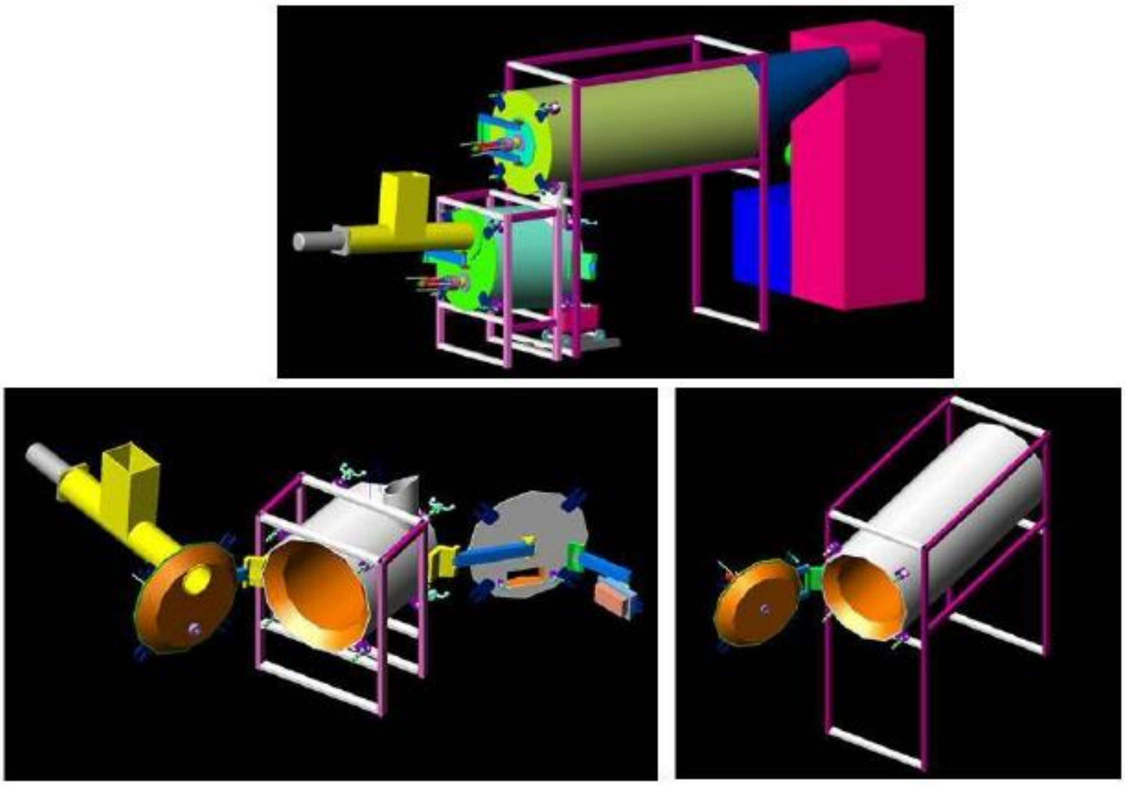
(Source: Anwar 2018:2)

2.9.3.6 Plasma furnace technology for the treatment and disposal of healthcare waste

Plasma furnace technology for treatment and disposal of HCW is an effective and safe alternative (see Figure 2.10) (Chakraborty, Veeregowda, Gowda, Sannegowda, Tiwari, Dhama & Singh 2014:67). The process minimizes the risk of toxic substances, biological wastes, pharmaceutical wastes and compact mineral residual. A plasma furnace for waste treatment and disposal of HCW can process 50 kg / h of waste and needs an additional 150 KW after the chamber has been burned. (Chakraborty et al 2014:67; Gautam et al 2010:191).



(a)



(b)

Figure 2.9 (a) Plasma arc torch PPT-100AC with a power of 100kW (b) Design details of plasma arc torch

(Source: Alhadlaq 2014:65)

2.9.3.7 Plasma furnace process

Through breaking down atoms into electrons and ions, the plasma state is obtained. By the means of plasma method, the temperature can reach 10000^{0}C easily and quickly. This technology can treat both liquid and solid medical waste due to the high energy supplied. Furthermore, the organic chloride can be handled rely on the ultraviolet radiation. The basic part of this technology is the plasma torch that consists of water-cooled anode and cathode surrounded by magnetic field coil. The direct current (DC) or microwave power source provides the energy and the nitrogen gas flow is introduced into troch for stabilizing the plasma arc. Because of the high resistance of conductive ionized gas, the electric energy is transformed to heat and the temperature range is above 1650^{0}C. The Figure 2.11 indicates a schematic of commercial plasma system. The healthcare waste enters the system through the feeder and then reaches the primary chamber. The primary products enter the secondary chamber to finish the pyrolysis process.

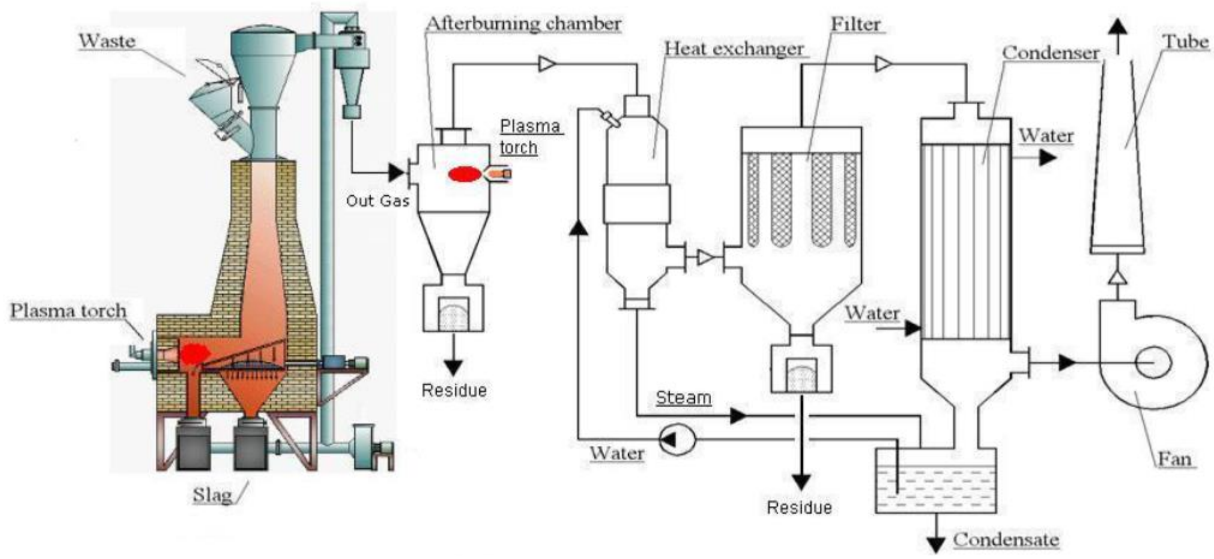


Figure 2.10 A complete plasma-based healthcare waste treatment system

(Source: Alhadlaq 2014:66)

After plasma pyrolysis, most of the healthcare wastes are destroyed. Hydrogen and carbon monoxide are produced as byproduct and heat from the combustion of these gases can be recycled. Other toxic gases produced are under the limit.

There is no doubt that plasma pyrolysis has a large potential to take the place of conventional incineration method. However, the extreme high temperature, complex chemistry and corrosion problem increase the difficulty of commercialization. There is no sufficient information of the small-scale plasma pyrolysis equipment for healthcare waste treatment in the market.

2.9.3.8 Advantages and disadvantages of plasma technology

Because of high temperatures, the plasma process efficiently utilizes all four forms of dangerous, poisonous or lethal waste capable of breaking down molecular bonds. The process of use of plasma waste happens in a closed system without releasing ashes, traces of waste, dust and toxic gasses into the environment. Returning regaining metals to the metallurgical industry is used as an alternative for road construction materials. Non-toxic gases emitted are stored in special containers (gas cylinders) and used as generators of fuel and energy (Alhadlaq 2014:67).

Plasma technology enables large amounts of municipal waste to be processed in the range of 10 to 500 tons per day. This waste reduction approach is the only viable tool for reducing electronic waste that is not biodegraded (Alhadlaq 2014:67).
Plasma gasification provides a number of key benefits over incineration systems. Using plasma technology in HCW management (Solis 2018:41):

- Unlocks the greatest amount of energy from waste.
- Allows mixed feed stocks, such as municipal solid waste, biomass, hazardous HCW, and auto shredder waste.
- Does not generate methane, a potent greenhouse gas.
- Is not incineration and therefore does not produce leachable bottom ash or fly ash.
- Achieves clean destruction of hazardous waste, preventing it from reaching landfills.
- Has virtually no harmful environmental emissions.
- Achieve a solid volume reduction of up to 300:1 where the conventional ratio of incineration is between 5 and 1.
- Provides solid weight reduction from1000 kgs to 45 kgs slag.

- Produces 100% recyclable by-products.
- Eliminates landfill requirements.
- Eliminates long-term liability for Healthcare waste.
- Is environmentally benign.
- Provides precise temperature and process control.
- Maintains control from "cradle to grave".
- The cost of creating biological by-products significantly reduces from $40/ton to zero. The cost of creating biological by-products significantly reduces from $40/ton to zero.
- Contemporary plasma converters are computer-controlled, safe, quite, and can be mobile or stationary.
- Organic waste treatment makes it possible to produce fuel syngas that can be used in different applications, such as the generation of electricity and thermal energy; the production of value-added goods (metals) from slag.

The main disadvantages of plasma technologies for waste treatment are:

- Release of carbon dioxide into the atmosphere from waste gasification and combustion.
- Need large capital costs and require large electric energy input.
- The highly corrosive plasma flame leads to frequent maintenance.
- The process is a source of toxic waste by acidifying water.

2.10 CONCLUSION

This chapter discussed the literature review undertaken for the study. The review covered HCW, HCW classification, categories of HCW, regulated HCW, the need for HCW management, monitoring and control, HCW management policies in developed and developing countries and HCW management practices and technologies.

The major plasma-based technologies were reviewed critically. The plasma processing technology for waste treatment is an ecologically clean process. The lack of oxygen and high temperature in a plasma reactor prevents the main elements of gas from forming toxic compounds, such as furans, dioxins, NOX, or sulphur dioxide. Extensive filtration removes inorganic residue such as ash and gaseous pollutants such as NO, HCl, and H_2S. This process allows the production of ecologically clean synthetic gas and gaseous compounds which do not contain phenols or complex hydrocarbons. Plasma arc facilities have been constructed at municipal-scale waste disposal locations, including landfill mining to return landfills to their original state. The use of plasma for HCW management also has a significant role in destroying medical and hazardous waste.

The review included practices and technologies that could be applied in Ethiopia's health sector. The literature review indicated the need to develop a framework for future HCW management technologies in Ethiopia.

Chapter 3 describes the research design and methodology of the study.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

Chapter 2 discussed the literature review. This chapter describes briefly the history of Addis Ababa, research paradigm, the research design and methodology used in the study. The pilot study, significance, limitations, ethical consideration are also discussed in this chapter.

3.2 PURPOSE AND OBJECTIVES

The purpose of the study was to develop a manual for healthcare waste management for health care facilities, based on the findings for the Addis Ababa City Administration Health Bureau public health facilities in Ethiopia. In order to achieve the purpose, the objectives of the study were to:

- Assess the current healthcare waste management practices in Addis Ababa City Administration Health Bureau public health facilities.
- Quantify the amount of healthcare waste generated in health centres in Addis Ababa City Administration Health Bureau public health facilities per patient utilization.
- Determine the level of knowledge and awareness of individuals involved in healthcare waste management in relation to waste management policies and procedures.
- Determine the extent to which the Addis Ababa City Administration Health Bureau implement and comply with healthcare waste management Code of Practice guidelines and all other related national waste management strategies.
- Develop a manual for the effective management of healthcare waste based on the findings in Addis Ababa City Administration Health Bureau public health facilities.

3.3 BRIEF HISTORY OF ADDIS ABABA

Addis Ababa is the capital of Ethiopia and situated in the highlands bordering the Great Rift Valley. Mount Entoto, the highest peak on the Entoto Mountains, overlooks the city. Menelik II was the *Negus* (King) of Shewa from 1866 to 1889 when he became the Emperor of Ethiopia. As king of Shewa, Menelik found Mt Entoto a useful base for military operations. Menelik searched for his grandfather's palace and found that it was at Mt Entoto. A monk told Menelik that if he made his palace at Entoto, his grandfather's original palace, and built a church for the Angel St Raguel (Raphael), his power would be safe and he would unify Ethiopia based on *Kibre Negest* (the glory of kings). Menelik returned to Ancober and moved to Entoto, and took five years to build the church of St Raguel. Empress Taitu built a Church to the Holy Virgin Mary at Entoto. Taitu also built a house there, which Menelik expanded to become the Imperial Palace, which remains the seat of government in Addis Ababa today (Henok Tibebu 2018; Pankhurst 2001).

Although suitable as a temporary camp, however, Entoto's location was not suitable for the capital of the country. Entoto was poorly supplied with firewood and water, and situated on a mountain 3 000 meters above sea level was often cold and windy and subject to thunderstorms. Addis Ababa was better situated, had an ample supply of water and better communication with the western and eastern parts of the country. Menelik took important steps to strengthen and modernise His domain and Addis Ababa; constructed a railroad; attempted to end the slave trade, and curbed the feudal nobility. His conquests doubled the size of the country and brought the present Southern Ethiopia (largely Muslim in population) into the realm. Menelik established the first Cabinet of Ministers to help in the administration of Ethiopia, and appointed trusted and widely respected nobles and retainers to the first Ministries. In 1896, Menelik led his forces in the Battle of Adwa and defeated the Italians, who had wanted to rule Ethiopia as a protectorate. He successfully pitted Italy against its European rivals while stockpiling advanced weapons to defend his empire against the Italians and British.

After becoming the capital of Ethiopia, the city grew rapidly and became the site of many of Ethiopia's innovations with a high degree of labour specialisation. Some of Ethiopia's first modern bridges were constructed soon after the Battle of Adwa. Menelik II died in 1913.

Addis Ababa has an altitude ranging from 3000m (at Mt Entoto) to 2050m (at Akaki plain) above sea level. The topography is rugged with typical volcanic features. While the central part of the city is characterized by gentle and rolling topography with scattered hills, the southern and south eastern parts are predominantly flat. The climate in Addis Ababa and its environs is mainly *Woina Dega* (temperate) with four seasons, namely *Bega* (dry season from October to January), *Kiremt* (the long season from June to September), *Belg* (short rainy season from February to May) and *Meher* (from November to December). The maximum, minimum and average annual rain fall is 1250 mm, 700 mm and 1180.4 mm, respectively (National Metrology Agency 2011).

Addis Ababa has almost equal status as a regional state with a city administration that reports directly to the Federal Government. Administratively, it is divided into 10 sub cities and 116 *Woredas* (lower administrative units). Addis Ababa’s city council is elected every five years. The city covers an area of 51948.85 hectares, which is about 32 percent of the total area of the country (AACACA 2016).

According to the 2007 population census, Addis Ababa had an estimated population of 3,194, 999 with a projected annual growth rate of 2.5% (Central Statistics Agency [CSA] 2012:30). Of the population, 1,515.001 (47.41%) were male and 1,679,998 (53%) were female. It is the largest and most populous city in the country.

Regarding health facilities in Addis Ababa, when relationships between Ethiopia and Italy were cordial, Menelik allowed a number of Italian doctors to visit and practise in Shoa (in Addis Ababa and outskirts) and parts of the country. The relationship was short-lived, however, and was suspended after the Battle of Adwa in 1896. Five months after Menelik’s victory at Adwa, the Russian Red Cross Mission arrived and was settled in the large compound in the Eastern part of Addis Ababa, Janmeda (Field of the King). The mission arrived in July 1896, five months after Menelik’s victory at Adwa. The original Russian mission was replaced in the following year (1887) by a second group of doctors. The achievement of this second mission was the establishment of Ethiopia’s first hospital in Addis Ababa called the Russian Red Cross Hospital. The hospital closed down in 1907 through a dispute with the customs offices over high customs duties. The first government hospital, Menelik II Hospital, opened in 1909/10 in Addis Ababa and the first poly clinic was also opened in Addis Ababa by Menelik's personal physician in 1910.

During the regency of Emperor Haile Selassie, I, there was significant development and expansion of hospitals and health centres in Addis Ababa. The period was dominated by the effort to rehabilitate facilities left by the Italians (after ruling the country for five years) and build new ones with curative services in Addis Ababa. Four of the hospitals in the city administration health bureau were built in this era. The health centres and clinics also be started by this era.

During the *Derg* (military rule) from 1974 to 1991 in the country, health services used a primary health care (PHC) approach to provide health care to the underserved by constructing more health centres and clinics. The basic health service approach was combined with vertical communicable disease programmes. Health facilities were expanded to lower level care and hospitals focused on the addition of more hospital beds. The physical expansion of health centres and clinics was better as they provided MCH/FP, health education and environmental hygiene as well as treatment services.

There has been progress in health service provision in Ethiopian since the Ethiopian People Revolutionary Front (EPRDF) came to power in 1991. At the time the current government took power, Ethiopia was in civil war, and many of the Hospitals and health centres were giving service predominantly for military personals and few services for mostly relied on communicable diseases. There were also few health professionals, scarce resources to address the aftermath of the civil war. The military personals and the civilians' patient were sent to few hospitals as referral, so the hospitals were facing challenge to treat their patients properly. Besides, there was centralized government system at the time. This was also a main obstacle for the health system because there was high interference by the government during the provision of health services. In 1995 the Transitional Government of Ethiopian introduced new political reforms which changed the centralized government system to decentralized government system and brought the new health policy. The existed new constitution also gave power to the regional government ''to formulate the country's policies in respect of overall economic and social development; it shall draw up and implant plans and strategies of development''. Addis Ababa City Government, as an autonomous and capital city of Ethiopia, has been given a mandate to provide health service for its rapidly growing population. Addis Ababa City administration designed its health strategic plan integrate with the health policy of the country and international policies to meet the health service demand of its population. The city administration started building new health centres and hospitals with a collaboration of the federal government and other stakeholders, and the number of health centres raised from 26 to 95 within five years (2011-2016). Currently, the Addis Ababa City government is designed it health strategic plan in line with the sustainable development goal (SDG) integrated with the country 20 years envisioning plan for health development up to 2030.

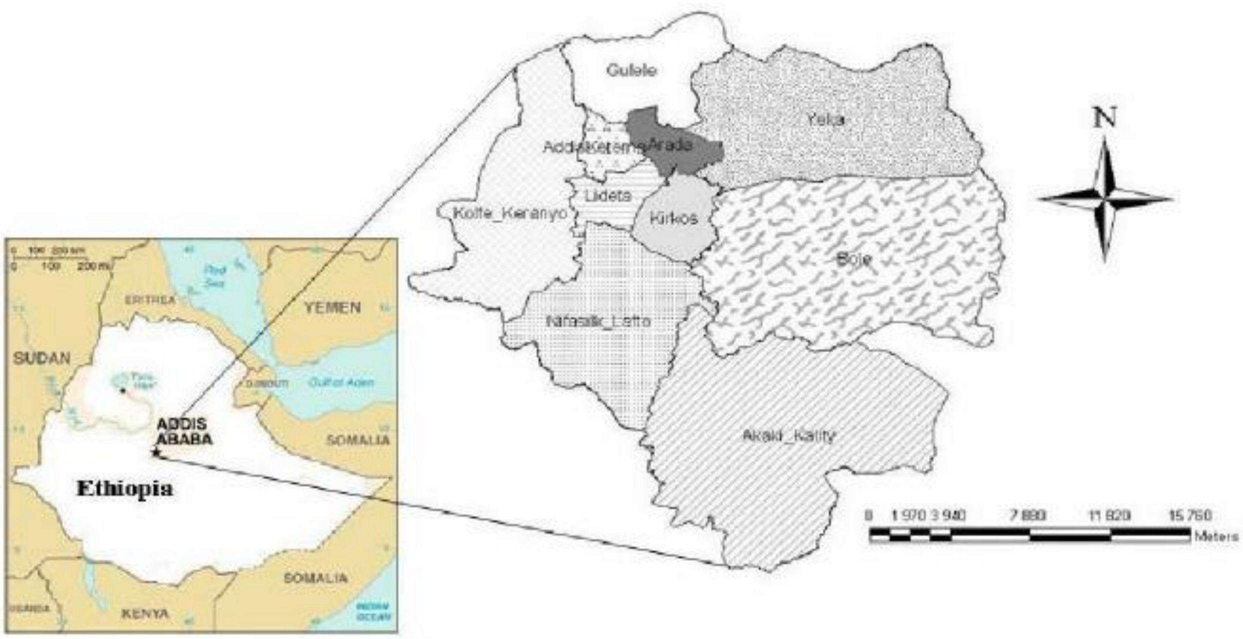


Figure 3.1 Map of Addis Ababa City

(Source: https://www.researchgate.net/profile/Fikirte_Tulu/publication/281460707/figure/fig1/)

3.4 RESEARCH PARADIGM

A paradigm is a way of looking at natural phenomena that encompasses a set of philosophical assumptions and that guides one's approach to inquiry (Polit & Beck 2012:11). Polit and Beck (2012:15) add that paradigms are lenses helping to sharpen the researcher's focus on a phenomenon. According to Gray (2014:127), a paradigm is an interpretative structure driven by a collection of beliefs and feelings and how to perceive and analyze it. The research paradigm and research approach are the same and may be qualitative, quantitative or mixed methods of research (Brink, Van der Walt

& Ban Rensburg 2012:55).In this study the researcher appropriated the quantitative paradigm research methodology.

3.5 RESEARCH DESIGN

Sekaran and Bougie (2016:95) define a research design as a master plan detailing the methods and procedures used to guide and conduct a study. A research design is a comprehensive plan for addressing research questions (Polit & Beck 2012:66). It is a blueprint or plan to direct the conduct of a study in order to maximize control over factors that would interfere with the study desired outcome.

The researcher selected a quantitative, exploratory, cross-sectional, descriptive and contextual design for the study in order to achieve the objectives.

3.5.1 Quantitative

A quantitative study is a formal, objective and systematic process to describe relationships and examine cause-and-effect interaction among variables (Burns & Grove 2011:747). Quantitative studies are largely based on the assumption that there is a single reality which can be uncovered or revealed by careful measurement (Creswell 2012:26). In quantitative studies, researchers use structured data-collection instruments and statistical data analysis (Polit & Beck 2012:16). In this study, the researcher used structured procedures and a formal instrument to collect numerical data that was then analysed statistically (Brink et al 2012:55). The quantitative approach included precise measurements of the amount and types of healthcare waste generated daily in the selected health centers. The data record sheet was used to record the amount of healthcare waste weight and how many people visit the selected for consecutive 7 days. The structured questionnaire was used to gather data from health centers and hospitals for HCW management, handling, and reporting of health care workers ' socio-demographic factors. The observation sheet was used to focus on places of interim storage, treatment and disposal of healthcare waste in health centres and hospitals.

3.5.2 Exploratory

Exploratory studies focus on gaining insight into a phenomenon or situation (De Vos, Strydom, Fouché & Delport 2010:95). In exploratory studies, researchers set out to explore a relatively unknown field in order to gain new insights, to extend a preliminary investigation into a more structured study, to determine the priorities for further research and to develop new hypotheses in respect of an existing phenomenon (Uys & Basson 2005:38). In this study the researcher insight the situation of healthcare waste generation by measurement from health centres and management practice by data collection from data collection and observation.

3.5.3 Cross-sectional

Cross-sectional studies are used to examine data at one time, i.e. data is only collected from participants on one occasion (Brink et al 2012:115). In cross-sectional studies, researchers begin with identifying the population to be studied, thereafter selecting an appropriate sample and collecting data at the same period at once for all the participants.

Cross-sectional studies examine a single phenomenon across a multiple population at a single point in time with no intention to follow up at a later stage (Houser 2012:260). HCW measurement, data collection from respondents and observation were done once, without follow-up, made this study cross-sectional.

3.5.4 Descriptive

Descriptive studies would like to observe, describe and portray accurately the features of specific situations and phenomena as they occur naturally (Polit & Beck 2012:226). Descriptive studies are considered to provide features that describe a specific situation and can also be used to identify current problem issues, justify current practice and even make judgments (Grove, Burns & Gray 2012:215). Such studies often yield accurate measurements of the studied phenomena, which can be explained by the collection of statistical data (Burns & Grove 2007:34).

The researcher has selected a descriptive approach to define the factors of effective HCWM in Addis Ababa City administration that affect health care services and the community.

3.5.5 Contextual

Burns and Grove (2007:32) note that contextual studies in naturalistic settings focus on specific events. Naturalistic settings are sometimes referred to as field settings as uncontrolled real-life situations. Therefore, to assess the current practices of solid HCW management, the researcher interviewed and observed participants in the health care facilities. In addition, HCW composition, generation rates and weight were measured; records of the number of patients per day in the selected health centres were reviewed, and observation and measurement sheets recorded the state and daily weight of variables respectively in the healthcare facilities.

3.6 RESEARCH METHODOLOGY

Research methodology is the process or plan for how the study will be conducted and includes the population, sample and sampling, data-collection instrument, and data collection and analysis (Grove, Burns & Gray 2012:215; Streubert & Carpenter 2011:366). Polit and Beck (2012:748) define research methodology as the steps procedures and techniques to address the problem and analyze the data collected. Research methods are techniques used to design a study and to collect and analyze relevant research information systematically for research question (Polit & Beck 2012:741). The research methodology covers population, sampling and sampling data collection and analysis as well as ethical considerations.

3.6.1 Population

A research population refers to all the elements from which data might be collected and could be "units, persons, organisations, events or objects” (Polit & Beck 2012:339). A study population comprises the entire aggregate of cases in which a researcher is interested (Creswell 2013:50). The source population consisted of 95 health centres and 6 hospitals. The study population were having the variety of healthcare professionals and ancillary staff in 15 health centers and 3 hospitals which was sampled.

In Ethiopia, the healthcare system organisation in urban settings classifies hospitals and health centres by the number of people served. General hospitals provide inpatient and ambulatory services to between 1 million and 1.5 million people. A specialised hospital serves inpatients and as a referral general hospital to between 3.5 million and 5 million people. The health centres are primary health care units (PHCUs) and provide preventive and curative services and serve 40,000 people. In this study, the target or source population included all the public hospitals and health centres in Addis Ababa City Administration Health Bureau (Yayehyirad, Gebre-Emmanuel, Hailu, Damen & Mitike 2017:225).

3.6.2 Sampling and sample

A sample is a subset of elements that comprise the entire population (Polit & Beck 2008:338). Sampling refers to the practice of selecting a proportion of the population to describe and analyse the features of the studied phenomenon (Polit & Beck 2008:339). For hospitals health centers and respondents, probability sampling was used. Probabilities sampling requires the random selection of elements from a population (Polit & Beck 2008:344). The researcher selected the sample by simple random sampling (lottery method). The consisted of 15 health centres and 3 hospitals with a variety of healthcare professionals and ancillary staff (see figures 3.2 and 3.3). The healthcare professionals included midwives, nursing staff, laboratory staff, pharmacists, health officers, doctors, radiographers, environmental health professionals and biomedical engineers. The ancillary staff comprised cleaners, porters and operatives for handling waste selected by proportion.

In quantitative research, when the data are available, the determination of sample size can be done by statistical computation. The data includes the total size of the population from which the sample is taken (Ryan 2013:33). Grove, Burns & Gray (2012:367) indicates that an effective size, power and standard error is needed to calculate the sample size. To determine the number of health centres in Addis Ababa City Administration, the following information and formula estimating a mean was used (Andy 2013:1074).

The following formula n= $(Z_{\alpha/2})^2 * \delta^2/d^2$ calculating sample size (n) for Addis Ababa City Administration Health Bureau Public Health Centres was used:

Standard normal variate of approximately 95% confidence ($Z_{\alpha/2}$) =1.96;

δ= population Standard Deviation (SD), estimated by sample Standard Error (SE)

SE (δ) =SD/√n=0.312

d= margin of error corresponding 95% of certainty; d= (Zα/2)*SE

1.96*0.312 = 0.6115

0.6115 of 9.61= 6.37% (i.e. within 6.37% from 9.61) give the number (see table 3.1).

Table 3.1 Assumptions and given used for sample size calculation for health centres, 2016

d, % of mean	D	$(Z_{\alpha/2})$	$(Z_{\alpha/2})^2$	SD	SD^2	d^2	N	# of HCs at 8 days measurement	# of HCs at 7 days measurement
2.0%	0.0481	1.96	3.8416	3.28	10.76	0.0023	17972	2246	2567.43
4.0%	0.3884	1.96	3.8416	3.28	10.76	0.1478	279.67	34.959	39.953
6.37%	0.612	1.96	3.8416	3.28	10.76	0.375	110.228	13.779	15.747
10%	0.961	1.96	3.8416	3.28	10.76	0.924	44.73	5.59	6.39
15%	1.442	1.96	3.8416	3.28	10.76	2.078	19.892	2.487	2.842

In Addis Ababa City Administration Health Bureau there are 95 functional health centres in 10 sub cities. The sub cities and the number of health centres are presented in figure 3.2. To get the exact number of health centres sampling fraction, i.e. the ratio of the number of units in the sample to the number of units in the reference population (n/N) where n=number of health centres in the sub city and N= total number of functional public health centres in Addis Ababa City Administration Health Bureau, was used to get the number of health centres.

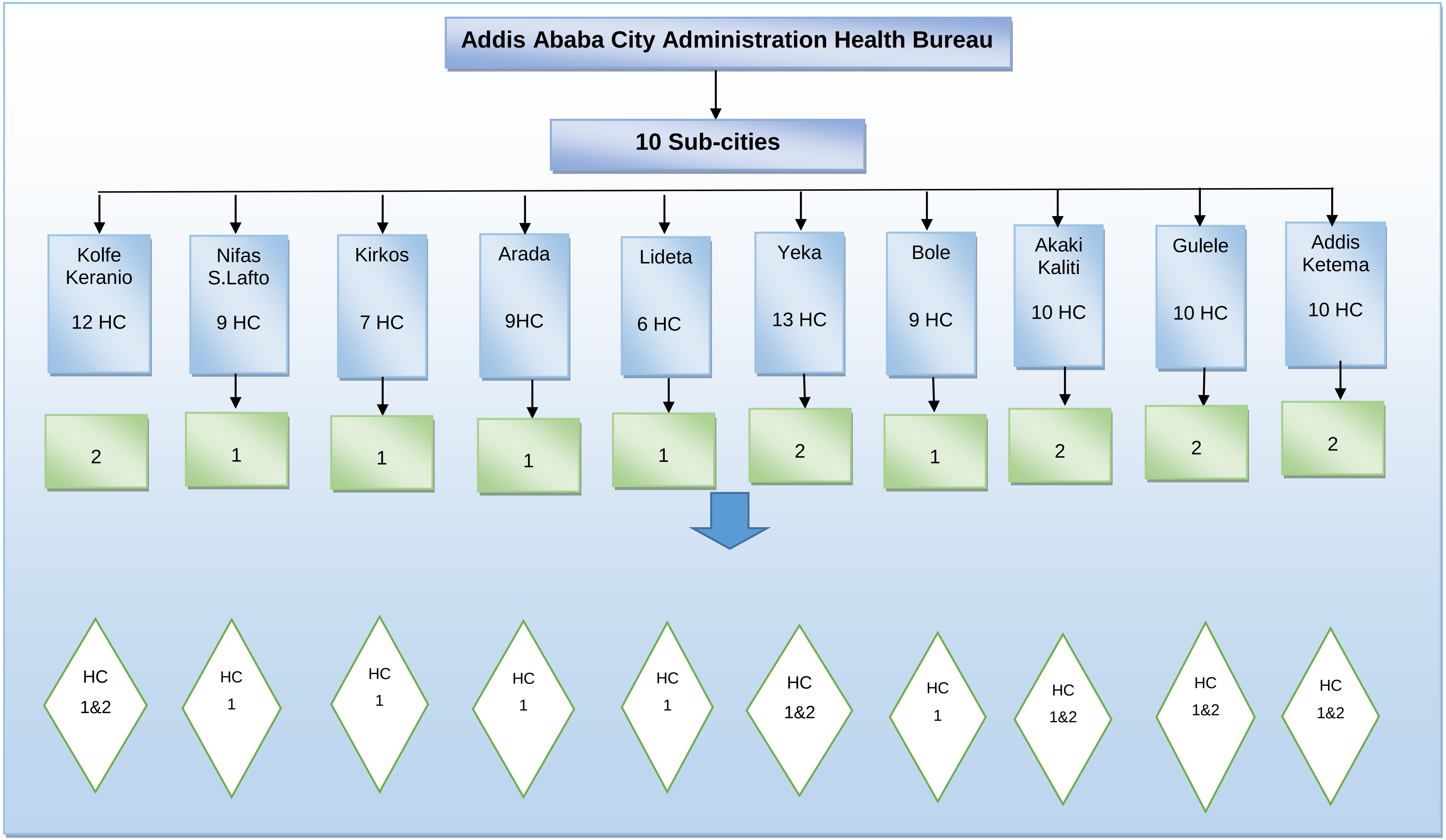


Figure 3.2 Number of health centres selected from ten sub-cities

There are six public hospitals in Addis Ababa City Administration Health Bureau. Three hospitals were selected by simple random sampling (SRS) (see Figure 3.3).

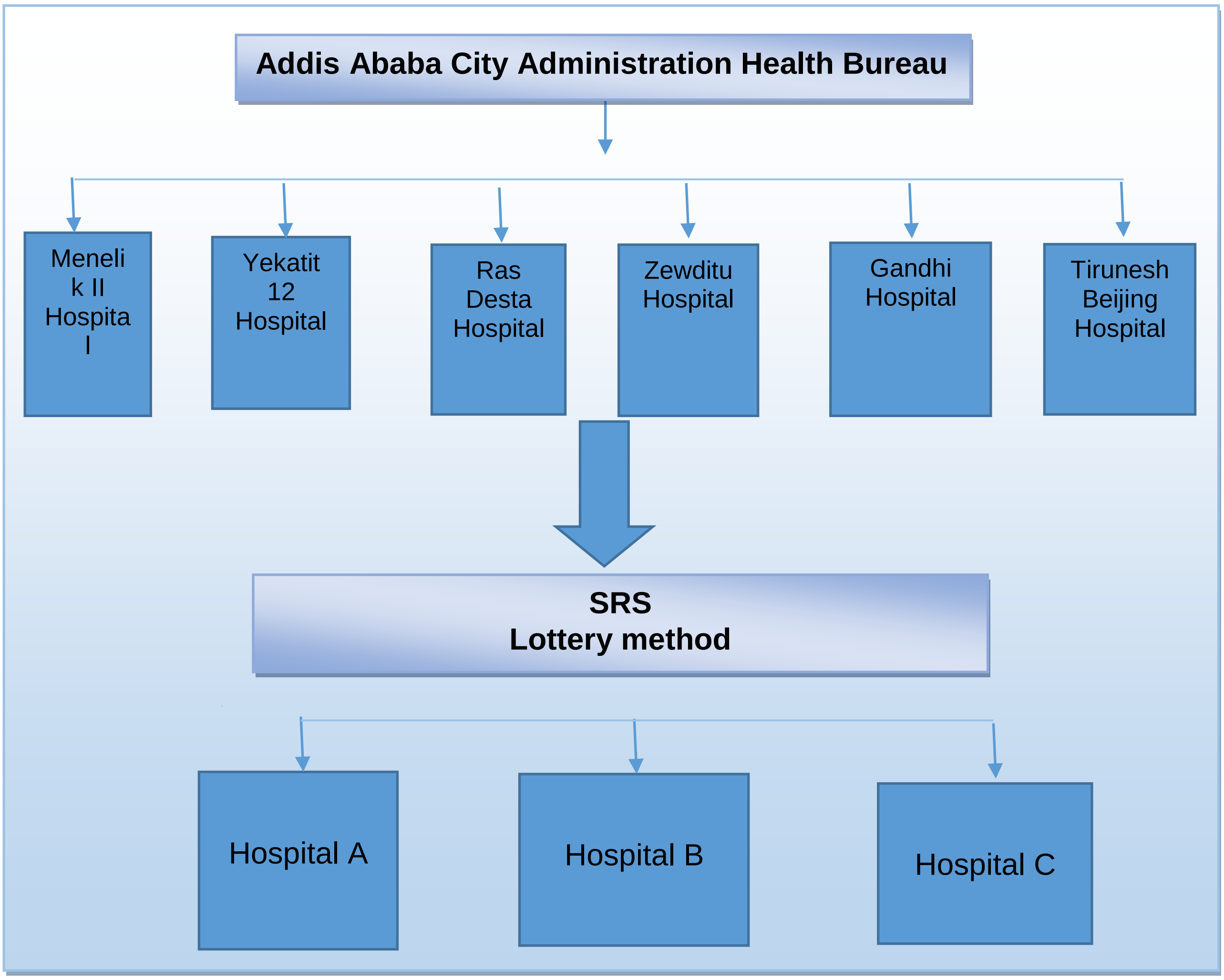


Figure 3.3 Number of hospitals selected from Addis Ababa City

Polit and Beck (2008:348) stated that large samples are recommended in quantitative studies. The larger the sample, the more representative the population and smaller chance of producing less accurate estimates. The researcher used multi-stage sampling in the study. The primary sampling units (PSU) were workers in the health centres and the second sampling was the sub-city where 9 866 health professionals work in Addis Ababa City Administration. Considering an assumption of 50%, 95% level of confidence and 5% margin of error were used to calculate the sample size. The degree of accuracy 5% was also required and 5% proportion to be true in the population as a whole. The confidence level required specified 95% and the design effect to be 2. To determine the number of participants for the study, the following formula was used: $n=(Z_{\alpha/2})^2$ $P(1-P)/W^2$. By using this formula and information the study included 384.16 or 385 participants but N=9866. The required minimum sample was obtained from the above estimate by making some adjustments so that 370 participants were part of the study. When 370 multiplies by the design effect of 2, 740 participants had been selected from the health centres and hospitals with the proportion of health care workers and ancillary staff.

3.6.3 Data collection

Data collection is the precise, systematic gathering of information relevant to the research purpose or objectives of the study (Burns & Grove 2007:52; Polit & Beck 2012:67). Data is collected from the respondents by means of a data-collection instrument (Polit & Beck 2012:68).

Data was collected by means of questionnaires, observation, measurement and field notes. To reduce subjectivity (information bias), the author developed a structured questionnaire as a data collection tool in line with the research objective. The researcher visited the survey site for observation and measured the exact amount of HCW generated and identify the types per day in the selected health centres. The HCW management practice of health care workers and ancillary staff and how many people visited the selected health centres per day were also examined. A measurement data record sheet and observation sheet were used for data on healthcare waste (see Annexures G and H).

3.6.3.1 Assessment of HCW management practice

To investigate the overall practice of HCW management, the researcher used a structured questionnaire and observational checklists adapted from the World Health Organization's healthcare waste management rapid assessment tools to describe the HCW management practices of healthcare workers in the healthcare facilities. The questionnaire included respondents' demographic characteristics, knowledge and practice of HCW management. The questionnaire consisted of closed questions (requiring a 'Yes' or 'No' answer). Data collectors distributed the questionnaires in the 15 health centres and 3 hospitals to the respondents (administrators, medical directors, and case team coordinators [e.g., pharmacy, laboratory, pathology, delivery, surgery and environmental health], ancillary staff and workers directly involved in waste handling). Fifteen data collectors who graduated in health science from universities or colleges were used to drop off and pick up questionnaires and for field observation. Respondents who were not able to read, the English language questionnaires were assisted by the data collectors. The number of participants from each health facility was determined in proportion to the total number of workers in case teams found in each health facility. The main questions covered segregation, collection, transportation, storage, treatment and disposal, waste recycling and re-use, occupational health and safety, internal policies, and administration and healthcare waste management.

Observation was also conducted by the data collectors and supervisors to see the waste management practice of the health centres and hospitals. The data collectors used the prepared observational check list to follow the HCW management practice and captured supporting photographs. The check list examined the six characteristics of waste management, descriptors and indicators of HCW management, namely general management strategy, collection, segregation, recycling, storage and disposal of waste.

3.6.3.2 Quantification of health centre solid HCW generation rate and composition

To determine the health centre solid HCW composition and generation rate, data was collected on 7 days to make provision for daily differences in the generation of waste. Fifteen data collectors who graduated from a secondary school with Grade 10 certificates were used for measurement of healthcare waste. Eight supervisors who were BSc graduates in Environmental Health or related fields assisted the principal investigator with the data collection. The supervisors calibrated the measuring balances and facilitated the collection of questionnaires which was distributed to the research participants (respondent). The researcher gave the fieldworkers three days of training in data collection and the data-collection tools as well as the relevant protocols and precautionary measures to not contaminate themselves and others. The researcher trained the data collectors, verified data and controlled the study.

All waste collection buckets, safety boxes and plastic bags (black, yellow and red) obtained for the study were labelled to indicate the different categories of healthcare waste, date of collection and sample number. The quantity of waste generated was estimated by collecting and weighing healthcare waste from all departments of the health care facilities, using a calibrated sensitive weight scale every day at 9:00 am for seven consecutive days from Monday to Sunday. The waste characterisation was done in accordance with World Health Organization (WHO) guidelines (Chartier et al 2014:14). The daily generation of waste together with the number of services and patients visited in outpatient and other case teams were recorded on a daily basis. The HCW generation rate was estimated on the basis of kg/patient/day (Chartier et al 2014:14).

3.6.4 Validity and reliability

The quality of research is determined by its validity and reliability (De Vos et al 2010:166). Validity refers to the degree to which an empirical measure accurately reflects the actual importance of the phenomenon being considered (Kimberlin & Winterstein 2008:2276). Validity refers to the extent to which an empirical measure adequately reflects the real meaning of the phenomenon under consideration. It is the measure of the truth or accuracy of what it claims, hence validity is used to check that the instrument measures the concept in question and that the concept is accurately measured (De Vos et al 2010:166). Reliability refers to the consistency with which an instrument measures study-related attributes or variables. Reliability is related to the stability consistency or dependability of a measure (Polit & Beck 2012:69). Reliability refers to the degree to which an instrument produces similar outcomes when performed under comparable conditions by independent persons (De Vos et al 2010:220). There are four types of validity, namely internal, external, content, and face validity (De Vos et al 2010:166). In this study, external and internal validity applied.

3.6.4.1 External validity

External validity of the instrument exists when results obtained can be generalised to other people and settings (Kimberlin & Winterstein 2008:2276). External validity is the degree to which the results of the study can be generalised to other settings and populations than the one studied. Researchers can apply the results from this study to other persons, settings and situations. In this study, there were no threats to external validity.

3.6.4.2 Internal validity

Internal validity is the degree to which it is possible to conclude that the independent variables influence the dependent variables and that the influence is not caused by confounding variables (Polit & Beck 2012:295). The findings of a study would be explained by other facts than the study itself.

3.6.5 Data-collection instruments

In this study, questionnaires, observation check lists and measurement data sheets were used as data-collection instruments. The researcher developed a semi-structured questionnaire based on the literature review and the research objectives.

3.6.5.1 Questionnaires

Questionnaires allow respondents to respond anonymously (Sekaran & Bougie 2016:158). The questionnaires covered socio-demographic factors for both healthcare facility healthcare waste handlers and managers. Healthcare waste handling knowledge, attitude and practice was prepared for healthcare waste handlers and healthcare waste management knowledge, attitude and practice for healthcare facility managers (see Annexure E and F).

3.6.5.2 Field observation and measurements

During observation, data was collected and recorded on an observation sheet and measurement data sheet. Polit and Beck (2008:433) state that observation requires the examination of research subjects in a natural social environment with special attention to their behaviour and actions. Observation can reveal habits that participants are unaware of and can help place behaviour in context (De Vos et al 2010:335). The observational tool was prepared to see the storage area, treatment and disposal of healthcare waste in the healthcare facilities. During observation the researcher focused on places of interim storage, treatment and disposal of HCW in the healthcare facilities. The activities were observed without direct involvement with the participants. The researcher personally walked through the healthcare facility compounds.

The measurement of healthcare waste was used to express the observed quantity. The pre-weighed separate bags, yellow for infectious HCW, red for pharmaceutical HCW, black for non-infectious and safety box for sharps, were used. A digital weighing scale model Sartorious Basic Type BA 6100 and electronic compact Balance Model EPB-10001 L digital were used to measure healthcare waste at all the selected healthcare facilities. A digital camera also was used to collect data for observation in the healthcare facilities.

3.7 PILOT STUDY

A pilot study or pre-test is a small-scale experiment of participants not included in the final study (Creswell 2013:206). The rationale for the pre-test was to determine the validity and reliability of the questionnaire and the observation check list. The researcher conducted a pilot study with 21 participants, in one of the health centres who were not included in the final study. Following the pre-test, the researcher updated the questionnaires according to the input of the respondents' (Brink et al 2012:174).

3.8 DATA ANALYSIS

Data analysis is the systematic organization and synthesis of research data (Polit & Beck 2012:725). The researcher conducted an analysis of the data manually, by sorting and organizing information according to similarities and differences. After that the data was categorised and relationships identified. To determine solid health centre waste generation rate and composition and to select the best fit predictive models to use to precisely estimate health care solid waste generation rate, Microsoft Excel, EPI- INFO TM 7 and IBM SPSS 20 were used for data entry, cleaning and analysis.

Data analysis was performed separately for each of the health facilities (health centres and hospitals) which were grouped by category of ownership. Pearson's correlation test for the bivariate associations; means; Standard Deviation (SD); frequencies; percentages, and graphs were used. To see the effect of the parameters and their confidence levels on the waste generation rate in healthcare services, analysis of variance (ANOVA) was performed to compare the rate by type of health centre.

3.9 ETHICAL CONSIDERATIONS

Ethics deals with matters of right and wrong. To protect their rights, ethical considerations are important for any research involving human subjects (Polit & Beck 2012:152). Human research should be intended to benefit the participants themselves or other people or society as a whole (Polit & Beck 2012:152). The researcher therefore obtained permission to conduct the study and maintained the principles of autonomy, anonymity and confidentiality, as well as protection against harm or risk.

- **Permission**

Ethical approval and clearance were obtained from the Higher Degrees Committee, Department of Health Studies, University of South Africa and Addis Ababa City Administration Health Bureau to conduct the study (see Annexure A and C).

- **Informed consent**

A written information sheet and consent form were provided to all participants. The participants were informed of the purpose of the study; that participation was voluntary, and that all information would be treated strictly confidentially. The participants signed informed consent.

- **Self-determination/autonomy and respect for human dignity**

Researchers have an obligation to respect the rights, needs, values and desires of the participants. Respect refers to the right of a person to participate in a study voluntarily (Modina 2016:13). The researcher contacted the participants and informed them of the purpose of the study. Participants were informed that they participated on a voluntary basis and could refuse to participate or withdraw from the study at any time if they so wished. In this study the participants gave informed consent.

- **Anonymity and confidentiality**

The participants were assured of anonymity and confidentiality. No names were provided on the questionnaires. All the questionnaires were numbered and no information given could be traced to any participant.

- **Risk**

Risk refers to exposure to danger, harm or loss. The data collectors and healthcare waste handlers were at risk when segregating, collecting and measuring the quantities of healthcare waste. Accordingly, during data collector training, the researcher explained the potential harm or danger in order to minimize the risk of infectious or hazardous healthcare waste. Personal Protective Equipment was distributed to the data collectors and worn during handling of healthcare waste.

3.10 CONCLUSION

This chapter described the research design and methodology used during the study. The research area, research paradigm, research design, research methodology; sampling technique, data collection, pilot study, significance, limitations, and ethical considerations of the study included in the study were presented.

Chapter 4 discusses the data analysis and interpretation and findings.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION, AND FINDINGS

4.1 INTRODUCTION

This chapter discusses the data analysis and interpretation, and findings.

4.2 PATIENT FLOW IN THE STUDY HEALTH CENTRES

A total of 13,897 patients visited the selected health centres on the seven (7) days of observation. Of these, 1,765 (12.7%) and 1,527 (10.99%) visited Meshoalekia and Filipos health centres, and 474 (3.41%) and 466(3.35%) visited Woreda 9 and Korea Zemachoch health centres, respectively. The mean (±SD) patients per day in all the selected health centres was 132.35±60.621 (see Table 4.1).

Table 4.1 Number of patients in the study health centres, Addis Ababa City Administration, February 2018

Name of health centre	Total patients to health centre on 7 days	Mean patients to health centre
Kolfe	1503	214.71
Filipos	1527	218.14
Meshoalekia	1765	252.14
Teklehaymanot	694	99.14
Woreda 1	685	97.86
Kella	620	88.57
Saris	784	112.00
Korea Zemachoch	466	66.57
Yeka	872	124.57
Goro	1498	214.00
Millennium	689	98.43
Woreda 9	474	67.71
Michew	690	98.57
Sheromeda	901	128.71
Arada	729	104.14
Mean	926.47	132.35
SD	424.35	60.621

4.3 GENERATION AND CLASSIFICATION OF HEALTHCARE WASTE

The researcher randomly selected 15 health centres for the study. Healthcare waste was generated from different case teams in the health centres. The HCW was classified into nonhazardous HCW (general waste) and hazardous HCW (sharps, infectious, pathological and pharmaceutical). The total HCW, nonhazardous HCW and hazardous HCW were calculated and presented in tables, figures and texts.

4.3.1 Daily HCW generation in health centres

The mean (±SD) HCW generation rate was 10.64 ± 5.790 kg/day, of which 3.96 ± 2.017 kg/day (37.26%) was general waste and 6.68 ± 4.293 kg/day (62.74%) was hazardous waste. A high amount of HCW per day was generated at Filipos and Yeka health centres, namely 26.90 kg/day and 16.96 kg/day, respectively. A small amount of HCW generation was recorded at Woreda 9 and Korea Zemachoch health centres, namely 4.71 kg/day and 5.25 kg/day, respectively (see Table 4.2 and Figure 4.1).

The study revealed that Filipos health centre had the highest HCW generation rate with an average of 0.123 kg/patient/day. All the health centres operated daily and were open for 24 hours and offered services but Filipos HC had more patients than the others. Filipos has a laboratory and delivery room that render service because of the geographical distance to the other health centres. Many patients therefore visit the health centre because of its operating hours which are flexible and convenient. An average of 218 people visited Filipos health centre daily (see Table 4.2).

Table 4.2 Daily HCW generation rate in the study health centres, Addis Ababa City Administration, February 2018

Name of health centre	Healthcare waste, Kg/day			
	Total HCW in 7 days (observed)	Mean of HCW Mean (± SD)	Mean of general waste (%)	Mean of hazardous waste (%)
Kolfe	67.44	9.63± 15.328	1.45 (15.31%)	8.19 (84.69%)
Filipos	188.30	26.90±31.341	8.00 (29.75%)	18.90 (70.25%)
Meshoalekia	53.88	7.69±11.041	3.79 (49.28%)	3.90 (50.72%)
Teklehaymanot	39.48	5.63±6.077	2.38 (42.14%)	3.26 (57.86%)
Woreda 1	110.11	15.70±19.070	6.60 (41.97%)	9.10 (58.03%)
Kella	66.30	9.47±11.382	4.098 (43.27%)	5.37 (56.73%)
Saris	94.41	13.49±10.446	2.92 (21.66%)	10.57 (78.34%)
Korea Zemachoch	36.57	5.25±7.489	2.44 (46.77%)	2.80 (53.23%)
Yeka	118.71	16.96±17.963	6.86 (40.42%)	10.10 (59.58%)
Goro	68.75	9.82±13.602	2.98 (30.35%)	6.84 (69.65%)
Millennium	40.75	5.82±8.419	2.85 (49.0%)	2.97 (50.99%)
Woreda 9	32.96	4.71±6.303	1.87 (39.81%)	2.83 (60.19%)
Michew	58.35	8.33±7.752	2.41 (28.97%)	5.92 (71.03%)
Sheromeda	65.27258	9.32±15.958	5.29 (56.77%)	4.03 (43.23%)
Arada	76.478	10.93±15.615	5.47 (50.07%)	5.45 (49.93%)
Overall mean	74.51	10.64	3.96 (37.26%)	6.68 (62.74%)
SD	40.532	5.790	2.017	4.293

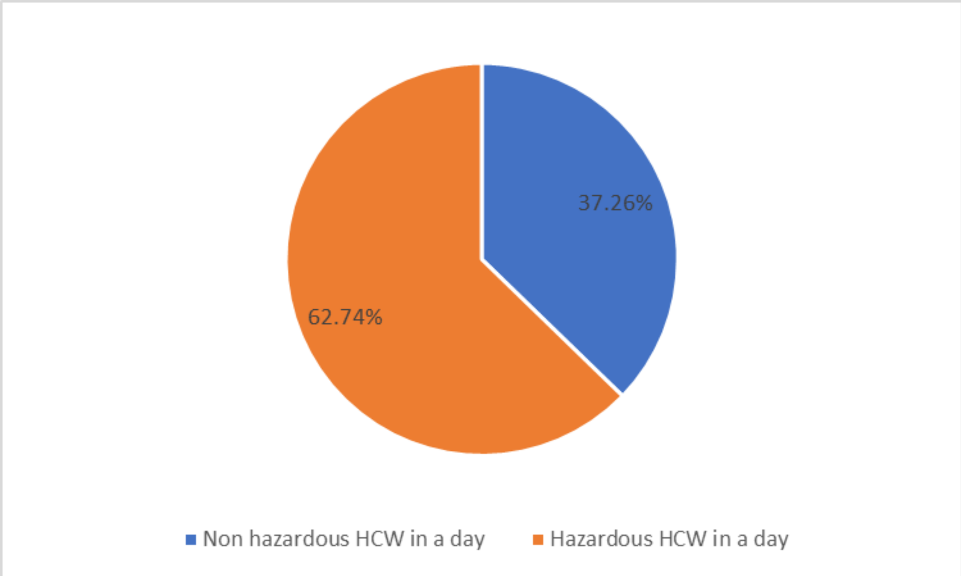


Figure 4.1 Percentage and type of HCW in the selected health centres, Addis Ababa City Administration, February 2018

The results for HCW collected weekly from the study health centres varied in amount of HCW generation. Figure 4.2 shows the average value for HCW in each health centre and standard deviation as error bar. The findings indicate significant variations in the HCW generation rates.

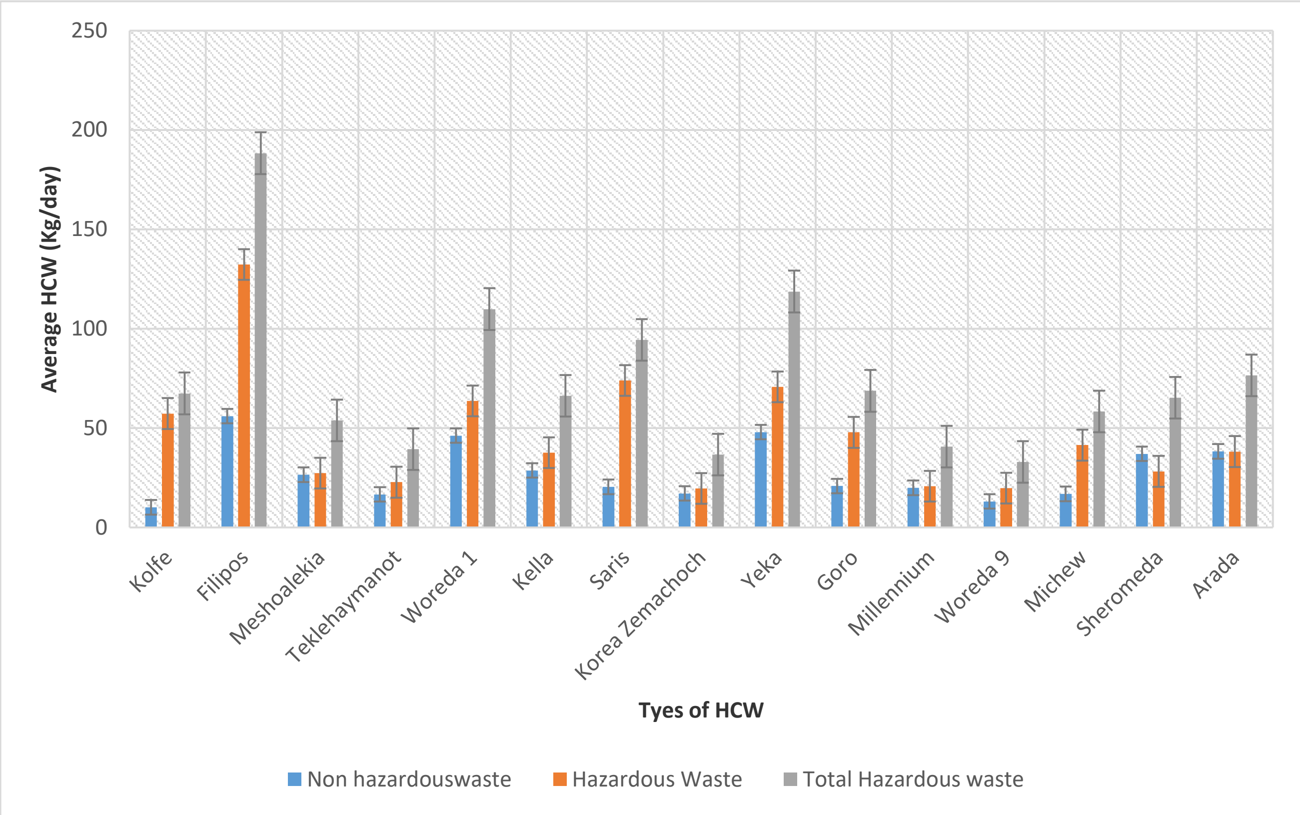


Figure 4.2 Error bar of average HCW generation rates in the study health centres, Addis Ababa City Administration, February 2018

The types of hazardous waste generated by the study health centres were sharps, infectious, pathological (placenta and blood) and pharmaceutical. The mean (±SD) generation rate of sharps, infectious, pathological and pharmaceutical waste in each health centre was 0.97± 1.031 (14.63%), 3.23± 2.603 (48.72%), 2.17± 1.917 (32.73%) and 0.26± 0.342 (3.58%) kg/day, respectively. Infectious and pathological waste comprised 81.3% of the hazardous waste (see Table 4.3 and Figure 4.3).

In most of the health centres, the generation of hazardous HCW was high. For example, Filipos HC generated 18,89 kg/day; Saris HC generated 10.57 kg/day, and Yeka HC generated 10.11 kg/day. The lowest amounts of hazardous HCW generated were from Korea Zemachoch HC (2.81 kg/day), Woreda 9 HC (2.83 kg/day) and Millennium HC (2.97 kg/day) (see Table 4.3). During the HCW collection survey week, the study found that more HCW was generated from health centres with no public hospital nearby. The smallest amounts of HCW generated were from health centres that used nearby public hospitals.

Table 4.3 Distribution of type and amount of daily hazardous HCW generation rate in the study health centres, Addis Ababa City Administration, February 2018

Name of health centre	Sharps Kg/day	Infectious Kg/day	Pathological Kg/day	Pharmaceutical Kg/day	Total hazardous waste Kg/day
Kolfe	0.73	0.19	5.77	0.37	7.06
Filipos	4.03	11.59	3.28	0	18.89
Meshoalekia	0.71	2.55	0.65	0	3.90
Teklehaymanot	0.78	1.11	1.37	0	3.26
Woreda 1	0.51	4.07	4.30	0.21	9.13
Kella	0.399	2.67	2.09	0.21	5.37
Saris	2.51	4.71	2.83	0.51	10.57
Korea Zemachoch	0.64	1.91	0.26	0	2.81
Yeka	1.06	4.03	4.37	0.64	10.11
Goro	0.28	1.88	4.68	0	6.84
Millennium	0.68	1.96	0.33	0	2.97
Woreda 9	0.36	1.94	0.54	0	2.83
Michew	0.69	3.24	1.78	0.43	6.14
Sheromeda	0.396	3.14	0.26	0.23	4.03
Arada	0.82	3.42	0	1.21	5.46
Average	0.97	3.23	2.17	0.25	6.63
SD	1.031	2.603	1.917	0.34	4.274

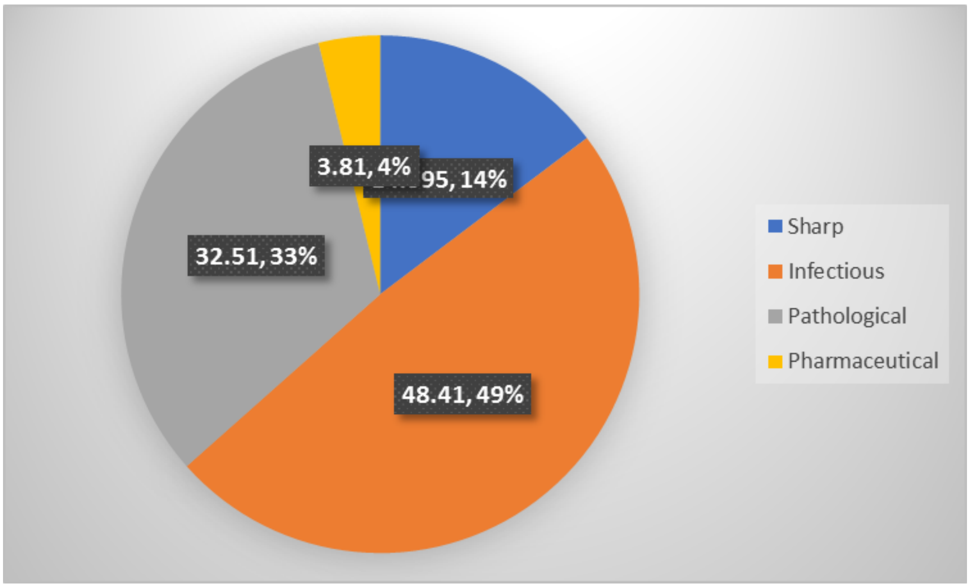


Figure 4.3 Composition, contribution and generation of hazardous HCW in the study health centres, Addis Ababa City Administration, February 2018

4.4 DAILY HCW GENERATION RATE IN DIFFERENT CASE TEAMS

In different case teams, the HCW generation rate varied. The mean (±SD) HCW generation rate in each section was 10.63±5.795 kg/day. Increased amounts of HCW (29.93%) were generated from delivery and postnatal case teams while less (0.32%) HCW was generated from NGM case teams (see Table 4.4). The mean health care waste generation rate in different case teams in the study health centres was statistically significant ($\chi 2$ = 229.2, p-value<0.001) (see Table 4.4).

Table 4.4 Distribution and daily HCW generation rates by point of source in the study health centres, Addis Ababa City Administration, February 2018

Case teams	Healthcare waste (Kg/day) Mean± (SD)	Percent	Mean rank*
OPD (Out patient department)	0.59±0.390	5.63	194.8
Pharmacy	0.99±0.636	9.28	225.43
Laboratory	1.76±1.094	16.59	255.53
Emergency and triage	1.085±0.893	10.21	222.60
Injection and dressing	0.64±0.537	5.99	181.1
FNAC	0.25±0.227	2.39	141.7
Delivery and post-natal	3.18±2.557	29.93	247.8
TB and Leprosy	0.18±0.173	1.66	119.73
EPI	0.54±0.607	5.07	180.23
Family planning	0.32±0.300	3.05	156.07
HTC	0.18±0.125	1.70	123.87
ART	0.34±0.334	3.22	142.63
Medical recording	0.21±0.145	1.97	134.33
NGM (Nutrition and growth monitoring)	0.03±0.068	0.32	54.03
Abortion procedures	0.038±0.086	0.36	53.17
HMIS	0.041±0.081	0.39	56.50
In-patient	0.077±0.119	0.72	73.73
Laundry	0.14±0.111	1.34	109.43
Adolescence and youth	0.019±0.057	0.18	44.6
Mean	10.63		
SD	5.795		

*X2= 229.196, p<0.001, df=18

4.5 ESTIMATED ANNUAL HCW GENERATION RATE

The estimation of HCW generation rate per year can be calculated in two ways. Firstly, by the annual patient flow and mean HCW generation rate per patient per day (the assumption was each patient who visited the health centre might generate the same amount of HCW throughout the year).

Total HCW Generation per year = Mean HCW generation in kg per patient per day* Number of patients flow in a year

Secondly, by using the HCW generation rate per day (kg/day) and number of days in the year (the assumption was the mean of HCW per day might represent throughout 365 days).

Total HCW generation per year = Mean HCW generation in kg per day * 365

The mean (±SD) patient flow per day per health centre was 132.35±60.621. The mean (±SD) HCW generation rate per health centre was per day or 10.63 ± 5.796 kg/day.

The annual mean (±SD) of HCW generation rate per health centre was 3870.53±2109.84kg/year using the first method and 3881.14±2195.01 kg/year using the second assumption. There was a slight variation of the annual HCW generation rate in both assumptions (see Table 4.5).

Table 4.5 Estimated total HCW generation rate per year in the study health centres, Addis Ababa City Administration, February 2018

Name of health centre	Patient flow in 2018	Patient flow per day 2018	Mean HCW kg/day	Mean HCW g/pat/day	*Total HCW kg/year	**Total HCW kg/ year
Kolfe	78371	214.71	9.63	44.85	3514.95	3514.94
Filipos	79622	218.14	26.90	123.31	9818.5	9818.19
Meshoalekia	92032	252.14	7.7	30.53	2810.5	2809.74
Teklehaymanot	36187	99.14	5.64	56.89	2058.6	2058.68
Woreda 1	35718	97.86	15.73	160.74	5741.45	5741.31
Kella	32329	88.57	9.47	106.93	3456.55	3456.94
Saris	40880	112	13.49	120.42	4923.85	4922.77
Korea Zemachoch	24299	66.57	5.22	78.48	1905.3	1906.99
Yeka	45469	124.57	16.96	136.13	6190.4	6189.70
Goro	78110	214	9.82	45.90	3584.3	3585.25
Millennium	35926	98.43	5.82	59.14	2124.3	2124.66
Woreda 9	24716	67.71	4.71	69.54	1719.15	1718.75
Michew	35979	98.57	8.34	84.56	3044.1	3042.38
Sheromeda	46981	128.71	9.32	72.44	3401.8	3403.30
Arada	38012	104.14	10.93	104.91	3989.45	3987.84
Average	48308.73	132.35	10.65	86.32	3885.55	3885.43
SD	22126.89	60.621	5.794	37.731	2114.74	2114.50

*Total HCW generation rate in kg per year=HCW generation rate in kg per day * 365

**Total HCW generation rate in kg per year= (HCW generation rate in grams per patient per day * Number of annual patients flow)/1000

4.6 PATIENT FLOW AND HCW GENERATION COMPARISON

The patient flow and HCW generation rate and types, such as general and hazardous waste (sharps, infectious, pathological and pharmaceutical waste), among the study health centres were compared using the Kruskal-Wallis test to check for the presence of significant difference**s** among their values.

There was no statistically significant difference for the mean patient flow (x^2=14.504, p-value=0.106) and the mean general waste (x^2=22.631, p-value=0.067), but there was a statistically significant difference for mean of healthcare waste (x^2=9.421, p-value=0.803) and the mean hazardous waste (x^2=35.819, p-value=0.001) among the study health centres (see Table 4.6).

Table 4.6 Comparison of patient flow and HCW generation rate and types among the study health centres, Addis Ababa City Administration, February 2018

Name of health centre	Mean rank			
	Patient flow	Total HCW	Nonhazardous HCW	Hazardous HCW
Kolfe	214.7	9.63	1.45	8.19
Filipos	218.1	26.90	8.00	18.90
Meshoalekia	252.1	7.70	3.79	3.90
Teklehaymanot	99.1	5.63	2.38	3.26
Woreda 1	97.9	15.70	6.60	9.10
Kella	88.6	9.47	4.10	5.37
Saris	112	13.49	2.92	10.57
Korea Zemachoch	66.6	5.25	2.44	2.80
Yeka	124.6	16.96	6.86	10.10
Goro	214	9.82	2.98	6.84
Millennium	98.4	5.82	2.85	2.97
Woreda 9	67.7	4.71	1.87	2.83
Michew	98.6	8.34	2.41	5.92
Sheromeda	128.7	9.32	5.29	4.03
Arada	104.1	10.93	5.47	5.45
Chi-square	14	22.631	35.819	9.421
Asymp. Sig.	0.450	0.067	0.001	0.803

Degree of freedom = 14

The extent or strength of linear relationships between the number of patients and amount of HCW generation rate was checked using the Spearman's rank correlation coefficient (r_s) in all the health centres. The Spearman's rank correlation coefficient showed a positive linear relationship: as the number of patients increased, HCW also increased in all the study health centres. A strong linear relationship was observed at Filipos and Meshoalekia health centres: the Spearman's correlation coefficient was 0.964 and 0.964, respectively which is far from a perfect linear relationship at Spearman's correlation coefficient value (r_s=1). A strong linear relationship was not observed at Saris, Kolfe, Teklehaymanot and Korea Zemachoch health centres: 0.126, 0.321, 0.342, and 0.342, respectively, which is far from a perfect linear relationship at Spearman's correlation coefficient value (r_s=1) (see Table 4.7).

Table 4.7 Correlation of patient numbers and quantity of waste generated in the study health centres, Addis Ababa City Administration, February 2018

Name of health centre	Spearman's rank correlation coefficient (r_s)
Kolfe	0.321
Filipos	0.964
Meshoalekia	0.964
Teklehaymanot	0.342
Woreda 1	0.559
Kella	0.631
Saris	0.126
Korea Zemachoch	0.342
Yeka	0.643
Goro	0.607
Millennium	0.893
Woreda 9	0.357
Michew	0.571
Sheromeda	0.607
Arada	0.429

The study found HCW variation (see Figure 4.4). Hazardous HCW and non-hazardous HCW had different lower scores and hazardous HCW was higher. The median for hazardous HCW was higher than for non-hazardous waste (see Figure 4.4). According to Figure 4.4, the first quartile (Q1) was equal to 47.32 kg/7days to the total HCW, about 25% of the total HCW was lower than 47.32 kg/7 days and about 75% was above 47.32 kg/7 days. Regarding non-hazardous HCW, the first quartile (Q1) was equal to 17.0 kg/7 days about 25% of non-hazardous HCW was lower than 17.0 kg/7 days. The total HCW showed a lower cut-off -9.87 and an upper cut-off 75.57 kg/7 days. The hazardous HCW also had a lower cut-off -28.1 kg/7 days and an upper cut-off 32.41 kg/7 days (see Figure 4.4).

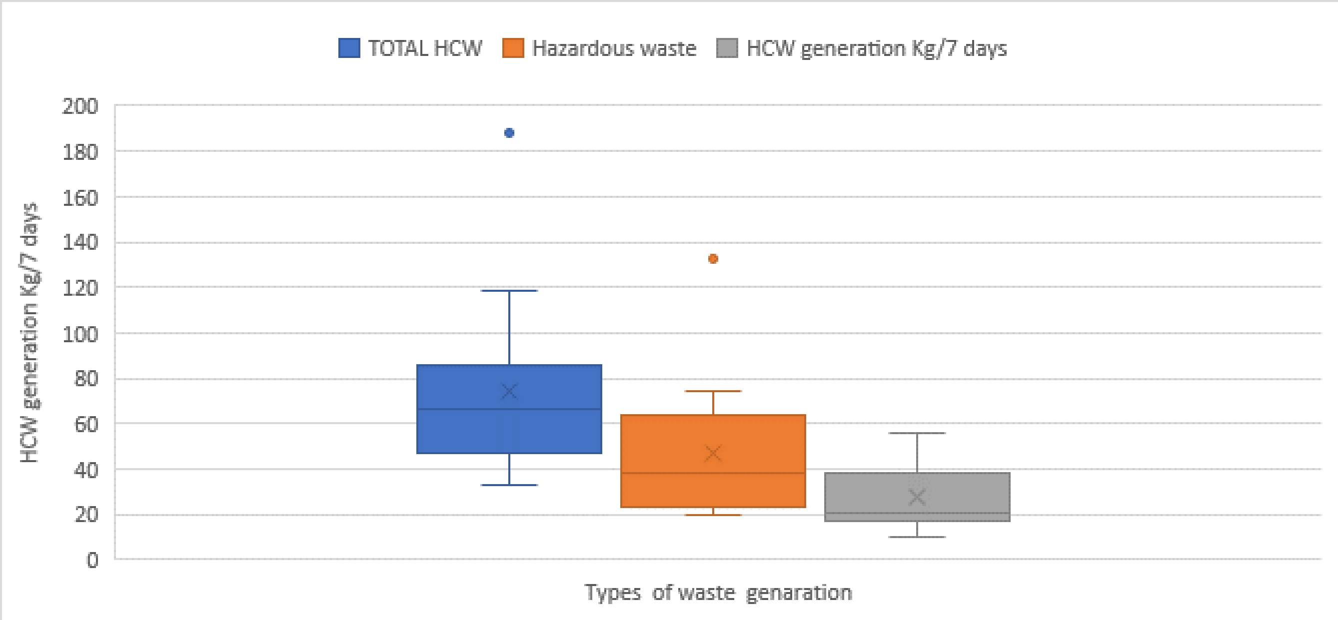


Figure 4.4 Hazardous HCW generation rate (kg/day) in the study health centres, Addis Ababa City Administration, February 2018

Figure 4.5 is a scatter plot between the daily amounts of HCW generated and the number of patients that visited the study health centres. A linear trend was evident between the amount of total HCW generation and total number of patients (statistically significant, $P<0.067$; $R^2=0.135$). Therefore, the number of patients that visited the health centres daily could be used as a predictor of HCW generation rates in the health centres. This R^2 also showed a moderate linear relationship between the number of patients that visited the health centres and the amount of HCW generated. In particular, 13.5% of the variability among the observed values of HCW generation in the 7 days of HCW measurement was explained by the linear relationship between the total number of patients that visited the health centres and generation of HCW.

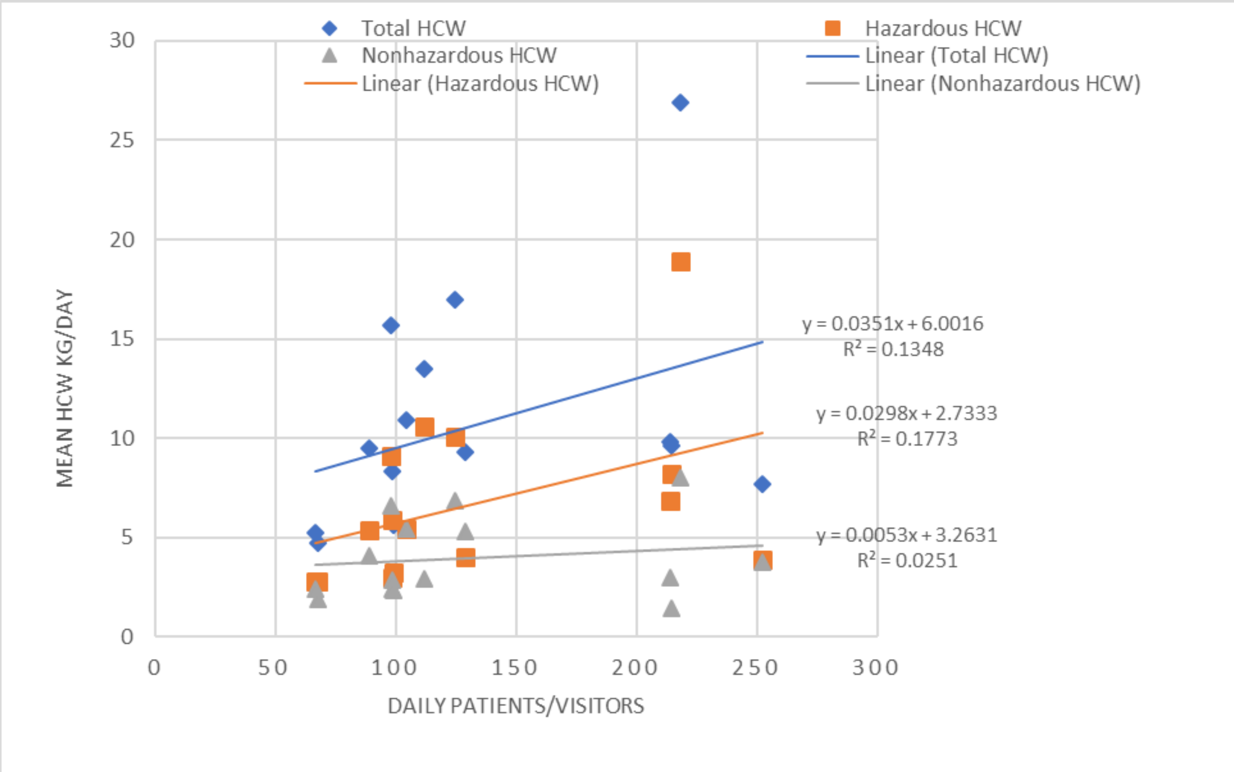


Figure 4.5 Relationship between HCW generated in kg/day and the daily number of patients at the study health centres, Addis Ababa City Admin, February 2018

4.7 HEALTHCARE WASTE (HCW) MANAGEMENT

The overall response rate was 85.95% from a total of 740 respondents. The selected healthcare facilities consisted of 3 general hospitals and 15 health centres. The mean age of the respondents was 30.9 years. Of the respondents, 41.82% (n=266) were males and 58.18% (n=370) were females (see Table 4.8).

Of the respondents, 39% (n=251) were nurses; 64.5% (n=162) worked at the health centres and 35.5% (n=89) worked at the hospitals, and 0.31% (n=2) were biomedical engineers. Figure 4.6 indicates that they worked at the hospitals.

Table 4.8 Respondents' gender and distribution at the study healthcare facilities, Addis Ababa City Administration, February 2018

Gender	Hospital	Health centre	Total	Percent
Male	72	194	266	41.82
Female	100	270	370	58.18
Total	**172**	**464**	**636**	**100.00**

The respondents' age ranged from 20 to 59 years. Of the respondents, 58.49% (n=372) were aged 20-29; 33.96% (n=216) were aged 30-39, and 5.03% (n=32) were aged 40-49 (see Table 4.9).

Table 4.9 Respondents' age distribution

Age group (N=636)	Number of respondents	Percent
20-29	372	58.49
30-39	216	33.96
40-49	32	5.03
50-59	16	2.52
60+	0	0.00
Total	**636**	**100.00**

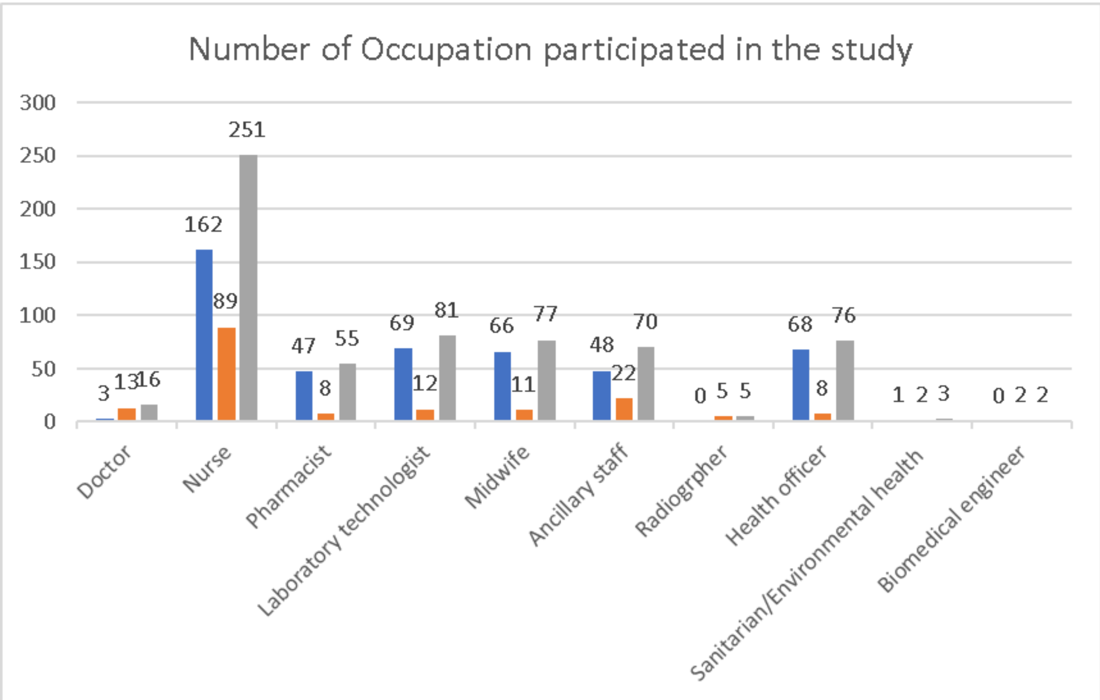


Figure 4.6 Number of respondents by occupation, Addis Ababa City Administration, February 2018

Of the respondents, 66.19% (n=421) had 1-5 years' work experience; 24.84% (n=158) had 6-10 years; 3.77% (n=24) had 11-15 years, and 3.3% (n=21) had 21 years and more experience (see Table 4.10).

Table 4.10 Study respondents' work experience at the study health facilities, Addis Ababa City Administration, February 2018

Respondents' work experience	**Number of respondents(n=636)**	**Percent**
1-5	421	66.19
6-10	158	24.84
11-15	24	3.77
16-20	12	1.89
21+	21	3.30
Total	**636**	**99.99**

4.7.1 Management of healthcare waste (HCW)

Once the waste was generated, it was collected and transferred to a temporary waste storage area. The respondents were asked to indicate how HCW was managed at their facilities (see Table 4.11).

Of the respondents, 88.83% (n=350) from the health centres and 92.03% (n=127) from the hospitals indicated that the health facility they worked at had separate storage areas for HCW. With reference to storage, 90.86% (n=358) from the health centres and 96.38% (n=133) from the hospitals indicated that their facilities had separate containers for hazardous and nonhazardous waste. Of the respondents, 15.48% (n=61) from the health centres and 21.01% (n=29) from the hospitals indicated that the healthcare waste containers were not clearly marked or labelled. This was confirmed by observation indicating that the health facilities used non-designated containers (see Table 4.11).

Of the respondents, 86.04% (n=339) from the health centres and 76.81% (n=106) from the hospitals indicated that the HCW containers were located in appropriate areas where they might be needed. Of the respondents, 82.49% (n=325) from the health centres and 76.09% (n=105) from the hospitals indicated that the HCW containers in the health facilities were made of leak-proof material. Of the respondents, 83.76%

(n=330) from the health centres and 71.74% (n=99) from the hospitals indicated that the HCW containers were easy to carry.

Of the respondents, 87.06% (n=343) from the health centres and 86.23% (n=119) from the hospitals stated that the sharps containers were made of puncture-resistant material. Of the respondents, 85.02% (n=335) from the health centres and 63.04% (n=87) from the hospitals stated that the HCW containers were emptied daily or whenever they were 3/4 full, while 12.94% (n=51) from the health centres and 22.71% (n=41) from the hospitals indicated that sharps containers were not closed securely and disposed of whenever they were 3/4 full.

Of the respondents, 24.37% (n=96) from the health centres and 29.71% (n=41) from the hospitals indicated that no formal or informal separation of waste took place at their health facilities. Of the respondents, 53.03% (n=209) from the health centres and 63.04% (n=87) from the hospitals indicated that plastics and intravenous sets were not kept separately for recycling; 31.98% (n=126) from the health centres and 35.51% (n=49) from the hospitals indicated that not all waste handlers wore heavy duty gloves and sturdy shoes when handling HCW. Of the respondents, 76.68% (n=310) from the health centres and 67.39% (n=93) from the hospitals indicated that HCW handlers washed their hands and their hard duty gloves after handling waste.

The respondents were asked to indicate whether their facilities generated waste of special concern. Of the respondents, 39.85% (n=157) from the health centres and 44.2% (n=61) from the hospitals indicated cytotoxic; 65.99% (n=260) from the health centres and 70.29% (n=97) from the hospitals indicated pathological; 58.12% (n=229) from the health centres and 67.39% (n= 93) from the hospitals indicated reagent; 62.44% (n=246) from the health centres and 65.22% (n=90) from the hospitals indicated outdated pharmaceutical, and 14.21% (n=56) from the health centres and 27.54% (n=38) from the hospitals indicated radioactive waste was generated. After this we can present both groups who said no – if we want to, but it’s not necessary.

None of the respondents who indicated that their facilities generated HCW of special concern indicated how the disposal thereof was handled. The respondents were asked to indicate how liquid waste was disposed of and to specify for cytotoxic and reagent processing liquids. Of the respondents, 5.08% (n=20) from the health centres and

7.25% (n=10) from the hospitals indicated that liquid waste was disposed of via sinks, and 5.84% (n=23) from the health centres and 2.9% (n=4) from the hospitals indicated via sewers. None of the respondents specified cytotoxic or reagent processing liquids (see Table 4.11).

Table 4.11 HCW handlers' management practice at the study health facilities, Addis Ababa City Administration, February 2018

Questions	**Health centre (n= 394)**		**Hospital (n= 138)**		**Total (n=532)**
	Yes	**No**	**Yes**	**No**	
Does the facility have a separate area or separate storage areas for HCW?	350 (88.83%)	44 (11.17%)	127 (92.03%)	11 (7.97%)	532
Does the facility have separate containers for nonhazardous and hazardous waste?	358 (90.86%)	36 (9.14%)	133 (96.38%)	5 (3.62%)	532
Are all types of waste containers clearly marked or labelled?	333 (84.52%)	61 (15.48%)	109 (78.99%)	29 (21.01%)	532
Are all types of containers located in appropriate areas where they might be needed?	339 (86.04%)	55 (13.96%)	106 (76.81%)	32 (23.19%)	532
Are containers made of leak-proof material (preferably plastic) for disposal of HCW?	325 (82.49%)	69 (17.51%)	105 (76.09%)	33 (23.91%)	532
Are the containers easy to carry by the workers?	330 (83.76%)	64 (16.24%)	99 (71.74%)	39 (28.26%)	532
Are sharps containers made of a puncture-resistant material (cardboard, plastic, or metal)?	343 (87.06%)	51 (12.94%)	119 (86.23%)	19 (13.77%)	532
Are HCW containers emptied daily or whenever they are 3/4 full?	335 (85.02%)	59 (14.97%)	87 (63.04%)	51 (36.96%)	532
Are sharps containers closed securely and disposed of whenever they are 3/4 full?	343 (87.06%)	51 (12.94%)	97 (70.29%)	41 (29.71%)	532
Does any formal or informal separation of waste take place?	298 (75.63%)	96 (24.37%)	97 (70.29%)	41 (29.71%)	532
Are used plastics and intravenous sets kept separately for recycling?	185 (46.95%)	209 (53.05%)	51 (36.96%)	87 (63.04%)	532
Do all waste handlers wear heavy duty gloves and sturdy shoes when handling medical waste?	268 (68.02%)	126 (31.98%)	89 (64.49%)	49 (35.51%)	532
Do waste handlers? wash their heavy-duty gloves and their hands after handling HCW?	310 (76.68%)	84 (21.32%)	93 (67.39%)	45 (32.61%)	532

Questions	Health centre (n= 394)		Hospital (n= 138)		Total (n=532)
	Yes	No	Yes	No	
Does the establishment generate any waste of special concern:					
• Cytotoxic?	157 (39.85%)	237 (60.15%)	61 (44.20%)	77 (55.8%)	532
• Pathological waste?	260 (65.99%)	134 (34.01%)	97 (70.29%)	41 (29.71%)	532
• Reagent?	229 (58.12%)	165 (41.89%)	93 (67.39%)	45 (32.61%)	532
• Out-dated pharmaceuticals?	246 (62.44%)	148 (37.56%)	90 (65.22%)	48 (34.78%)	532
• Radioactive waste?	56 (14.21%)	338 (85.79%)	38 (27.54%)	100 (72.46%)	532
If yes, how is their disposal handled?	-	-	-	-	-
How is liquid waste **disposal?**	Sinks 20 (5.08%) Sewer 23 (5.84%)	43 (10.91%)	Sinks 10 (7.25%) Sewers 4 (2.90%)	14 (10.14%)	57

The respondents were asked to indicate the types of HCW generated daily at their facilities (see Table 4.12). According to the respondents, the following types of HCW were most generated daily at their health facilities:

- Used gloves (70.30% (n=277) at health centres; 85.51% (n=118) at hospitals).
- Sharps (67.26% (n=265) at health centres; 82.61% (n=114) at hospitals).
- General or non-infectious (66.24% (n=261) at health centres; 73.19% (n=101) at hospitals).
- Dressing and genital swabs, absorbents (54.7% (n=215) at health centres; 66.67% (n=92) at hospitals).
- Used bandages (46.95% (n=185) at health centres; 57.25% (n=79) at hospitals).

The types of HCW least generated by the selected health centres and hospitals were human tissue and organs; used sanitary pads, and excreta. Table 4.12 lists the types of HCW generated.

Table 4.12 Types of HCW generated daily at the selected healthcare facilities, Addis Ababa City Administration, February 2018

Type of healthcare waste	Health centre (n=394)		Hospital (n=138)	
	Number of respondents	Percent of respondents	Number of respondents	Percent of respondents
Dressing swabs, genital swabs, absorbents	215	54.57	92	66.67
Used sanitary pads	130	33.0	59	42.75
Used gloves	277	70.30	118	85.51
Fluids	125	31.73	79	57.25
Used bandages	185	46.95	79	57.25
Human tissue and organs	80	20.30	67	48.55
Excreta	60	15.23	59	42.75
Sharps (used cannulas, needles, surgical blades, vials injections, syringes)	265	67.26	114	82.61
General waste or non-infectious	261	66.24	101	73.19
Used toilet paper	136	34.52	71	51.45

The respondents were asked to indicate the on-site means of transportation of HCW in their healthcare facilities. The study found that the health centres mainly used buckets followed by pedal bins and trolleys to transport HCW on site while the hospitals used mainly pedal bins and sometimes buckets and trolleys (see Figure 4.7).

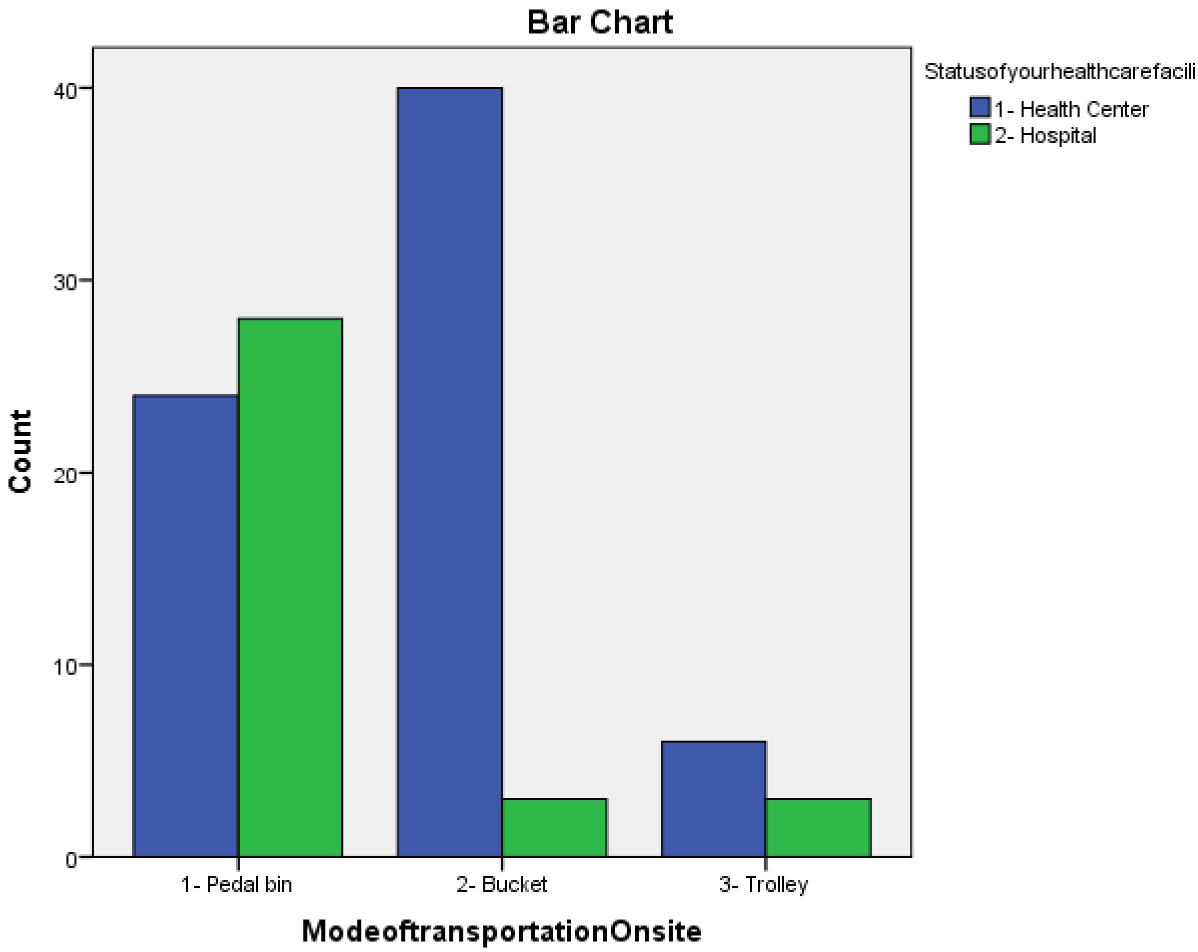


Figure 4.7 On-site means of transportation for HCW in the selected healthcare facilities, Addis Ababa City Administration, February 2018

4.7.2 Healthcare waste management

Regarding HCW management, 104 managers responded, namely 70 from the health centres and 34 from the hospitals. Of the respondents, 98.57% (n=69) from the health centres and 91.18% (n=31) from the hospitals indicated that HCW generated by their facilities was segregated and 61.43% (n=47) from the health centres and 70.59% (n=24) from the hospitals indicated that the HCW was securely stored before transportation to the incinerator. Of the respondents, 92.86% (n=65) from the health centres and 91.18% (n=31) from the hospitals indicated that healthcare waste handlers used protective clothing when handling waste, and 91.43% (n=64) from the health centres and 88.24% (n=30) indicated that the waste handlers were provided with protective clothing when handling HCW (see Table 4.13).

Table 4.13 HCW management in the study health facilities, Addis Ababa City Administration, February 2018

Questions	Health centre (n= 70)		Hospital (n= 34)		Total (n=104)
	Yes	No	Yes	No	
Is healthcare waste generated in your healthcare facility segregated?	69 (98.57%)	1 (1.43%)	31 (91.18%)	3 (8.82%)	104
How is healthcare waste awaiting transportation to the incinerator stored?	Secure 47 (61.43%)	Insecure 23 (38.57%)	Secure 24 (70.59%)	Insecure 10 (29.41%)	104
Do you the waste handlers use protective clothing when handling healthcare waste?	65 (92.86%)	5 (7.14%)	31 (91.18%)	3 (8.82%)	104
Do you provide the handlers/workers with protective clothing when handling healthcare waste?	64 (91.43%)	6 (8.57%)	30 (88.24%)	4 (11.76%)	104

The respondent managers were asked to indicate the type of protective clothing used for handling HCW (see Table 4.14). Of the respondents in the health centres, 64.29% (n=45) used gloves; 50% (n=35) used gowns; 24.29% (n=17) used aprons; 32.86% (n=23) used sturdy shoes; 14.29% (n=10) used goggles; 7.14% (n=5) used capes, and 28.57% (n=20) used masks. Of the respondents in the hospitals, 61.76% (n=21) used gloves; 26.47% (n=9) used gowns; 32.35% (n=11) used aprons; 26.47% (n=9) used sturdy shoes; 35.29% (n=12) used goggles; 8.82% (n=3) used capes, and 23.53% (n=8) used masks (see Table 4.14).

Table 4.14 Protective clothing used in the study health facilities, Addis Ababa City Administration, February 2018

Type of protective clothing	Health centre (n=70)		Hospital (n=34)	
	Number of respondents	Percent of respondents	Number of respondents	Percent of respondents
Gloves	45	64.29	21	61.76
Gowns	35	50.00	9	26.47
Aprons	17	24.29	11	32.35
Sturdy shoes	23	32.86	9	26.47
Goggles	10	14.29	12	35.29
Caps	5	7.14	3	8.82
Mask	20	28.57	8	23.53

The respondents were asked to rate their facilities' handling and segregation of HCW (see Figure 4.8). Of the respondents in the health centres, 52.86% (n=37) rated the handling of HCW good; 28.57% (n=20) rated it very good; 10% (n=7) rated it excellent, and 8.57% (n=6) rated it poor. Of the respondents in the hospitals, 47.06% (n=16) rated the handling good; 38.24% (n=13) very good; 14.71% (n=5) poor, and none rated it excellent.

Of the respondents in the health centres, 48.57% (n=34) rated the segregation good; 32.86% (n=23) very good; 11.43% (n=8) poor, and 7.14% (n=5) excellent. Of the respondents in the hospitals, 52.94% (n=18) rated the segregation good; 29.41% (n=10) rated it very good; 14.71% (n=5) rated it poor, and 2.94% (n=1) rated it excellent. Figure 4.8 a and b depicts the ratings.

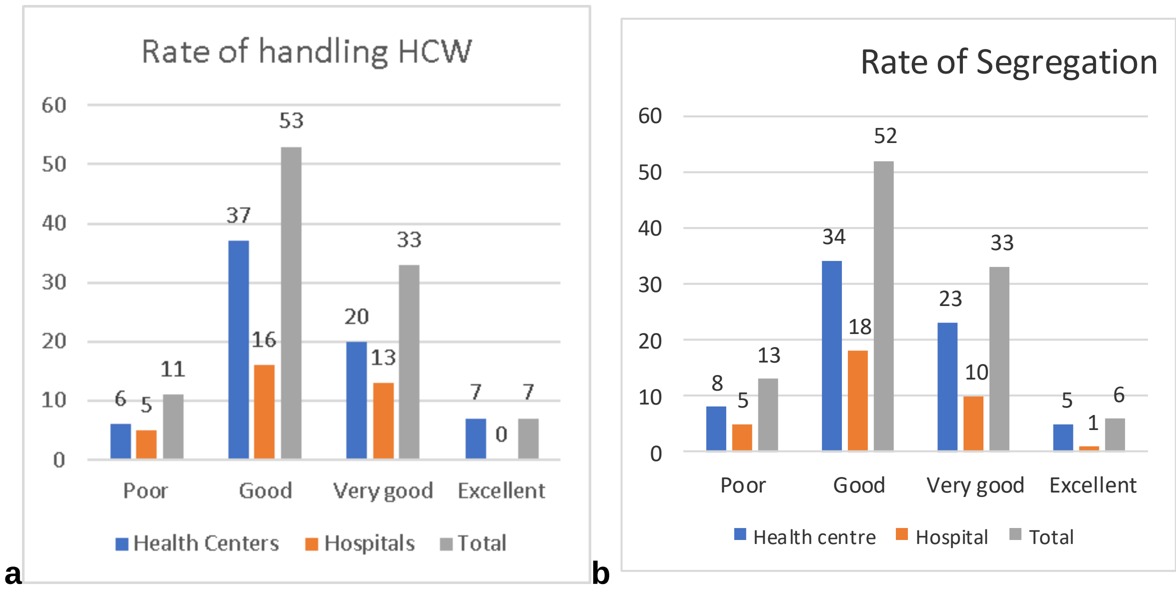


Figure 4.8 (a and b) Rate of handling (a) and segregation (b) of HCW in the study health facilities, Addis Ababa City Administration, February 2018

The respondents were asked to indicate the method and means of collection and off-site disposal of HCW. Of the respondents, 20% (n=14) from the health centres and 20.60% (n=7) from the hospitals indicated that the municipality collected the HCW for off-site disposal. Of the respondents, 1.43% (n=1) from the health centres and 2.94% (n=1) from the hospitals indicated that a cooperative organisation was responsible for collection and off-site HCW disposal (see Table 4.15). Most of the respondents did not answer the question.

Table 4.15 Off-site HCW collectors in the study health facilities, Addis Ababa City Administration, February 2018

Type of organisation	**Health centre (n=70)**		**Hospital (n=34)**	
	Number of respondents	**Percent of respondents**	**Number of respondents**	**Percent of respondents**
Municipality	14	20.00	7	20.60
Cooperative organization	1	1.43	1	2.94

The respondents were asked to indicate the frequency of off-site HCW collection. Of the respondents, 27.14% (n=19) from the health centres and 23.53% (n=8) from the hospitals indicated daily; 8.57% (n=6) from the health centres and 26.47% (n=9) from the hospitals indicated once a week, and 1.43% (n=1) from the health centres indicated once a fortnight (see Table 4.16).

Table 4.16 Frequency of HCW collection by off-site authorities in the study health facilities, Addis Ababa City Administration, February 2018

Time of HCW collection (off-site)	Health centre (n=70)		Hospital (n=34)	
	Number of respondents	Percent of respondents	Number of respondents	Percent of respondents
Daily	19	27.14	8	23.53
Once a week	6	8.57	9	26.47
Once per fortnight	1	1.43	-	-

The respondents were asked what was used to store hazardous HCW prior to disposal. Of the respondents from the health centres, 48.57% (n=34) indicated red plastic healthcare waste bags; 22.86% (n=16) indicated yellow sharps containers; 15.71% (n=11) indicated ‘other’ and specified large interim containers; 7.14% (n=5) indicated black plastic refuse bags; 4.29% (n=3) indicated pedal bins; 1.43% (n=1) indicated standard metal dustbins. Of the respondents from the hospitals, 58.82% (n=20) indicated red plastic healthcare waste bags; 17.65% (n=6) yellow sharps containers; 11.76% (n=4) pedal bins; 5.88% (n=2) black plastic refuse bags; 2.94% (n=1) indicated standard metal dustbins, and 2.94% (n=1) indicated ‘other’ and specified large interim containers (see Figure 4.9).

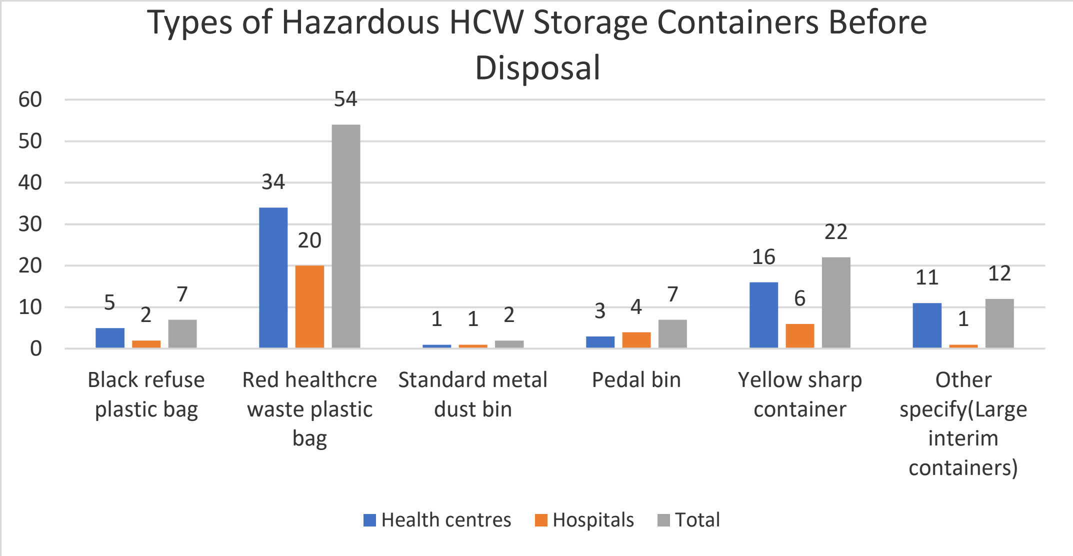


Figure 4.9 Type of Hazardous HCW storage containers before disposal in the study health facilities, Addis Ababa City Administration, February 2018

The respondents were asked how HCW was transported on-site for storage before collection for off-site disposal. Of the respondents from the health centres, 34.29% (n=24) indicated in pedal bins; 57.14% (n=40) indicated buckets, and 8.57% (n=6) indicated trolleys. Of the respondents from the hospitals, 82.35% (n=28) indicated pedal bins; 8.82% (n=3) indicated buckets, and 8.82% (n=3) indicated trolleys (see Table 4.17).

Table 4.17 Mode of on-site transportation used in the study health facilities, Addis Ababa City Administration, February 2018

On-site HCW mode of transportation	Health centre (n=70)		Hospital (n=34)	
	Number of respondents	Percent of respondents	Number of respondents	Percent of respondents
Pedal bin	24	34.29	28	82.35
Bucket	40	57.14	3	8.82
Trolley	6	8.57	3	8.82

4.7.3 Management issues

The respondents were asked about operational standards and guidelines for HCW management (see Table 4.18). Of the respondents from the health centres, 67.14%

(n=47) indicated there was a current operational standard for HCW management; 70.0% (n=49) indicated they had applicable guidelines for HCW management, and 81.43% (n=57) indicated they had HCW management committees. Of the respondents from the hospitals, 61.76% (n=21) indicated there was a current operational standard for HCW management; 73.53% (n=25) indicated they had applicable guidelines for HCW management, and 67.65% (n=23) indicated they had HCW management committees (see Table 4.18).

Table 4.18 HCW management issues in the study health facilities, Addis Ababa City Administration, February 2018

Questions	Health centre (n=70)		Hospital (n=34)		Total
	Yes	No	Yes	No	
Is there a current operational standard for HCW management?	47 (67.14%)	23 (32.86%)	21 (61.76%)	13 (38.23%)	104
Are there any applicable national, regional, and local guidelines for HCW management in the health centre?	49 (70.0%)	21 (30%)	25 (73.53%)	9 (26.47%)	104
Is there a healthcare waste management committee?	57 (81.43%)	13 (18.57%)	23 (67.65%)	11 (32.35%)	104

The respondents were asked who was responsible for HCW management in their facilities (see Figure 4.10). Of the respondents in the health centres, 40% (n=28) indicated sanitarian/environmental health professionals were responsible for HCW management; 38.57% (n=27) indicated safety officers, and 21.43% (n=15) indicated ‘other’ and specified (laboratory technicians, midwifes, ancillary staffs).

Of the respondents in the hospitals, 82.35% (n=28) indicated sanitarian/environmental health professionals were responsible for HCW management; 14.71% (n=5) indicated safety officers, and 2.94% (n=1) indicated ‘other’ and specified ancillary staff.

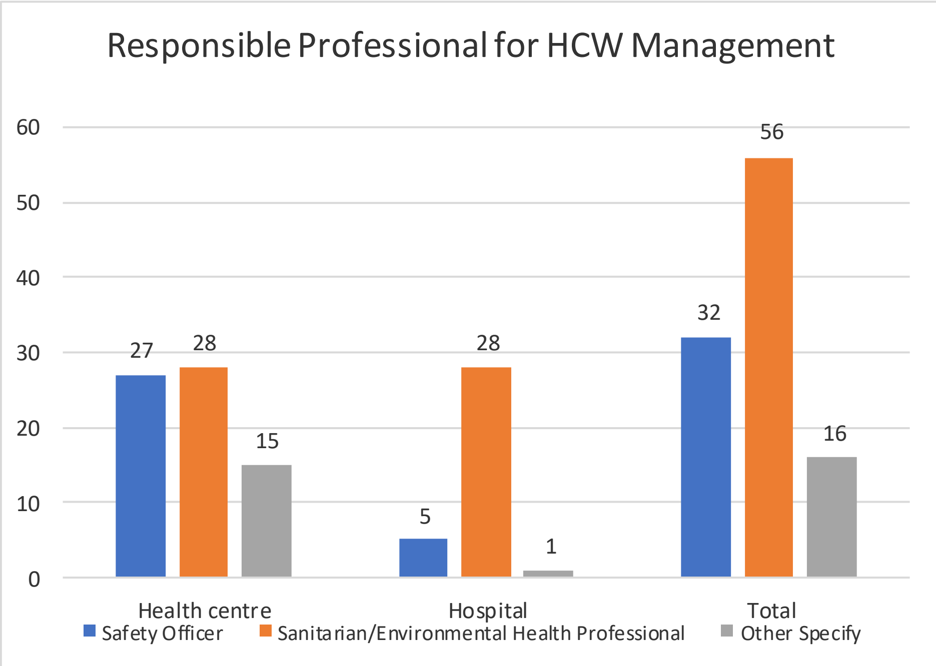


Figure 4.10 Responsibility for HCW management in the study health facilities, Addis Ababa City Administration, February 2018

4.7.4 Risks of the current waste management system

The respondents were asked to indicate whether their health facilities had concerns about HCW management. Of the respondents, 91.43% (n=64) from the health centres and 88.24% (n=30) from the hospitals indicated that management had concerns about HCW management. Of the respondents, 50.0% (n=35) from the health centres and 61.76% (n=21) indicated that the HCW posed risks to waste collectors; 27.14% (n=19) from the health centres and 70.59% (n=24) from the hospitals indicated that waste collectors (handlers?) had been injured by needles. Of the respondents, 57.14% (n=40) from the health centres and 70.59% (n=24) from the hospitals indicated that their facilities had a register for injury or HCW contamination to staff (see Table 4.19).

Table 4.19 Concerns about HCW management in the study health facilities, Addis Ababa City Administration, February 2018

Questions	Health centre (n=70)		Hospital (n=34)		Total (n=104)
	Yes	No	Yes	No	
Does the management of the health facility have concerns about HCW management?	64 (91.43%)	6 (8.57%)	30 (88.24%)	4 (11.76%)	104
Does the waste pose any risk to waste collectors? If yes, what kind?	35 (50%)	35 (50%)	21 (61.76%)	13 (38.24%)	104
Was anyone getting injured by needle**s** in the past 12 months and reported?	19 (27.14%)	51 (72.86%)	24 (70.59%)	10 (29.41%)	104
Does the health facility have registration book/a register for any injury or HCW contamination to the collectors/handlers**?**	40 (57.14%)	30 (42.86%)	24 (70.59%)	10 (29.41%)	104

The respondents were asked to indicate the number of HCW handlers (ancillary/janitors) working at their facilities (see Figure 4.11). Of the respondents from the health centres, 84.29% (n=59) indicated 5 or more; 4.29% (n=3) indicated 4; 7.14% (n=5) indicated 3, and 1.43% (n=1) indicated 1. Of the respondents from the hospitals, 29% (n=85.29) indicated 5 or more; 8.82% (n=3) indicated 2, and 5.88% (n=2) indicated 1 (see Figure 4.11).

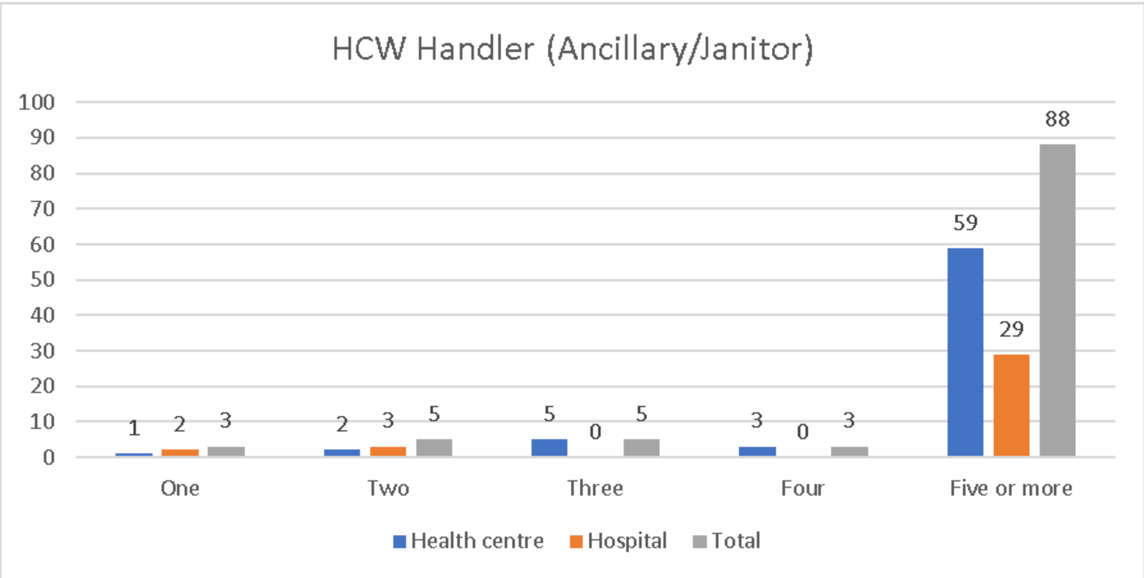


Figure 4.11 Number of HCW handlers (ancillary/Janitors) in the study health facilities, Addis Ababa City Administration, February 2018

The respondents were asked to indicate the type of injuries sustained in their health facilities in the previous 12 months. Of the respondents from the health centres, 11.43% (n=8) indicated deep injuries; 14.29% (n=10) indicated slight skin penetration; 7.14% (n=5) indicated superficial, and 10% (n=7) indicated splash injuries. Of the respondents from the hospitals, 35.29% (n=12) indicated deep injuries; 44.12% (n=15) indicated slight skin penetration; 41.18% (n=14) indicated superficial, and 38.24% (n=13) indicated splash injuries (see Table 4.20).

Table 4.20 Type of injury sustained in the study health facilities, Addis Ababa City Administration, February 2018

Type of injury	**Health centre (n=70)**		**Hospital (n=34)**	
	Number of respondents	**Percent of respondents**	**Number of respondents**	**Percent of respondents**
Deep injury	8	**11.43**	12	**35.29**
Slight skin penetration	10	**14.29**	15	**44.12**
Superficial	5	**7.14**	14	**41.18**
Splash	7	**10.00**	13	**38.24**

4.8 OBSERVATION

The tide line of waste management with reference to waste minimisation, segregation, storage, handling, collection, and treatment was not properly and adequately practised by any of the surveyed health centres and hospitals.

During the study the 15 health centres and 3 hospitals selected were observed. This section discusses the findings on waste management with reference to storage and treatment and disposal of HCW.

4.8.1 Interim storage

Of the health care facilities, 13 health centres and 1 hospital had interim storage sites and HCW disposal sites located in areas minimally accessible to their staff. Of the facilities, 6 health centres and 2 hospitals had interim storage containers that had no lids to prevent odour and escape of wastes and waste leakage? Open plastic buckets and safety boxes were used to transport waste manually to the disposal site. In 10 health centres and the 3 hospitals HCW stored on site remained on site for more than 48 hours before final disposal (see Table 4.21).

Table 4.21 Interim storage for HCW observed in the study health facilities, Addis Ababa City Administration, February 2018

Questions	Health centre (n=15)		Hospital (n=3)		Total (n=18)
	Yes	No	Yes	No	
Are all interim storage sites and healthcare waste disposal sites located in areas that are minimally accessible to staff?	13	2	1	2	18
Do interim storage containers have lids?	9	6	1	2	18
Is waste stored on site for more than 48 hours before final disposal?	5	10	-	3	18

4.8.2 Treatment and disposal of HCW

During the study period, almost all the health centres and hospitals did no treatment (used chemical treatment or autoclaving) for HCW before disposal on-site and off-site. Disinfection of HCW storage/collection utilities was non-existent. Almost All the health centres and hospitals disposed of all HCW inside their compounds (on-site) as incineration considered the final treatment. During observation, 1 health centre and 3 hospitals disposed of the HCW outside the compound (off-site) (see Table 4.21). The disposals (ash residues) were seen during observation. Incinerators and burial pits (placenta pits and surgical removal pits) were employed for final waste disposal on-site. All the health facilities except 1 health centre had incinerators on the premises. In 3 of the health facilities, the incinerators were located downwind from the main service area. The incinerators of 11 health centres and 2 hospitals had sufficient air inlets on the side. At 12 of the health centres and all the hospitals (3) ash from the incinerators was disposed of inside the compound (see Figure 4.12). The incinerators at 8 of the health centres and 2 of the hospitals were not surrounded by a fence or wall to limit access to scavengers (see Figure 4.13a and b). The burial site for surgical removals and placenta were away from any water source at most of the health centres and hospitals. The burial pits in most of the health centres and hospitals was 1-2 meters wide and 2-5 meters deep and the bottom of the pit was at least 1.8 meters above the water table (see Table 4.22). All types of HCW were burned in the incinerators of the healthcare facilities except placenta and surgically removed body parts (see Table 4.22).

Table 4.22 Observed treatment and disposal of HCW in the study health facilities, Addis Ababa City Administration, February 2018

Questions	**Health centre**		**Hospital**		**Total**
	Yes	**No**	**Yes**	**No**	
Is there any treatment of HCW before disposal? (if any chemical, autoclaving, crashing of needles)	**2**	**13**	**-**	**3**	**18**
If yes, how the residuals handled? If yes, how are the residuals handled?	Chemical dis-infection	-	-	-	2
Is the health care waste disposed of					
On-site?	15	-	3	-	18
Off-site?	1	14	3	-	18
Is there an incinerator at healthcare facility?	14	1	3	-	18
Is the incinerator located downwind from the health centre?	12	3	3	-	18
Does the incinerator have sufficient air inlets on the side?	11	4	2	1	18
Where is the ash from the incinerator disposed of?	On-site 12	Off-site 3	On-site 3	Off-site -	18
Is the incinerator surrounded by a fence or wall to limit access?	7	8	1	2	18
Is the burial site away from any water source at the healthcare facility?	12	3	2	1	18
Is the pit 1-2 meters wide and 2-5 meters deep? Is the bottom of the pit at least 1.8 meters above the water table?	13	2	3	-	18
What type of HCW is burned in the incinerator?	All types of HCW		All types of HCW		

The study found that the main forms of on-site treatment of HCW before disposal were burning, crushing sharps, sterilisation and chemical disinfection (see Table 4.23).

Table 4.23 On-site practice of HCW treatment in the study facilities, Addis Ababa City Administration, February 2018

Practice of HCW treatment	Health centre (n=15)	Hospital (n=3)
Crushing of sharps	3	3
Sterilisation	2	3
Chemical disinfection	2	3
Destruction through burning	15	3

During observation, all the study health facilities except 1 health centre used incineration for on-site HCW disposal. The health centre that did not incinerate HCW disposed of it by open burning (see Table 4.24).

Table 4.24 On-site HCW disposal in the study health facilities, Addis Ababa City Administration, February 2018

HCW disposal	Health centre (n=15)	Hospital (n=3)
Open burning	1	-
Incineration	14	3

Regarding off-site disposal of HCW, it was observed that the 3 hospitals used the municipality and 3 of the health centres used cooperative organisations to collect the HCW for off-site disposal (see Table 4.25). Of the health centres, 12 were observed to make no use of collectors and off-site disposal.

Table 4.25 Collection and off-site disposal of HCW from the study health facilities, Addis Ababa City Administration, February 2018

Collection and off-site disposal of HCW	Health centre (n=15)	Hospital (n=3)
Municipality	-	3
Cooperatives	3	-
No disposal off-site	12	-

Figure 4.12 Ash disposal inside the compound of one of the study health care facilities, Addis Ababa City Administration, February 2018

a  b

Figure 4.13 Incinerator (a) and placenta pit (b) with no fencing in one of the study health centres, Addis Ababa City Administration, February 2018

4.9 FACTORS ASSOCIATED WITH HEALTHCARE WASTE HANDLING PRACTICE

Table 4.26 presents 23 independent variables of HCW handling practice. In the bivariate logistic regression analysis; Sex, age group, occupational category, work experience, type of health facility, separate container for HCW, located in appropriate place , leak proof materials used for HCW collection, labelling or marking of HCW container, easy to carry by the handlers, puncture- resistant material for sharps, HCW containers emptied daily or whenever ¾ full, formal or informal separation of HCW takes place, recycling of used plastic materials, HCW handlers wear heavy duty gloves and sturdy shoes, wash both hard heavy duty gloves and hands after handling HCW, means of transportation for HCW and generation of HCW of special concern (cytotoxic) showed statistically significant association with separate storage area for healthcare waste. All independent variables had significant association with separate storage area for healthcare waste at 5%, 1% and 0.01 level of significance (Table 4.27). However, in the backward stepwise multivariate logistic regression analysis only two variables have shown significant and independent association with separate storage area for HCW, which were as follows: Puncture resistant material for sharps $p< 0.001$, AOR,4.82(2.32, 10.02) and generation of cytotoxic waste $p< 0.001$, AOR, 8.37 (3.20, 21.88). While the remaining independent variables Sex, age group, occupational category, work experience, type of health facility, separate container for HCW, located in appropriate place , leak proof materials used for HCW collection, labelling or marking of HCW container, easy to carry by the handlers, puncture- resistant material for sharps, HCW containers emptied daily or whenever ¾ full, formal or informal separation of HCW takes place, recycling of used plastic materials, HCW handlers wear heavy duty gloves and sturdy shoes, wash both hard heavy duty gloves and hands after handling HCW, means of transportation for HCW and generation of HCW of special concern (cytotoxic) had no association with separate storage in multivariate logistic regression (Table 4.26).

Table 4.26 Factors associated with HCW handling practice among HCW handlers in the study health facilities, Addis Ababa City Administration, February 2018

Variable		Separate storage area for HCW		Crude OR No (95% CI)	Adjusted OR No (95% CI)
		Yes	No		
Sex	Male	194	21	1.00	
	Female	283	34	0.901(0.508,1.599)	
Age group	20-35	426	44	2.088(1.015,4.297)*	
	36+	51	11	1	
Occupational category	Doctors, Nurses and Midwives	267	28	0.605(0.205,1.788)	
	Pharmacist and Laboratory Technology	95	14	0.431(0.136, 1.369)	
	Ancillary staff	52	9	0.367(0.107,1.260)	
	Health officer Biomedical engineer, Environmental health and Radiographer	63	4	1.00	
Work experience	1-10	444	47	2.290 (1.010,5.246)*	
	11+	33	8	1	
Type of health facility	Health centre	350	44	0.689(0.345,1.375)	
	Hospital	127	11	1.00	
Separate container for HCW	Yes	448	43	4.311(2.053,9.054)***	
	No	29	12	1.00	
Located in appropriate place	Yes	408	37	2.877(1.550,5.338)***	
	No	69	18	1.00	
Leak proof materials used for HCW collection	Yes	393	37	2.276(1.236,4.191)**	
	No	84	18	1.00	
Labelling or marking of HCW container	Yes	405	37	2.736(1.477,5.069) ***	
	No	72	18	1.00	
Containers easy to carry by the handlers	Yes	398	31	3.900(2.173,7.001) ***	
	No	79	24	1.00	
Puncture-resistant material for sharps	Yes	432	30	8.000(4.333,14.770) ***	4.824(2.324,10.015)***
	No	45	25	1.00	

Variable		Separate storage area for HCW		Crude OR No (95% CI)	Adjusted OR No (95% CI)
		Yes	No		
HCW containers emptied daily or whenever ¾ full	Yes	389	33	2.947(1.639,5.300) ***	
	No	88	22	1.00	
Formal or informal separation of HCW take**s** place	Yes	364	31	2.494(1.406,4.424) **	
	No	113	24	1.00	
Recycling of used plastic materials	Yes	226	10	4.052(1.995,8.228) ***	
	No	251	45	1.00	
HCW handlers wear heavy duty gloves and sturdy shoe**s**	Yes	328	29	1.974(1.123,3.468) *	
	No	149	26	1.00	
Wash both heavy-duty gloves and hands after handling HCW	Yes	372	31	2.743(1.543,4.876) ***	
	No	105	24	1.00	
Means of transportation for HCW	Cart	136	8		
	Open bucket	305	43	2.000(0.569,7.035)	
	Pedal bin	34	4	0.834(0.282,2.467)	
	Trolley	2	0	1.00	
Generation of HCW of special concern					
Cytotoxic	Yes	213	5	8.068(3.16,20.590) ***	8.37(3.202,21.875)***
	No	264	50	1.00	
Pathological	Yes	324	33	1.415(0.796,2.503)	
	No	153	22	1.00	
Reagent	Yes	294	28	1.549(0.885,2.712)	
	No	183	27	1.00	
Outdated pharmaceuticals	Yes	302	34	1.066(0.600,1.894)	
	No	175	21	1.00	
Radioactive	Yes	87	7	1.530(0.669,3.495)	
	No	390	48	1.00	

*P< 0.05, **P< 0.01, ***P< 0.001

4.10 CONCLUSION

This chapter discussed procedures employed in the data analysis, the research findings and their interpretations. The analysis was performed with the help of IBM SPSS Version 20.0 statistical software package and Microsoft excel 2016. Data analysed and presented in this chapter include measurement of HCW in daily generation rate by point of source, classification and distribution in the study health centres. Estimation of annual HCW generation rate also calculated. Healthcare waste management also analysed and presented in this chapter included demographic characteristics, knowledge, attitude and practice of HCW and management issues from HCW handlers and managers. Finding on bivariate correlation and multivariate regression also discussed. Graphs, charts, scatterplot and frequency tables were used along with the text description to present and analysed the findings.

Chapter 5 presents the manual developed for the effective management of healthcare waste based on the findings in Addis Ababa City Administration Health Bureau public health facilities. This study indicated the need for the development of the manual as an important input for healthcare workers, managers and ancillary staff about the management of healthcare waste based on the empirical findings above. According to the above findings healthcare waste handlers and managers have different knowledge, practice and attitude. In the finding such aspects create gap for the good practice and management of healthcare waste. Therefore, Chapter 5 helps all healthcare waste handlers and managers a good opportunity for training in an introduction of healthcare waste, occupational health and safety, healthcare waste identification, segregation, collection and disposal.

CHAPTER 5

MANUAL FOR HEALTHCARE WASTE GENERATION AND MANAGEMENT PRACTICE

by Menelik Legesse Tadesse (BSc, MPH)

5.1 INTRODUCTION

Healthcare facilities wish to reduce health problems and treatment of diseases. Healthcare waste is a by-product of healthcare facilities and may be called regulated infectious waste or biomedical waste, or clinical waste. Public health problems and their impact on the environment are frequently a consequence of inappropriate and inadequate handling and disposal of HCW. Incineration of HCW is a major contributor to the release of persistent organic pollutants (POPs), dioxins and furans into the environment. Therefore, the sound management of HCW is a crucial component of environmental health protection.

The Stockholm Convention on Persistent Organic Pollutants is an international treaty, signed in Vienna in 2001 and effective from May 2004, that aims to eliminate or restrict the production and use of persistent organic pollutants (POPs). The aim of this international agreement is to protect human health and the environment from chemicals that remain intact in the environment for long periods of time, become globally widely distributed, accumulate in human and wildlife fatty tissue, and have harmful effects on human health or the environment. In 2018, there were 182 member countries or states of the treaty. One of the requirements of the Stockholm Convention is that countries manage and dispose of POPs wastes in an environmentally sound manner (United Nations Industrial Development Organisation [UNIDO] 2001).

The International Agency for Research on Cancer (IARC), established in 1965 in Lyon, France, is an intergovernmental agency that forms part of the World Health Organization (WHO). The role of the IARC is to conduct and coordinate research into the causes of cancer. It also collects and publishes surveillance data regarding the occurrence of cancer worldwide and POPs that pose a potential carcinogenic risk.

For effective HCW management, healthcare facilities have a vital role in the implementation of policies, strategies and programmes. Interaction at all levels and community involvement and participation are also essential. Multisectoral involvement and a systematic approach are also required for HCW management in order to identify needs and resources as well as community needs. Improper, inadequate or disorganised HCW management at healthcare facilities represents poor standards of care and an avoidable source of infection and injury. It is incumbent on healthcare professionals and providers as well as allied workers to take responsibility for HCW management and storage.

This manual provides information and techniques for HCW generation and management training in the context of environmental science and occupational health. The main target of the manual is health professionals and other staff who work in healthcare facilities to identify, segregate, collect and dispose of HCW. It is intended for use in training HCW handlers and collectors.

5.2 HOW TO USE THE MANUAL

This manual serves as a reference and training guide for HCW handlers. The manual is divided into four sections. Section 1 briefly introduces healthcare waste and its general concepts. Section 2 explains HCW handling safety. Section 3 covers identification and segregation of chemical, biological and radioactive wastes. Section 4 describes the collection, treatment and disposal of HCW. The manual concludes with annexures containing examples of spillage and injury registers, waste incinerator log and supervision checklist, and a brief list of references. The manual is structured to promote and ensure environmentally sound management of healthcare waste.

5.2.1 Purpose of the manual

The purpose of the manual is to serve as a reference and training guide for HCW handlers to raise awareness, improve skills and promote consistency in day-to-day management of HCW in healthcare facilities. The manual is designed to help reduce variation in HCW management, gain HCW handlers' cooperation and compliance, and instil a sense of direction and problem-solving.

5.2.2 Approach

The manual is intended to provide trainers with basic training techniques. The approach and format are clear, direct and practical. Headings and pictures help trainers or managers illustrate lectures, case studies, group discussions, individual or group exercises or reflections, guided activities or systematic reflection, site observation or healthcare facility visits and discussion.

5.2.3 Tips for users

Waste handlers play an important role in the environmentally sound management of healthcare waste (HCW).

- This manual should assist in the proper handling of HCW and the training of waste handlers in the health care facility (HCF).
- Plan the training schedule so that it is divided for 5 days of a week, allotting 2 hours per day (4 lessons to be covered per day) to allow time for training in the middle of waste handlers' working schedule and facilitate the organisation of training.
- Emphasise and encourage attitudinal change regarding clean practices to prevent injuries and the spread of infections, improve the cleanliness of the surroundings, and maintain a healthy environment.
- Environmentally sound management of HCW will result in the minimization of hazards. Emphasise measures for robust infection control, including segregation and containment at the source of generation; proper hand washing; use of personal protective equipment like gloves, aprons, masks, boots and goggles; immunization against Tetanus and Hepatitis B; timely reporting of injuries and advice; regular health check-ups, and proper management of spills.
- Collection and disposal of HCW should not extend beyond a period of 48 hours.
- Meticulous keeping of records is an essential step in the proper management of HCW.
- Strict adherence to good practice should result in environmentally sound management of HCW.

- The use of the local language and informal teaching and training are preferable. The use of audiovisual aids is encouraged, such as films, PowerPoint presentations, flip charts, demonstrations and field visits.

The four sections of the manual cover the following:

- Section 1: An introduction to healthcare waste (HCW) and handling hazardous and non-hazardous wastes.
- Section 2: Aspects of occupational health safety, and security during handling at the workplace, transporting and at disposal sites; personal protective equipment (PPE); safety measures, and what to do in case of needle stick and other injuries; emergency response protocol in case of accidental spillage of infectious waste, and security at the waste disposal sites.
- Section 3: Classes of HCW identification and segregation of chemical, biological and radioactive wastes.
- Section 4: Collection and disposal of HCW; when to dispose, including daily, weekly and monthly; importance of recording; types of recording tools; recording and reporting accidents, and the recording responsibilities of HCW handlers.

5.3 OBJECTIVE OF THE MANUAL

The objective of the manual is to provide instruction to facilitate planning and training for operational level health workers to improve HCW handling and management practices.

5.4 SECTION 1: INTRODUCTION TO HEALTH CARE WASTE (HCW)

Learning outcome

By the end of this section, the HCW handler should be able to:

- Define health care waste.
- Explain the importance of proper waste disposal.
- Describe the categories of waste.
- List the steps involved in waste management.

- Identify the location of waste generation at the healthcare facility.
- Classify the waste into two general categories depending on whether it poses a risk or not.
- Describe the general features of the waste.

5.4.1 Definition of HCW

The World Health Organization (WHO) (2008:4) defines HCW as the total waste stream from a healthcare or research facility and includes both potential-risk waste and non-risk waste materials. The Federal Ministry of Health Ethiopia FMHACA (2005:5) defines HCW means a by-product of health care facility that includes potential risk and non-risk wastes.

5.4.2 Importance of proper HCW disposal

Proper HCW disposal reduces the spread of blood-borne infections, such as Hepatitis B, Hepatitis C, and HIV. It also reduces the risk of accidental injury to health care workers, patients, and the community.

5.4.3 Categories of HCW

The WHO (2008:9) classifies health care waste (HCW) into 10 categories. Hazardous HCW is classified as infectious; pathological and anatomical; hazardous pharmaceutical waste; hazardous chemical; waste with a high content of heavy metals; pressurised containers; sharps; highly infectious; genotoxic/cytotoxic, and radioactive waste. Non-infectious HCW is general, no risk waste.

5.4.3.1 Infectious waste

Infectious waste is suspected of containing any of a variety of pathogenic organisms (bacteria, virus, parasites and fungi) in adequate concentration or dose cause disease to susceptible hosts.

5.4.3.2 Pathological and anatomical waste

Pathological waste consists of organs, tissues, body parts, or fluids such as blood. Even if pathological waste contains healthy body parts, it has to be considered as infectious waste for precautionary reasons. Pathological waste includes intravenous fluid lines, anatomical waste and placentas, specimen containers, and blood containers.

Anatomical waste is a sub-group of pathological waste and consists of recognizable human body parts, whether infected or not. Following the precautionary principal, anatomical waste is always considered potentially infectious waste.

5.4.3.3 Hazardous pharmaceutical waste

Pharmaceutical waste includes expired, unused, spilt and contaminated pharmaceutical products, drugs and vaccines. This category includes discarded items used in the handling of pharmaceuticals like bottles, vials, connecting tubing. Since the Ministry of Health has taken specific measures to reduce the wastage of drugs, healthcare facilities (HCFs) should deal only with small quantities of pharmaceutical waste.

Also included in this category are the drugs and equipment used for the mixing and administration of cytotoxic drugs. Cytotoxic drugs or genotoxic drugs are drugs that have the ability to reduce/stop the growth of certain living cells and are used in chemotherapy for cancer.

5.4.3.4 Cytotoxic waste

Cytotoxic waste is dealt with under genotoxic/cytotoxic waste.

5.4.3.5 Hazardous chemical waste

Chemical waste consists of discarded chemicals (solid, liquid or gaseous) that are generated during disinfecting procedures or cleaning processes and preparing routine laboratory reagents or chemicals. They may be hazardous (toxic, corrosive, flammable, ignitable, reactive) and must be used and disposed of according to the specifications printed on each container. However, non-explosive residues or small quantities of outdated products may be treated together with infectious waste.

5.4.3.6 Waste with a high content of heavy metals

Waste with a high content of heavy metals and derivatives is potentially highly toxic (e.g., cadmium or mercury from thermometers or manometers). Although this waste is considered a sub-group of chemical waste, it should be treated specifically.

5.4.3.7 Pressurized containers

Pressurized containers consist of full or emptied containers or aerosol cans with pressurized liquids, gas or powdered materials.

The next four categories of HCW, namely sharps, highly infectious, genotoxic/cytotoxic, and radioactive, are considered highly hazardous and therefore require special attention.

5.4.3.8 Sharps

Sharps are items that can cause cuts or puncture wounds (e.g., needle stick injuries and cuts by broken glass). They are considered highly dangerous and potentially infectious waste whether infected or not. They must be segregated, packed and handled specifically within the HCFs to ensure the safety of the medical and ancillary staff.

5.4.3.9 Highly infectious waste

Highly infectious waste consists of microbial cultures and stocks of highly infectious agents from medical analysis laboratories. This category also includes body fluids of patients with highly infectious diseases.

5.4.3.10 Genotoxic/cytotoxic waste

Genotoxic waste derives from drugs generally used in oncology or radiotherapy units that have a high hazardous mutagenic or cytotoxic effect. Faeces, vomit or urine from patients treated with cytotoxic drugs or chemicals should be considered genotoxic. In specialized cancer hospitals, their proper treatment or disposal raises serious safety problems.

5.4.3.11 Radioactive waste

Radioactive waste includes liquids, gas and solids contaminated with radionuclides whose ionizing radiations have genotoxic effects. The ionizing radiations of interest in medicine include X- and g-rays as well as a- and b- particles. An important difference between these types of radiations is that X-rays are emitted from X-ray tubes only when generating equipment is switched on whereas g-rays and a- and b-particles emit radiations continuously. The type of radioactive material used in HCFs results in low level radioactive waste. It concerns mainly therapeutic and imaging investigation activities where Cobalt ^{60}Co, Technetium 99mTc, iodine 131I and iridium 192Ir are most commonly used.

With the exception of Cobalt ^{60}Co, their half-life is reasonably short (6 hours for 99mTc, 8 days for 131I and 74 days for 192Ir) and the concentrations used remain low. Proper storage with an appropriate retention time is sufficient to prevent radioactivity to spillage in the environment.

5.4.3.12 Non-infectious waste

Non-infectious waste is general waste that presents no risk to persons who may handle it. Examples include paper, packaging materials, office supplies, drink containers, hand towels, cartons, unbroken glass, plastic bottles, and food remnants.

5.4.4 Sources of HCW

There are many sources of HCW, including hospitals; health centres; health posts; clinics; laboratories; nursing homes; acupuncturists; ambulance and paramedic services, veterinary clinics; animal research laboratories; blood banks; mortuaries and centers for autopsy; physicians' offices; dental clinics; chiropractors; psychiatric hospitals; cosmetic piercing and tattooing; institutions for people with disabilities; funeral services, and home healthcare.

Figure 5.1 depicts institutions that generate HCW.

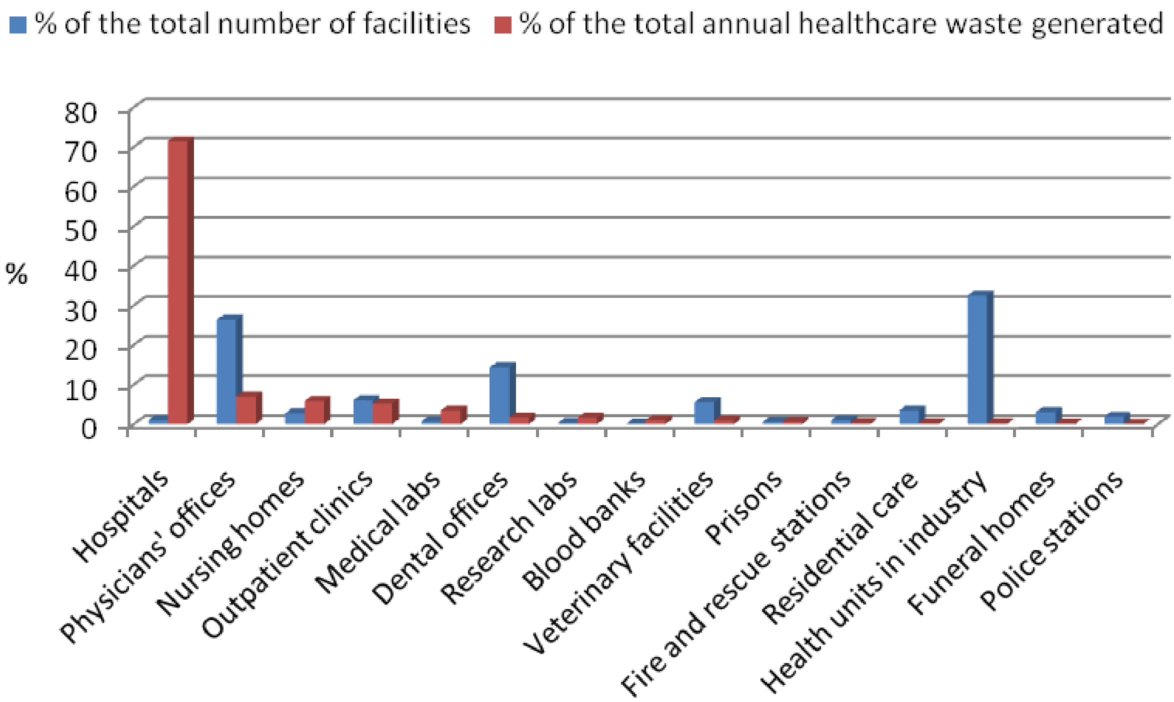


Figure 5.1 HCW generation from different departments and settings

(Source: United Nations Development Programme (UNDP), WHO & Health Care Without Harm (HCWH) 2008:8)

Table 5.1 HCW generation from different departments and settings

Department	Sharps	Infectious and pathological waste	Chemical, pharmaceutical and cytotoxic waste	Non-hazardous or general
Medical ward	Needles such as hypodermic and intravenous set needles; broken glasswares such as vials and ampoules	Medical supplies and materials such as (Dressings, bandages, gauze, cotton, gloves and masks contaminated with blood or body fluids	Medical materials such as (Broken thermometers and blood pressure gauges), drugs like spilt medicines and chemicals such as spent disinfectants	Packaging, food scraps, paper, flowers, empty bottles of saline, non-bloody diapers; non-bloody IV tubing and bags
Operating theatre	Medical supplies, such as needles, IV sets, scalpels, blades and saws	Blood and other body fluids; suction collection container; gowns, gloves, masks, gauze, and other contaminated waste and organs, tissues and body parts	Disinfectants used	Uncontaminated gowns, gloves masks, caps and shoes cover are and packaging
Laboratory	Medical supplies such as needles, broken glass, petri dishes, slides and pipettes	Blood and body fluids; microbiological culture and stocks; tissue; carcasses of infected animals; blood or body fluid contaminated tubes and containers	Chemicals such as formalin, fixatives, toluene, xylene, methanol and staining reagents and supplies such as broken laboratory thermometers	Packaging; paper, plastic containers
Pharmacy store	Broken glasswares and broken thermometers		Expired drugs, spilled drugs empty containers	Empty containers, packaging paper
Radiology			Chemicals include Silver nitrate, developer and fixer, acetic	Paper and Packaging

Department	Sharps	Infectious and pathological waste	Chemical, pharmaceutical and cytotoxic waste	Non-hazardous or general
			acid and glutaraldehyde	
Chemotherapy	Needles and syringes		Supplies, drugs and different body fluids contaminated with cytotoxic agents such as IV sets containing chemotherapy drugs and cytotoxic waste; vials, gloves and other material; contaminated excreta and urine.	Paper and Packaging
Vaccination campaigns	Needles and syringes		Bulk vaccine waste; vials, gloves	Packaging
Cleaning services	Broken glass		Chemical disinfectants and pesticides such as (glutaraldehyde, phenols, etc), cleaners, spilled mercury	Packaging, flowers, newspapers, magazines, cardboard, plastic and glass containers, yard waste
Engineering			Chemicals and materials such as cleaning solvents, broken mercury devices, oils, , thinners, asbestos, , batteries, lubricants	Construction or demolition waste, wood, metal, Packaging
Food services				Food scraps; plastic, metal and glass containers; packaging
Other sources				

Department	**Sharps**	**Infectious and pathological waste**	**Chemical, pharmaceutical and cytotoxic waste**	**Non-hazardous or general**
Physicians' offices	Hypodermic needles and syringes, broken glasswares like ampoules and vials	Medical supplies and materials such as (Dressings, bandages, gauze, cotton, gloves and masks contaminated with blood or body fluids	Medical materials such as (Broken thermometers and blood pressure gauges), drugs like spilt medicines and chemicals such as spent disinfectants.	Packaging, office paper, newspapers, magazines, uncontaminated gloves and masks
Dental offices	Needles and syringes, broken ampoules	Cotton, gauze, gloves, masks and other materials contaminated with blood Medical supplies and materials such as (Dressings, bandages, gauze, cotton, gloves and masks contaminated with blood or body fluids	Dental amalgam; spent disinfectants	Packaging, office paper, newspapers, magazines, gloves and masks that are not infected
Home health care	Lancets and insulin injection needles	Supplies and materials contaminated with blood or other body fluid	Broken thermometers	Domestic waste

(Source: UNDP, WHO & HCWH 2008:11)

Figure 5.2 presents a typical breakdown of material constituents in HCW.

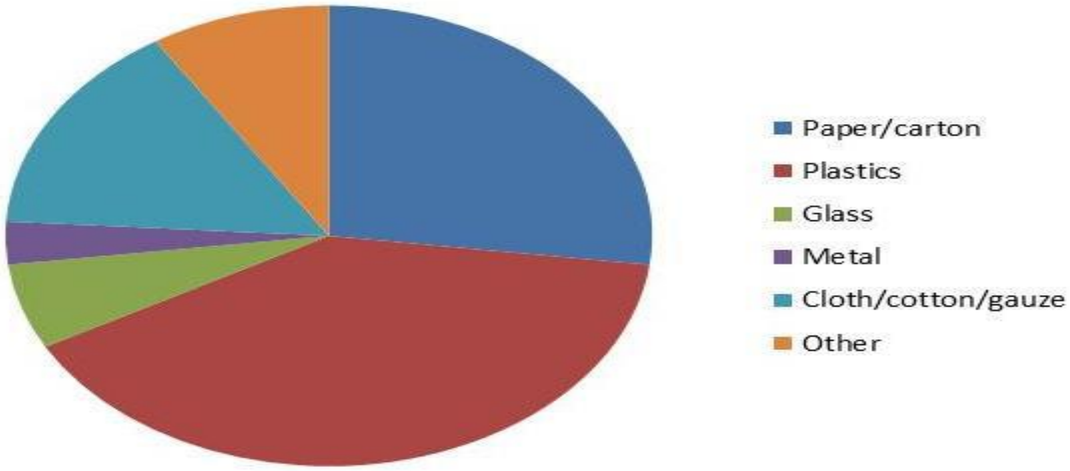


Figure 5.2 Typical breakdown of material constituents in HCW (excluding food)

(Source: UNDP, WHO & HCWH 2008:13)

5.4.5 Discussion

- What do you think of major or minor HCW sources? Provide some examples of these sources of HCW.
- How does the HCW (such as sharp, chemical, etc.) interact with your facility? Do you know of any strategies that might reduce HCW exposure?
- Would you give examples of waste mismanagement in your facility? If so, what can you do in this regard?

5.5 SECTION 2: SAFETY OF HCW HANDLERS

Learning outcome

By the end of this section, the HCW handler should be able to

- Identify risks in the workplace and who is at risk.
- Discuss how to avoid/restrict HCW exposure.
- Demonstrate good hygiene of the hand.
- Discuss the use of personal protective equipment and its drawbacks.
- Demonstrate the appropriate use and removal of personal protective equipment.
- Discuss the roles of the Committee on Occupational Health and Safety.

5.5.1 Principles of worker health and safety

All personnel who are directly involved in the handling of healthcare waste must be provided with adequate protection from the hazards associated with it. Protection against personal injuries is essential for all workers at risk. The people or department responsible for the management of HCW should ensure that all risks are identified and suitable protection from risk is provided. HCW management administration strategies or plans should incorporate a course of action for consistent observation of workers' wellbeing and safety.

- The production, segregation, transportation, treatment, and disposal of HCW involve the handling of potentially hazardous material.
- Protection against personal injury is essential for all workers.
- HCW management policies should include provision for continuous monitoring and enhancement of workers' health and safety.

Eleven (11) functions are integral to worker health and safety:

- Identifying and assessing risk.
- Surveillance of workplace hazards.
- Designing safe workplaces.
- Developing programmes to improve work practices and evaluating new equipment.
- Advising on occupational health, safety and hygiene.
- Surveillance of workers' health.
- Promoting the adaptation of work to the worker.
- Managing vocational rehabilitation.
- Organizing training and education.
- Organizing first aid, and emergency treatment.
- Analyzing adverse conditions that lead to injury and illness.

5.5.2 Occupational Health Safety (OHS) measures that should be developed and practised by healthcare facilities (HCFs)

Appropriate training for healthcare personnel to adopt ‘good work practices’ should be tailored to the different needs of various levels or functions in HCFs. The aim of the training is to develop awareness of the health, safety and environmental issues related to HCW and how these can affect employees in their day-to-day work. The training should highlight the roles and responsibilities of the healthcare personnel in the overall management programme.

Examples of ‘good work practices’ are:

- Waste handlers must wear personal protective equipment.
- Regular training of healthcare workers and proper hand washing techniques.

HCFs have a responsibility to ensure the occupational health safety of all categories of healthcare personnel. The following measures are recommended:

- Establish an occupational health and safety (OHS) programme.
- Prepare standard operating procedures (SOPs) for HCW management.
- HCW handlers should carry out their duties properly and fastidiously.
- HCW handlers should be involved in identifying hazards.

5.5.2.1 Occupational health safety (OHS) programme

The OHS programme should include the immunisation and annual health check-up of all healthcare staff; provision of adequate personal protective equipment (PPE) and clothing; first aid; reporting and further action; incident reporting; post-exposure prophylactic treatment (PEP); regular medical surveillance, and training and re-training of staff.

5.5.2.1.1 Immunisation and annual health check-up of all healthcare workers

Immunisation

- Healthcare personnel should be given immunisation against the potential infection from viruses causing hepatitis B and tetanus infection.
- Each HCF is encouraged to conduct a pre-employment hepatitis B screening programme and put in place employee vaccination arrangements.
- The HCF should maintain and keep long-term records of vaccinations to ensure that booster doses are given as required.

Annual health check-up

- An annual health check-up provides valuable information on the health status of the employee that can be evaluated against his/her baseline medical examination. It is recommended that staff be offered counselling and immunisation for certain diseases (e.g., hepatitis B and tetanus). Counselling and treatment should also be offered to staff after occupational exposure to blood-borne pathogens (e.g., HIV). It is furthermore recommended that employees who decline immunisation, or who do not seroconvert, be advised in writing about the occupational risk associated within their unique work environment. All healthcare personnel must be provided with an annual medical check-up by the employing HCF. The check-up should include:

    - Clinical examination, including blood pressure measurement.
    - ECG (Echocardiogram).
    - Chest X-ray.
    - Fasting blood sugar and lipid profile.
    - Any other investigations, depending on health complaints.

5.5.2.1.2 Provision of adequate personal protective equipment (PPE) and clothing

Personal protective equipment refers to specialized clothing or equipment worn by an employee to reduce the risk of injuries, other potentially infectious materials and chemicals. The type of protective clothing used will depend to some extent upon the risk associated with the HCW, but PPE should be made available to all personnel who handle waste.

The following individuals should use PPE:

- Healthcare workers and medical staff who provide direct care to patients and who work in situations in which they might have contact with blood, body fluids, excretions, or secretions must wear obligatory disposable gloves.
- Support staff, including waste handlers, cleaners, and laundry staff, who work in situations in which they may have contact with blood, body fluids, excretions, or secretions must use obligatory heavy-duty gloves.
- Laboratory staff who handle patient specimens must use obligatory disposable gloves.
- Family members who provide care to patients and could come into contact with blood, body fluids, excretions, or secretions must use obligatory disposable gloves.

Principles for using PPE

The following principles apply to the use of PPE:

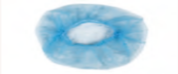
- Assess the risk of exposure to blood, body fluids, excretions, or secretions and choose items for PPE accordingly.
- Use the right PPE for the right purpose.
- Avoid any contact between contaminated (used) PPE and surfaces, clothing, or people outside the patient care area.
- Do not share PPE.
- Change PPE completely and thoroughly wash your hands each time you leave a patient to attend to another patient or another duty.
- Disinfect reusable PPE appropriately.
- Discard used PPE appropriately in designated disposable bags.

Figure 5.3 and Tables 5.2 and 5.3 present the recommended types of PPE and their uses.

Figure 5.3 Types of personal protective equipment (PPE) used in HCFs

(Source: United Nations Industrial Development Organization (UNIDO) 2018:98)

Table 5.2 List of personal protective equipment (PPE)

Equipment	Use	Technical specifications
1. Cap or head cover 	Protects scalp	Should cover the hair Should fit the head completely and be comfortable to wear
2. Goggles or face shield 	Protects eyes	1. Provide adequate protection against the particular hazards to eyes. 2. Reasonably comfortable when worn. 3. Fit snugly and not unduly interfere with the movements of the wearer. 4. Durable. 5. Capable of being disinfected. 6. Able to be worn without disturbing the adjustment of any existing prescriptive eyewear.[4]
3. Face mask, respirator  	Protects mouth/ nose, protect respiratory tract from airborne infectious agents	1. Gives safety against dust, fiber, fume, fog, smoke and soot. 2. Is sensibly comfortable when worn. 3. Fits cozily and does not unduly interfere with the movements of the wearer. 4. Is made of material that is fit for being disinfected frequently. 5. Has a belt that is either plastic or movable. 6. Is made of silicone or thermal plastic polymer. 7. Is accessible in at least three sizes: small, medium and large. Size measurements will change by maker.[4] **Determinations for the cartridges:** 1. Can accomplish the National Institute for Occupational Safety and Health P100 or N100 rating or proportionate European Committee for Standardization certification. P100 cartridges will ensure protection against any particulates including oil-based materials. N series arrangement cartridges ensure protection against solid and water-based particulates, for example, nuisance dust. 2. Contains a granular or permeable material, for example, carbon or coconut—which expels particular air particulates. 3. Is accessible in bayonet, push-in mounted cartridge, or canister frame; can evacuate 99.9% of dust and non-oil-based fogs. 4. Empowers simple breathing amid usage.[4]
4. Gown or apron 	Protects skin and/or clothing	Natural or man-made, reusable or disposable, resistance to fluid penetration and clean or sterile.
5. Gloves 	Protects hands	1. Durable, reusable design that is able to withstand periodic disinfection. 2. Available in sizes appropriate for all cleaning staff in the health care facility. 3. Prevent contact with blood borne pathogens contained in health care waste. 4. Made from puncture-resistant materials to protect against needle sticks and cuts from other sharps.
6. Impermeable shoes or gum 	Protects feet	1. Made using cut-proof materials. 2. Slip-safe sole. 3. Puncture proof sole. 4. Defensive against minimal impact. 5. Fit cozily and not unduly interfere with the movements of the wearer. 6. Strong. 7. Equipped for being sterilized. 8. Accessible in sizes to fit every single waste handler (toes ought to be around 12.5 mm from the front). 9. For incinerator operators, boots ought to be produced using heat-safe materials when accessible.[4]

(Source: UNIDO 2018:99)

Table 5.3 Personal Protective Equipment – when to use

Procedure	Glove	Gown	Mask	Goggles
Taking BP	-	-	-	-
Temperature, pulse,	-	-	-	-
Counting respiration	-	-	-	-
IM injection	✓	-	-	-
Starting IV line or taking blood or IV injection	✓	-	-	-
Controlling minor bleeding	✓		-	-
Cleaning an incontinent patient with diarrhoea	✓	-	✓	-
Handling soiled laundry	✓	✓	✓	✓
Cleaning contaminated instruments*	✓	✓	✓	✓
Controlling massive bleeding	✓	✓	✓	✓
Irrigating a wound	✓	✓	✓	✓
Conducting Delivery	✓	✓	✓	✓
Intubation	✓	✓	✓	✓
Suctioning	✓	✓	✓	✓
Liquid spill management	✓	✓	✓	✓
Mercury spill management	✓	✓	✓	✓
Handling waste(support staff)	✓	✓	✓	✓

(Source: UNIDO 2018:100)

Sequence of donning PPE

- Hand hygiene
- Gown (if applicable)
- Mask
- Eyewear or eye protection
- Gloves

Sequence of removing PPE

- Gloves (assume outside of glove is contaminated).
- Gown (assume gown/apron front and sleeves are contaminated).
- Goggles or face shield (assume outside is contaminated).
- Mask (assume front is contaminated).
- Perform hand hygiene:
    - Immediately after removing PPE.
    - Wash hands thoroughly with soap and water or use alcohol-based hand rub.

5.5.2.1.2.1 First aid

Immediate care following needle stick injury/accidental exposure to body fluids.

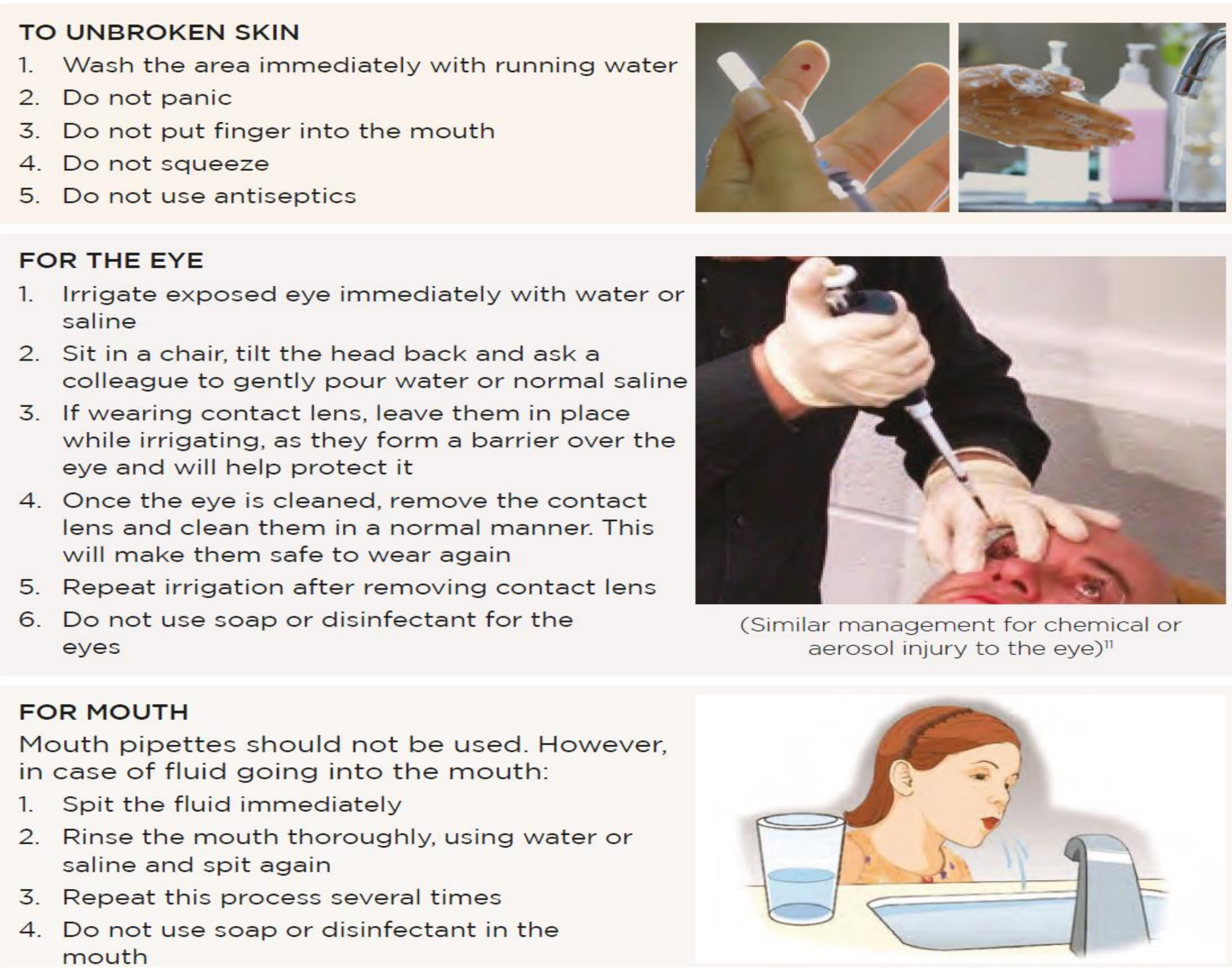


Figure 5.4 First aid following needle stick injury/accidental exposure to body fluids

(Source: UNIDO 2018:102)

5.5.2.1.2.2 Reporting and further action

- In any case, it is important to alert the responsible persons whose names and telephone numbers are clearly displayed at the door of the premises concerned.
- It is the supervisor's responsibility to notify the medical service which must record the accident in the register of accidents at work with the health and safety committee/works council and contact outside services. In-charge/supervisor will document the injury/incident in the injury register.
- The immediate action taken by the supervisor has the following objectives:
    - Evacuate workers rapidly if contamination is caused by gas, toxic substance, aerosol, powdery solid or liquid in compliance with a prearranged plan.
    - Avoid air currents: if the contaminant is a powder, door must be closed and ventilation hoods turned off.
    - Restrict access to the contaminated area.
    - Organize exposed personnel's prompt decontamination using suitable methods
    - Organize prompt decontamination of the premises and exposed equipment.
- Adequate precaution must be taken to prevent contamination of premises, equipment and people.
- Further, refer to the nodal person for counselling and action for PEP.

5.5.2.1.2.3 How to hand wash

Duration of the entire hand wash technique: 40-60 seconds.

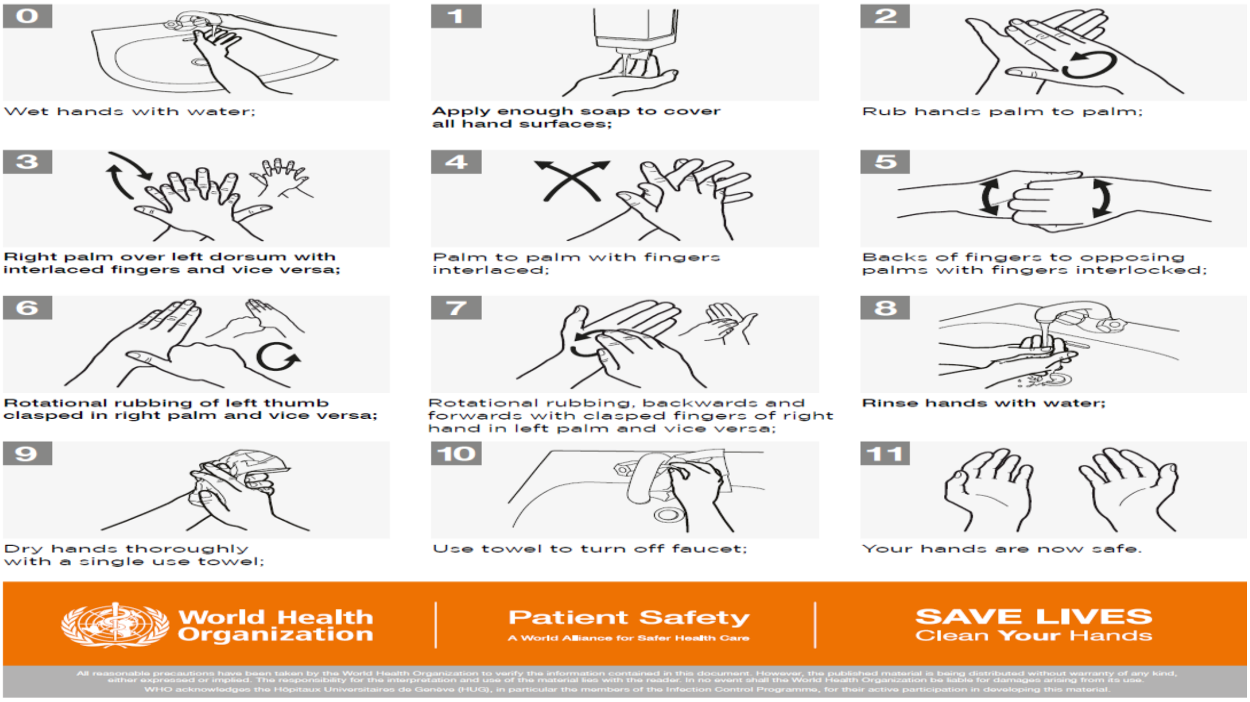


Figure 5.5 Hand wash technique

(Source: UNIDO 2018:101)

5.5.2.1.2.4 Incident reporting

The following procedures must be followed for incident reporting:

- All incidents including near misses (no injuries) should be reported to the OHS committee or a specific representative.
- A report should be filed and kept on record.
- Review reports regularly to make workplace or practice changes.

All waste management personnel should be trained in emergency response and should be made aware of the appropriate reporting procedure. Accidents including near-misses, spillages, broken containers, improper segregation and any sharp incidents, should be reported to the waste management officer (if waste is involved) or to another designated person.

- The report should include the following details:
  - Nature of the accident or incident
  - Place and time of the accident or incident

- Staff who were directly involved
- Any other relevant circumstances

5.5.2.1.3 Post-exposure prophylactic treatment (PEP)

The UNIDO (2018:105) requires that HCFs:

- Assure that post-exposure information, education and communication is accessible to all staff.
- Provide support and guidance to exposed persons.
- Initiate PEP within the first few hours of exposure and within 72 hours of exposure.
- Analyze reported cases of exposure to improve practices.

5.5.2.1.3.1 Occupational post-exposure prophylaxis (PEP)

Post-exposure prophylaxis (PEP) is short-term antiretroviral treatment (for HIV) or immunization (for hepatitis B) to reduce the likelihood of infection following potential exposure occupationally. PEP should be given within the health sector as part of a comprehensive program of uniform measures that eliminates workers exposure to occupational infectious hazards.

PEP for HIV includes a range of services to prevent the development of the exposed person's infection. These include first aid care; counselling and risk assessment; HIV blood testing; and the availability of short-term antiretroviral drugs (28 days) with follow-up and support, depending on the risk assessment. Within health care facilities, several incidents occurred due to occupational exposure to blood-borne pathogens occur.

In 2007, the World Health Organization and International Labour Organization (WHO/ILO) published guidelines on PEP to prevent HIV infection. According to the WHO/ILO PEP guidelines (2007:12):

- PEP should be provided as part of a package of prevention measures that reduce staff exposure to infectious hazards.

- PEP should be available to health-care workers and patients.
- Occupational PEP should also be available to all workers who could be exposed while performing their duties (such as social workers, law enforcement personnel, rescue workers, and refuse collectors).
- Countries should include occupational PEP in national health-care plans.
- Appropriate training to service providers should ensure the effective management and follow-up of PEP.
- PEP should be initiated as soon as possible within the first few hours and no later than 72 hours after exposure to potentially infected blood or body fluids.
- PEP should not be prescribed to a person already known to be infected with HIV.
- In addition, risk evaluation, and counselling on side effects, and benefits of adherence and psychosocial support is needed.
- Any occupational exposure to HIV should lead to evaluation and, where relevant, strengthening of safety and working conditions.

5.5.2.1.4 Regular medical surveillance

A medical surveillance program is a systematic approach to protect employees exposed to occupational hazards or potentially exposed to them. The programme monitors individuals for adverse health effects (pre- and post-employment) and determines the effectiveness of exposure prevention strategies. A medical surveillance program involves the analysis over time of individual and aggregate surveillance data to minimize and eventually avoid occupational illness and injury.

Medical surveillance in HCFs should focus on the following issues: mercury exposure; needle-stick injuries (NSI); blood-borne pathogens; TB surveillance (MDR TB and XDR); noise (may be an issue with loud equipment), and radiation and chemical (formaldehyde, glutaraldehyde, ethylene oxide) exposure.

Surveillance systems use data to:

- Prevent further injuries.
- Prevent exposure to blood, blood products and body fluids.
- Enhance control measures, investigate the incident, identify and implement remedial action.

- Follow an outbreak or other hazards to be recognized and investigated.
- Follow the quality of emissions into the air/environment.

5.5.2.1.5 Training and re-training of all healthcare workers

Training is a process of transferring or obtaining the knowledge, attitude and skills needed to carry out a specific activity. Healthcare workers' training in HCW management should be based on the assumption that there will be occasions of handling HCW in their day-to-day work. To achieve and maintain proper management of HCW requires updating healthcare workers' knowledge, attitude and practice for the prevention and control of diseases which affect health and environment.

- Training should be needs based. HCFs must prepare a plan for staff development.
- Provide training to healthcare workers and involve them in the identification and control of hazards. The waste generation and segregation activities in medical areas have a significant impact on workers involved in waste handling and treatment.
- Training of medical staff and other consumers of sharps should include illustrating the effect of improper waste practices on cleaners and waste handlers. The intention is to stress their responsibility to properly segregate waste in order to protect not only themselves and their patients, but also other workers and the entire community.
- It is essential to institutionalize training and become part of the HCF's standard functions. Therefore, training is related to improvements in quality of health care, institutional policies and procedures, development of human resources and performance evaluations of personnel, and coordination of facilities to ensure someone takes responsibility for the training program. Minimum training standards in HCW management could be recognized at national level in national policies as well as in accreditation or licensing of health care facilities.
- Together with training the availability of appropriate waste equipment such as sharp containers and PPE. Nothing is more frustrating than training HCWs in proper methods of segregation when the HCF has insufficient or incorrect containers, thereby preventing workers from putting their knowledge into practice.

Therefore, equipment procurement and budgeting are also correlated with training. In addition, training costs should be included in the annual budget of the HCF

- Training of health care workers in the implementation of a waste policy is a key requirement if improvements in waste management are to be effective. Training, however, is not a goal in itself, but rather a means of achieving an objective, such as modifying behaviors to strengthen waste management practices However, training is not a goal in itself (training for the sake of training), but rather a means to achieve a goal, such as behaviour change to improve waste management practices. Training is effective if it leads to significant performance improvements. For this reason, training is used in conjunction with creating a supportive environment, other forms of communication (e.g., posters, signs), incentives (e.g., awards and recognition to individuals), a means for personnel to provide input on improving practices, monitoring, reflective supervision, and corrective action.

5.5.2.1.6 Occupational health and safety committee (OHS)

At the HCF, the roles and responsibilities of personnel vary according to their titles and their functions. Overall, managers are responsible for overseeing the safe disposal of HCW generated in their establishments and fostering an environment that can provide necessary and quality health care at maximum profit. The composition of managers depends on the services offered in the institution, and should at least comprise Hospital Medical Superintendent, Heads of Hospital Departments, Infection Control Officer, Head of Pharmacy, Radiation Officer, Nursing Officers in Charge, Waste Management focal persons, Senior Nursing Officers, food service managers and Housekeeping supervisors.

5.5.2.1.7 Importance of an OHS committee

An OHS committee

- Promotes a culture good work practice and of safety.
- Works to reduce the number of injuries, illnesses and accidents that can contribute to

- cost savings
- savings in medical bills, workers compensation, etc
- avoiding costs of hiring and training new employees, repairing or replacing equipment/material damaged in incidents, etc.

5.5.3 Discussion

- What are some common health hazards in your workplace that you see in your facility? Who do you think is at risk from healthcare wastes?
- Do you know of any health and safety policies that have been found in your country or region?
- What do you consider the most important elements of good personal hygiene when working in a healthcare facility? Do you think readily practiced good hygiene habits in your facility?
- Does your facility offer training programs for workers in health and safety, or other opportunities for specific training about healthcare wastes and hazards? Do you know (apart from this one) about other similar training programs?
- What kinds of personal protective equipment do you wear / use in your job at the health care facility on a regular basis?
- Are you responsible for reporting incidents? Are the protocols developed in the facility for PEP?

5.6 SECTION 3: HCW IDENTIFICATION AND SEGREGATION OF CHEMICAL, BIOLOGICAL AND RADIOACTIVE WASTES

Learning outcome

By the end of this section, the HCW handler should be able to:

- Discuss the benefits of segregation and general principles of waste segregation.
- Demonstrate proper labelling, marking and colour coding and placement of bins.
- Describe the hierarchy of waste management.
- Describe practices that facilitate waste minimisation.

- Describe green procurement and purchasing practices that are environmentally friendly.
- Describe safe reuse, recycling, and recovery.
- Introduce environmental management systems.

5.6.1 Introduction

A life cycle approach to HCW management is very important. The management of waste starts from waste minimization and segregation at source until its final treatment and disposal options. The important component that should be kept in mind throughout the life cycle approach is that of worker, patient and environment safety. The most preferable approach is one that produces as little waste as possible, thus minimizing the amount entering the waste stream.

Segregation is the primary step and the "HEART" of safe management of HCW. Put simply, segregation means the collection and separation of different types of waste right from the point of generation to final disposal.

The proper segregation of HCW is the responsibility of the person who produces every waste item irrespective of their organizational role. It is the duty of all workers the HCF management to ensure that adequate segregation occurs and that adhere to the correct procedures.
Segregation should be done by the waste producer as close as possible to its place of generation, meaning segregation should be performed by nurses, physicians and technicians in a medical area, at a bedside, in an operating theatre or laboratory. If the classification of a waste is uncertain it should be stored as a precaution in a container used for hazardous healthcare waste in health care facilities.

The best method for waste segregation is to separate all hazardous waste from the larger amount of non-hazardous general waste. Nevertheless, the hazardous waste portion is generally separated into two parts in order to provide a reasonable level of safety for staff and patients: used sharps and potentially infectious items. Typically tubing, bandages, discarded medical items, swabs and tissues are the main components of potentially infectious waste. Consequently, the segregation into separate containers of general, non-hazardous waste, potentially infectious waste and sharps is often referred to as the "three bin system”. Other container types may be used for certain waste categories, such as chemical and pharmaceutical waste, or for separating pathological waste, where it is to be handled and disposed of in different ways to the other portions of the waste flow.

5.6.2 Benefits of segregation

Segregation of waste is the key to proper HCWM and has the following benefits or advantages:

- Facilitates safe handling of the waste.
- Separates recyclable waste from hazardous waste.
- Ensures that the waste will be treated according to its hazard.
- Reduces the overall costs of waste management, including transport, treatment, and disposal.

5.6.3 General principles of waste segregation

The general principles of waste management are containment, and colour coding and labelling. Containment or containing ensures and keeps waste controlled and separated correctly. Colour coding and labelling ensures safe handling, transport and disposal.

5.6.3.1 Containment

Containment or containing refers to segregating and then depositing and keeping HCW in separate safe, clearly marked containers for collection, transportation and disposal. Containment keeps waste controlled and separated correctly.

5.6.3.2 Colour coding and labelling of containers/waste bins

The use of colour coding and marking helps to easily segregate waste and identify the different categories of waste. It therefore contributes to safer handling of waste by clearly associating a specific colour with a specific category and its associated hazard.

5.6.4 Containers for waste collection

Waste containers come in many shapes and sizes and are made from different materials. Some modern waste containers are designed for automated systems that empty their contents into the waste disposal system and wash and disinfect them mechanically. Waste containers may also be made from reused plastic and metal. The following requirements apply to HCW containers:

- They should be sturdy and leak-proof in all situations and fitted with a sturdy plastic bag, with the exception of sharp containers.
- The recommended infectious waste bag thickness is 70 µm (ISO 7765 2004). Chlorine-free plastics used for containers or bags. Not all plastic bags can withstand 121 ° C temperatures, during an autoclave process some can melt.
- Containers should have well fitted lids, either removed by hand or operated preferably with a foot pedal. For the waste they are intended to collect and clearly labelled, both the container and the bag should be of the right color. It is important to avoid combining colors such as yellow bags in black bins, because this will increase the potential for confusion and poor segregation.
- Because sharps can cause injuries and leave people vulnerable to infection, both contaminated and uncontaminated sharps should be stored in a puncture-proof and impermeable container that after closure is difficult to break open. The UNIDO (2018:42) stipulates performance specifications for these containers Sharps containers may be disposable or designed for disinfection and reuse. Disposables are boxes made of plastic or plasticized cardboard; plastic or metal are reusable designs. Low-cost choices include plastic bottles or metal bottles being reused. In order to do this, the original labels should be removed or blurred and the containers should be explicitly re-labelled as "Sharps containers."
- The appropriate waste receptacles (bags, bins, sharps boxes) should be available to staff in each medical and other waste producing area in a healthcare facility. This permits staff to segregate and dispose of waste at the point of generation and reduces the need for staff to carry waste through a medical area. Posters showing the type of waste that should be disposed of in each container should be posted on walls to guide staff and reinforce safety and good practice.

- Segregation success can be improved by making sure that the containers are large enough for the quantity of waste generated at that location during the period between collections. Up-to-date waste audit data can be used to assess the volume and type of waste containers necessary, since waste managers also need to spend time with staff in medical areas identifying the type of work that is undertaken. No two areas will be the same.
- Medical staff should be encouraged to think of waste disposal as part of a patient's treatment, so that all aspects of the care process are completed at the bedside or treatment room. If intervention at the bedside is required, a waste container should be taken to the bed. Sharps bins are also sometimes taken to a patient for drug administration or blood sampling. A mobile trolley with infectious waste and sharps containers may therefore be more versatile and should be seriously considered. An alternative is to set up a limited number of sites in a medical area where general waste (black bags) and infectious HCW (yellow bags and sharp containers) containers are placed. The locations should be away from patients. Typical locations are the space for the sluice room, the treatment room and the station for the nurses.
- Where containers are used to segregate hazardous and non-hazardous HCW, they should be located nearby whenever possible. Infectious waste containers should not be placed in public areas, because patients and visitors can use the containers and come into contact with potentially infectious waste.
- Static bins should be placed as close to sinks and washing facilities as possible, because after treating patients, most workers may deposit gloves and aprons. If the general waste container is closest to the sink or under a towel dispenser, workers are encouraged to put towels in the non-infectious receptacle. Containers should be of the same size to overcome the staff's reported propensity to put waste in the largest receptacle.
- Unless patients are known or suspected of having readily transmitted infections, it should be presumed that general waste produced in a medical area is of low risk. Furthermore, if a suspected transmissible infection (e.g. methicillin-resistant *Staphylococcus aureus*, tuberculosis or leprosy) exists, all waste used in and around the patient should be identified as a risk of infection and placed in the yellow, potentially infectious waste container. This "blanket" approach to all waste being assumed to be infectious can be avoided where there is a high level of

training and communication between the clinical and support staff. Waste should be managed according to the known infection status of each patient.

5.6.5 Colour coding

Colour coding is important in HCW management and refers to the correct colour container for specific waste. Certain regulations apply to HCW containers. For example, regarding plastic bags:

- A plastic bag with a capacity of 60 litres or more must be at least 80 microns thick.
- A plastic bag with a capacity of less than 60 litres must be at least 60 microns thick.
- A plastic bag used as a barrier in a health care risk waste container must be at least 60 microns thick.
- Colour coding allows health care workers to classify waste items into the correct waste containers.
- Colour coding supports health workers who are less experienced in maintaining segregated waste during transportation storage and final disposal.
- Colour coding offers a visual indication of the contained waste's potential risk.

Figure 5.6 Colour coded healthcare waste bags/containers

(Source: UNIDO 2018:40)

5.6.6 Placement of HCW bins

- Colour coded bins for collection of biomedical waste and safety boxes for sharps waste should be in the strict charge of relevant health workers (nurses, pathologists, laboratory technicians, etc), and are to be placed specifically at the places of generation of such waste (nursing station, labour room, laboratory, etc). Patients and visitors should not have access to these containers.
- Place the HCW bin in the right location to the general landfill waste (for general or hazardous wastes) and recycling bin should be placed as close to the main area of waste generation as possible:
  - This is to limit the distance that the staff have to walk with waste.
  - Staff must decide which bin to use.
- Place the HCW bin in the right location to facilitate segregation areas where both infectious and non-infectious wastes are generated.
- Place the HCW bin in the right location to facilitate for sharps, container placed in the area where to be either wall mounted or placed on a table.
- For expired drugs placed in the pharmacy as a central storage area from which the products can be returned to the manufacturer or moved to CBWTF, whichever is the policy of the HCF.
- Place the HCW bin in the right location to facilitate any colour other than that used for BMW and according to HCW policy of the country, appropriate bins should be used for general waste.

Figure 5.7 Healthcare waste that should go into a yellow bin

(Source: UNIDO 2018:41)

All contaminated (recyclable) waste should be put into a red bin.

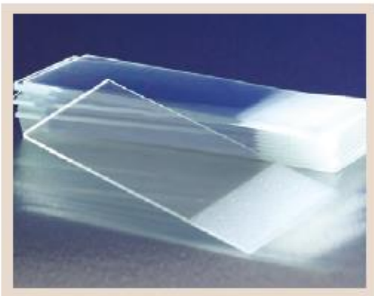
Figure 5.8 Healthcare waste that should go into a red bin

(Source: UNIDO 2018:42)

Glass waste and metallic body implants **should go** into **a** puncture-proof and leak-proof **blue** box or container.

Metallic body implants

Broken ampules



Slides

Empty vials

Puncture proof , Leak proof Box/ Container with blue colored marking

Figure 5.9 Blue puncture-proof and leak-proof box/container

(Source: UNIDO 2018:43)

Sharps **should go** into **a** white tamper-proof, puncture-proof, leak-proof container.

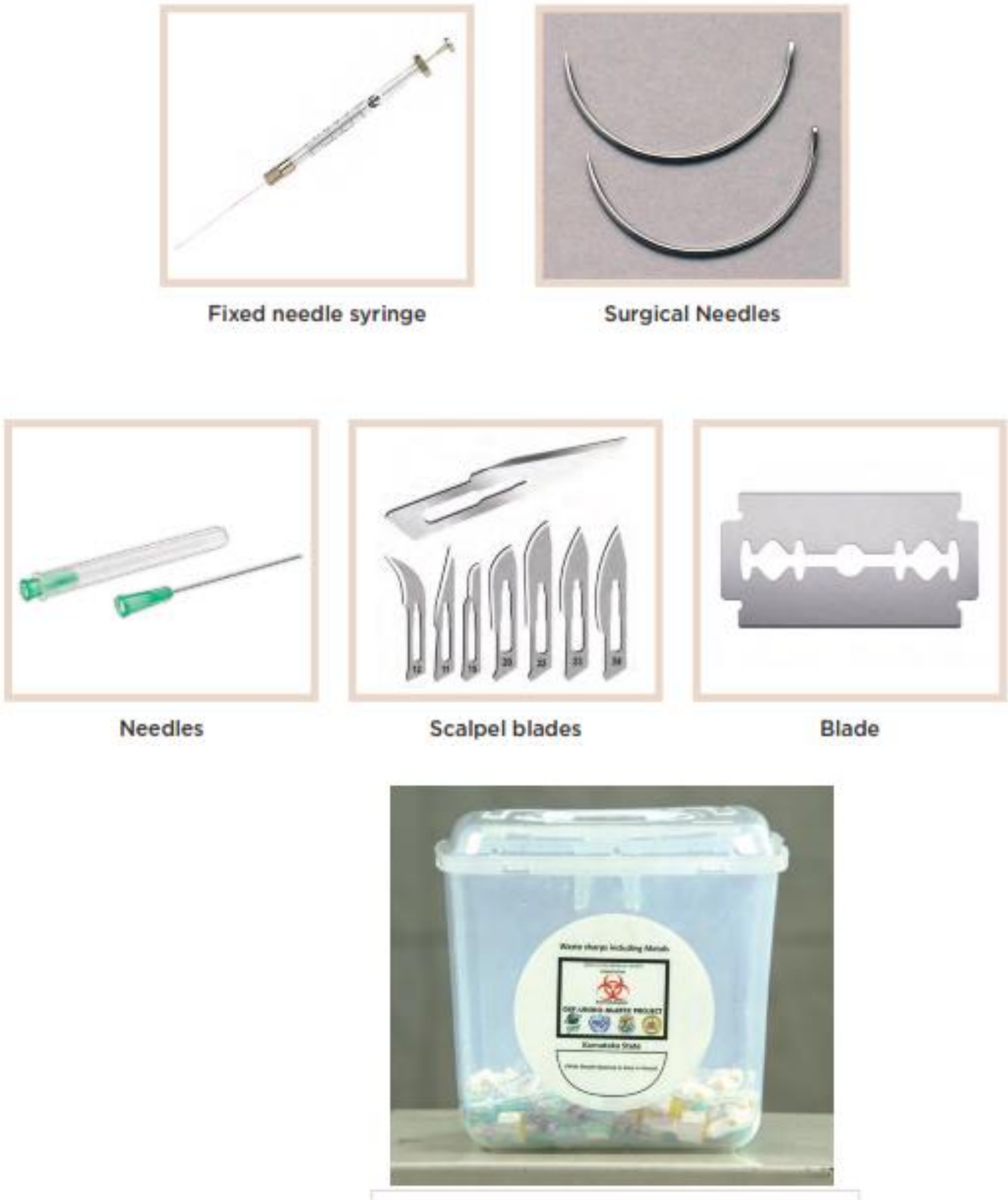


Figure 5.10 Healthcare waste that should go into a White or translucent white container

(Source: UNIDO 2018:42)

5.6.7 What is waste minimization?

Waste minimization refers to the elimination or reduction of waste generation by an emphasis on source reduction and recycling.

Source reduction of the is desired, if appropriate, and the emphasis should be on collaborating with the medical staff to make improvements to less wasteful clinical practice for effective waste minimization. This refers to approaches adopted by the HCF to reduce the amount of HCW generated during delivery of services.

Health facilities can adopt various policies, facility guidelines, and practices that might reduce their waste volume, such as:

- *Source reduction (Green Procurement)*: Purchasing and supplying materials which are less wasteful and/or generate less medical waste.
- *Stock management*: Frequent auditing; use of the oldest stock first and checking the expiry date of products during receiving and issuing of commodities.
- *Encouraging the use of recyclable products*: Using materials that can be recycled both off- and on-site.
- *Centralized **management***: purchasing, supply**ing**, and monitoring and control of medical goods.
- *Segregation of waste at the point of generation*: Sorting the waste into different categories helps to minimize the quantities of infectious waste generated.
- *Reduction of unnecessary injections*.

Figure 5.11 depicts the waste management hierarchy.

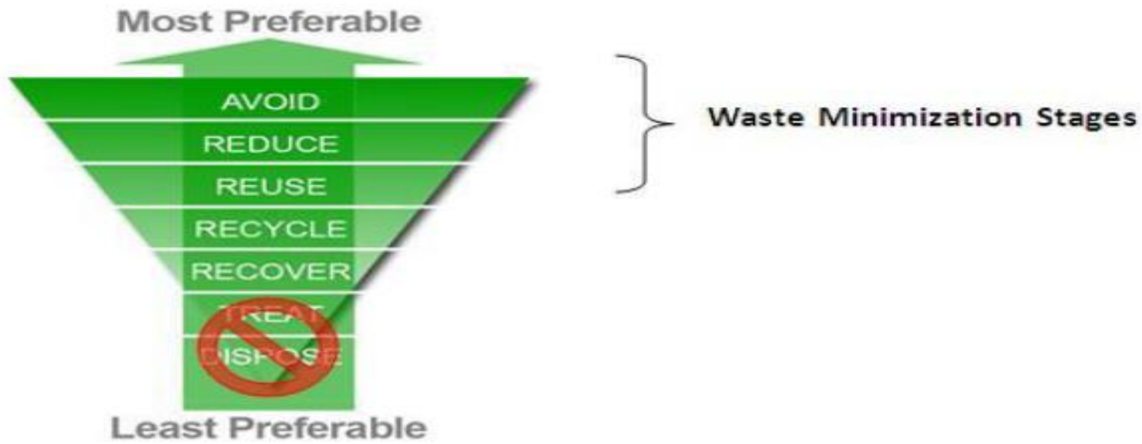


Figure 5.11 Waste management hierarchy

(Source: UNDP, WHO & HCWH Module 11 2008:6)

Waste minimization can be done at two points in HCFs:

- First, review purchase practice as the key in aggressive purchasing waste minimization. The HCF should work with the purchasing department to select reusable rather than disposable products.
- Second, separate different types of waste at a point of generation and keep them isolated from each other by applying the 4R's principle (Reduce, Reuse, Recycle and Recover) not only protects human health and the environment, but saves institutions substantial amounts of money.

5.6.8 The 4 R's rule

The four R's rule refers to reduce, reuse, recycle and recover.

5.6.8.1 Reduce

Source reduction involves measures that either completely eliminate the use of a material to generate less waste or cut down the use to achieve the same result. This can be achieved by a careful re-evaluation of a hospital's purchasing practices, product choices, and operating procedures, which can reveal several opportunities for waste reduction. This includes everything from recycled paper at the simplest level to medical equipment at higher levels. Products or services whose environmental impacts have been assessed and found to be not harmful to human health and environment.

5.6.8.2 Reuse

Re-use means not only finding another use for a product but, more importantly, reusing the product over and over again for a given function as intended. Promoting re-use entails the selection of reusable rather than disposable products whenever possible. Re-use will also entail setting reliable standards for disinfection and sterilization of equipment and materials for use.

Standards for disinfection and sterilization must be strictly followed if equipment and materials have to be reused. All or a combination of sterilization **processes**, such as autoclaving, disinfection, cleaning, reconditioning and decontamination methods, should be used for the devices so that they are safe for reuse.

5.6.8.3 Recover

The recovery of waste is done in two main ways. Most simply, "recovery" refers to the recovery of energy by converting waste into fuel for electricity generation or direct heating. The heat generated by on-site incinerators can be an attractive and cost-effective option for heating hospitals, public buildings and residential districts in temperate climates. Alternatively, "waste recovery" is a term used to include recycling of waste items waste to be converted into new products and composting organic waste to produce compost or soil conditioner for use in agriculture or similar purposes.

5.6.8.4 Recycle

Recycling refers to collecting waste and processing it into something new. In recycling, products lose their original form and shape and may be used for different purposes. Many items in HFCs can be recycled, such as organics, plastic, paper, glass and metal.

5.6.9 Benefits of waste minimization

Waste minimization:

- Reduces the waste disposal costs.
- Reduces the impact on the environment.
- Improve public health.
- Improves the health and safety of employees.
- Enhances the public image of HFCs.

Assessment of waste minimization opportunities is a structured method for identifying ways of reducing or eliminating waste and consists of four steps: planning and organization; assessment; review of feasibility and implementation.

- Planning and organization
  - It is very important to gain management support.
  - One or more environmental champions often initiate and support successful waste minimization programs.
  - Planning requires setting overall goals.
  - Appointing of a task force to begin the assessment process.

- Assessment
  - Collect data from the facility and process.
  - Identify the types amounts and rates of generation of different waste streams.
  - Prepare maps or diagrams of waste flow.
    - ✓ Prioritize and select assessment targets:
      - Prioritize waste with the greatest potential for minimization.
      - Include total amounts, features (toxicity, bio-accumulative properties persistence in the environment), health of the worker, and costs.
    - ✓ Select people for assessment teams.
    - ✓ Review data and inspect site:
      - Follow from the point of generation to where the waste exits the facility pursue the target activities.

- ✓ Generate options:
  - Consider the techniques for waste minimization.
  - Get feedback/ideas from a wide range of sources.
- ✓ Screen and select options for further study.

- Feasibility analysis:
  - ➢ Technical evaluation.
  - ➢ Economic evaluation.
  - ➢ Select options for implementation.
- Implementation:
  - ➢ Justify projects and obtain funding.
  - ➢ Installation (Equipment).
  - ➢ Implementation (Procedure).
  - ➢ Evaluate performance.

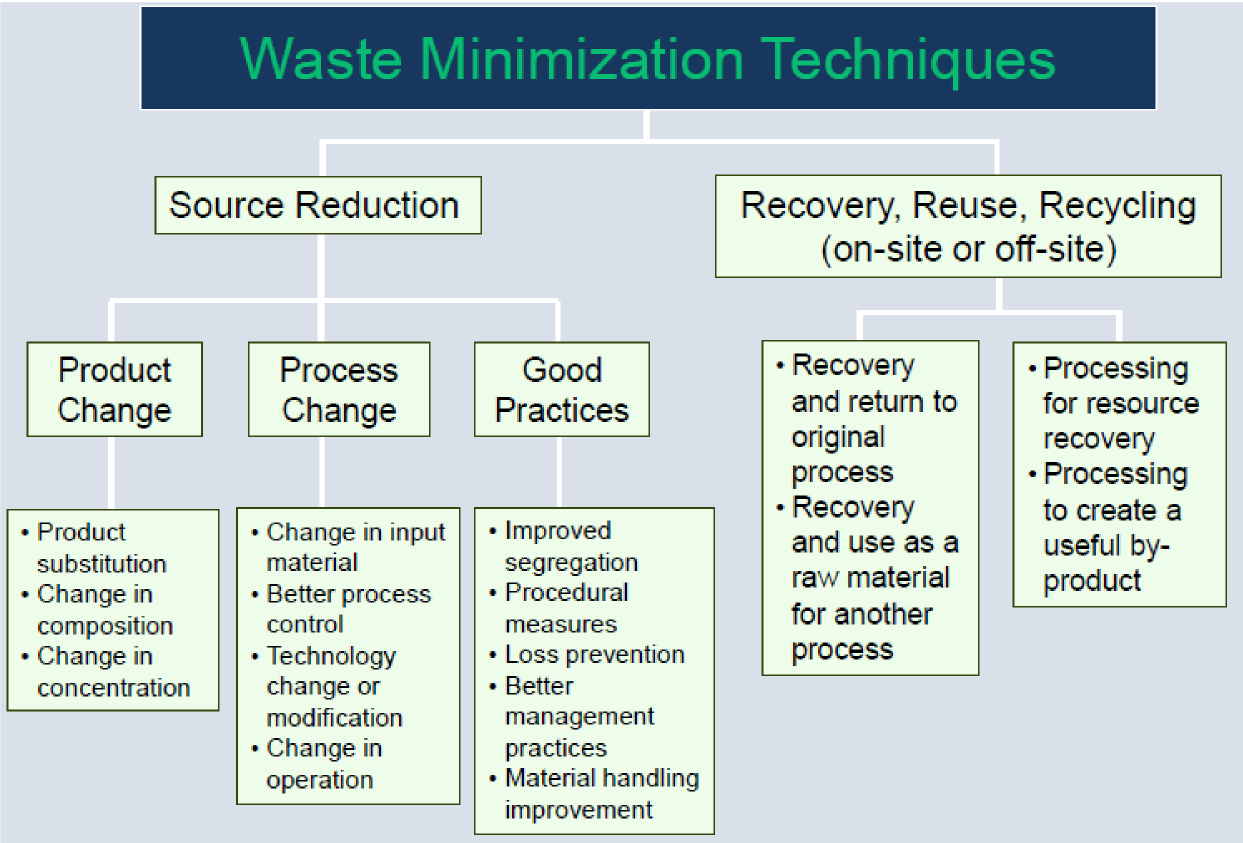


Figure 5.12 Waste minimization techniques

(Source: UNDP, WHO & HCWH Module 11 2008:14)

5.6.10 Discussion

- What is segregation?
- What is containment?
- Indicate the colour codes for different healthcare wastes.
- What is the aim of the hierarchy of waste management?
- Consider of specific ways in your facility to implement waste minimization strategies

5.7 SECTION 4: COLLECTION, TREATMENT AND DISPOSAL OF HCW

Learning outcome

By the end of this section, the HCW handler should be able to:

- Describe the labelling requirements.
- Describe the handling and collection criteria for various types of waste.
- List and perform the steps in developing a collection system.
- Demonstrate correct bag closure, handling and collection methods.
- Demonstrate the techniques used to address common problems.

5.7.1 Introduction

HCF inhabitants have a "duty of care" to ensure that the violation or misuse of HCW is avoided from generation to on- or off-site safe disposal. Proper segregation and on-site and off-site transportation systems provide a continuous safekeeping sequence at every step of the process, from the point of waste generation to its final treatment or disposal. The safe transportation of waste without contamination and spillage is therefore an essential part of the waste management process.

Steps in HCW management:

- Waste classification (see the previous session).
- Waste segregation (see the previous session).

- Waste minimization (see the previous session).
- Handling and collection.
- On-site transport and storage.
- Treatment and disposal.

5.7.2 Collection

Wastes should not be allowed to accumulate at the point of production. A routine programme for their collection should be established as part of the HCW management plan.

Nursing and other clinical staff should ensure that waste bags are tightly closed or sealed when they are about three-quarters full. Light-gauge bags can be closed by tying the neck, but heavier-gauge bags probably require a plastic sealing tag of the self-locking type. Bags should *not* be closed by stapling.

Certain recommendations should be followed by the ancillary workers in charge of waste collection:

- Health workers handling waste must wear appropriate PPE when handling waste.
- Sharps must always be placed in injection safety boxes, must not be over-filled (fill to approximately three-quarters of capacity) and never be placed in waste bags.
- Waste must be contained in colour-coded and well labelled plastic bags.
- General waste should be contained in well labelled black bags.
- Waste bags must not be over-filled (fill to approximately three-quarters of capacity).
- The volume of a waste bag should not exceed 55 litres.
- At the point of waste generation, excess air should be expelled from the bag, without compacting the contents, prior to closure using a bag tie.
- All bags should be held away from the body by the closed top of the bag and placed directly into a mobile garbage bin or trolley.

- Where waste bags are sealed and stored pending collection, they should be in a secure place with restricted access.
- A waste collection schedule should be in place.
- The label must at least contain the following information:
  - Date
  - Area/Floor/Unit shift
  - Type of waste
  - Weight of the waste

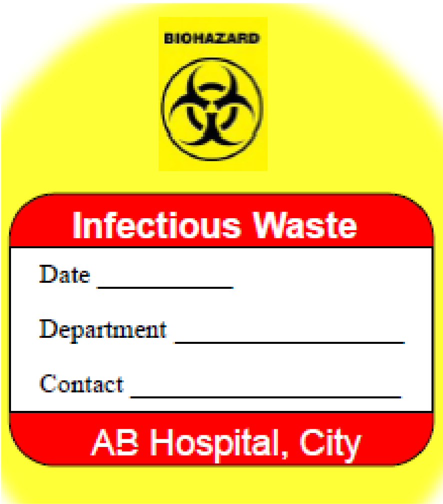


Figure 5.13 Label for HCW container

(Source: UNDP, WHO & HCWH Module 12 2008:5)

5.7.3 Waste handling

Waste handling:

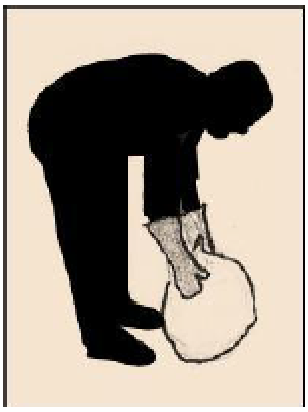
- Should be built up as part of a waste management plan for health care
- Requires the correct use of the PPE
- Needs the implementation of good body mechanics

5.7.4 Body mechanics

Body mechanics refer to the way we move when conducting activities:

- Good body mechanics could protect the body from injury.

- Examples of bad and good body mechanics when lifting:



WRONG

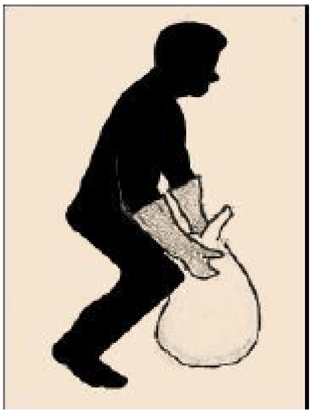


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Figure 5.14 Body mechanics

(Source: UNDP, WHO & HCWH Module 12 2008:7)

5.7.5 Steps for developing a waste collection system

- Identify the points of generation within the health care facility for different types of waste.
- Quantify the amount of waste and measure the optimum size of the container for each location.
- Assess how quickly the containers are filling.
- Set up fixed collection times so infectious waste containers are removed when 3/4 full. Establish a notification system for quicker removal of waste
- Deliver bags or containers when removing them.
- Conduct continuous monitoring and improvement.

5.7.6 Considerations when scheduling collection times

- Match collection times with the regular pattern of waste generation during the day.
- Examples:
    - In medical areas where the morning routine starts with changing dressings-collect mid-morning healthcare waste to avoid soiled bandages from accumulating.

- In facilities with set hours of visiting – collect general and recyclable waste after visitors have left.
- Collect infectious waste according to the schedule of operations from surgical theatres.

5.7.7 Infectious waste containers

Ideal infectious waste containers are ones that have:

- Lids that remain closed except when waste is discarded.
- Pedal-operated tools to open the lids.
- Inside the bins, should keep colour coded bags

Figure 5.15 Healthcare waste containers

(Source: UNDP, WHO & HCWH Module 12 2008:11)

5.7.8 Infectious waste collection

- Waste should be transferred to the central or temporary storage area allocated.
- Waste bags and containers should be labelled with the date, type of waste and point of generation so that they can be monitored for disposal correctly and easily.

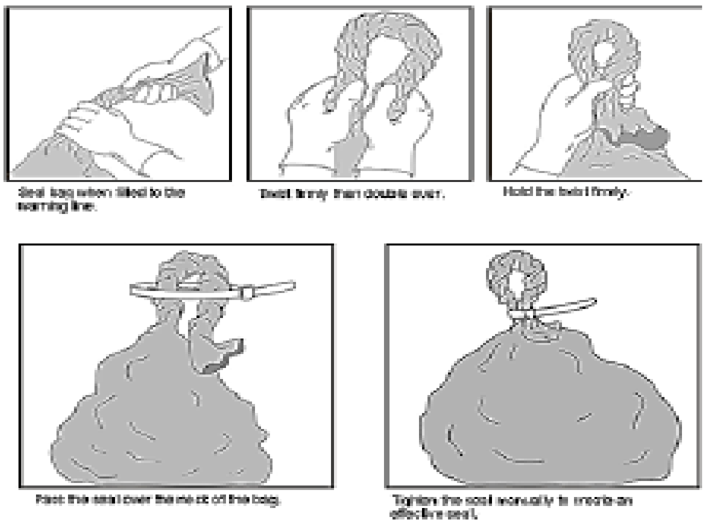
- Do not redistribute the waste material by shaking the bag as this may result in the release of liquids or aerosols.

5.7.9 Proper bag closure

- Waste bags should be sealed or closed tightly when they are approximately 3⁄4 full.
- Stapling (which can cause tears) should not be used to close the containers.
- It is possible to use a plastic tag or tie.
- Light-gauge bags can be closed by tying the neck.
- Heavy-gauge bags may require a plastic sealing tag of the self-locking type.

Examples of bag tying methods:

- Simple knot
- Goose-neck or swan-neck method



–Self-

Figure 5.16 Bag tying methods

(Source: UNDP, WHO & HCWH Module 12 2008:14)

5.7.10 Bag removal and replacement

- Immediately replace the bags or containers with new ones of the same type.
- A supply of fresh collection bags or containers at all sites where waste is produced should be readily available.

5.7.11 Collection of sharps

- Safety boxes should not be more than ¾ full when closing and sealing them. When closing and sealing safety boxes should not be more than 3⁄4.
- Overfilling increases the risk of injury to the needle-stick.
- If a safety box in the cardboard has a broken handle, check the sides and bottom before removing the container to ensure that there are no protruding needles.
- Heavy duty gloves should be used when handling sharps containers.

5.7.12 Chemical waste collection

- Chemical wastes should never be mixed or disposed of down the drain but stored in containers that are leak-proof.
- All chemicals should be clearly labelled:
    - Type of waste.
    - Name of the major chemicals.
    - any necessary hazard labels, e.g. corrosive, flammable, explosive, or toxic.

5.7.13 Pharmaceutical waste collection

- Unused pharmaceutical products should be returned to the pharmacy for return to the manufacturer or suppliers or sent to waste treatment contractor.
- Spilled and contaminated pharmaceuticals would enter the facility waste storage directly from the point of generation.
- To help identify and prevent reactions between incompatible chemicals, pharmaceuticals should be kept in their original packaging.

5.7.14 Radioactive waste collection

- Where there are specialized disposal facilities, radioactive waste should be collected and handled appropriately.
- Therefore, waste may be stored in radiation-proof repositories (leak-proof, lead-lined, and clearly labelled with radionuclide and deposition date) where it may naturally decay.

5.7.15 How to handle improperly segregated waste

- Poorly segregated waste should never be processed, but treated as the most dangerous type of waste in the container.
- There must be corrective action to ensure that waste is adequately segregated in the future.

5.7.16 How to handle leaking bags or containers

- Leaking bags or sharps containers should be placed in a secondary container (e.g., another plastic bag) with the same colour code and label.

5.7.17 How to handle an overfilled sharps container

- Do not attempt to transfer portions of the waste to another container.
- Use long heavy-duty gloves to secure the arms carefully place the overfilled container into a bigger, secondary container that is puncture-resistant (e.g. a thick hard cardboard box or plastic box).
- If it is not labelled, add a special label to the outside container and follow clean-up instructions when a spill occurs.
- Report to your supervisor about overfilled container.

Figure 5.17 Overfilled sharps container

(Source: UNDP, WHO & HCWH Module 12 2008:26)

5.7.18 How to handle overfilled bags

- Don't try to transfer portions of the waste to another bag or container.
- Two workers with proper PPE are needed.
- With one worker holding a larger secondary container (for example, a larger plastic bag of the same color code), another worker should carefully place the overfilled bag or container in the secondary container placing the overflowing waste in first.
- If it is not color-coded, place a special label on the outside container; follow clean-up protocols when a spill occurs.
- Report to your supervisor about overfilled container.

Figure 5.18 Overfilling healthcare waste container

(Source: UNDP, WHO & HCWH Module 12 2008:25)

5.7.18.1 Ethiopia's HCW management directives

The following guidelines are in Federal Democratic Republic of Ethiopian Ministry of Health FMHACA, Healthcare waste directive 2005 Ethiopian Calendar (2013 GC:11) stated the following requirements for labelling, handling and collection of HCW:

- Healthcare facilities shall have the obligation to prepare and implement standard operating procedures in the handling of healthcare wastes.
- It shall be the responsibility of the service providing health professional to appropriately segregate healthcare waste at the point of service delivery.
- It shall be the responsibility of the health facility to make sure that all waste bags or containers are to be labelled containing basic information about the content and sources of wastes or department.
- Segregation shall be maintained in the subsequent waste management steps from collection to disposal.
- All non-sharp infectious waste shall be placed in yellow polyethylene bags having a minimum 300 micron gauge and marked "danger! infectious waste" and indicated with the international biohazard symbol.

- Every person who is involved in segregating healthcare wastes shall ensure the absence of infectious and hazardous healthcare waste in the domestic waste flow line.
- Health professionals and waste handlers shall understand the colour-coding system and safe handling of waste in accordance with the directive.
- Segregation shall be regularly monitored to ensure compliance or fulfilment.
- A safety box shall be located within arm's reach of any place where an injection is given and shall be sealed and collected when ¾ full and must never be emptied, reused or opened.
- Where any waste is found not to be incinerated, it shall be segregated separately according to the type and nature of the waste.
- Health professionals shall make sure used needles with syringes are put in the safety box immediately after the injection without recapping.
- Pharmaceutical wastes spilled or contaminated drugs or packaging containing drug residue generated from any place in the healthcare facility other than the store and dispensary area shall not be returned to the store or dispensary areas. They shall be contained in the correct container at the point of generation.
- Employees of the health facility shall never attempt to correct errors of segregation by removing items from a bag or container.

Discussion:

- What are some waste handling and collection procedures and protocols in place in your facility?
- Are there different guidelines for different types of wastes – infectious, chemical, etc.?
- Did you prepare standard operational procedure for handling and collection of HCW in your organisation?
- How does your facility deal with the removal of wastes?
- What labelling process do you follow?
- What are some of the weaknesses and strengths of your current system?
- How can the existing practices be improved?
- State the requirements for labelling, handling, and collection of HCW by in your country?

5.7.19 Transportation within the healthcare facility (HCF)

5.7.19.1 General requirements

There should always be separate transport of hazardous and non-hazardous waste. There are three types of transport systems:

- Trolleys for general waste transportation should be painted black, used only for non-hazardous types of waste, and clearly labelled "General Waste" or "Non-hazardous Waste."
- Sharp waste together with infectious waste can be transported. Infectious waste should not be shipped in combination with other hazardous waste to avoid possible spread of infectious agents. Infectious waste trolleys should be painted in the appropriate colour (yellow) and should be labelled with an "Infectious waste" sign.
- Other hazardous waste, such as chemical and pharmaceutical waste, should be transported to central storage sites separately in boxes.

It is not advised to use waste chutes in HCFs because they can increase the risk of airborne infection transmission.

5.7.19.2 Transport systems

When moving waste from one place to another either on- or off-site, using trolleys and routing are important.

5.7.19.2.1 Transport trolleys

Healthcare waste can be bulky and heavy and should be transported using wheeled trolleys or carts that are not used for any other purpose. To avoid injuries and infection transmission, trolleys and carts should:

- be easy to load and unload
- have no sharp edges that could damage waste bags or containers during loading and unloading
- be easy to clean and, if enclosed, fitted with a drainage hole and plug
- be labelled and dedicated to a particular waste type
- be easy to push and pull
- not be too high (to avoid restricting the view of staff transporting waste)
- be secured with a lock (for hazardous waste)
- be appropriately sized according to the volumes of waste generated at a health-care facility

Waste, especially hazardous waste, should never be transported by hand due to the risk of accident or injury from infectious material or incorrectly disposed sharps that may protrude from a container.

Spare trolleys should be available in case of breakdowns and maintenance. The vehicles should be cleaned and disinfected daily. All waste bag seals should be in place and intact at the end of transportation.

Figure 5.19 Transport trolley for healthcare waste

(Source: UNIDO 2018:55)

5.7.19.2.2 Routing

It is essential to plan and use separate hazardous and non-hazardous routes. In general, the "from clean to dirty" rule should be enforced by a waste route. Collection should start from the most hygienically sensitive areas of medical care (e.g. operation theaters, intensive care units, dialysis unit) and follow a fixed route around other medical areas and interim storage location. In ensure that there are no overflowing waste bins at any time, the collection frequency should be improved by experience. It is necessary to collect biologically active waste (e.g. infectious waste) at least daily. A routing plan would be influenced by:

- The quantity of waste and the number of bags or containers.
- Waste types.
- Waste storage capacity in medical and interim storage areas.
- Transportation trolley capacity.
- Transportation distances and travel times between the points of collection.

Figure 5.20 Healthcare waste transportation within the HCF

(Source: UNIDO 2018:55)

5.7.19.3 Off-site transportation for HCW

When transporting HCW off-site from the HCF, it is preferable to use transport vehicles designated for HCW transport only. Furthermore, the drivers and transporters should have certified training in handling HCW. The training certificate should be renewed annually. An emergency response intervention card should be in the driver's cabin.

5.7.19.4 Vehicle requirements

When transporting waste outside the health facility, it is preferable that the transport vehicle is designated for waste transport only. The following requirements apply:

- The vehicle should be covered.
- The vehicle should follow the scheduled routes approved by the local environmental management authority from the point of collection to the disposal site or plant.
- The transporter should possess a completed tracking document at all times during transportation of the waste and produce it on demand to any law enforcement officer.
- The vehicle must be cleaned and sanitized at the end of each day.
- Bins/bags/safety boxes must be kept upright, secured, dry (i.e., protected against rain), and out of direct contact with other supplies.
- The person responsible for waste disposal must be aware of the schedule for pickup and delivery of waste.
- Vehicles used for transporting healthcare waste should display the biohazard symbol and emergency telephone numbers.

5.7.19.5 Cleaning of vehicle

The vehicle:

- Must be cleaned and sanitized at the end of each day.
- Must have soaps and detergents for cleaning.
- Should be serviced regularly.

5.7.19.6 Transport documentation

The driver of the vehicle must carry a consignment note or waste tracking note.

The consignment note should include:

- The vehicle should follow the scheduled routes approved by the local environmental management authority from the point of collection to the disposal site or plant.
- The transporter should, at all times during transportation of the waste, possess a completed tracking document (waste categories, sources of waste, pick-up date and time, destination, driver's name, number of containers or volume of waste, receipt of load received from responsible person at pick-up areas) and produce it on demand to any law enforcement officer.

Figure 5.21 Off-site transportation vehicle for healthcare waste

(Source: UNIDO 2018:56)

5.7.20 Final treatment and disposal options

Healthcare waste should be treated prior to disposal to ensure protection from potential hazards posed by waste. The purpose of treatment is to make the waste free from any hazard or infection risk before discharging it into the environment (FMHACA 2013:15). Non-infectious wastes shall be disposed without any prior treatment.

The Stockholm Convention aims to eliminate or restrict the production and use of persistent organic pollutants (UNIDO 2001). The purpose of this global treaty is to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. One of the requirements of the Stockholm Convention is that countries manage and dispose of POPs wastes in an environmentally sound manner (UNIDO 2001).

Healthcare waste may be treated through incineration, steam sterilization, gas or vapour sterilization, thermal inactivation or chemical disinfection. To be effective, treatment technology must reduce or eliminate the risk present in the waste and no longer pose a hazard to humans and the environment. The treatment technology should be chosen according to the local, national and international situation. The following factors should be considered when selecting a treatment technology:

- Treatment efficiency.
- Occupational health and safety (OHS) and environmental considerations**:** quality, safety, health and environment (QSHE).
- Volume and mass reduction.
- Types and quantity of waste for treatment and disposal capacity of the system.
- Infrastructure and space requirements (investment and operational costs)
- Locally available treatment options for final disposal
- Training requirements for operation of the method (availability of skills)
- Operation and maintenance considerations
- Location of the treatment site and disposal facility
- Social and political acceptability
- Regulatory requirements.

5.7.21 Selection of treatment

The treatment model selection requires consideration of waste characteristics capacity and prerequisites for innovation, environmental and security conditions, and expenses.

5.7.22 Waste characteristics

- Amount of waste to be treated and disposed of.
- Types of waste for disposal and treatment.

- Capability of the HCF to handle the quantity of waste.

5.7.23 Technology capabilities and requirements

- Common Biomedical Waste Treatment Facility's (CBWTF) capacity.
- Treatment efficiency.
- Local access to treatment options and technologies.
- Volume and mass reduction.
- Requirements to installation.
- Available space for equipment.
- Infrastructure requirements.
- Maintenance and operation criteria.
- Skills required to operate the technology.

5.7.24 Environmental and safety factors

- Environmental releases.
- Location of the treatment site and disposal facility and its surroundings.
- Considerations in occupational health and safety.
- Public acceptability.
- Options for final disposal.
- Regulatory requirements.

5.7.25 Cost considerations

- Purchase cost of equipment.
- Shipping fees and customs duties.
- Costs for installation and commissioning.
- Annual operating costs including testing and maintenance.
- Transport and disposal costs of treated waste.
- Decommissioning costs.

5.7.26 Waste treatment technologies

This section discusses various waste treatment technologies, how they operate and their advantages and disadvantages.

5.7.26.1 Microwave

Principle: Steam-based process where treatment occurs through the action of moist heat and steam generated by microwave energy.

The waste is automatically fed into a waste-grinding device where it is shredded and sprayed with steam to increase the moisture content of the waste to approximately 10 percent. The moist ground waste is then heated by exposure to six microwave irradiation units over a two-hour period. The process heats the waste to over 90°C.

Advantages

- Good disinfection efficiency under appropriate operating conditions.
- Drastic reduction in waste volume.
- Environmentally sound.

Figure 5.22 Microwave

(Source: Safe and Eco-friendly infectious waste management Meteka GmbH, Austria 2015:1)

Disadvantages

- Relatively high investment and operating costs.
- Potential operation and maintenance problems.

Note: Volatile and semi-volatile organic compounds, chemotherapeutic waste, mercury, other hazardous chemical waste and radiological waste should not be treated in a microwave.

5.7.26.2 Hydroclave

Principle: Similar to autoclave, except that the heat does not come in direct contact with the waste but is subjected indirectly to the waste through the outer jacket.

Used for:

- Soiled waste: Blood, body fluid, and microbiology infected items, biotechnology, and other clinical laboratory waste.
- Contaminated waste (recyclable), including metals and sharps.
- Glassware: Contaminated or broken glass that contains vials and ampoules of medicine.

Advantages

- It shreds the waste.
- Reduces the weight and quantity of waste.
- This produces significantly less emissions of air pollution than thermal processes with high heat.

Figure 5.23 Hydroclave

(Source: UNIDO 2018:88)

Disadvantage

- Cannot treat medical waste of all kinds, especially pharmaceutical, cytotoxic and radioactive waste.

5.7.26.3 Autoclave

Principle: Pressure and vacuum, using high temperature steam.

This is the use of steam under pressure to decontaminate waste or sterilize waste between 121°C and 134°C, typically for 15 to 20 minutes, depending on the size of the load and the contents, at 15 psi/2 bar.

Sterilization occurs by three mechanisms:

- Temperature.
- Pressure.
- Thermal oxidation.

Advantages

- Environmentally sound.
- Drastic reduction in waste volume.
- Relatively low investment and operating costs.

Figure 5.24 Autoclave

(Source: UNIDO 2018:89)

Disadvantages

- Shredders are subject to frequent breakdowns and poor functioning.
- Operation requires qualified technicians.
- Inadequate for anatomical, pharmaceutical, and chemical waste and waste that is not readily steam-permeable. Large and bulky bedding material, large animal carcasses, sealed heat-resistant containers and other waste loads that impede the transfer of heat should be avoided.

5.7.26.4 Circulating hot-air ovens

Principle: Heat is applied without the addition of steam or water.

Used for:

- Glassware and other reusable instruments.
- Waste sharps (used, discarded, and contaminated metal sharps).

Advantages

- Dry heat never corrodes or rusts the tools or needles.
- Used to sterilize devices having multiple parts that cannot be dismantled.

Figure 5.25 Circulating hot-air oven

(Source: UNIDO 2018:89)

Disadvantage

- Not suitable for plastic and rubber items.

Note: Do not use for plastic and rubber items. Not commonly used in large-scale facilities.

5.7.26.5 Incineration

Principle: Incineration is high-temperature dry oxidation at > 850ºC in the primary chamber and 1,100ºC in the secondary chamber with a retention time of two seconds to avoid formation of dioxins and furans. Incineration applies the three T principles (3 Ts):

- Temperature.
- Time.
- Turbulence.

This process is usually selected to treat waste that cannot be recycled, reused, or disposed of in a sanitary landfill.

Advantages

- Reduces organic and combustible waste to incombustible inorganic matter.
- Results in significant quantity and weight reduction of waste.

Figure 5.26 Incinerator

(Source: UNIDO 2018:90)

Disadvantages

- Release of combustion by-products into the environment.
- Generation of residual ash.

Note: Do not use mercury, chlorinated plastic waste and aerosolized containers.

5.7.26.6 Plasma pyrolysis

Principle: Processes operate with sub stoichiometric air levels.

Used for:

- Human anatomical waste.
- Animal anatomical waste.
- Expired or discarded medicines.
- Chemical waste.
- Discarded linen/mattresses, bedding contaminated with blood or body fluid.

Advantages

- The amount of toxic waste (dioxins and furans) is much below the accepted emission standards.
- Does not need hazardous waste segregation
- The pathogens are completely killed and energy recovery is possible.

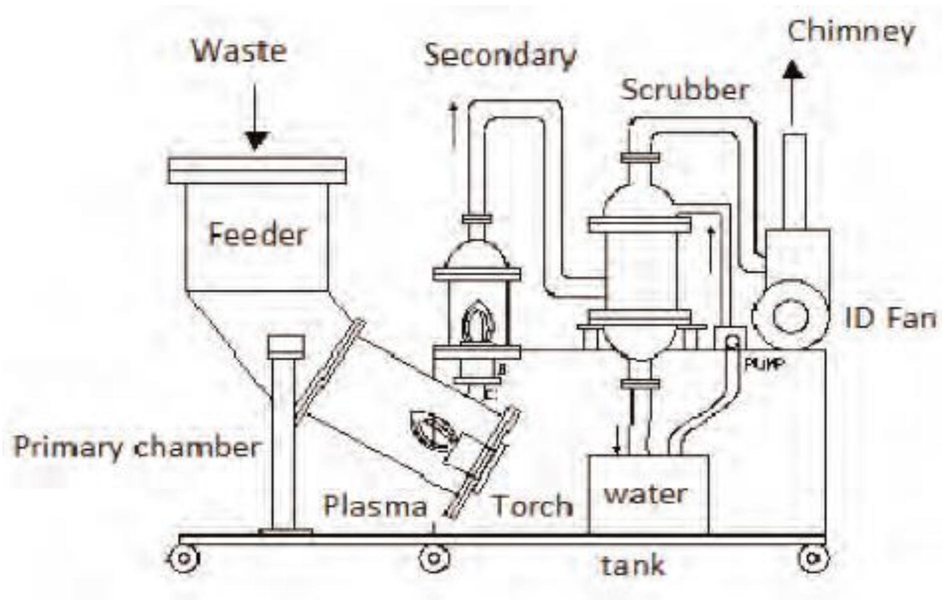


Figure 5.27 Plasma pyrolysis

(Source: UNIDO 2018:90)

Disadvantages

- Requires significant quantities of electrical energy.
- Very expensive.

Note: Do not use for:

- Pressurized containers.
- Halogenated plastics such as PVC.
- Wastes with high heavy metal content.

5.7.26.7 Chemical treatment

Principle: This treatment uses chemicals, such as hypochlorite solution, to render the waste safe and is most suitable for treating liquid and solid healthcare waste.

Advantages

- Highly efficient disinfection under good operating conditions.
- Some chemical disinfectants are relatively inexpensive.
- Drastic reduction in waste volume.

Figure 5.28 Container for sodium hypochlorite solution
(Source: UNIDO 2018:91)

Disadvantages

- Requires highly qualified technicians for operation of the process.
- Uses hazardous substances that require comprehensive safety measures.
- Is inadequate for pharmaceutical, chemical, and some types of infectious waste.

5.7.26.8 Encapsulation

Principle: Involves filling containers with waste, adding an immobilizing material, and sealing the containers. The process uses either cubic boxes made of high-density polyethylene or metallic drums, in both cases 75% filled with HCRW and then topped up with a medium such as plastic foam, bituminous sand or cement mortar. After the medium has dried, containers are sealed and disposed of in a special landfill site. The process is particularly appropriate for the disposal of sharps and chemical residues.

Advantage

- This process is very effective in reducing the risk of scavengers gaining access to HCW.

Figure 5.29 Encapsulation container

Source: UNIDO (2018:91)

Disadvantage

- Polyethylene does not incorporate the waste chemically, and the volatilization of mercury-containing waste may be a key concern. Secondary wastes are generated in small amount. To remove moisture, waste must be pre-treated.

5.7.26.9 Deep burial

Principle: This is the final disposal of waste and residues or by-products from the treatment of waste. Some of the common methods of disposal are:

Municipal landfills: This is a designated site for disposal of municipal waste in a controlled manner to minimize pollution to ground water, land, and the air (atmosphere).

Burial in pits: Infectious waste pits, placenta pits, ash pits.

Advantages

- Low costs.
- Relatively safe if access to site is restricted and where natural infiltration is limited.

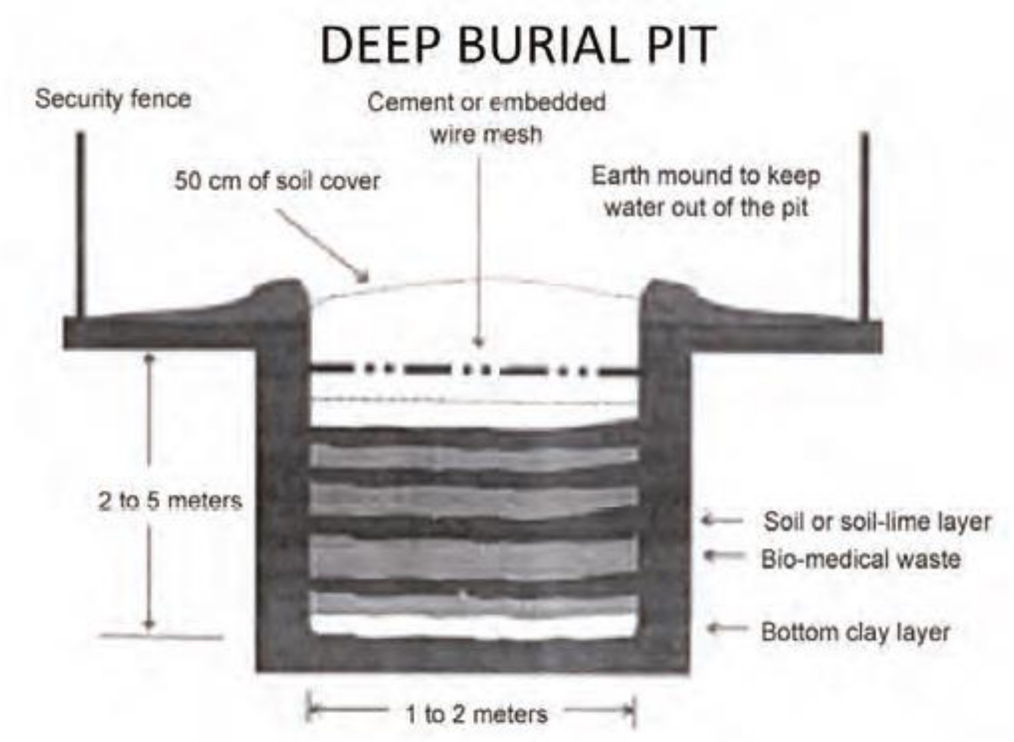


Figure 5.30 Deep burial pit

(Source: UNIDO 2018:92)

Disadvantage

- Safe only if access to site is limited and certain precautions are taken.

5.7.26.10 Sanitary landfill

Principle: After minimization or treatment of HCW, the remaining waste needs access to land for final disposal.

The site must be situated in a location away from human habitants (residents), with an appropriate soil type and an adequate distance away from water sources, with the following requirements:

- Waste delivery and site vehicles have access to the site and its working areas.
- Presence of site staff capable of effective control of daily operations.
- Division of the site into manageable phases, appropriately prepared, before the landfill starts.
- Adequate sealing of the base and sides of the site to minimize the movement of wastewater (leachate).
- Adequate mechanisms for leachate collection and treatment systems.
- Organized deposit of waste in a small area, allowing wastes to be spread, compacted and covered daily.
- Surface water collection trenches around site boundaries.
- Construction of final cover to minimize rainwater infiltration when each phase of the landfill is completed.

Advantages

- Scientifically sound design.
- Does not affect the environment.

Figure 5.31 Landfill area

(Source: UNIDO 2018:94)

Disadvantages

- Completed landfill areas can settle and require maintenance.
- Requires proper planning, design, and operation.

Note: Unregulated dumping is characterized by scattered, uncontrolled waste deposit at a site. It is a practice that almost always leads to acute pollution problems, burning, increased risk of transmission of disease and open access to scavengers and animals.

5.7.26.11 Mechanical treatment

Principle: Mechanical treatment processes include techniques for shredding, grinding, mixing, and compaction that minimize waste volume, while pathogens cannot be destroyed.

In most instances, mechanical processes are not stand-alone HCW treatment processes but supplement other treatment methods.

Used for:

Waste from disposable items such as tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles and fixed needle syringes).

Advantages

- Reduces the volume of the waste significantly.
- Exposes the surface of the waste to disinfection.

Figure 5.32 Shredder

(Source: UNIDO 2018:92)

Disadvantage

- Workers are often at increased risk of being exposed to pathogens by mechanical destruction of untreated waste bags results in aerosols released into the environment.

5.7.26.12 Irradiation

Most microorganisms are destroyed by the action of microwaves of a frequency of about 2450 MHz and a wavelength of 12.24 cm. The water contained within the wastes is rapidly heated by the microwaves and the infectious components are destroyed by heat conduction.

Advantage

- Fatal to microorganisms.

Disadvantages

- Is expensive.
- Requires dedicated space.
- Requires post shredding.
- Some contaminated surfaces may face away from the radiation source.

5.7.27 International agreements

Two international agreements or treaties are of particular importance and relevance to hazardous waste and HCW management, namely the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (usually known as the Basel Convention), 1989 and the Stockholm Convention on Persistent Organic Pollutants (usually known as the Stockholm Convention), 2001. In addition, the Rio Declaration on Environment and Development (usually shortened to the Rio Declaration), 1992 produced at the United Nations Conference on Environment and Development (UNCED) lists 27 principles to guide sustainable development and protection of human health and the environment.

- **The Basel Convention,1989**

The Basel Convention is an international treaty designed to address the problems and challenges posed by hazardous waste, to reduce the movements of waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries. The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes.

The key objectives of the Basel Convention are to:

- Minimize the generation of hazardous wastes in terms of quantity and hazardousness.
- Dispose of them as close to the source of generation as possible.
- Reduce the movement of hazardous wastes.

A central goal of the Basel Convention is environmentally sound management (ESM), with the aim of protecting human health and the environment by minimizing hazardous waste production whenever possible. ESM means addressing the issue through an integrated life-cycle approach, which involves strong controls from the generation of hazardous waste to its storage, transport, treatment, reuse, recycling, recovery and final disposal.

- **The Stockholm Convention, 2001**

The Stockholm Convention on Persistent Organic Pollutants is an international treaty, signed in Vienna in 2001 and effective from May 2004, that aims to eliminate or restrict the production and use of persistent organic pollutants (POPs). The purpose of this global treaty is to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. In 2018, there were 182 member countries or states of the treaty. Exposure to POPS can lead to serious health effects including certain cancers, birth defects, dysfunctional immune and reproductive systems, and greater susceptibility to disease. One of the requirements of the Stockholm Convention is that countries manage and dispose of POPs wastes in an environmentally sound manner (United Nations Industrial Development Organisation [UNIDO] 2001).

POPs circulate globally and can cause damage wherever they travel. In implementing the Convention, Governments will take measures to eliminate or reduce the release of POPs into the environment.

- **Rio Declaration on Environment and Development, 1992**

The Rio Declaration is a set of principles that recognize the importance of preserving the environment. The first principle states that human beings are at the centre of concerns for sustainable development and are entitled to a healthy and productive life in harmony with nature. Four principles are of particular relevance to HCW management: the polluter pays; duty of care; precautionary, and proximity principles.

- ***Polluter pays principle***

In environmental law, the polluter pays principle is the commonly accepted practice that whoever produces pollution should bear the costs of managing it to prevent damage to human health or the environment. This principle underpins most of the regulation of pollution affecting land, water or air. Pollution refers to contamination of the land, water or air by harmful or potentially harmful substances. Consequently, all waste producers are legally and financially responsible for the safe handling and environmentally sound disposal of the waste they produce. This principle was first introduced in 1972 by the Organization for Economic Cooperation and Development (OECD) guiding principles concerning international economic aspects of environmental policies.

In the case of accidental pollution, the organization is liable for the costs of cleaning it up. Therefore, if pollution results from poor management of HCW then the HCF is responsible. However, if the pollution results because of poor standards at the treatment facility then the HCF is likely to be held jointly accountable for the pollution with the treatment facility. Likewise, this could happen with the service provider. The fact that the polluters should pay for the costs they impose on the environment is seen as an efficient incentive to produce less and segregate waste well.

- ***Duty of care principle***

A duty of care is a legal obligation that requires adherence to a standard of reasonable care while performing any acts that could foreseeably harm others. This principle stipulates that any organization that generates waste has a duty to dispose of the waste safely. Therefore, it is the HCF that is ultimately responsibility for how waste is segregated, containerized, handled on-site and off-site and finally disposed of.

- ***Precautionary principle***

According to this principle, when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically. The principle emphasises that where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. Following this principle, one must always assume that waste is hazardous until shown to be safe. This means that where it is unknown what the hazard may be, it is important to take all the necessary precautions.

- ***Proximity principle***

The proximity principle stresses the need to treat and/or dispose of wastes in reasonable proximity to their point of generation. The transportation of waste can incur significant environmental impacts as well as unwanted additional cost. Therefore, the proximity principle encourages processing, recycling, reuse or disposal of waste as near to the point of its production as possible. Hence it is recommended that treatment and disposal of hazardous waste take place at the closest possible location to its source in order to minimize the risks involved in its transport.

Likewise, a community should recycle or dispose of the waste it produces, inside its own territorial limits.

5.7.28 Management of HCW in emergencies

Special care must be taken with refuse from a field hospital or outreach service or health centre. The main categories of waste of concern in such situations are: infectious waste; sharps and pathological waste. These wastes must be handled, stored, treated and disposed of properly to reduce public health risks.

In the case of small health centres, health posts and clinics particularly in rural areas, well-managed on-site burial may be appropriate. In larger HCFs (health centres and hospitals) that produce a significant quantity of sharps and infected waste, more sophisticated technology will be required. When HCFs operate diagnostic laboratory services, radiological diagnosis and treatment facilities, and pharmacies, waste management is a specialized activity requiring trained and well-equipped staff.

REMEMBER, to reduce risk:

- Wash hands after working with waste or infected material.
- Handle all waste with care to minimize needle stick injury.
- Do not sort waste or open waste containers to sort waste.
- Know the procedures for treatment of injuries and cleaning of contaminated areas.
- Report sharps injuries to the appropriate personnel.
- Injuries should be followed up by PEP.
- Anyone handling sharps should be vaccinated with a full course of vaccination to provide protection from the hepatitis B virus and tetanus.

Security at the waste disposal site (WDS)

- Entry to the WDS site should be restricted.
- Keep the incinerator site locked at all times.
- Do not allow unauthorized persons to enter the incinerator area during periods of incineration.
- Immediately report any vandalism, theft, or unauthorized entry to the waste-management supervisor.

5.7.29 HCW management and management planning

In view of the difficulties and challenges presented by HCW and its management, the WHO (2004:2) recommends:

- Prevent the health risks associated with exposure to HCW for both health workers and the public by promoting environmentally sound management policies for healthcare waste.

- Support global efforts to reduce the amount of noxious emissions released into the atmosphere to reduce disease and defer the onset of global change.
- Support the Stockholm Convention on Persistent Organic Pollutants (POPs).
- Support the Basel Convention on hazardous and other waste
- Reduce exposure to toxic pollutants associated with the combustion process through the promotion of appropriate practices for high temperature incineration.

5.7.30 Strategy

To better understand the problem of healthcare waste management (HCWM), the WHO (2004:2) recommends that countries conduct assessments prior to any decision on which HCWM methods should be selected. Tools are available to assist with the assessment and decision-making process so that appropriate policies lead to the choice of adapted technologies. The WHO (2004:2) recommends the following strategies:

- **Short-term**

Production of all syringe components made of the same plastic to facilitate recycling; selection of PVC-free medical devices; identification and development of recycling options wherever possible (e.g., for plastic, glass), and research on and promotion of new technology or alternatives to small-scale incineration.

Until countries in transition and developing countries have access to HCWM options that are safer to the environment and health, incineration may be an acceptable response when used appropriately.

Key elements of the appropriate operation of incinerators include effective waste reduction and waste segregation, placing incinerators away from populated areas, satisfactory engineered designs, construction following appropriate dimensional plans, proper operation, periodic maintenance, and staff training and management.

- **Medium-term**

  - Further efforts should be made to reduce the number of unnecessary injections to reduce the amount of hazardous healthcare waste that needs to be treated.
  - Research should be conducted on the health effects of chronic exposure to low levels of dioxin and furan.
  - Risk assessment should be done to compare the health risks associated with (i) incineration, and (ii) exposure to HCW.

- **Long-term**

  - Effective, scaled-up promotion of non-incineration technologies for the final disposal of HCW to prevent the disease burden from:
    - unsafe healthcare waste management
    - exposure to dioxins and furans

  - Support to countries in developing a national guidance manual for sound management of HCW.
  - Support to countries in the development and implementation of a national plan, policies and legislation on healthcare waste.
  - Promotion of the principles of environmentally sound management of HCW as set out in the Basel Convention.
  - Support to allocate human and financial resources to safely manage HCW in countries.

5.7.31 Additional instructions for using sharps and safety boxes

- Place all syringes and retractable syringes in a safety box
- Keep a record of every safety box that is filled and discarded.
- Take extra care when handling the safety box; hold it on the top.
- Do not recap syringes, using the one-handed scoop technique if you need to recap the syringe: Place the cap on a flat surface and remove your hand from the cap; with one hand hold the syringe and use the needle to scoop up the cap.

When the cap covers the needle completely, use the other hand to secure the cap on the needle hub. Be careful to handle the cap at the bottom only (near the hub).

- Do not carry used syringes around the work site.
- Do not hold the safety box in your hand when inserting the needle into the box opening.
- Do not manually bend or remove the contaminated needle from the syringe or save the needle for later removal.
- Do not empty or reuse the safety box (always dispose of entire box and its contents).
- Do not shake, crush, sit, or stand on the safety box.
- Do not put the following items in a safety box (discard in non-sharps infectious or general waste containers): Empty vials − discarded vaccine vials − cotton pads − compressors − dressing materials − latex gloves − any plastic materials or waste products.
- If there are no adequate safety boxes, using sturdy, leak-proof plastic bottles or glass jars with a lid. You can use a plastic bucket with a round hole cut into the lid or other reusable hard or puncture-proof plastic containers with holes cut in the top (medicine jars, empty detergent/disinfectant containers, empty cooking oil containers, etc).
    - Never empty these containers and never reuse a container used as a safety box. When the containers are ¾ full, if possible dispose of the containers when it is 3⁄4 full, in a cement-lined pit or return to your supplier.

5.7.32 Additional instructions for non-sharps infectious hazardous waste

- If you are using a bin empty it every day and clean it with 0.5% chlorine (bleach) solution. Change the bag at the end of each day when using a plastic bag. Use only high-quality plastic bags, if possible, which do not tear. Do not overfill the plastic bags or containers in any case. When ¾ full, close the container and remove. Do not reuse the bag.
- Collect infectious waste (used test kits, bandages and gauze, swabs, gloves, sputum cups and slides) in a strong, leak-resistant plastic bag placed with a lid in a metal or plastic container. A black bag is commonly used foe non-hazardous

wastes; a red bag is commonly used for general infectious waste; a yellow bag is commonly used for anatomical infectious waste such as placenta or male circumcision excised foreskin.

- When the plastic bag is ¾ full, close it, and remove it from the bin.
- Store the closed bin in a safe place, out of the reach of children and stray animals.
- While wearing gloves, disinfect the bin with 0.5% chorine solution (bleach) before putting in a new plastic bag.
- If possible, bury anatomical waste in a secured burial pit.
- Try to separate plastic infectious waste from non-plastic waste (not including sharps, such as needles from syringes) when waste is burned on-site. Non-plastics can be burned on site; do not burn plastics.
- If sputum cups and slides are segregated, disinfect them with 0.5% chlorine solution (bleach) for at least one hour, prior to disposal.

5.7.33 Additional instructions for cleaning infectious waste spills

If liquid infectious waste, such as blood, body fluids, pus, or discharge, is spilled, do the following:

- Wear protective clothing if possible; overalls or industrial aprons, boots, goggles, and heavy-duty gloves while handling infectious waste.
- To avoid splashing, carefully pour liquid bleach or bleach powder on the spill; cover the area with paper towels and leave it for 30 minutes.
- After 30 minutes, wearing heavy duty gloves, wipe the area and pick up the paper towels, disinfectant, and spilled material. Work toward the centre of the spill carefully to minimize splashing and splattering of the spilled material.
- Place all the material in a plastic liner or infectious waste bin. Do not reuse any cloth that was used to clean the spill.
- If broken glass or other sharp objects are present, use a mechanical device brush and dustpan, tongs or forceps to pick up the waste. Dispose of any sharps in a safety box.
- Remove all personal protective equipment with care to avoid contamination; fold the contaminated area inward.

- Place all disposable personal protective equipment inside a plastic liner within a reusable container for disposal. Close all plastic liners and bins. Immediately, wash all body parts, including arms, face, and hands.

5.7.34 Additional instructions for non-infectious hazardous waste

Most pharmaceuticals (drugs or medicines) become less effective after their expiry date. Under most circumstances, they are not toxic and are relatively harmless to the environment if disposed of properly. However, there are a few pharmaceuticals that do become toxic when they expire (tetracycline) or are toxic originally (anti-neoplastic-cancer medicines). Dispose of them with caution. Whenever possible, return expired or damaged medicines to their source for proper disposal. Keep them in a secure place to prevent the products from being diverted into unofficial markets for resale. Dispose of these products as follows:

- Collect in a brown bin or bag, if available.
- Store in a secure, safe place, out of the reach of children and stray animals.
- Return as much of the pharmaceutical waste to the supplier as possible.

If only a small amount is involved (1% or less of the general waste):

- Remove the medicine from the container or blister pack and mix with something that will hide the medicine or make it unappealing, such as used coffee grounds or dirt. Place the mixture in a container, such as a sealed plastic bag, and place the container in the general waste bin.
- For liquid waste (diluted liquids, syrups, intravenous fluids, small quantities of diluted disinfectants), dispose of them in the sewer system or waterway. Do NOT dispose of anti-neoplastics, undiluted disinfectants, and antiseptics in this way.

For large amounts of pharmaceutical waste, use the following options described under the Disposal section:

- encapsulate
- inertize

5.7.35 Additional instructions for non-hazardous general waste

Non-hazardous general waste (e.g., packaging, desiccant, and buffer) is regular solid household waste. It does not require any special processing; it can be collected using a bin, plastic bag, or other collection device (e.g., cardboard box). Make sure the colour of the bin or plastic bag is noticeably different from the bag or bin you are using to collect infectious waste; the bins and bags for non-hazardous general waste are usually black. Dispose of the waste in a burial pit onsite or send it to a municipal waste processing site.

- Recycle, reuse, or compost as much of the general waste as possible.
- Collect in leak-proof black bags or bins with a lid, if they are available.
- Dispose of the waste in a burial pit onsite or send it to a waste disposal location offsite.

5.8 CONCLUSION

This manual was prepared to improve and enhance HCW handlers' knowledge, practice and attitude towards the management of HCW. The manual should help trainers and benefit HCW handlers as a training resource material. The manual should guide HCF managers to manage HCW appropriately and professionally during day-to-day service delivery practice.

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ANNEXURES

Annexure 1:

a. Documentation at the point of generation of waste

Temporary HCF storage and pre-treatment facilities

Format for registers - 100 page note book/printed sheet/register indicating details as given in the examples below:

Information to be maintained in the Waste Register at the point of generation

Date	Time	Location	Yellow	Red	White	Blue puncture-proof, leak-proof box /Container	Sign of ward nurse	Sign of house keeping staff
			N	N	N	N		
N: number, Wt: weight								

Sample of records to be maintained at the temporary storage area in the HCF.

Date	Time	Location	Yellow	Red	White	Blue puncture-proof leak-proof box/Container	Total Quantity (kg)	Signature of supervisor in storage area	Vehicle number, date and time of collection

b. Documentation in spillage-spill register

Spillage of any of the following material has to be documented and reported to the seniors:

1. Blood or body fluid
2. Chemicals
3. Cytotoxic material
4. Mercury - whenever possible, spilt drops of mercury should be recovered.

Example of spill register

Serial No.	Date and time	Type of spilt material	Action taken and time	Signature of staff in-charge

c. Documentation of a record of injuries should be kept in each ward and follow-up of injuries should be done.

Example of injury register

Serial No.	Date	Name	Age	Gender	Designation	Signature of ward I/C	Signature of Infection control Nurse/I/C Nodal Officer

d. Documentation of investigation and follow-up schedule for injuries

Date	
Name, age, gender	
Time of injury	
Time of reporting	
Work area where exposure occurred	
How did it happen?	
Patient's HIV, HBsAg status	
Type of exposure (blood-filled device, body or blood fluid exposure, body part exposed, type of device)	
Post-exposure prophylaxis (PEP) investigations done	
Treatment given	
Follow-up dates for treating and testing	

e. Documentation of request protocols for using, repairing and replacing emergency equipment

I. For replacement of the emergency equipment, the equipment is shown as condemned and **a** new indent is prepared for the equipment.

II. Request**s** should be sent to the maintenance department and records kept in a register in the ward

Sample of record of request for equipment

Serial No.	Date and time of request	Name of equipment required	Date and time of problem with equipment	Date and time of collection of equipment by the maintenance department	Name and signature of the ward in-charge

Annexure 2: Waste Incineration Log

Record of waste incinerated							
Health facility:				**Month/Year:**			
Type of incinerator:				**Name of incinerator operator:**			
Date	**Sharps (no.)**	**Non-infectious waste (kg or no.)**	**Infectious waste (kg or no.)**	**Amount of fuel used**		**Duration**	
				Fuel	Qty.	Start	Finish
TOTAL							
Waste problems or accidents:							
Equipment problems:							
Comments:							

NB: To be totalled monthly

Annexure 3: Supervision checklist

Health facility:			**Date:**	
Type of incinerator:				
	Activity	**Yes**	**No**	**Remarks**
A	**Safety**			
1	Is there adequate personal protective equipment (PPE)?			
2	Is the PPE being used?			
3	Is the PPE in good condition?			
4	Is there restricted entry to the waste disposal site?			
5	Is there functional fire safety equipment?			
6	Do the operators know how to use the equipment?			
7	Is there **an** adequate first aid kit?			
8	Are the operators conversant with **the** use of the kit?			
9	Is flammable material stored away from the incinerator?			
10	Are the operators medically examined annually/regularly?			
11	**Have** they **been** immunized against hepatitis B?			
12	**Have** they **been** immunized against tetanus?			
13	Is there adequate water at the WDS?			
14	Are warning signs distinctly displayed?			
Additional comments on safety:				

B	**Operation**			
	Activity	**Yes**	**No**	**Remarks**
1	Is there a sufficient supply of fuel wood?			
2	Is the procedure for preparation for incineration being followed?			
3	Is the incinerator clean?			
4	Is the waste weighed upon reception?			
5	Is the waste temporarily stored neatly?			
6	Is the loading of the incinerator done in the right way?			
7	Is the temperature regulated adequately during the burn?			
8	Is the incinerator allowed to burn down and cool before being cleaned?			
9	Is the ash properly disposed **of in** the ash pit?			
10	Are the following tools and equipment available?			
A	Ash rakes			
B	Shovel			
C	Hand brush/dustpan			
D	Hard broom			
E	Wheelbarrow			
F	Chimney cleaning brush and cord			
G	Weighing scales			
H	Sand bucket			
I	Fire retardant gloves			
J	Eye protection/face mask			
K	Overalls or suitable clothing to cover the upper body, including the lower arms			
L	Safety first aid kit			
Additional comments on operation:				

C	Maintenance			
	Activity	**Yes**	**No**	**Remarks**
1	Is there evidence of cracks?			
2	Is there general good housekeeping?			
3	Is the status of the ash pit good?			
Additional comments on maintenance:				

D	Records			
	Activity	**Yes**	**No**	**Remarks**
1	Are the relevant forms available?			
2	Are the forms filled **in** accurately and completely?			
3	Are needle pricks and other accidents recorded?			
4	Are reports of the waste incinerated done on time?			
Additional comments on records:				

Name of supervisor:	Signature	Designation

CHAPTER 6

FINDINGS AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter briefly discusses the findings, limitations and contribution of the study, and makes recommendations for HCW policy, segregation, storage, transportation and disposal, and for further research.

6.2 PURPOSE AND OBJECTIVES

The purpose of the study was to develop a manual for healthcare waste management for health care facilities, based on the findings for the Addis Ababa City Administration Health Bureau public health facilities in Ethiopia. In order to achieve the purpose, the objectives of the study were to:

- Assess the current HCW management practices in Addis Ababa City Administration Health Bureau public health facilities.
- Quantify the amount of HCW generated in health centres in Addis Ababa City Administration Health Bureau public health facilities per patient utilization.
- Determine the level of knowledge and awareness of individuals involved in HCW management in relation to waste management policies and procedures.
- Determine the extent to which the Addis Ababa City Administration Health Bureau public health facilities implement and comply with healthcare waste management Code of Practice guidelines and all other related national waste management strategies.
- Develop a manual for the effective management of healthcare waste based on the findings in Addis Ababa City Administration Health Bureau public health facilities.

6.3 FINDINGS

The study examined and assessed current HCW management practices in selected Addis Ababa City Administration healthcare facilities, namely 15 health centres and 3 hospitals. The findings are summarised next.

The mean HCW generation rate was 10.64 $\pm$ 5.79 kg/day, of which 37.26% (3.96 $\pm$ 2.017kg/day) was general waste and 62.74% (6.68 $\pm$ 4.293 kg/day) was hazardous waste from the surveyed health centres.

HCW generation and quantification was not measured and documented in any of the HCFs. Improvement requires HCW to be quantified. Quantifying HCW would help determine the type of waste and also the HCFs that generate the highest and lowest HCW, which could have implications for resource allocation in managing HCW.

Segregation of different types of wastes was not regularly done. Poor segregation and instances of hazardous HCW mixed with non-hazardous HCW were found at the incinerators. Some HCFs had separate storage areas for HCW and separate containers for hazardous and non-hazardous waste. In some instances, however, the containers were not clearly marked. Although HCW receptacles were well labelled before segregation, they were not labelled after segregation. This indicated poor HCW management practice because HCW from the case teams could not be traced to the origin of generation and when it arrived at the incinerator. The possible presence of pathogens meant that the HCW could also be potentially dangerous. Waste pre-sorting and segregation have been found to significantly reduce unregulated discharge of waste and ash volume and toxicity (Babanyara 2013:757).

Regarding storage, some of the HCFs had interim storage sites and HCW disposal sites located in areas minimally accessible to their staff. In some instances, open plastic buckets and safety boxes were used to transport waste manually to the disposal site. Some interim storage containers had no lids to prevent odour and waste leakage. Several interim storage facilities lacked security and surveillance and were not cleaned after collection. In addition, HCW remained at the interim storage facilities for more than 48 hours before final disposal.

The respondents were asked how HCW was transported on-site for storage before collection for off-site disposal, and indicated in pedal bins, buckets and trolleys.

The study found that the main forms of on-site treatment of HCW before disposal were burning, crushing sharps, sterilisation and chemical disinfection. During observation, all the study HCFs except 1 health centre used incineration for on-site HCW disposal. The health centre that did not incinerate HCW disposed of it by open burning.

Incineration was the most common method of treatment for HCW. There is no centralized incineration for all HCFs in Addis Ababa and surrounding regions to destroy pharmaceutical wastes. Most of the study HCFs had incinerators on the premises; only a few incinerators were located downwind from the main service area, and most incinerators had sufficient air inlets on the side. In most cases, ash from the incinerators was disposed of inside the compound. Many of the incinerators were not surrounded by a fence or wall to limit access to scavengers. Most of the burial sites for surgical removals and placenta were away from any water source. In most cases, the burial pits were 1-2 meters wide and 2-5 meters deep and the bottom of the pit was at least 1.8 meters above the water table. All types of HCW were burned in the incinerators of the HCFs except placenta and surgically removed body parts.

Most HCW handlers had not received adequate training; did not wear PPE, and did not take precautionary measures, such as washing their hands and heavy duty gloves after handling HCW.

Offsite transportation of HCW to the Addis Ababa City Administration solid waste open land fill from health centres was not operated, but there were used by surveyed hospitals. Landfill was not done by any of the healthcare facilities but ashes residues from incineration buried in ash pits prepared in all health centres compound. On-site HCW was not transported safely using designated containers which met the required safety standards.

The most common treatment technology used for HCW was incineration. There is no centralized incineration for all HCFs in Addis Ababa and surrounding regions to destroy pharmaceutical wastes. None of the HF observed well-regulated and systematic treatment of HCW following the Guidelines for Waste Disposal. The incinerators at the health centres met the FDREMoH regulation/requirement but there were no regular maintenances.

Healthcare facilities has no specific managers assigned for HCW. From the surveyed HF most of the managers control HCW handlers transported from case teams to waste disposal site.

Most of respondent managers were used applicable national, regional and local guidelines for HCW management practice. Every case teams at health centre and hospital have not HCW management related documents for management of healthcare waste. Due to the lack of application of documents related to healthcare waste in the surveyed hospitals and health centers case team management of healthcare waste is poor and inconsistent. Healthcare workers at health centers and hospitals were unaware of the waste regulations and standards available in healthcare waste management except for professional and ancillary staff training in infection prevention.

As indicated in the empirical findings above there is a gap in knowledge, practice and attitude towards the healthcare waste management. To fill this gap, the researcher prepared manual for healthcare waste generation and management practice. The manual will help healthcare waste handlers and managers to promote and ensure environmentally sound management of healthcare waste.

6.4 LIMITATIONS OF THE STUDY

Healthcare waste is generated in all healthcare facilities in Addis Ababa City Administration. It was not possible for the researcher to examine HCW management at all public and private healthcare facilities in Addis Ababa therefore the study was restricted to 15 public health centres and 3 public hospitals. The findings can therefore not be generalised to federal healthcare facilities, research institutions, and private healthcare facilities.

During data collection self-reporting questionnaire respondents may have been biased in favour of those with an interest in looking good or bad.

6.5 CONTRIBUTION OF THE STUDY

Notwithstanding the limitations, this study has provided evidence-based information about HCW generation and management practice and systems in selected public HCFs. The findings should assist policy makers, government organizations, like the Ethiopian Environmental Protection Agency, universities, teaching and training institutions, non-governmental organizations, and professional associations to implement effective HCW policy; develop courses, programmes and material on HCW management, and raise public awareness of HCW and sustainable HCW management.

The findings of the study should contribute to the achievement of the United Nations (UNDP, 2015) sustainable development goals (SDGs) for 2016-2030, which are aimed at bringing about a sustainable world and protecting the planet. Effective, responsible HCW management would assist progress towards meeting the following SDGs:

- **SDG 3: Good health and well-being**

Good health is an essential element of sustainable development. Despite progress in life expectancy, maternal and child health, HIV and other areas, many diseases and persistent and emerging health issues remain. Healthcare waste management is one area that has been persistently under-recognised and under-resourced, with enormous ripple effects for workers, patients and communities. Solving or reducing this problem would remove many direct and indirect health threats.

- **SDG 6: Clean water and sanitation**

Water quality would be improved by reducing pollution; eliminating dumping; minimizing release of hazardous chemicals and materials; improving waste water treatment and increasing recycling and safe reuse globally. Recognizing the interrelation between waste and water, the World Health Organization (WHO 2018) incorporated HCW management into its water, sanitation and health programme for healthcare.

- **SDG 8: Decent work and economic growth**

Work should provide people a way out of poverty. Despite performing a task vital to society, waste workers are often underpaid, under-educated and under-protected. Moreover, working conditions violate their human right to a safe working environment. HCW management should be recognised as an essential public service with professional standards and HCW workers given vaccinations, training, decent working conditions, a living wage, and respect.

- **SDG 12: Responsible consumption and production**

This goal includes reducing pollution and health impacts through environmentally sound management (ESM) of all waste throughout the product life cycle; promoting waste prevention, reduction, recycling and reuse. Sustainable procurement is also required: almost all healthcare waste has come in the front door as a product. Healthcare needs to leverage its buying power to ensure that the materials purchased generate as little waste as possible that is toxic, non-repairable, non-recyclable or simply unnecessary. By advocating for the replacement of these products with safer alternatives, the healthcare system can help kick-start the global circular economy.

- **SDG13: Climate action**

Minimizing waste, segregating at source, avoiding incineration, and recycling all contribute to conserving resources and energy. Research has found that autoclaving HCW has CO^2 emissions at least fifteen times lower than waste incineration. Organic wastes produce methane gas as they degrade, but if this is done in a controlled manner in a bio-digester, the methane can be captured for use as a fuel. Because methane has a stronger greenhouse effect than carbon dioxide, burning it reduces the CO^2 emissions of the waste. These techniques all help mitigate climate change. Sustainable HCW management technologies such as bio-digestion and autoclaving play a role in making healthcare systems more resilient to disasters.

6.6 RECOMMENDATIONS

Based on the findings of this study, the researcher makes the following recommendations for policy, education, HCW management, including generation, segregation, storage, transportation and disposal, and further research.

6.6.1 Healthcare waste policy

The Federal Ministry of Health Ethiopia should:

- Ensure that all universities, nursing and medical colleges, and healthcare facilities (health centres, hospitals and clinics) have copies of the *Healthcare waste management directive, 2013.*
- Include HCW management in the amended health policy of Ethiopia.
- Compare and ensure that HCW management policy agrees with local and international environmental law.
- Review and revise/amend HCW management rules, regulations, legislation and directives regularly.

The Addis Ababa City Administration Health Bureau should develop and implement a HCW management strategic plan in all public healthcare facilities.

Private and NGO HCFs should have copies of the *Healthcare waste management directive, 2005* and the *National healthcare waste management plan, 2015-2019* and develop and implement HCW management strategic plans in accordance with national policy.

6.6.2 HCW education and training

Universities and colleges should develop and include HCW management modules in their curricula and courses at all levels.

Training programmes at all levels should be standardized and the effectiveness thereof assessed regularly by the Federal Ministry of Health Ethiopia, the Department of Education, and the Addis Ababa City Administration Health Bureau.

Training and in-service training in HCW management issues should be provided to all HCF staff to ensure adherence and standardized practice.

Training modules on HCW management practice should be prepared for health professionals and ancillary staff in Amharic, local languages and English.

To improve their operations HCFs should appoint infection control teams / committees that include specialists to occupational and environmental health and waste management experts.

Health promotion programmes on HCW management practice should be developed and implemented. Information on HCW-related risks should be disseminated to the public by means of posters, brochures, radio and TV.

By using this developed manual in Chapter 5 health facilities or other stakeholder agencies can prepare in-service training for their staff. This manual can help setting out rich training programs to the community about healthcare waste management practice. Healthcare waste management is critically important for human health and environment.

6.6.3 HCW generation and quantification

HCFs should have weighing facilities for quantification of HCW generated to assist in decision making on HCW management from generation to final disposal.
HCFs should keep full documentation of HCW generation and quantification in order to update and maintain a sound HCW management system.

HCFs should develop and maintain monitoring and control programmes to reduce the HCW burden on human **health** and **the** environment.

6.6.4 HCW segregation

Proper training should be given on appropriate segregation practices and potential hazards associated with unsafe procedures such as handling without personal protective equipment for healthcare professionals, ancillary staff, and waste handlers.

HCW containers should be labelled consistently according to the requirements of HCW management regulations, legislation or directives in HCFs.

HCFs should ensure that different types of containers and materials in adequate quantities are continuously available in order for HCW to be segregated.

HCF management/managers should ensure that HCW handlers do not use their bare hands to transport any bags or containers containing HCW.

HCF managers should ensure adequate personal protective equipment (PPE) is available and HCW handlers should always wear all necessary PPE when managing HCW.

6.6.5 HCW storage and collection

Secure storage facilities should be built for HCW in HCFs with visible restriction signs to inform unauthorized persons of the danger of entering controlled areas.

Temporary storage areas should be designed in HCFs away from service areas such as treatment rooms, patient waiting areas, and toilets.

In accordance with HCW management legislation, rules and regulations, HCFs should clean and disinfect their HCW storage facilities regularly.

Climate conditions in Addis Ababa should be considered. High temperatures can affect and change microorganisms and chemicals therefore HCW should be collected daily at HCFs.

6.6.6 HCW treatment and disposal

HCFs should control the HCW collected in their compounds and check whether it has been treated and disposed of appropriately to minimize risk to human health and the environment.

HCF storage rooms should be near to the incineration plant to avoid putting HCW on the floors and reduce improper incineration.

Private companies should be involved and work with the government to own treatment and disposal equipment, such as autoclaves, incinerators or alternative technologies like pyrolysis, for HCW they collect.

Federal regulatory authorities/agencies should provide licences to private companies to own treatment and disposal facilities and strengthen the public private partnership (PPP).

Regulatory authorities/agencies at all levels should regularly test harmful substances from residuals/ash that could affect human health and the environment.

Recycling waste materials should be regulated and encouraged as a source of income.

6.6.7 HCW transportation

On-site transportation of HCW should be in suitable wheeled leak-proof containers and trolleys which are clearly labelled with the international bio hazard symbol in all HCFs. HCFs should ensure that HCW, which is subject to off-site transport for treatment and disposal, is packed and labelled in compliance with the requirements of international standards and regulations for HCW management.

Off-site transportation schedules should be fixed for HCW thereby reducing the complexity of HCW management.

6.6.8 HCF management of HCW

HCFs should:

- Prepare and integrate HCW management strategic and tactical plans with HCW management policy.

- Monitor, control and assess the efficiency and effectiveness of their HCW management systems and practice.
- Appropriately reduce potential hazards posed by HCW in order to protect human health and the environment.
- Encourage and strengthen community participation and private sector involvement in HCW management systems.

6.6.9 Further research

Further research should be conducted on the following topics:

- An investigation into the feasibility of creating a business model for future HCW recycling investment.
- An examination of models for technology transfer for HCW treatment technologies.
- Seasonal effects on the generation and management of HCW in healthcare facilities.
- The cost of HCW management in healthcare facilities.
- An assessment of HCW management practices in Addis Ababa private HCFs and public health research institutions.
- Assessment of the generation of healthcare waste in the community is very important, it is because of home care and the like have grown in Addis Ababa from time to time.

6.7 CONCLUDING REMARKS

The study generated information on the status of HCW generation and management in selected Addis Ababa City Administration Health Bureau health care facilities. It highlighted key areas that need to be addressed in order to improve service delivery and eliminate or reduce environmental pollution. The researcher developed a manual for effective HCW management and training of HCW handlers. A comparison of the research outcomes with the situation in other regions in Ethiopia or elsewhere would enhance and improve public and professional understanding of HCW management.

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ANNEXURES

Annexure A: Certificate of clearance from the University of South Africa Health Studies Higher Degrees Committee

UNISA university of south africa

RESEARCH ETHICS COMMITTEE: DEPARTMENT OF HEALTH STUDIES
REC-012714-039 (NHERC)

1 March 2017

HSHDC/641/2017
Mr ML Tadesse
Student: 5854-411-9
Supervisor: Prof BL Dolamo
Qualification: D Cur
Joint Supervisor: -

Dear Mr ML Tadesse

Decision: Ethics Approval

Name: Mr ML Tadesse

Proposal: Healthcare Waste Management, quantification and intervention in Addis Ababa City Administration Health Bureau Public Health Facilities.

Qualification: DPCHS04

Thank you for the application for research ethics approval from the Research Ethics Committee: Department of Health Studies, for the above mentioned research. Final approval is granted for the duration of the research period as indicated in your application.

The application was reviewed in compliance with the Unisa Policy on Research Ethics by the Research Ethics Committee: Department of Health Studies on 1 March 2017.

The proposed research may now commence with the proviso that:

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the Research Ethics Review Committee, Department of Health Studies. An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for the research participants.*

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

3) *The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.*

4) *[Stipulate any reporting requirements if applicable].*

Note:
The reference numbers [top middle and right corner of this communiqué] should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants, as well as with the Research Ethics Committee: Department of Health Studies.

Kind regards,

pp

Prof L Roets
CHAIRPERSON
roetsl@unisa.ac.za

pp Prof MM Moleki
ACADEMIC CHAIRPERSON
molekmm@unisa.ac.za

Annexure B: Letter of permission to undertake the research from Addis Ababa City Administration Health Bureau

Ref: A/A/H/B/1220/272

Date 5/11/09 E.C

To UNISA Regional Learning Center

Addis Ababa

P.O.X. 13836

Ethiopia

RE: Permission to Undertake Study

This is to notify you that **Mr. Menelik Legesse Tadesse** have been given permission to undertake a Healthcare Waste research in Addis Ababa City Administration Health Bureau Public Health Facilities. The City Administration Health Bureau needs Copy of the research findings. As indicated before we believe this research will only be used for academic purposes and therefore under no circumstances should the information found be revealed to the media or public.

With best regards,

Tadesse Atlabachew
Deputy Health Bureau Head

Cc

Ato Menelik Legesse Tadesse

Addis Ababa

Annexure C: Letter of clearance from the Addis Ababa City Administration Health Bureau Public Health Research and Emergency Management Core Process

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City Government of Addis Ababa Health Bureau

Ref. No A/A/H/B/4501/227

Date 1/12/2017

- **Bole sub city health office**
- **Yeka sub city health office**
- **Kirkos sub city health office**
- **Kolfe Keranio sub city health office**
- **Arada sub city health office**
- **Lideta sub city health office**
- **Akaki-Kality sub city health office**
- **Gulele sub city health office**
- **Nifasilk Lafto sub city health office**
- **Addis Ketema sub city health office**
- **TiruneshBejing hospital**
- **Gandhi Memorial hospital**
- **Menelik II hospital**

Addis Ababa

Subject: Request to access Health Facilities to conduct approved research

This letter is to support **MENELIK LEGESSE** to conduct research, which is entitled as **"Healthcare Waste Management, Quantification and Intervention in Addis Ababa City Administration Health Bureau Public Health Facilities."** The study proposal was reviewed and approved by Addis Ababa Health Bureau ERC, and the investigator is informed with a copy of this letter to report any changes in the study procedures and to submit progressive report once in six months, apply for renewal 30 days prior to the expiry date, and submit technical report within three months of study completion.

Therefore we request the mentioned Facilities and staffs to provide support to the investigator.

With Regards

Kassayenew Amare

ERC

The Addis Ababa City Administration Health Bureau

- **MENELIK LEGESSE**
- **Ethical Clearance Committee (ERC)**

Addis Ababa

Annexure D: Information sheet and consent form for participants

University of South Africa (UNISA)

TOOLS FOR CLIENT SURVEY

INFORMATION SHEET

1. Introduction

Hello my name is MENELIK LEGESSE TADESSSE (Student Number 58544119). I am a doctoral student of the University of South Africa, Pretoria. I work on the research entitle "Healthcare Waste Management, Quantification and Intervention in Addis Ababa City Administration Health Bureau Public Health Facilities." The aim of the study is to assess the current situation of healthcare waste management practice and quantification in Addis Ababa city Administration Health Bureau health facilities, based on the findings of the empirical phase of the study will develop a manual for health care waste management for health care facilities. The information you provide will be used to improve healthcare waste management in Addis Ababa City Administration Health Facilities. The survey asks you question about healthcare waste management and practice issues.

2. Participation Procedure and Guideline

a. The information you provide will be kept completely anonymous. That is, your name will not be indicated on any of the forms.

b. It will take about 45 minutes to complete the survey. Nevertheless if you do not want to participate in the study it is your right and has no influence on the care being provided in this health institution or other areas

c. Since the questions are prepared in English, the discussion will be in English, but if you want to use the Amharic the Amharic translated questioner will be provided or the interviewers will ask you in the language that you are familiar with.

3. Participation Benefits and Risk

a. Risk:-Your participation in this study does not involve risks to you than those you experience in your daily life. You might feel some mild discomfort in responding question and the time you spent, but it is not different from your appointment time.

b. Benefits: - you may experience some benefits from participating in the project. These benefits might be positive feelings from helping with important research project and your response will assist in improving healthcare waste management and practice in health institution in Addis Ababa.

c. Incentives/Payment for Participation: No payment will be given in participating in this study.

4. Confidentiality

The information gathered from you will be confidential and will not be exposed to anybody. The information will be stored in secured place locked by using coded identification without indicating your name.

5. Right to Refuse or withdraw

Your participation is Voluntary, and there is no penalty for you not wanting to participate. This means that you are free to stop fully or choose not to answer any particular question or all questions.

6. Right as a participant

You have a right to have any questions about this research project answered. Please direct call to any question to Ato Menelik Legesse Tadesse cell phone +251911239535.

Ethical approval and clearance is obtained from the Higher Degrees Committee Department of Health Studies, University of South Africa and Addis Ababa City Administration Health Bureau Institutional Review Board.

7. Informed Consent Form

With do understanding of the aforementioned information, are you willing to participate in the study?

1. If Yes_________ (continue the interview) 2. No_________ (Terminate the interview)

Signature of the participant _______________________Date:_______________

Consent Form

In signing this document, I am giving my consent to participate in the study entitled "Healthcare Waste Management, Quantification and Intervention in Addis Ababa City Administration Health Bureau Public Health Facilities." I have been informed that the aim of the study is to assess the current situation of healthcare waste management practice and quantification in Addis Ababa city Administration Health Bureau health facilities, based on the findings of the empirical phase of the study will develop a manual for health care waste management for health care facilities. I am also informed that eligible for this study.

I have been informed that participation in the study is entirely voluntary, I can refuse from participating fully or partially and to terminate at any time. I have been told that my answers to questions will not be given to anyone else and no reports of this study will ever identify me in any way. I have also been informed that my participation or non-participation or my refusal to answer questions will have no effect on me or on the service that I can get. I am told that the question will take 40-45 minutes to complete the survey.

I have been informed that no monetary incentives will be given for my participation in this study. I understand that participation in this study does not involve risk. The study will help to improve healthcare waste management in Addis Ababa City Administration Health Facilities.

I understand that the results of this research will be given to me if I ask for the study. Ato Menelik Legesse Tadesse cell phone +251911239535, cell phone the contact persons if I have questions about the study or about my rights as a study respondent.

Respondent's signature______________________ Date ____________________

Thank You

Annexure E: Tool for client survey for healthcare waste handlers

University of South Africa (UNISA)

TOOLS FOR CLIENT SURVEY

For Healthcare Waste Handlers

1. General Information (Socio-demographic factors)

Serial Number	**Question**	**Response**
101	Name of your healthcare facility	
102	Status of your healthcare facility	1) Referral hospital 2) Health center
103	Gender	1) Male 2) Female
104	Age (Years)	
105	Occupation	1) Doctor 2) Nurse 3) Pharmacist 4) Laboratory Staff 5) Midwife 6) Ancillary Staff 7) Radiographer 8) Other Specify____________
106	Work experience in health facility (Years)	

2. Handling of Healthcare Waste (HCW)

Ser. No	Question	Response
201	What are the types of wastes generated at your healthcare facility?	1) Dressing swabs, genital swabs/absorbents 2) Used sanitary pads 3) Used gloves 4) Fluids 5) Used bandages 6) Human tissue and organs 7) Excreta 8) Sharps (used cannulas, needles, surgical blades, vials Injections, syringes) 9) General waste or noninfectious 10) Used toilet paper
202	Does the facility have a separate area or storage areas for HCW?	1) Yes 2) No
203	Does the health center /hospital has separate containers for nonhazardous and hazardous waste?	1) Yes 2) No
204	Does all types of waste containers are clearly marked or labeled?	1) Yes 2) No
205	Are all types of containers are located in appropriate area where they might be needed?	1) Yes 2) No
206	Are containers leak-proof materials (preferably plastic) for disposal of HCW?	1) Yes 2) No
207	Are the containers easy to carry by the workers?	1) Yes 2) No
208	Are Sharps containers made of a puncture-resistant materials (cardboard, plastic, or metal)?	1) Yes 2) No
209	Are HCW containers emptied daily or whenever they are 3/4 full	1) Yes 2) No

210	Are sharps containers closed securely and disposed of whenever they are 3/4 full?	1) Yes 2) No
211	Does any formal or informal separation of waste take place?	1) Yes 2) No
212	Are used plastics and intravenous sets kept separately for recycling?	1) Yes 2) No
213	Do all waste handlers wear heavy duty gloves and sturdy shoes when handling medical waste?	1) Yes 2) No
214	Do staff (waste handlers) wash both their hard duty gloves and their hands after handling HCW?	1) Yes 2) No
215	What containers used for transporting HCW?	1) Cart 2) Open bucket 3) Other specify________
216	Does the establishment generate any waste of special concern: Cytotoxics?	1) Yes **2)** No
	Pathological waste?	1) Yes 2) No
	Reagent?	1) Yes 2) No
	Outdated pharmaceuticals?	1) Yes 2) No
	Radioactive waste?	1) Yes 2) No
	If yes, how are their disposal handled?	
217	How is liquid waste disposal handled? Specify for cytotoxics and reagents processing liquids?	

Annexure F: Tool for client survey for Managers

University of South Africa (UNISA)

TOOLS FOR CLIENT SURVEY

For Managers

1. General Information

Serial Number	**Question**	**Response**
101	Name of your healthcare facility	
102	Status of your healthcare facility	1. Referral hospital 2. Health center
103	Gender	1. Male 2. Female
104	Age (Years)	
105	Occupation	1. Doctor 2. Nurse 3. Pharmacist 4. Laboratory Staff 5. Midwife 6. Ancillary Staff 7. Radiographer 8. Other Specify_____________
106	Work experience in health facility (Years)	

2. Healthcare waste management

Serial Number	**Question**	**Response**
301	Is healthcare waste generated in your healthcare facility segregated?	1) Yes 2) No
302	How do you rate segregation of healthcare waste?	1) Poor 2) Good 3) Very good 4) Excellent
303	Where is hazardous healthcare waste stored?	1) Black refuse plastic bag 2) Red healthcare

Serial Number	Question	Response
		waste plastic bag 3) Standard metal dust bin 4) Pedal bin 5) Yellow Sharp container 6) others specify________
304	How is the storage of healthcare waste awaiting transportation to the incinerator?	a) Secure b) Insecure
305	How do you rate the handling of healthcare waste?	1) Poor 2) Good 3) Very good 4) Excellent
306	Do the waste handlers use protective clothing when handling healthcare waste?	a) Yes b) No
307	Are you provided with protective clothing when handing healthcare waste?	a) Yes b) No
308	If yes to question number 307 state the protective clothing and materials you use:	
309	Who collects healthcare waste in your healthcare facility?	
310	How often healthcare waste is collected by the authority mentioned in question number 309?	a) Daily b) Once a week c) Once per fortnight d) Once per month e) Others specify ____________
311	What is the mode of transportation of healthcare waste within the healthcare facility (onsite)?	a) Pedal bin b) Bucket c) Trolley d) Cart e) Others specify______

3. Management issues

601	Who is responsible for healthcare waste management at the healthcare facility?	1) Safety officer 2) Sanitarian/Environmental health professional 3) Other specify_________
602	Is there a current operational standard for HCW management?	1) Yes 2) No
603	Are there any applicable national, regional, and local guideline for HCW management in the Health center?	1) Yes 2) No
604	Is there a Healthcare Waste management committee?	1) Yes 2) No

4. Risks of the current waste management system

701	Does the management of the health center have concerns about HCW management?	1) Yes 2) No
702	Does the waste pose any risk to waste collectors? If yes, what kind?	1) Yes 2) No
703	How many waste handlers are working in this health center?	1) One 2) Two 3) Three 4) Four 5) Five or more
704	Was any one getting injured by needle in the past 12 months and reported?	1) Yes 2) No
705	Types of injury sustained	1) deep injury 2) slight skin penetration 3) superficial 4) Splash 5) others specify_____
706	Does the health facility has a register for any injury or HCW contamination to the collectors/handlers?	1) Yes 2) No

Annexure G: Tool for survey observation to health facilities

University of South Africa (UNISA)

TOOLS FOR SURVEY

For observation

Only for data collectors

1. Interim Storage

401	Do all interim storage sites and medical waste disposal sites are located in areas that are minimally accessible to staff?	a) Yes b) No
402	Do interim storage containers have lids?	a) Yes b) No
403	Do waste stored on site for more than 48 hours before final disposal?	a) Yes b) No

2. Treatment and disposal of health care waste

501	Is there any treatment (chemical/autoclaving) of HCW before disposal? If yes, how the residuals handled?	1) Yes 2) No
502	Is the health care waste disposed of at On- site?	1) Yes 2) No
	Off- site?	1) Yes 2) No
503	What are the on-site practices for HCW treatment?	1) Crushing of sharps 2) Sterilization 3) Chemical 4) disinfection 5) Destruction 6) through burning
504	What are the practices for on-site disposal?	1) Dumping 2) Open burning 3) Incineration
506	Is there an incinerator at in healthcare facility?	1) Yes 2) No
507	Is the incinerator located downwind from the health center?	1) Yes 2) No

508	Does the incinerator have sufficient air inlets on the side?	1) Yes 2) No
509	Where is the ash from the incinerator disposed of?	
510	Is the incinerator surrounded by a fence or wall to limit access?	1) Yes 2) No
511	Is the burial site away from any water source at the healthcare facility?	1) Yes 2) No
512	Is the pit have 1-2 meters wide and 2-5 meters deep? Is the bottom of the pit is at least 1.8 meters above the water table?	1) Yes 2) No
513	Is there any of the waste taken off-site, how are the wastes transported outside the premises of the health care facility?	1) Municipality 2) Cooperators 3) Other specify________
514	What type of HCW is burned in the incinerator?	1) Infectious 2) Syringes 3) Plastics 4) All type

Annexure H: Recording data sheet for HealthCare Waste generation rate in Health Centers

University of South Africa (UNISA)

TOOLS FOR SURVEY

Recording data sheet for HealthCare Waste generation rate in Health Centers

Only for measurement data collectors

Name of health center___________________________________

From ________ to _________ 2018

I.OPD

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No of visitors New							
Old							
Types of Waste: General Waste							
Infectious							
Sharp							

II. PHARMACY

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No of visitors New							
Old							
Types of Waste: General Waste							

III.LABORATORY

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No of visitors New							
Old							
Types of Waste: General Waste							
Sharps							
Infectious							
Pathological							

IV. EMERGENCYROOM, INJECTION ROOM AND DRESSING ROOM

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No of visitors New							
Old							
Types of Waste: General waste							
Sharps							
Infectious							
Pathological							

V.FANC UNITS

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No of visitors New							
Old							
Types of Waste: General waste							
Sharps							
Infectious							
Pathological							

VI. DELIVERY ROOM AND POSTNATAL

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No of visitors New							
Old							
Types of Waste: General Waste							
Sharps							
Infectious							
Pathological							

VII.TB AND LEPROSY ROOM

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No of Visitors New							
Old							
Types of Waste: General waste							
Sharps							
Infectious							
Pharmaceutical							

VIII. EPI ROOM

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No____of visitors New							
Old							
Types of Waste: General waste							
Sharps							
Infectious							

IX.FAMILY PLANNING ROOM

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No of visitors New							
Old							
Types of Waste: General waste							
sharps							
Infectious							

X. VCT AND ART ROOMS

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No of visitors New							
Old							
Types of Waste: General waste							
Sharps							
Infectious							

Other Rooms

Date	__/__/18	__/__18	__/__/18	__/__18	__/__/18	__/__18	__/__18
No of visitors New							
Old							
Types of Waste: General waste							

Annexure I: Letter from the editor

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Doringkloof
0157 Centurion

7 August 2019

TO WHOM IT MAY CONCERN

I hereby certify that I have edited Menelik Legesse Tadesse’s doctoral dissertation, **Healthcare waste management, quantification and intervention in Addis Ababa City Administration Health Bureau Public Health Facilities**, for language and content.

IM Cooper

Iauma M Cooper
192-290-4

Annexure J: Turnitin originality report

Tadesse ML HCW submit 22/12/2019

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