RESEARCH SUBMITTED TO WERABE UNIVERSITY COLLEGE OF SOCIAL SCIENCE GEOGRAPHY AND ENVIRONMENTAL STUDIES

ASSESSMENT OF MEDICAL SOLID WASTE MANAGEMENT PRACTICE AND CHALLENGES AT WERABE COMPREHENSIVE SPECIALIZED HOSPITAL

BY

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WERABE,ET

DECLARATION

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This is to certify that the thesis prepared by Mrs. Yitagesu Kebede entitled "Assessment of Medical Solid Waste Management Practice and Challenges at Werabe Comprehensive Specialized Hospital" and submitted as a partial fulfillment for the award of the Department of Geography and Environmental Studies in Werabe University to obtain a Master of Arts degree in Urban and Regional Developmental Planning complies with the regulations of the university and meets the accepted standards with respect to originality, content and quality.

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DEDICATION

With immense confidence, I dedicate this thesis manuscript to my beloved wife, Sakina Nasir Muktar, and to all of my family members. Their unwavering love and dedicated support have been the cornerstone of my academic achievements.

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ABBREVIATIONS AND ACRONYMS

BMW……..Biomedical Waste

EIA ..... Environmental Impact Assessment

FEPA……. Federal Environmental Protection Authority

FMHACA……Food Medicine and Healthcare Administration and Control Authority

GEF……. Global Environmental Facility

GDP…… Gross domestic product

HBV……Hepatitis B Virus

HCWM…… healthcare waste management

HCV……Hepatitis C Viru

HCF ..... Health-Care Facility

HCRW……. Health Care Risk Waste

HCSW:..... .....Health Care Solid Waste

HCW ..... Health-Care waste

HCWM ..... Health-care Waste Management

HSW……. Hospital solid waste

IPD,……. Inpatient department

MOH: .....Ministry of Health

MSW ..... Medical Solid Waste

MSWM .....Municipal Solid Waste Management

MEA…….. Multilateral Environmental Agreements

MW ..... Medical waste

NGO: .....Non Governmental Organization

OR ..... Operation Rooms

OPD…..... Out-Patient Department

PCDD/Fs…….. polychlorinateddibenzo-dioxins/furnaces

PAHs…… polycyclic aromatic hydrocarbons

SDA…… Siltie Development Association

SPSS……. Statistical Package for Social Science

SNNPR……....Southern Nations Nationalities and Peoples Region

SW .....Solid Waste

SW M .....Solid Waste Management

TEPA……Taiwan Environmental Protection Administration

UNEP……..United Nations Environmental Program

UNICEF…….United Nations International Children's Emergency Fund

WCSH.....Werabe Comprehensive Specialized Hospital

WHO:..... World Health Organization

WLAO.....werabe town land administrative office

WTE ..... Waste-to-Energy

ABSTRACT

A study conducted at Werabe Comprehensive Specialized Hospital in Werabe town, Silte Zone, SNNPR Ethiopia from September 11 to December 17, 2023 aimed to promote environmentally responsible and safe waste disposal practices. The study analyzed the management of medical waste and identified areas for improvement, utilizing waste management assessments, checklists, and interviews as both qualitative and quantitative data collection methods. The questionnaires were translated into Amharic and then back to English to ensure consistency. The findings revealed that the hospital generated an average of 0.244 kg of biomedical waste per patient per day. However, there were areas for improvement, such as waste segregation and the use of substandard open plastic bins for waste collection and transport. Proper segregation of medical waste from general waste is essential, and taking a comprehensive approach to managing solid medical waste could lead to significant cost savings. Additionally, involving environmental health and waste management experts in the infection control team could enhance medical waste handling and prevent improper disposal in public landfills. The study also highlighted that the hospital's average biomedical waste generation rate was 0.244 kg per bed per day, exceeding the hazardous waste generation rate recommended by the World Health Organization for low-income countries. Therefore, standardized biomedical waste management protocols, effective waste segregation, and adequate waste collection infrastructure should be put in place in various departments to ensure safe and responsible waste disposal practices.

Key words: *SNNPR, Cost savings, environmental health , hazardous waste , waste segregation,*

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the study

Medical waste implies any waste that is produced through treatment, immunization of human beings or animals or in inquiry about workout routines, or inside the generation or trying out of organic and counting human anatomical waste, animal waste, microbiology and biotechnology waste, waste sharps, disposed of options and cytotoxic drugs, soiled waste, strong waste (catheter, saline bottle, etc.), incineration ash remains, and chemical waste (Rao ,M.N. Sultana et al. 2017).

Medical waste typically consists of different materials. While the relative percentage of the components of scientific waste produced from hospitals depends upon the sorts of healthcare facilities, the management practices of waste (e.g. handling, segregation, and disposal), and the regulations of waste as a whole, the most important factors of medical encompass tissues, single-use disposable plastics, absorbent cotton, and pathological wastes (Jang, Yong-Chul,, 2006).

Poor management of healthcare waste can cause serious diseases to healthcare personnel, waste workers, patients, and the general public. The greatest risk of infectious waste is accidental needle stick injuries and the reuse of syringes. WHO estimated that in 2000, worldwide, injections undertaken with contaminated syringes caused about 23 million infections of hepatitis B, Hepatitis A, and AIDS infections, in addition to other diseases. During handling waste, injuries occur when needles or other sharps have not been collected properly in rigid containers. Conditions such as inappropriate design of waste collection, overflow of existing sharp containers, unprotected pits, improper dumping, and easy public access to healthcare wastes are risk factors increasing the public's risk exposure to needle stick injuries. Children are particularly at risk of exposure to healthcare waste. (WHO,2005).

Healthcare waste management has not received sufficient attention in most developing countries from the government. As a result, safe and proper healthcare waste management is a challenge Health authorities and healthcare centers must ensure the safe and effective management of medical waste as it is a legal necessity and a social responsibility. Proper collection,segregation, storage, transport, treatment, and disposal methods are essential for maintaining a clean and healthy environment (Bebcko et al. 2003; Rao et al. 2004).

In developed countries like Germany, waste management must adhere to various laws and regulations, with the "Closed Substance Cycle Waste Management Act" being the primary legislation governing the prevention, recycling, reuse, and disposal of waste. Additionally, compliance with infection control and safety regulations is mandatory. Hospitals are required to designate an individual responsible for appropriate waste disposal, with their duties taking precedence over other responsibilities. This person is accountable for ensuring compliance with occupational safety and legal requirements, and integrating segregation and proper waste disposal into the facility's quality management. Proper disposal of hazardous waste must be verified with authorities, and transportation of hazardous waste must adhere to the Dangerous Goods Regulation. Incineration of waste must comply with Federal Control of Pollution regulations (International Journal of Infection Control, 2008)

Predicting the amount of healthcare waste in Ethiopia is challenging due to limited research on the types of waste generated from healthcare activities. The scarcity of data makes it difficult for decision-makers and experts to prioritize the development of a waste management plan and policy. Common improper waste disposal practices in developing countries, such as dumping medical waste into municipal waste, open spaces, and water bodies, as well as burning waste in open areas or primitive incinerators, contribute to poor management of healthcare waste, leading to disease spread and pollution (EsubalewTesfahun, 2015).

Improper waste management can harm workers, the public, and the environment. However, converting solid medical waste to energy in an economically and environmentally friendly manner can play a significant role in waste minimization. The waste-to-energy (WTE) process involves

converting solid waste to energy, generating electricity from the recovered heat, and producing hot water or steam for various applications in the community, industry, business, or residential heating.

This research proposal aimed to assess healthcare waste management practices at Werabe Comprehensive Specialized Hospital, including collection, storage, transport, and final disposal, while also identifying the quantities of solid waste generated by the hospital.

1.2 Statements of the Problem

Research indicates that poor medical waste management has historically posed significant public health and environmental risks. For instance, a severe outbreak of acute respiratory syndrome in Taiwan in 2003 prompted authorities to take more stringent measures in managing solid medical waste (TEPA, 2003). Studies have shown a clear association between exposure to incinerator emissions and adverse health impacts due to high levels of heavy metals. Incinerator workers, children, and residents living near incinerators in Japan, Spain, and Germany have been found to have significantly higher levels of dioxins, furans, and hydrocarbons in their blood or urine compared to control groups or national averages (Kumagai et al., 2005).

Improper waste management at Werabe Comprehensive Specialized Hospital, from generation to disposal, poses a significant public health risk. This affects health workers, waste collectors, the public, and the environment. Healthcare workers managing waste and patient care face occupational hazards from sharp injuries and exposure to human blood and body fluids.

The hospital's use of a brick incinerator without proper control of combustion temperature, flue gas treatment mechanism, and unknown fuel consumption can lead to environmental air pollution. Ineffective and poorly managed solid waste management at the hospital puts societal well-being and public health at risk.

Solid medical waste has become a major concern at Werabe Comprehensive Specialized Hospital, as scattered waste is leading to health and environmental issues across the hospital premises.

Domestic waste is estimated at 5 kg per garbage container per day, and the daily production of domestic waste was 01 ton. Additionally, a certain amount of domestic waste was removed from the hospital. However, 0.05 tons (50 kg) are left abandoned in the hospital every day.

Therefore, this thesis aims to address the current literature gap regarding the reasons why the hospital improperly disposes of its waste, within the specific context of the study area.The study aims to assess hospital practices in managing medical solid waste, identify challenges affecting the effectiveness of hospital MSWM, and propose a preliminary plan to address the issue at its source.

1.3 Objective of the study

1.3.1 General objective

The main aim of this study was to evaluate the hospital's solid waste management systems and practices in order to enhance environmental management by encouraging safe and proper waste management at Werabe Comprehensive Specialized Hospital, located in Werabe town, Silte Zone, SNNPR Ethiopia.

1.3.2 Specific objectives

The study was guided by the following specific objectives:

1. To identify the type and nature of healthcare waste generated in Werabe Comprehensive Specialized Hospital.

2. Estimate healthcare waste generation rate in Werabe Comprehensive Specialized Hospital.

3. To identify the current waste management systems and practices at Werabe Comprehensive Specialized Hospital.

4. To investigate possible environmental problems associated with the current HCWM at Werabe Comprehensive Specialized Hospital.

1.4 Research Questions

The following research questions were formulated to address the issues raised in the research objectives:

1. What are the types and nature of healthcare waste generated at Werabe Comprehensive Specialized Hospital?
2. What is the estimated healthcare waste generation rate at Werabe Comprehensive Specialized Hospital?
3. What are the hospital waste management systems and practices at Werabe Comprehensive Specialized Hospital?
4. What are the environmental problems associated with the current HCWM at Werabe Comprehensive Specialized Hospital.?

1.5 Scope of the study

The study was geographically limited to Werabe Comprehensive Specialized Hospital. Thematically, the research centered on assessing the practices and challenges of medical solid waste management, taking into account the constraints of limited human, financial, and material resources.

1.6 Limitations of the study

The study has the following main limitations:

- The lack of studies, recorded, and documented data on MSWM activities in the Hospital restricts the depth and scope of the study.
- Some respondents could not provide accurate information due to reasons like misunderstanding the study's purpose, lack of knowledge and experience, and apathy.
- As the study was carried out in specific areas, the results may not be applicable to all sections of the hospital. Nonetheless, these limitations did not impact the research findings.

1.7 Significance of the study

The research will significantly enhance the existing knowledge of Healthcare Waste (HCW) management and treatment. The study outcomes will aid in formulating strategic suggestions for establishing efficient HCW management procedures and developing environmentally sustainable, economically viable, and safe treatment and disposal facilities. Furthermore, the study results will lay the groundwork for future research at analogous sites and other similar locations nationwide.

CHAPTER TWO

2. RELATED LITERATURE REVIEW

A thorough literature search was conducted to analyze the various experiences related to biomedical solid waste generation rates and management strategies, focusing on agreed-upon study topics. Computerized literature search engines of scholarly articles, including Science Direct, PubMed, and Google Scholar, were used to identify relevant papers. Additionally, a manual search was performed.

Healthcare facilities produce Health Care Risk Waste (HCRW) containing infectious materials, sharps, hazardous chemicals, or radioactivity, posing risks to human health (Harsh M, 2017). Hospitals, as complex institutions, generate a wide spectrum of hazardous waste materials in the course of their healthcare activities (Rao PH, 2018). The majority of biomedical waste (75-90 percent) is non-risk or general healthcare waste, similar to Municipal Solid Waste (MSW), while a smaller portion (10-25 percent) is hazardous waste, presenting various health concerns. Improper waste management can lead to the entire waste mass becoming potentially infectious if infectious waste is mixed with non-infectious waste (Lars M, Johannessen E, 2017).

Biomedical solid waste, defined as solid waste generated due to patient diagnosis, treatment, or immunization of humans or animals, is produced in significant quantities in hospitals (Jorge Emmanuel, 2013). According to the World Health Organization (WHO), hospital-generated waste poses a higher risk of infection and damage compared to other types of waste. Biomedical waste is a significant challenge in many developing countries due to its increasing generation and inadequate management (Askarian M, Vakili M, Kabir G, 2004).

Biomedical solid waste management encompasses the storage, collection, transportation, treatment, and disposal of waste (Moradi A, 2017). The objective is to clean up the surrounding environment and ensure that waste does not pose a health risk. Biomedical waste management has evolved to not only include proper disposal planning but also efforts to determine whether certain waste materials can be reused and recycled (DavorinKralj, Stamenković M, 2016).

Healthcare practitioners bear the responsibility for the safe and proper disposal of biomedical solid waste. There is an urgent need in healthcare settings to reduce both the cost and the environmental impact of biomedical solid waste generation and disposal (RCN, 2017).

2.1 Waste generated by hospitals.

Hospitals generate mainly solid municipal waste, hazardous waste which is considered infectious waste and may be toxic or radioactive. Approximately 80% of the waste produced by hospitals is solid municipal waste, which is non-contaminated waste and poses no infectious risk to the personnel who handle it (MOH, 2008). The impacts of solid waste produced in hospitals have grown worldwide, especially in developing countries (Windfeld and Brooks, 2015). Previous studies have reported the great potential of hospital solid waste (HSW) to spread pathogens and hazardous compounds such as toxic chemicals as well as nuclear and radioactive materials into the environment (Ghasemi et al., 2018). However, a few case studies have been conducted on the generation rate and composition of HSW in developing countries. In these case studies, a wide range of variations in generation rate and percent composition are reported. Therefore, the generation rate and composition should be estimated separately, considering environmental and economic status (Tesfahun et al., 2016).

Healthcare waste includes all the waste hazardous or not generated during medical activities. There are by-products of healthcare, for example, sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices, and radioactive wastes, paper waste, leftover food (Samuel V.Manyele et al, 2004). These wastes if not properly managed can risk infectious diseases for both workers, patients, and the public in general (WHO, 2004). Healthcare waste management requires increased attention and diligence to avoid the substantial disease burden associated with poor practice.

2.2 Hospital Waste Generation

Hospitals produce various types of waste, including solid municipal waste and hazardous waste, which can be infectious, toxic, or radioactive. Around 80% of hospital waste is non-contaminated solid municipal waste, posing no infectious risk to personnel (MOH, 2004). The global impact of hospital waste, particularly in developing countries, has increased, with studies

highlighting its potential to spread pathogens and hazardous compounds into the environment (Windfeld and Brooks, 2015; Ghasemi et al., 2018). However, there is limited data on the generation rate and composition of hospital solid waste (HSW) in developing countries, necessitating separate estimations based on environmental and economic factors (Tesfahun et al., 2016).

Healthcare waste encompasses all waste generated during medical activities, including sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices, radioactive wastes, paper waste, and leftover food (Samuel V.Manyele et al, 2004). Improper management of these wastes can pose infectious disease risks for workers, patients, and the public at large (WHO, 2004). Effective healthcare waste management is essential to mitigate the substantial disease burden associated with poor practices.

2.3 Classification of Hospital Waste

Various authors propose different methods for classifying hospital waste based on its state (solid, liquid), character, source, and impact. One such classification by Eigenheer&Zanon (1991) categorizes hospital waste as follows:

1. Liquid Wastes:

- Biological waste (blood, excrement, body fluids)

- Chemical waste (solutions, inorganic salts)

- Over-dated medicines (unused or expired drugs)

- Radioactive waste (radiology waste)

2. Solid Wastes:

- Perforating and cutting wastes (needles, syringes, scalpels, broken glass)

- Non-perforating and non-cutting wastes (treatment waste, body parts, expired drugs, household-type waste)

Hospital waste can also be categorized based on its source and potential hazards:

1. **Clinical Waste:** High-risk waste, including body fluids, blood collection tubes, glassware in contact with infectious agents, and pathological waste.

2. Laboratory Waste: Also high-risk waste, encompassing chemicals, microbial cultures, clinical specimens, and radioactive materials.

3. Non-Clinical Waste: Non-risk waste, such as wrapping paper, office paper, food waste, wash and wastewater, and plastic not in contact with patient body fluids.

2.4 Hospital Waste Management Systems and Practices

Healthcare waste management is crucial for maintaining hygiene in health institutions and ensuring the safety of healthcare workers and communities. According to Johannessen et al. (2000), proper management of medical waste can minimize risks within and outside healthcare facilities. The primary focus is on segregating waste at the point of generation into reusable and non-reusable, hazardous and non-hazardous components. Other important steps include implementing a sharps management system, waste reduction, avoiding hazardous substances when possible, ensuring worker safety, providing secure methods of waste collection and transportation, and installing safe treatment and disposal mechanisms.

Johannessen et al. (2000) outlined four main steps for medical waste management: (1) segregation into different components with safe storage, (2) transportation to waste treatment and disposal sites, (3) treatment, and (4) final disposal. Acharya and Singh (2000) also identified key steps in the medical waste management process, including handling, segregation, mutilation, disinfection, storage, transportation, and final disposal, emphasizing their importance for safe and scientific

waste management. According to Rao, Ranyal, and Sharm (2004), effective medical waste management hinges on segregation and waste identification, recommending the use of color-coded plastic bags or containers for sorting waste into appropriate categories at the point of generation.

The WHO recommends that hospitals provide plastic bags and strong containers for infectious waste, such as empty antiseptic containers used in the hospital (Pruss, Giroult, and Rushbrook, 1999). General waste, such as garbage and garden refuse, should be disposed of with domestic refuse. Sharps should be collected in puncture-proof containers, and infectious waste containers should be marked with a biohazard symbol. Highly infectious waste should be sterilized by autoclaving, and cytotoxic waste should be collected in leak proof containers labeled as such (Acharya, 2000).

Needles and syringes should be disposed of using a needle destroyer and syringe cutters available at the point of generation. Infusion sets, bottles, and gloves should be cut with curved scissors. Sharps, soiled linen, and plastic and rubber items should be disinfected at the point of generation using sodium hypochlorite with minimal contact for an hour. When waste bags are three-quarters full, on-site staff should close them by tying the neck or sealing the bag. The storage area must be impermeable and hard standing with good drainage, and provide easy access for waste collection vehicles (Srivastava, 2000).

In tropical areas, infectious wastes can be stored for 24 hours in hot seasons and up to 48 hours in cooler seasons. Within hospitals, medical waste should be transported using dedicated wheeled trolleys, containers, or carts. Off-site vehicles must be labeled with the carrier's name and address, and biohazard symbols should be displayed. Secure transportation systems should be in place, and trained staff should handle the waste in dedicated vehicles when transporting it on public roads. Final treatment methods for medical waste include incineration, autoclave, hydrolase, and microwave technologies.

2.5 Technology for Hospital Waste Treatment and Disposal

The selection of technology for waste treatment and disposal must prioritize enhancing existing health and environmental outcomes (UNEP/SBC& WHO, 2004). Additionally, technology selection should emphasize functionality, safety, economic viability, and sustainability.

2.5.1 Landfill Technology

Sanitary landfills may be suitable for disposing of certain types of special healthcare waste, but other types should undergo treatment before disposal. Ultimately, residues from a treatment system will typically need to be finally disposed of in a landfill. Landfills should undergo review to ensure they have appropriate liners and leach rate collection systems, as well as include groundwater monitoring. This technology is primarily utilized in rural areas with limited options.

2.5.2 The technology of incineration.

When done properly, it is a highly advanced technology that can adequately treat all types of special healthcare waste. The key parameters of controlled incineration are combustion at a sufficiently high temperature (between 1,000°C and 1,200°C in the combustion chamber) for a long enough time in a combustion chamber with sufficient turbulence and oxygen for complete combustion to be achieved; and problematic gases to be minimized. Incinerators require skilled operators, extensive flue gas emission controls, and, frequently, imported spares and supplies. Properly controlled incineration is relatively expensive. Incineration of waste generates residues, including air emissions and ash. Environmental controls on incinerators in developed countries have been tightened in recent years, principally because of concerns about air emissions such as dioxins and furans as well as heavy metals.

2.5.3 Autoclaving

This involves heating waste material with steam in a sealed container under high pressure. By maintaining specific levels of time (> 60 mm), temperature (>121°C), and pressure (100 kPa), effective elimination of all vegetative microorganisms and most bacterial spores can be achieved.

Before autoclaving, material preparation includes segregating to remove unsuitable items and shredding to reduce waste into appropriately sized pieces.

2.5.4 Chemical disinfection

This is used routinely in healthcare to kill microorganisms on medical equipment. It has been lately extended to the treatment of L-ICW. Chemicals (mostly strong oxidants like chlorine compounds, ammonium salts, aldehydes, and phenolic compounds) are added to the waste to kill or inactivate pathogens. This treatment is most suitable for liquid wastes such as blood, urine stools, or hospital sewage.

2.5.5 Chemical disinfection

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2.6 Healthcare waste Legislations, guidelines and Regulations aspects

2.6.1 National Regulations

Healthcare facilities and centralized treatment/disposal facilities need to comply with relevant national legislation. Regulations should include clear definitions; precise indications of legal obligations for healthcare facilities, waste managers, and disposal facilities; applicable enforcement and penalty systems; and delegation of legal courts to handle disputes (Lars M. Johannessen et al., 2000).

At the national level, the Government of Rwanda has elaborated the environmental legislation through the organic law n° 04/2005 of 08/04/2005 determining the modalities of protection, conservation, and promotion of the environment in Rwanda.

This law defines waste category management and addresses waste disposal, collection, removal, and treatment in a manner that does not affect human health and the nature of the environment, prohibition of indecent waste dumping, and applicable enforcement and penalty systems (G0R,

2005). There is no specific legislation pertaining directly to the handling, transportation, or disposal of hospital waste in the organic law. However, waste from hospitals can be classified under this.

2.6.2 International Regulations

The following are major international regulations: the Basel Convention

The Basel Convention on the Control of Trans boundary Movements of Hazardous Wastes and their Disposal was adopted in 1989 and entered into force on 5 May 1992. This environmental treaty strictly regulates the trans boundary movements of hazardous wastes appropriately. The

Basel Convention is administered at the national and also obligates its parties to ensure that such wastes are managed and disposed of at a state level, depending on the contracting party's legislation; as of 22 July 1997, all countries had ratified the convention. The Basel Convention makes specific reference to the control of special HCWs: sharps, infectious waste, hazardous chemical waste, and pharmaceutical waste (UNEP, 2002).

At the international level Rwanda has ratified the Multilateral Environmental Agreements (MEA5) on wastes and chemicals, in particular the BASEL Convention on the Control of Trans boundary Movements of Hazardous Waste and their Disposal as adopted on 22 March 1989, the STOCKHOLM Convention on the Persistent Organic Pollutants signed on 22 May 200l and the ROTTERDAM Convention on commerce transactions of agricultural pesticides and other poisonous products, signed in Rotterdam on 11 September 1998, and in New York from 12 November 1998 to 10 September 1999 (MINITERE, 2006).

2.7 Healthcare waste

WHO defines medical waste as waste generated by health care activities, ranging from used needles and syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices and radioactive materials.

Waste management is an essential part of health care. Poor management of health care waste exposes health care workers, waste handlers and the community to infections, toxic effects and injuries, and risks that pollute the environment.Of the total amount of waste generated by health care activities, 15% is considered hazardous material that may be infectious, chemical or

radioactive. In 2010, unsafe injections were responsible for as many as 33 800 new HIV infections, 1.7 million hepatitis B infections and 315 000 hepatitis C infections.

The management of health care waste requires increased attention and diligence to avoid adverse health outcomes associated with poor practices, including exposure to infectious agents and toxic substances. Government commitment and support is needed for universal, sustained and long-term improvement.

WHO developed the first global and comprehensive guidance document in 2014 - Safe management of wastes from health care activities. The guide addresses aspects such as regulatory framework, planning issues, waste minimization and recycling, handling, storage and transportation, treatment and disposal options, and training.

2.7.1 Types of Healthcare waste

Waste and by-products cover a diverse range of materials, as the following list illustrates:

- Infectious waste: waste contaminated with blood and other bodily fluids (e.g. from discarded diagnostic samples), cultures and stocks of infectious agents from laboratory
- work (e.g. waste from autopsies and infected animals from laboratories), or waste from patients with infections (e.g. swabs, bandages and disposable medical devices);

- Pathological waste: includes human tissues, organs or fluids, body parts, and contaminated animal carcasses.
- Sharps waste : encompasses syringes, needles, disposable scalpels, and blades.
- Chemical waste : consists of solvents, reagents, disinfectants, sterilants, and heavy metals contained in medical devices.
- Pharmaceutical waste : includes expired, unused, and contaminated drugs and vaccines.
- Cytotoxic waste : refers to waste containing substances with genotoxic properties, such as cytotoxic drugs used in cancer treatment and their metabolites.
- Radioactive waste : encompasses products contaminated by radionuclides, including radioactive diagnostic material or radio therapeutic materials.
- Non-hazardous or general waste : refers to waste that does not pose any particular biological, chemical, radioactive, or physical hazard.

Figure 1 Types of healthcare waste

Sources Healthcare (Basel). 2021 Mar; 9(3): 284.

The major sources of health-care waste are:

- hospitals and other health facilities
- laboratories and research centers
- mortuary and autopsy centers
- animal research and testing laboratories
- blood banks and collection services
- nursing homes for the elderly

High-income nations typically generate an average of 0.5 kg of hazardous waste per hospital bed per day, whereas low-income countries generate an average of 0.2 kg. Nevertheless, in low-income nations, healthcare waste is frequently not segregated into hazardous or non-hazardous classifications, resulting in a significantly larger volume of hazardous waste.

2.7.2 Health risks

Healthcare waste has the potential to harbor harmful microorganisms that can cause infections in patients, health workers, and the general public. In addition, drug-resistant microorganisms that escape from healthcare facilities into the environment can pose a significant risk. Improper disposal of healthcare waste and by-products can lead to a wide range of negative health outcomes, such as injuries caused by sharp objects, exposure to toxic pharmaceuticals such as antibiotics and cytotoxic drugs, as well as exposure to hazardous substances such as mercury or dioxins during the handling or incineration process. Other potential hazards associated with healthcare waste include chemical burns from disinfection, sterilization, or waste treatment activities, air pollution caused by the release of particulate matter during medical waste incineration, thermal injuries resulting from open burning and the operation of medical waste incinerators, and radiation burns.

2.7.3 Sharps-related

An estimated 16 billion injections are given globally each year. However, not all needles and syringes are disposed of safely, posing risks of injury, infection, and potential reuse.

Efforts to reduce the reuse of injection devices have led to a significant decrease in contaminated needles and syringes in low- and middle-income countries. Despite this progress, unsafe injections in 2010 resulted in approximately 33,800 new HIV infections, 1.7 million hepatitis B infections, and 315,000 hepatitis C infections.

A person who experiences a needle stick injury from an infected source patient faces respective infection risks of 30% for HBV, 1.8% for HCV, and 0.3% for HIV. Furthermore, hazards arise from scavenging at waste disposal sites and the manual sorting of hazardous waste from health-care facilities, particularly in low- and middle-income countries. Waste handlers are at immediate risk of needle-stick injuries and exposure to toxic or infectious materials. A joint WHO/UNICEF assessment in 2015 revealed that only 58% of sampled facilities from 24 countries had adequate systems for the safe disposal of health care waste.

2.7.4 Environmental Impact

The treatment and disposal of healthcare waste can indirectly pose health risks by releasing pathogens and toxic pollutants into the environment.

- ✓ Untreated healthcare waste in landfills can contaminate drinking, surface, and ground waters if the landfills are not properly constructed.
- ✓ Using chemical disinfectants to treat healthcare waste can result in the release of chemical substances into the environment if not handled, stored, and disposed of in an environmentally sound manner.
- ✓ Incineration of waste, if not done adequately or with unsuitable materials, can release pollutants into the air and generate ash residue. Incinerating materials containing or treated with chlorine can generate dioxins and furans, which are human carcinogens and have been linked to a range of adverse health effects. Incinerating heavy metals or materials with high

metal content can spread toxic metals in the environment, particularly lead, mercury, and cadmium.

- ✓ Modern incinerators operating at 850-1100 °C and equipped with special gas-cleaning equipment can comply with international emission standards for dioxins and furans.
- ✓ Alternatives to incineration, such as autoclaving, microwaving, and steam treatment with internal mixing to minimize the formation and release of chemicals or hazardous emissions, should be considered in settings with sufficient resources to operate and maintain such systems and dispose of the treated waste.

2.8 Hospital biomedical solid waste generation rate

Biomedical solid waste is produced as a result of healthcare activity. The pace of generation varies depending on the type of hospital. Different generation rates exist, which vary not only from country to country but also within a country (Alagoz AZ, Kocasoy G, 2015). Based on the WHO (2013) report, Factors affecting biomedical solid waste generation are established waste management methods, type of healthcare establishment, hospital

specializations, the proportion of reusable items employed in healthcare, and the proportion of patients treated on a day-care basis. (Jorge & Emmanuel, 2013) Furthermore, the study found that the rate of biomedical solid waste generation is affected by a country's level of economic development, national health insurance reimbursement, the location of a healthcare establishment, the proportion of disposable substances used in healthcare activities, and the season of the year; this seasonal variation could be because the nature of illness of patients admitted to hospitals changes with the seasons. (Katoch S, Kumar V, 2016).

When comparing the generation rates of middle-income and low-income countries, it is clear that the latter has a lower rate. However, in high-income countries, the range of values for countries with similar income levels is likely to be as wide as in low-income countries (WHO, 2004).

According to the WHO, 80 percent of general healthcare waste, 15% pathological and infectious waste, 1% sharps waste, 3% chemical or pharmaceutical waste, and less than 1% special waste,

such as radioactive or cytostatic waste, pressurized containers or broken thermometers, and used batteries, generate biomedical waste (Annette Prüss, 2017).

Table 1 Hospital waste generation rate in different Regions of the world, 1999.

Region	Kg/bed/day	Proportion of hazardous waste (%
North America	7-10	5-20
Latin America	3	5-20
Western Europe	3-6	No data
Eastern Europe	1.4-2	No data
Middle East	1.4-2	No data
East Asia High income	2.4-4	5-10
East Asia Middle Income	1.8-2.2	No data
Western Europe	3-6	No data
Rural sub-Saharan Africans	0.3 -1.5	2-10
Low - income countries	0.3-3	No data

Source:PrussA.etal.(1999

Table 2 biomedical waste generation rate in different African countries

	country	BMWGR(kg/Bed/Day)	Country	BMWGR(kg/Bed/Day)
Africa	Algeria	0.96	Mauritius	0.44
	Cameroon	0.55	Morocco	0.53
	Egypt	1.03	Sudan	0.87
	Ethiopia	1.1	Tanzania	0.75

Source,Sustainability2017

Table 3 Biomedical waste generation rate in different hospitals.

Source	Source Daily waste generation(kg/bed/day)
University hospital/Referralhospital	4.1–8.7
General hospital	2.1–4.2
Primary hospital	0.5–1.8
Primary health-care center	0.05–0.2

Sources: Commission of the European Union (1995),Halbwachs (1994), Durand (1995).

According to research conducted in Sylhet, Bangladesh (2006), the average trash generation rate for hospitals was 0.934 kg/bed/day, with non-hazardous waste accounting for 77.08 percent and hazardous waste accounting for 22.92 percent (Shahjahan K, Alam S, Muhammad A, 2016).

A survey done in Irbid, Jordan, showed the generation rates of healthcare waste in three hospitals: 6.904kg/pat/day (4.315kg/bed/day)at the Princess Basma Hospital,5.718kg/pat/day (3.212 kg/bed/day) at Princess Bade'ahHospital,and4.532kg/pat/day(2.556kg/bed/day)at IbnAl-NafisHospital(Al-Shareif M, 2014).

Even among hospitals in the same category, according to a study conducted in Greece (2012), there is substantial variance in the rate of healthcare waste generation.

The average amount of total biomedical solid waste created per bed per day ranged from 0.012 kg/bed/day in public psychiatric hospitals to 0.72 kg/bed/day in public university hospitals. The average amount of biomedical waste generated in private hospitals ranged from 0.0012 kg/bed/day

in psychiatric clinics to 0.49 kg/bed/day in delivery clinics. Biomedical solid waste was statistically similar to birth and general hospitals in both the public and private sectors, according to nonparametric statistics. In comparison to similar public hospitals, private birth, and general hospitals created statistically more waste. Infectious or toxic and toxic medical wastes accounted for 10% of total hazardous medical waste solids generated in public cancer hospitals and 50% in university hospitals (Komilis D, Katsafaros N, Vassilopoulos P, 2016).

The biomedical solid waste generation rate in Nigeria (2011) in eight hospitals found in Ibadan Metropolis revealed that the public Hospitals generated waste between 0.37 and 1.25

kg/patient/day, while private hospitals generated between 0.12 and 0.28 kg/pt./day. Regarding the composition of biomedical solid waste, infectious waste represented 26 to 37%. (Wahab A, 2011).

In Kenya, the amount of infectious waste was higher than general waste which indicates lack of proper segregation of waste (Global Environmental Facility, 2009).

A study done at Amana District Hospital, Tanzania showed that the average medical solid waste generation rate was 1.8kg/patient/day. (I. S. Kagonji, S. V. Manyele, 2015). Nearby, a study conducted in Hawassa City, Southern Nations, Nationalities and Peoples Region (SNNPR) Ethiopia (2011) revealed that 48.73% (range: 41.0-67.7%) were infectious and 6.16% sharps (range: 2.12_9.98%) (Rahman H,2017)/A studyconduct in Gondar University Teaching Hospital (2007)) revealed that the average generation rate biomedical solid waste estimated based on the number of inpatient was 0.95 kg/bed/day and 0.142 kg/outpatient/day. There was a statistically significant correlation between patient flow and the generation rate of biomedical solid waste with a P-value less than 0.002 (DagnewE, HameedS, Seyoum L,2017).

A study conducted in Addis Ababa, Ethiopia (2011) showed that non-hazardous healthcare waste (median: 58.69%, range: 46.89–70.49%) and hazardous biomedical solid waste (median: 41.31%, range: 29.5 –53.12%), the majority of which was infectious (median:13.29%, range:6.12-20.48%) and pathological waste (median:10.99%, range: 4.73-17.25%) and the rest sharps and pharmaceutical were (median: 8.74%, range:6.41-11.07%) and (median:6.14%, range:3.54-8.73%) respectively. The total quantity of biomedical solid waste generated from public hospitals was significantly more ($p<0.05$) But, there was no statistically significant difference between the amount of Biomedical solid waste generated from public versus private hospitals (Debere MK, Gelaye KA, Alamdo AG, Trifa ZM, 2013). The literature analysis showed that the rate at which hospitals generate biomedical solid waste differs from hospital to hospital, even within the same country. To establish the rate of biomedical solid waste creation in hospitals, it is necessary to consider the nature and function of hospitals in Ethiopia, such as private, public, primary, general, referral, and teaching hospitals.

2.9 Hospital biomedical solid waste management practices.

According to the World Health Organization, biomedical solid waste should be segregated by the person who produces each waste item based on potential hazard characteristics, treatment requirements, and disposal route by the person who produces each waste item (WHP, 2004).

For each kind of biomedical solid waste, separate labeled color coded containers (infectious waste yellow, chemical and pharmaceutical waste brown, general waste black) should be supplied in each medical area. Each medical area should have separate labeled color-coded bins for each category of biomedical waste (infectious waste yellow, chemical and pharmaceutical waste brown, general waste black). In each hospital room, closed color-coded labeled containers for temporary or short-term storage of biomedical solid waste (depending on the type of waste, not more than 12 hours) are stored away from patients indoors. Not more than three-quarters of a waste bag or sharp container should be used (WHO ,2005).

The collection period should be set and acceptable for the amount of waste, but should not exceed one day. To reduce the transit of laden carts into wards and other clean areas, biological waste collection must follow precise routes through hospitals. The useless waste materials should ideally be processed to lessen their potential health or environmental hazard and volume,

with the residual residues being delivered for land disposal to a suitable place. After reduction or treatment, all biomedical waste systems will require access to land for the final disposal of leftover biological waste materials. Restricted access to avoid scavenging, daily soil cover to reduce odors, and frequent compaction and isolation of waste to prevent pollution of groundwater and neighboring regions are all desirable qualities of a landfill (WHO,2019).

It should be highlighted that no single solution is suitable for all types of biomedical solid waste or for all operational scales. Incineration, landfilling, burning, autoclaving, and chemical treatment are all common technologies. Microwave disinfection, plasma touch technology, detoxification, and advanced wet oxidation are some of the newer technologies. In addition, India has created a new solar treatment method (WHO, 2019).

In biomedical, Solid waste there are batteries, which come in all sizes and shapes. These substances contain toxic chemicals that should never be incinerated (Kim EH, p. 2017). Batteries depending upon their types may contain mercury, lead, cadmium, and lithium. Some of the solutions related to the problem of battery waste are whenever possible, rechargeable batteries should be employed. When this is not possible, a careful battery roundup 14 should be implemented to capture and recycle or appropriately dispose of the batteries (Prokopowicz A, p. 2015). In many hospitals mercury from damaged thermometers and blood pressure apparatus disposed of without proper precaution could contaminate the environment (Stephen O, 2010).

If a country decides to use incineration as a biomedical solid waste treatment choice it should be the national governments might utilize emission restrictions and other requirements to safeguard

effective waste treatment, diminish emissions, and also decrease exposure and risks to workers and the community (Eker HH, p. 2016).

The spread of blood-borne pathogens in biomedical solid waste motivated the World Health Organization to also issue a policy in 2004 calling for the progress of national policies, guidance, and plans for biomedical solid waste management. The policy paper, however, also recognizes the risks associated With incineration, which in developing countries can be problematic due to the lack of capacity for emission testing or regulatory enforcement (Global Environmental Facility (GEF), 2018).

A significant amount of Polyhalogenated Aromatic Hydrocarbons (PAHs) are found in biomedical solid waste and those substances have been of concern over several decades because of their increasing occurrence and persistence in the environment and their biochemical waste and toxic effects (Labib OA, 2010).

In India there have been improvements in the management of biomedical waste in the last decade and developing countries have been learning lessons from India's experience. Since 1995, India has made great progress in managing biomedical solid waste, nevertheless, delays caused by weaknesses in the country’s legal and institutional framework for biomedical solid waste management (Katoch S, 2008).

The National Government has formulated biomedical solid waste rules, prepared national guidelines, and implemented a national training program. Countries have devised their own biomedical solid waste management strategies and guidelines and assisted government hospitals in implementing biomedical solid waste management initiatives. Non-governmental organizations (NGOs) have played a major role in bringing the BMW management agenda to the attention of government officials, creating public awareness of BMW issues, and training healthcare facility personnel (Patil AD, p. 2016).WHO in 2004 prepared a policy paper calling on developing countries and countries in transition to develop national policies, guidance manuals, and implementation plans for sound management of biomedical solid waste (WHO, p.2015). the management of biomedical waste in many developing countries has been often poor and it raises concerns about inappropriate BMW management methods employed in such

states. Inappropriate treatment and final disposal of BMWs leads to an adverse impact on public health, occupational health and safety, and the environment (Chen SJ, p. 2017).

A study done in South Africa showed that incineration was a leading option for treatment technology for biomedical solid waste with most of the incinerators situated on healthcare facility sites. Similar to numerous first-world countries, though, non-incineration technologies are quickly becoming the dominant treatment technologies, mainly due to increased costs associated with raised air emission control standards mandatory for incineration facilities (Kobus O, John C, 2018). In Ethiopia, there is no specific biomedical solid waste management legislation. However, there are policies and regulations with requirements that may offer a legal framework for the management of biomedical waste solids (MOH, 2008).

The Ethiopia Environmental Pollution Control Proclamation, No 300 of 2002, after defining hazardous waste as ―an unwanted material that is believed to be deleterious to human safety or health and the environment, pronounces the following prohibitions and restrictions in its management.―No person shall pollute or cause any other person to pollute the environment by violating the relevant environmental Standards (Article3-subarticle1). Concerning the management of hazardous waste, it states that the generation, keeping, storage, transportation, treatment, or disposal of any hazardous waste without a permit from The Environmental Protection Authority or the respective Regional Environmental Agency is prohibited (68), (MOH, 2008).

The Ethiopia 2000 Public Health Proclamation No.200 pronounces the following prohibitions and restrictions about hospital waste - Any solid, liquid, and other waste generated from hospitals should be handled with special care, and their disposal procedures should meet the standards set by the public health authorities. The proclamation neither provided a clear definition of the various categories of HCW nor did it indicate the legal obligations that biomedical solid waste producers have about segregation, safe handling, treatment, and disposal. In addition, it did not indicate specifications for recordkeeping and reporting, and inspection systems for enforcement of the law (FEPA,2008).

The 16 Environmental Impact Assessment Proclamation no.299/2002 requires proponents to undertake an Environmental Impact Assessment (EIA) for those projects considered to have significant environmental impacts and listed as such in directives issued under this proclamation. According to the EIA guidelines issued by the Federal Environmental Protection Authority (FEPA), Large hospital waste incineration facilities, chemical treatment facilities, and landfills for toxic, hazardous, and dangerous waste are among the list of projects considered to have adverse and significant environmental impacts and hence require full environmental impact assessment (EPA,2005). A study conducted in Hawassa City showed that most (67%) of healthcare facilities (BMWs) had no segregation of waste at their facility. In two (22%) BMWs, the waste was segregated into sharps and other waste. Only one (11%) BMW reported using a complete color coding system (yellow puncture-proof plastic container for infectious waste, black for general waste, and a puncture-proof safety box for sharps waste).

However, even at this facility, it was observed that general waste was frequently mixed with infectious waste. Six (67%) of the BMWs did not use safety boxes for sharps, and some of them mixed sharps with other waste in simple wastebaskets. The absence of waste segregation at most of those BMWs and the improper segregation in other facilities indicate a low level of

awareness of the importance of waste segregation by those who manage waste at those BMWs.For instance, the study results showed that in most of these BMWs, waste management issues were under the responsibilities of administrators, without health backgrounds, who probably have little knowledge of biomedical and solid waste management (Israel Deneke H, HanibaleAtsbeha Z, 2011).

Another study conducted in 2009 on the Evaluation of Injection Safety and biomedical solid waste management in Ethiopia showed the absence of segregation practices in 75% of the BMW sand mixing of Hazardous BMWs with other wastes in healthcare facilities in addition to observed burning of BMWs in open holes, enclosures, and open areas in 65% of healthcare facilities (Habtetsion T, 2019).

A study done by Crown (2007) on preliminary health center assessment findings from three regions of Ethiopia in 2007 indicated that in some instances, improper use of incinerators was observed (USAID, 2007). A study conducted in Addis Ababa (2011) revealed that almost in all of the hospitals there was no segregation of waste into infectious, pathological, and pharmaceutical, and there were no separate bins for the collection of infectious waste. Non-hazardous biomedical waste was often mixed with infectious waste. Although four of the surveyed hospitals disposed of their waste on-site in their incinerators and the others were disposed of both off-site (non-pathological waste) and on-site (pathological waste), the remaining one hospital disposed of the waste off-site because the incinerator was not done at the time of data collection). Pre-treatment of highly infectious laboratory waste was also not done in any of the hospitals (Debere MK, 2013).

Much more can be done in terms of biomedical solid waste management, but in a developing country like Ethiopia, the handling of waste generated in healthcare institutions continues to pose significant health and environmental risks. As a result, developing countries must continue to make significant efforts to decrease the public health and environmental consequences of inefficient biomedical solid waste management systems. As part of promotional and preventative efforts, Ethiopia's health policy prioritizes the development of environmental health, the promotion of occupational health and safety, and the prevention of environmental pollution from hazardous chemical waste.

There is no formal biomedical waste management legislation in Ethiopia for the management of biomedical solid waste (Ethiopian Health Police of the Transitional Government of Ethiopia,1993).

In Ethiopia currently, there are two national guidelines and one voluntary code of practice formulated independently by the Federal Ministry of Health, and the second one by was Federal Environmental Protection Authority and Quality Standard Authority of Ethiopia that exclusively deal with biomedical waste solid management (MOH, 2008). Because of inadequate research data on the existing situation of biomedical solid waste management in the country, the national guidelines have been developed by considering the general situation in developing countries and based on the biomedical solid and biomedical solid waste guidelines prepared by the United Nations Environment Program (Federal Environmental Protection Authority2000).

2.10 Segregation of biomedical waste

Segregation practices across the country. Such waste segregation systems should rely on a consistent color coding system that provides a visual indication of the potential risk posed by waste that container And makes it easier to place waste items in the correct container and maintain segregation during transport, storage, treatment, and disposal (Harsh M, 2015).

Segregation should always be the responsibility of the producer and should take place as close to the source of the waste as possible (Rush Brook P, 2014).

The bag and container must bear the international symbol and be made of leak-proof plastic bags or receptacles. To safely handle sharps, the container should be rigid and impermeable, retaining not only the sharps but also any residual liquid from the syringe. There is no color marking for radioactive waste containers, but they must be lead boxes labeled with radioactive symbols. The lead box will prevent material emissions (WHO, 2017b).

Health care management studies conducted in Amhara region HCFs, Ethiopia, revealed the absence of segregation practice in 75% of HCFs and the mixing of hazardous HCW with other waste in the health care facilities; additionally, waste was scattered on the road surrounding the treatment site due to the use of substandard waste containers during transportation (Teshiwal&Deress, 2019). According to a study conducted in Addis Abeba (2011),

Almost all hospitals did not segregate waste into infectious, pathology, and pharmaceutical waste and did not have a separate bin for infectious waste collection. Non-hazardous health care waste is frequently mixed with infectious waste. Another study was conducted at Hawassa University's referral hospital (Debere, et al, 2017).

Another study conducted in Hawasa town revealed that the majority (67%) of healthcare facilities had no waste segregation at their facility by using complete color coding (yellow punctured–proof plastic container for infectious waste, black for general waste, and puncture–proof safety box for sharp waste (Asrat et al, 2018). Another study conducted in Hawasa town showed that most (67%)of the health care facilities had no segregation of waste at their facility by using complete color coding (Yellow punctured –proof plastic container for infectious, black for general waste, and puncture–proof safety box for sharp waste (Alamdo AG, 2017).

2.11 Collection of biomedical waste

Biomedical waste must often be stored before transport for final treatment and/or disposal site after segregation at the source of generation and collection. To avoid waste accumulation, waste must be collected regularly and transported to the HCF's central storage area before being treated or removed. To reduce the passage of loaded carts through wards and clean areas, collection musttake a specific route through the HCF. Hospital staff should exercise extreme caution when handling to avoid occupational hazards.

The most serious risks are associated with injuries that sharps can cause. When working with biomedical waste, sanitary staff, and cleaners should always wear protective clothing, which should include an overall or industrial apron, boats, and heavy-duty gloves (WHO, 2004).

Collection should begin in the most hygienically sensitive medical areas (e.g. intensive care unit, dialysis, operating rooms) and proceed on a predetermined route around other medical areas and temporary storage locations. The frequency of collection should be refined over time to ensure that no waste containers are overflowing at any time (WHO, 2017b).

The study conducted at Hawasa University's referral hospital discovered that, except for a few wards, the majority of departments (units) did not have temporary storage. As a result, when the buckets in the containers become full, patient attendants simply store or place waste on the floor or ground. There was no storage container outside the hospital for health care waste, patient attendants, or others.

The area must be enclosed and separate from the supply room of the food preparation area. Only authorized staff should have access to waste storage areas. Loading docks, space for compactors and balers, staging areas for sharp boxes, recycling containers, and secure storage for hazardous items such as batteries should all be provided (WHO, 2017b). Unless a refrigerated storage room is available, the facility should not be located near food stores or food preparation areas, and access should always be limited to authorized personnel. Cytotoxic waste should be stored separately from other healthcare waste in a designated secure location (Emmanuel et al., 2016).

2.12 Transport of biomedical waste

Biomedical waste should be transported within the hospital or other facility using wheeled trolleys, containers, or carts that are not used for anything else. The cart should be simple to load and unload, with no sharp edges that could damage waste bags or containers, and simple to clean (Emmanuel et al., 2014). However, according to a study conducted in public health care facilities in the city of Adama, the majority of the devices used for non-site transportation of HCF were open or unprotected. (Asrat M, 2018).

Another study conducted at Meneilk –II referral hospital found that the majority of devices used for on-site transportation of BMW were closed bins with wheels. The waste in the municipal garbage tank (completely infectious) was stored for a minimum of one week and a maximum of three weeks before being transported to the city municipal disposal site by an outsourced private campaign (Atnafu and Kumie, 2017). Furthermore, a study conducted in Addis Abeba City and Hawasa town health care facilities revealed that the majority of solid waste at the HCFs was discovered to be collected primarily in open plastic containers from the point of generation to the treatment area.(Hayleamicheal et al, 2018).

2.13 Treatment and Disposal of technology biomedical waste

In the selection of BMWMG technologies, the terms treatment and disposal are frequently used incorrectly interchangeably (Koscasoy,2017) to clarify "treatment as an alteration of a waste stream or contaminated site to reduce, eliminate, or immobilize hazardous constituents," while "disposal implies disregard for return, and is thus considered to be permanent storage or release. According to the literature, the most common methods of disposing of biomedical solid waste, particularly in developing countries, are open dumping, landfilling, or incineration (Hossain et al, 2011). Infectious waste and healthcare waste pose a greater risk to health and should be treated before disposal; a variety of options are available, including incineration, chemical treatment, autoclaving, microwaving, and shredding/compacting (WHO, 2014)

2.14 Incineration of biomedical waste

In Ethiopia and elsewhere, incinerating medical waste is the most preferred and widely used treatment method. The waste management hierarchy is topped by incineration, which is followed by source reduction, reuse, recycling, and final disposal/landfilling. In the current study, approximately 94 percent of health facilities used burning as their preferred medical waste treatment method; 3 percent used 2-chamber incinerators. 39 percent used 1-chamber incinerators, and in the remaining health facilities, a significant number, used open burning as their medical waste treatment method (WHO, 2019).

Inadequate or inefficient medical waste incineration can result in the release of toxic pollutants into the atmosphere as well as bottom and fly ash, which contains toxic organic and inorganic compounds. Toxic emissions include organic emissions such as polychlorinated dibenzo-dioxins/furnaces (PCDD/Fs) polycyclic aromatic hydrocarbons (PAHs), inorganic emissions, and toxic metal ashes. These products are carcinogenic and have an impact on human development, reproduction, and immune systems. (WHO, 2018).

Incineration is a high-temperature process (8500C to 1100oC). Dry oxidation is a process that converts organic and combustible waste into inorganic, incombustible matter, resulting in a significant reduction in waste volume and weight. Incineration is the most commonly used medical waste treatment method (WHO,2019)When properly designed and operated, the incinerator will destroy all biologically and chemically hazardous materials and reduce the volume of waste that needs to be disposed of to about 10% of its original volume.

The technique also has the significant advantage of rendering hypodermic syringes ("sharp") unusable by melting and/or deforming them and then oxidizing them into ash. Based on the requirements for the final disposition of any waste treatment process and the types of waste that may be classified as infectious, it appears that incineration is an environmentally responsible option for volume reduction, cost and convenience of handling the final product, and assurance of permanent disposal of potentially biologically hazardous materials (Harsh M, 2017).

2.15 Autoclave

The autoclave of biomedical waste is regarded as an alternative technology to incineration, but it is regarded as a more precise method than incineration (Jang, et, al,2006). This is because autoclaves are a dual treatment option for biomedical solid waste management, and autoclaving waste necessitates another treatment method as a final method. Furthermore, it is incapable of handling large amounts of hazardous waste. Furthermore, autoclaves cannot treat a wide range of chemical and hazardous substances, including chemotherapy waste, mercury, volatile and semi-volatile organic compounds, radioactive waste, and other chemical wastes (UNEP 2012). It is not appropriate for or not suitable for treating large body parts, animal carcasses, or other large items that, due to their mass and characteristics, make heating the entire material to the prescribed temperature difficult or time-consuming (.(Emmanuel et, al, 2014))

2.16 Open dump and open burning of biomedical waste

In developing countries, the most common method of biomedical waste disposal is an open dump. This is most likely less expensive, and no other alternatives are available at this low cost. Although this is the cheapest option, open dumps have long been recognized as a Potential source of public and environmental pollution.

It is an uncontrolled and insufficient disposal option for biomedical waste because it is accessible to scavengers and animals (WHO, 2019)As a result, BW should not be disposed of on or near an operational dump. This is because uncontrolled BM spreads infectious pathogenic microorganisms to the environment. This is because uncontrolled BM spreads infectious pathogenic microorganisms to the environment through direct contact through wounds, inhalation or ingestion, or indirect contact with the food chain, or pathogenic host species (Emmanuel et al, 2014).

Each year, it is estimated that more than three million MBW are exposed to the stressful events of pre-cutaneous injuries with a contaminated sharp object. In 2000, WHO estimated that contaminated syringe injections caused: 2.1 million HBV infections (32 percent of all new infections), 2 million HCV infections (40 percent of all new infections); and 260,000 HIV infections (5 percent of all new infections).

Epidemiological studies show that a person who receives one needle–stick injury from a needle used on an infected source patient has a 30%,1.8%, and 0.3% risk of becoming infected with HBV, HCV, and HIV, respectively (Rapiti et al, 2015).

2.17 Health impact of biomedical waste

Healthcare activities generate waste, which can hurt one's health. Infectious components in biomedical waste, such as contaminated sharps and syringes, pose the greatest health risk due to the possibility of direct exposure to pathogens in blood and other fluids from patients via pre-cutaneous injuries (PI), abrasion, and a cut in the skin (Rapiti et al,2017). We know that appropriate biomedical solid waste management can be achieved by: the presence of a

responsible waste management team, the preparation of a compressive plan, the waste handlers being equipped with the most up-to-date information, skills, and practices, the allocation of adequate funding, the estimation of the quantities and types of biomedical solid waste, the use of enforced codes of practice and guidelines, and the provision of regular training (MOH 2008). The value of biomedical solid waste information has been highlighted in the literature review when creating a biomedical solid waste management intervention strategy. This inquiry (auditing biomedical waste in public and private institutions in the Region) was planned against this backdrop. The existing state of biomedical waste management in Africa, according to research findings, cannot ensure the safety of healthcare facility workers, patients, and the public.

Instead, current mismanagement puts the public's health and the environment under threat. In Ethiopia, as in many other African countries, the degree of safety in the handling and disposal of biomedical waste is quite low. Biomedical solid waste management is a major concern. The general assumption is that healthcare facilities lack proper biomedical waste management practices.

As a result, developing a biomedical solid waste management intervention strategy that can be implemented consistently in Bako Primary Hospital is serious. It is difficult to plan and establish an effective intervention strategy for better biomedical solid waste management. As a result, an examination of biomedical solid waste management techniques was required, as well as the determination of the generation rate.

2.18 Challenges of Solid Waste Management

The challenges of solid waste management, which affect solid waste collection, disposal and transportation activities, are the following:

2.18.1 Financial Challenges

Medical solid waste management is given low priority in developing countries; as a result, very limited funds are allocated to the sector by governments. This problem is acute at the local government level where the local revenue collection system is inadequately developed and the financial base for public services including medical solid waste management is weak. In addition to limited funds, many local governments in developing countries lack good financialmanagement and planning. Lack of financial management and planning, particularly

cost accounting depletes the limited resources available for the sector even more quickly and causes medical solid waste management services to halt for some periods, thus losing the trust of service users. Information obtained from the interview revealed that the problem of finance is very acute. Information obtained from the interview revealed that the problem of finance is very acute. There is an inadequate and equal distribution of annual budgets for all the sectors. Therefore, the factors that influenced MSWM in the hospital for the ineffective service delivery were the shortage of finance. (Zurbrugg and Christian, 2003); and (GebrieKassa, 2009).

2.18.2 Lack of Public Awareness and Attitudes

Public awareness and attitudes to waste can affect the medical solid waste management system. All steps in municipal solid waste management starting from household waste storage, to waste segregation, recycling, collection frequency, willingness to pay for waste management services, and opposition to sitting of waste treatment and disposal facilities depend on public awareness and participation. Thus, lack of public awareness and school education about the importance of proper solid waste management for the health and well-being of people severely restricts the use of 17 community-based approaches in developing countries and is a crucial factor for failure of a solid waste management practice in developing countries (Zerbock, 2003).

Therefore, the lack of public awareness and attitude creation was another challenge for municipal solid waste management in the town. The majority of households were not well informed about the consequences of poor solid waste handling and disposal methods. The survey result shows that awareness creation by the municipality of the town on solid waste management is very low. As shown in Table 16, the majority of households (83.1 %) reported that they did not have any awareness or education concerning solid waste management.

2.18.3 . Low Level of Implementation of Rules and Regulation

The study found that the lack of adequate legislation makes it difficult to assign clear mandates to different sectors connected with waste management services. The rules and regulations and their implementation program in the town were weak. On the other hand, there was little effort made to create awareness about solid waste management in the community including the rules and regulations and associated penalties.

2.19 Policy Related Issues Regarding Solid Waste Management

To fully understand current waste management practices and their effects, it is important to examine the legal system that governs waste. Ethiopia follows a civil law pattern where laws are written by legislators instead of mandated by judges.

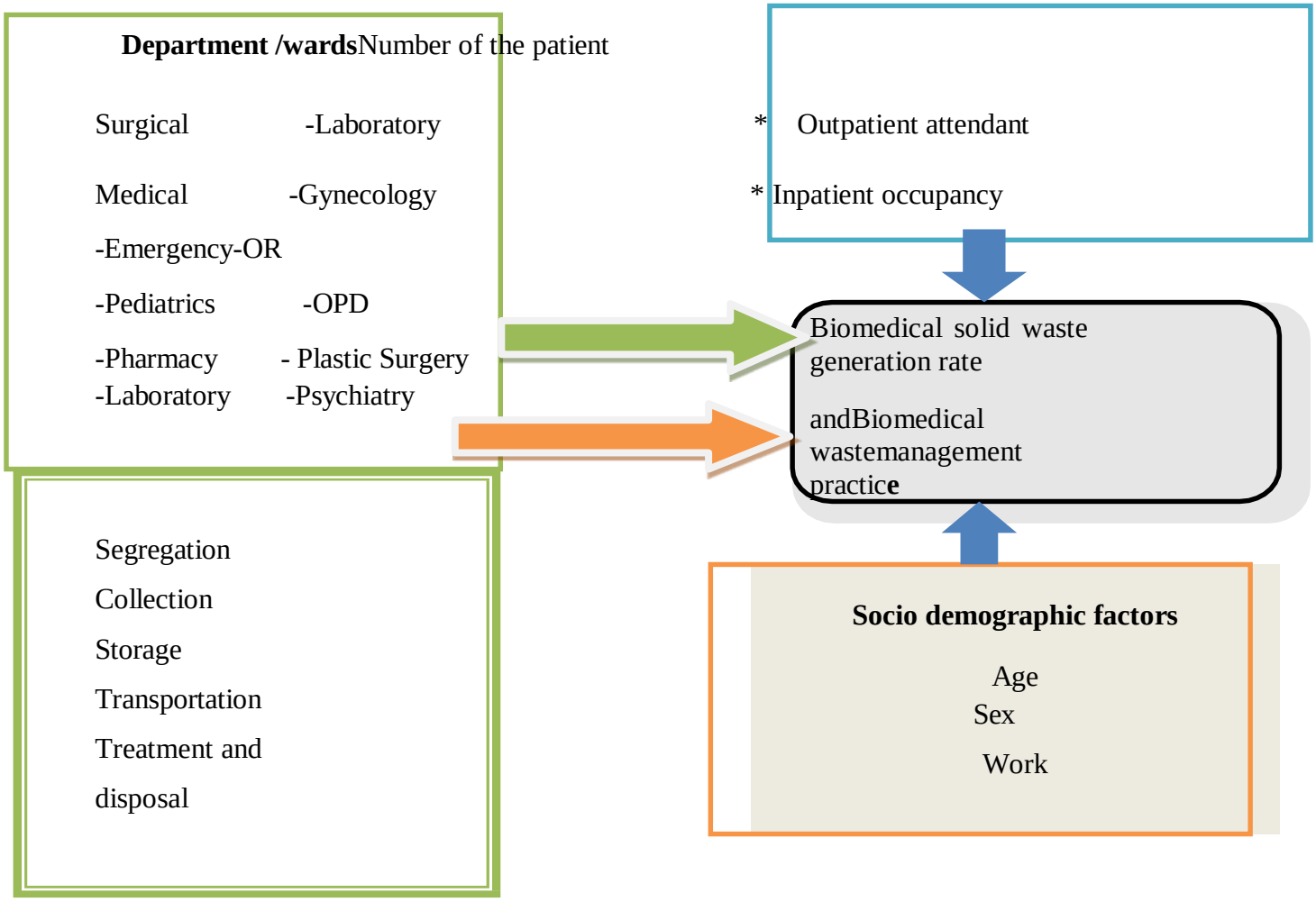
In terms of environmental law, “Ethiopia’s Constitution is the most important source of environmental law”. The bases for the Environmental Policy of Ethiopia are articles 92.1 and 92.2 of the Constitution of the Federal Democratic Republic of Ethiopia: “Article 92.1: “Government shall endeavor to ensure that all Ethiopians live in a clean and healthy environment”; Article 92.2: “Government and citizens shall have the duty to protect the environment” (Forum for Environment, 2010)”. The Environmental Policy of Ethiopia refers to solid waste management in three different articles, either directly or indirectly: - “Article 3.7 addresses issues related to human settlement, urban environment, and environmental health; Article 3.8 addresses issues related to the control of hazardous materials and pollution from industrial waste; and Article 3.9 addresses atmospheric pollution and climate change”.

The primary national policy on waste management is Solid Waste Management Proclamation No. 513. Released in February 2007, the proclamation’s main goal was to increase community participation. The proclamation states: - “It is essential to promote community participation to prevent the adverse effects and to enhance the benefits resulting from solid waste; and solid waste management action plans designed by, and implemented at, the lowest administrative units of urban administrations can ensure community participation (Proclamation No. 513, 2007).

2.20 Conceptual Framework of the study

According to the review literature, the rate of biomedical solid waste generation is directly affected by the number of patients (the number of patients is determined by the type of service). Furthermore, the rate of biomedical solid waste generation can be affected by healthcare facility waste management practices, such as the presence of waste recycling practices and the proportion of disposable substance use in healthcare activities, which directly affect the amount of waste generated.

***Figure 2*: conceptual frame work showing the relation between factors affecting biomedical solid waste generation rate and its management practice 2023.**



CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1 Description of the study area

3.1.1 Location

The study was conducted in Werabe town, situated in the Site Zone of the southern nations, nationalities, and Peoples Region (SNNPR) of Ethiopia. Werabe is approximately 172 km south of Addis Ababa, the country's capital, and 200 km northwest of Hawassa, the capital of SNNPR. The town is bordered by Dalochaworeda to the south, Hulebargeworeda to the west, Alichoworeda to the north, and Silitiworedas to the east. The estimated population of the town is 65,045, with 35,750 males and 29,295 females. Geographically, Werabe is located between 7° 48'04" and 7° 55'15" N latitudes and 38° 08'42" to 38° 13'42" E longitudes. (Data sourced from the Werabe administration office in 2021)

3.1.2 Topography, climate and soil

The agroecology of Werabe features Dega 27.5%¸ Weyinadega 65.3% ¸ Kola 3 % climate with a topography that includes mountainous (hill area), rugged terrain, and other characteristics. The altitude in these areas ranges between 1900-3000m a.s.l. Various types of soil can be found in the area, such as black, grey, red, and others. The average rainfall is 641 mm, and the average temperature ranges from 14.8°C (58.6 °F) Abdo, H., Muluye, D., Mehamed, S. (2023).

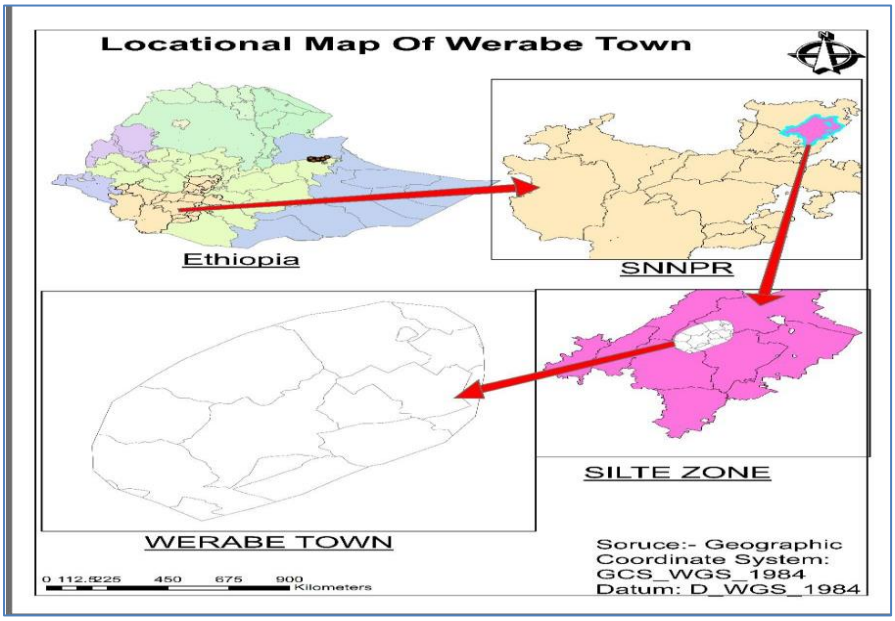
3.1.3 The study area

This study was carried out at Worabe Comprehensive Specialized Hospital (WCSH), established in late 2006 E.C. In May 1999, the Siltie Development Association (SDA) initiated plans to establish a new hospital in the capital city of Siltie Zone, Worabe Town, due to the absence of any hospitals in the zone at that time. Around 85% of the community seeking healthcare had chosen to go to Butajra and HossnaNigestEline Hospital due to patient feedback and maternal and child deaths resulting from the lack of a hospital. The construction costs were covered by a combination of community participation and government funding.

The hospital was specifically designed, constructed, and operated to meet high quality medical care standards. It was completed between 2002 and 2006 E.C., with a total surface area of approximately 16 hectares (160,000m2). This facility is located 172 KM away from Addis Ababa and 180 KM from the regional capital of Hawassa in SNNPR.

The hospital was engaged in providing diagnostic and medical treatment to inpatients, while also offering other services, such as Outpatient; laboratory services, pharmacy services, cafeteria, emergency delivery, etc. Data from the hospital recorded data in 2015; currently, the hospital has a total of 306 beds and serves 355,875 patients per year; where 313,170 patients are Outpatients and also had greater than 658 & 516 clinical & supportive staffs respectively.

Figure 3 Location map of the study area.



Source: Adapted from Ethio-GIS and Werabe town Plan (2021)

3.2 Research design

This study uses a descriptive research design. It indicates that a descriptive research design was used to develop theory, identify problems with current practice, justify current practice, make judgments, or identify what others in similar situations may be doing. This method was selected because it is easy to administer questionnaires and it saves time.

In addition, the observation method was also used, particularly in all departments of WCSH, to see how HCWM would take place in the field.

3.3 Data source

The major source of data includes raw information gathered from the field, which constitutes the primary source of data. To supplement the primary data information derived, there is a secondary source that includes various articles, books, publications on solid waste management, and accredited past project work of other researchers that attempts to investigate the socio-economic factors influencing the management of solid waste in Werabe town. The information was collected from primary and secondary data sources. The primary data for the study was collected from health worker subordinate staff and key informant interviews. The secondary data was collected from published and unpublished written documents.

3.4 Methods of data collection

Data were collected using three approaches: a survey, on-site inspections, and detailed interviews. The study included gathering primary and secondary data on-site between September 11 and December 17, 2023, concentrating on different facets of medical waste handling. Primary data comprised specifics regarding the origins and makeup of municipal solid waste (MSW) as well as the existing condition of MSW handling, encompassing production, sorting, conveyance, gathering, and elimination. Secondary data encompassed details on existing amenities, bed capacities, occupancy rates for inpatients, and organizational setup.

All departments and sections within healthcare facilities were randomly assessed to characterize and quantify healthcare waste (HCW) generation. HCW was collected and weighed twice daily for seven consecutive days using a balance to account for daily fluctuations. Different waste types were placed in labeled plastic bags, with daily weight measurements recorded. An observational checklist was used to monitor daily waste generation rates and assess the effectiveness of the management system in segregating, collecting, transporting, and treating HCW. Solid wastes from medical departments, wards, operation rooms (OR), and outpatient departments (OPD) were categorized as hazardous or non-hazardous waste based on potential risks.

Hazardous waste included infectious materials like sharps, while non-hazardous waste comprised general items such as paper and plastic bottles. These categories were weighed separately, and the results were documented. Primary data were collected through interviews with key informants, survey questionnaires, waste generation surveys, and field observations, combining these methods to enhance the study's comprehensiveness.

I initially inspected all wards and departments at Werabe Comprehensive Specialized Hospital (WCSH) to identify waste types. Different-colored plastic bags, in line with national guidelines, were allocated to WCSH departments based on waste type for characterization following the 2008 National Healthcare Waste Management Guidelines. Buckets and bags were labeled to show waste categories, generation locations, collection dates, and times. Medical solid waste quantity was determined by weighing waste from all wards over seven days using a calibrated balance. The current medical solid waste management system at WCSH was assessed via semi-structured interviews with the waste management committee and an observational checklist based on Ethiopian Food Medicine and Healthcare Administration and Control Authority (FMHACA) guidelines for healthcare waste management in facilities.

3.4.1 Sampling Methods

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3.4.2 Materials and Instruments

During the study time the following listed materials and equipment were used

1. Hand protective plastic gloves;
    - To protect hand from direct contact with dirt.
2. Mouth &Nose Mask;
    - To protect one from bad smells and the inhalation of fumes.
3. Wood boxes(with different types of volume)
    - For volume measurement

4. Balance the scale

    - For weight measurement of collected samples of waste

5. 25 mm and 20 mm wire mesh

    - For particle size determination

6. Plastic sheets

    - To ensure no loss of waste during sorting

7. Different types and colours of plastic bags

    - For the collection of solid waste from each household

8. Trash bags

    - For handling the collection of plastic bags

9. Audio and video cameras

    - For recording capturing pictures of the working process

3.5 Sample size and sampling procedure

In order to obtain statistical significance, an optimal sample size needs to be obtained in research (Owino, 2013). The following Slovin's formula was therefore used to determine the sample size for the current study, as shown below:

$n= \{ N / (1 +Ne^2) \}$

Where n= number of samples

N= total population

e= 0.05 (margin of error)

$n= \{ 1050/ (1 +1050*0.05^2) \}$

n = 290 management personnel

The formula had been used successfully by Noor (2014), where a precision of 10% was used to come up with a representative sample size. It is also in agreement with Krejcie and Morgan's formula, which also gives almost the same sample size. With a precision of 10%, the sample is almost what is proposed by Jankowicz (2012), indicating that 30% of the population gives a representative sample for the study.

Finally, the research was concerned with 154 medical staff (nurses and paramedical staff), 129 subordinate staff (waste collectors), and 7 key informant interviewers (managers and selected staff) working at Werabe Comprehensive Specialized Hospital. Figure 1 gives the number of participants in this study, and Table 1 shows the responses of respondents by considering their services or departments. This shows that the sample was mainly composed of health workers, with a proportion of 53.10% of the whole sample.

Table 4 population and Random sample size Repartition of respondents per department

	Departments	Hospital care workers			Total
		Medical Staff	subordinate staff (Cleaners & Administrative staffs)	Key informant interviewers	
Service	Emergency	10	4	----	14
	Medical Ward	21	4	----	25
	Surgical Ward	21	4	----	25
	Delivery	15	4	----	19
	Paediatrics Ward	15	5	----	20
	Gynaecology Ward	15	4	----	19
	Orthopaedics Ward	15	4	----	19
	Plastic Surgery Ward	5	3	----	8
	Forensic Medicine	2	4	----	6
	OPD	15	4		19
	OR	10	4	----	14
	Laboratory	10	1		11
	Administration	----	84	7	91
Total		**154**	**129**	**7**	**290**

3.6 Methods of data analysis

The analysis of the study was descriptive, which combined qualitative and quantitative data. After the necessary information was gathered, the data was analyzed and presented using different statistical tools such as tables, graphs, and percentages that reflect the true nature of the information collected from respondents. The quantitative data was analyzed using statistical tools such as tables, graphs, and percentages. The qualitative data was analyzed using narration.

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1 RESULT

4.1.1 Background information about the respondents

Ten aspects of demographic profiles appeared in the first section of the questionnaire. The demographics of the respondents may have influenced the findings and, therefore, it was necessary to establish their profiles. The results of questions relating to the following aspects of their profiles are covered.

Hospital staff have different background information and are considered as important in this study. Hospital staff's working period and experiences that he/she has along with their qualification and educational level or background are some of the most important things in the health care process.

This general information is presented in the form of tables.

Age bracket of the Respondent

The respondents were further asked to indicate the age bracket to which they belong. Their responses were as shown in Table.5.

Table 5 Age of the Respondent

	Frequency	**Percent**
18-26 years	110	37.9
27-38 years	164	56.6
39-50 years	16	5.5
51-60 years	0	0
Above 60	0	0
Total	**290**	**100**

The results indicate that the majority of the participants were in the age range of 27 to 38 years, accounting for 56.6% of the total sample. 37.9% of the respondents were between 18 and 26 years old, while only 5.5% were aged between 39 and 50 years. This suggests that the majority of the participants were mature enough to provide reliable information about the subject matter and were cooperative during the study.

Gender bracket of the Respondent

The respondents were requested to indicate their gender. Their responses were as shown in Table 6:

Table 6 Gender of the Respondent

	Frequency	**Percent**
Male	176	60.7
Female	114	39.3
Total	**299**	**100**

The results showed that the majority of respondents were male as shown by 60.7 % while the rest were female as shown by 39.3 %. This shows that the researcher considered all respondents irrespective of gender to obtain reliable information concerning the subject under study.

Respondents Level of Education

The respondents were asked to indicate their highest level of. Their responses are presented in table 7:

Table 7 Respondents Level of Education

	Frequency	**Percent**
No formal education	**0**	**0**
1-8 Grades complete	**35**	**12.1**
9-12 Grades complete	**27**	**9.3**
Certificate and above	**228**	**78.6**
Total	**290**	**100**

According to the study, a significant 78.6% of participants had attained a Certificate or higher level of education, while 9.3% had completed Grades 9-12, and 12.1% finished Grades 1-8. It is worth noting that none of the respondents reported having no formal education. These findings indicate that the majority of participants possessed a strong academic background, allowing them to provide reliable and informed insights on the subject matter under scrutiny.

Table 8Marital status of the Respondent

	Frequency	**Percent**
Not married	**105**	**36.2**
married	**174**	**60.0**
Divorce	**11**	**3.8**
Total	**290**	**100**

As for the Marital status of the Respondents, it is found through this study that 174 (60%) of the Respondents are married 105 (36,2%) are Not married and 11 (3.8%) are Divorced. This indicates that married people prefer this profession because of the need to spend on their families

Table 9 Family size of the Respondent

	Frequency	**Percent**
1-4 family member	**198**	**68.3**
5-8 family Member	**85**	**29.3**
9-12 family member and above	**7**	**2.4**
Total	**290**	**100**

This table shows the number of family members for the respondents. 68.30% (N=198) reported having 1-4 family members, 29.30% (N=85) reported having 5-8 family members, while only 2.40% (N=7) reported having 9-12 family members or more.

Table 10 Employment status of the Respondent

	Frequency	Percent
Permanent	**188**	**64.8**
Temporary	**102**	**35.2**
Total	**290**	**100**

This insightful figure illustrates that an overwhelming majority of 64.8% (N=188) of respondents have secured permanent employment, whereas 35.2% (N=102) are still in theprocess of finding a more stable footing with temporary employment. It's clear that a permanent job is the way to go to ensure long-term financial stability and career growth.

Period at the hospital.

The respondents were also requested to indicate the number of years they had been in the hospital. Their responses were as shown in table 11.

Table 11 Work experience in the hospital

	Frequency	Percent
< 1 Year	**70**	**24.1**
1-5 Year	**164**	**56.6**
6-9 Year	**56**	**19.3**
Total	**290**	**100**

As per the findings, 56.6 % of the respondents had been in the Hospital for 1-5 years, 24.1% were in the Hospital for Less than 1 year, 19.3.6% were in the Hospital for Less than 1 year for 6-9 years. This shows that the majority were in the Hospital for long enough to comprehend and give reliable and accurate information on the subject under study.

Table 12 Work experience in management

	Frequency	Percent
< 1 Year	**3**	**13.6**
1-5 Year	**5**	**22.7**
6-9 Year	**14**	**63.6**
Total	**22**	**100**

Out of the respondents, 63.6% had worked in management for 6-9 years, 22.7% had worked for 1-5 years, and 13.6% had worked for less than a year. This indicates that the majority ofrespondents had sufficient experience in management and were capable of providing dependable and precise information on the topic being studied

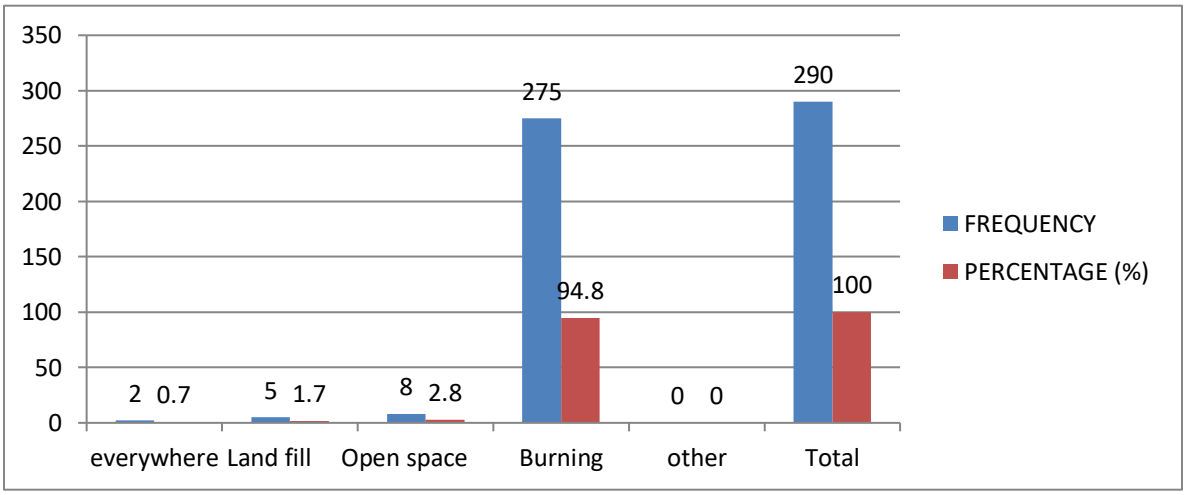
Provision of protective equipment

All participants in this study reported that they have been provided with protective equipment against potential risks associated with healthcare waste management (HCWM), including masks, gloves, boots, and uniforms or aprons. It is essential to note that the lack of suitable and sufficient protective equipment, along with inadequate knowledge regarding the correct usage of equipment and the benefits of using protective equipment, increases the risk of potential health effects for personnel, such as infections and respiratory infections (WHO, 2005). A survey showed that most healthcare workers involved in HCWM did not wear masks during their daily activities, but a significant percentage was familiar with gloves and uniforms or aprons. It was also observed that medical staff was not provided with masks and specific shoes (sandals & boots) except for special services such as the operation theatre and gynecology-obstetrics service. Occasionally, the waste collectors were observed wearing uniforms, gloves, and boots while cleaning.

4.1.2 Staff Survey Questionnaires

The below table presents categories of respondents' knowledge and there is a variation on their knowledge about dealing with medical waste and their views were considered important for this study. 290 participants fully responded to the questionnaire and obtained the following.

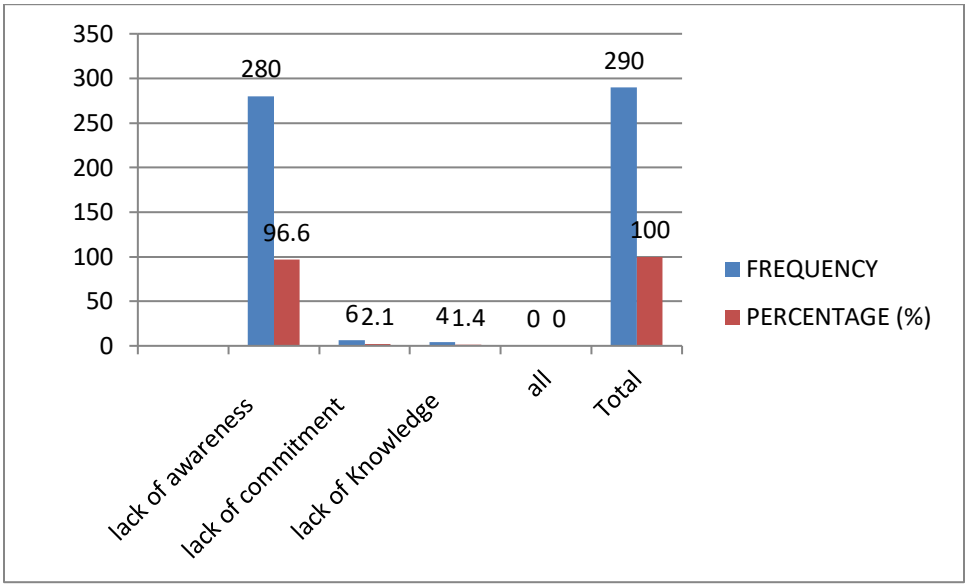
Figure 4 Where is dumped Medical Solid waste that is generate from the hospital ?



As can be noted from Fig 4:All participants are able to identify Where is dumped Medical solid waste that is generated from the Hospital ? 100% (N=290) and 94.8% (N=275) of respondents have good knowledge of identification need to where is dumped Medical solid waste that is generated from the Hospital .

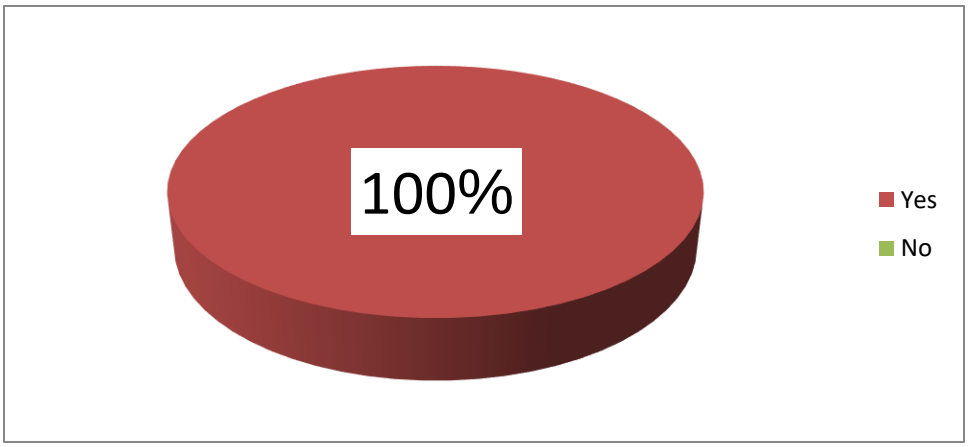
While 5.2% (N=15) are have not able to identify where is dumped Medical solid waste that is generated from the Hospital

Figure 5 If your answer is everywhere what is the reason ?



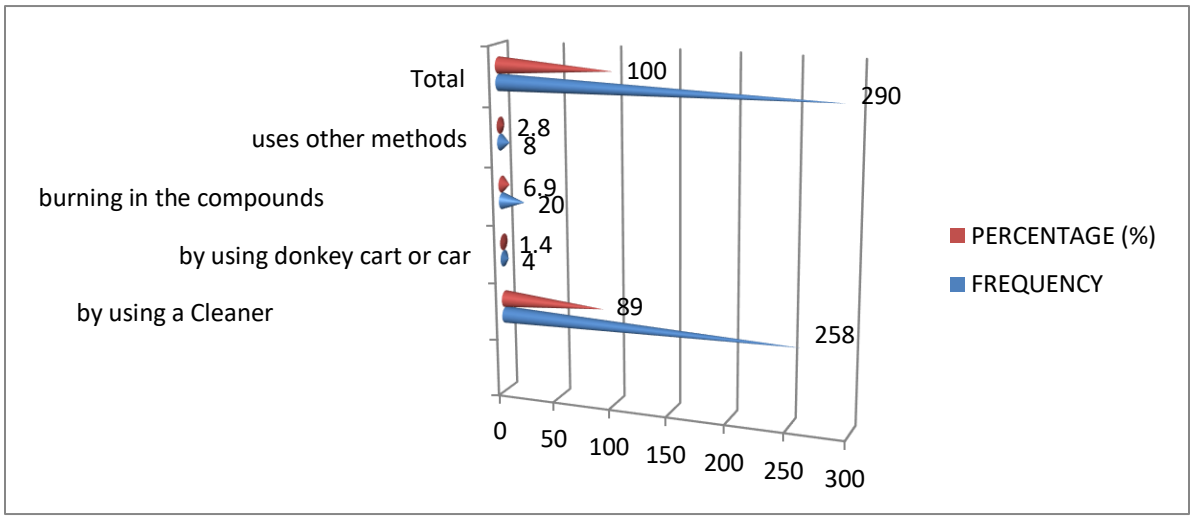
When respondents were asked about medical solid waste being thrown anywhere, 96.6% (N=280) out of 290 respondents responded with a lack of awareness, 2.1% (N=6) reported a lack of focus, and 1.4% (N=4) reported a lack of knowledge. These were their responses.

Figure 6 Do you have Medical Solid waste and disposal strategies in your hospital ?



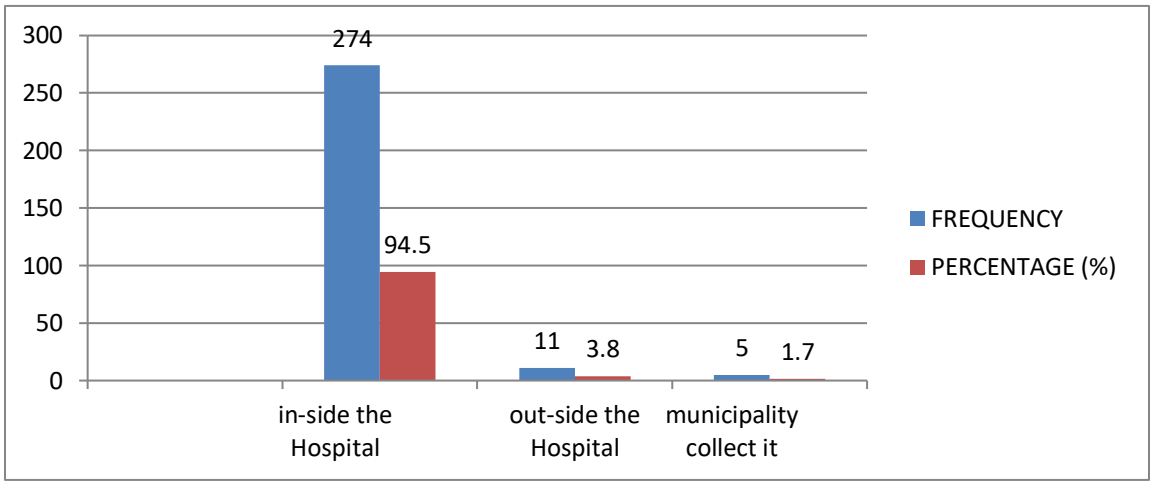
All of the respondents were able to answer the question, Do you have medical solid waste and disposal strategies in your hospital? 100% (N=290) answered yes. From this we understand that every employee knows about the presence of medical solid waste and disposal strategies in the hospital.

Figure 7 If your answer is yes what are the means of collection and transportation mechanisms ?



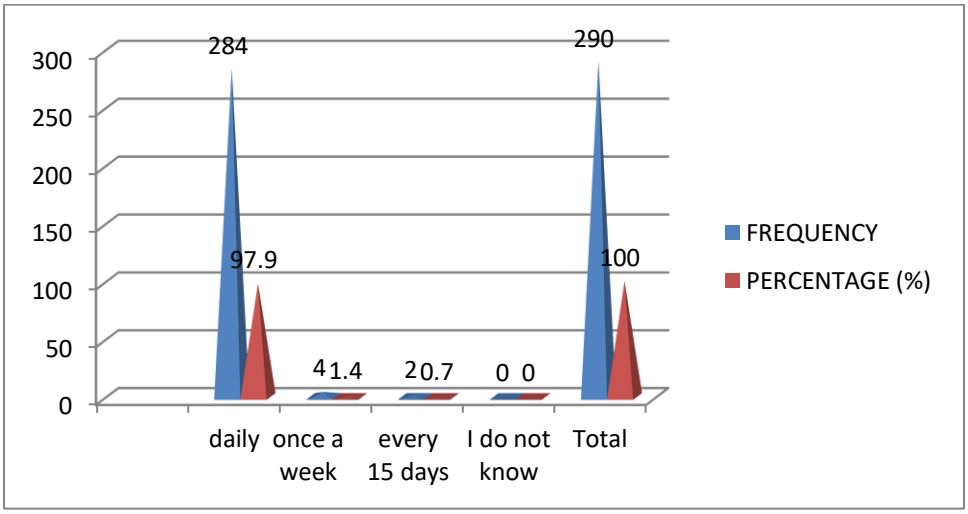
"What are the various methods used for collecting and transporting waste data? Out of the total respondents (N=290), 89% (N=258) reported using a cleaner, such as a vacuum truck or a mechanical sweeper, for waste collection and transportation. 6.9% (N=20) reported burning the waste on the compounds, which is not an environmentally friendly method. 2.8% (N=8) reported using other methods, such as manual cleaning or using a wheelbarrow. Finally, 1.4% (N=4) reported using a donkey cart or car for waste collection and transportation, which is more common in rural areas."

Figure 8 Where are you incinerating Medical Solid wastes which is generate from your Hospital ?



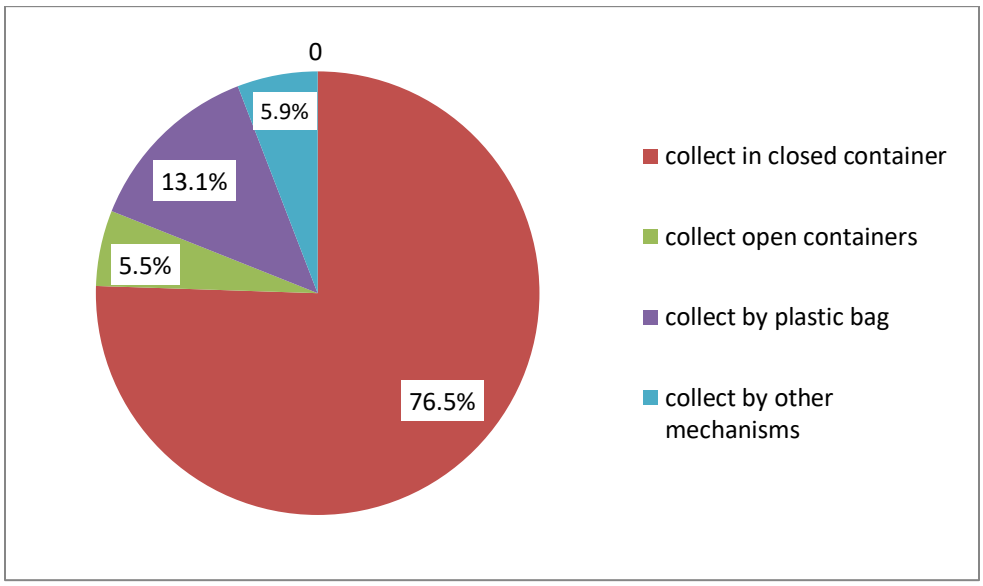
Findings from a survey conducted among hospitals reveal that a significant proportion (94.5% or N=274) of them incinerate medical solid waste within their premises. A smaller number of hospitals (3.8% or N=11) incinerate medical solid waste outside the hospital, while an even smaller number (1.7% or N=5) have arrangements for the municipality to collect such waste. These results suggest that a majority of hospitals prefer to handle medical solid waste internally, with only a small minority relying on external collection services.

Figure 9 The frequency of Medical solid waste burning practices ?



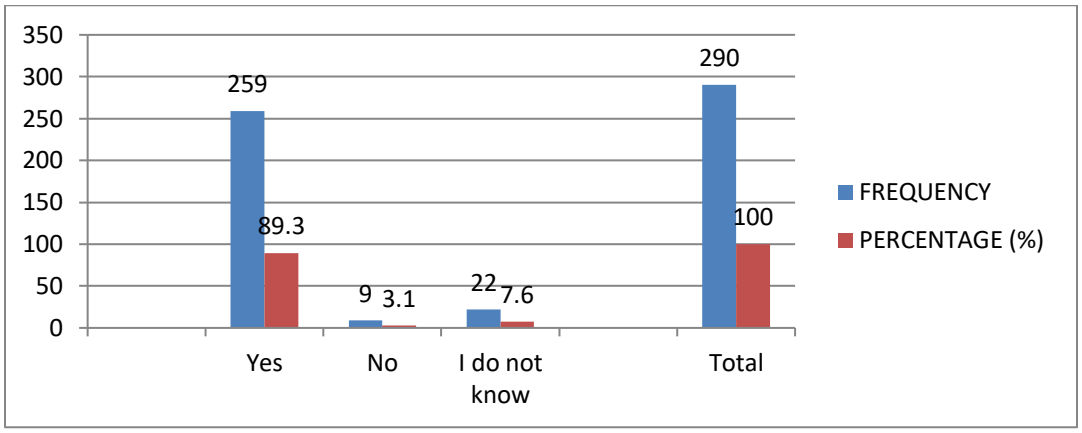
The findings of the study indicate that the facility in question efficiently disposes of medical solid waste predominantly through incineration. This process occurs on a daily basis at an impressive rate of 97.9%, weekly at 1.4%, and every 15 days at 0.7%, as reported by reliable hospital sources.

Figure 10 How to manage or handle Medical solid waste which are generated from your hospital ?



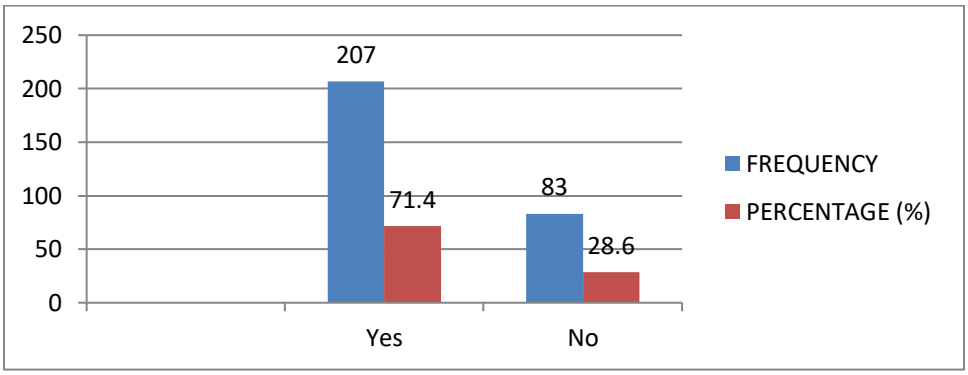
Seventy-six point five percent of the respondents, totaling two hundred and nineteen, indicated that they collect medical solid wastes in closed containers. Furthermore, thirteen point one percent, with a total of thirty-eight respondents, reported using plastic bags for waste collection. A mere five point nine percent, comprising seventeen respondents, utilize alternative methods for waste collection, while five point five percent, totaling sixteen respondents, prefer open containers.

Figure 11 Do you agree improper medical solid waste disposal practices affect environment, human life and the ecology?



According to a survey, 89.3% of the respondents agreed that improper disposal practices of medical solid waste can have adverse effects on the environment and human life. On the other hand, 29.7% of respondents disagreed, and 1.0% claimed they did not know. Almost half of the respondents (89.3%) believed that medical waste management should be improved to prevent any negative impacts on the environment and public health.

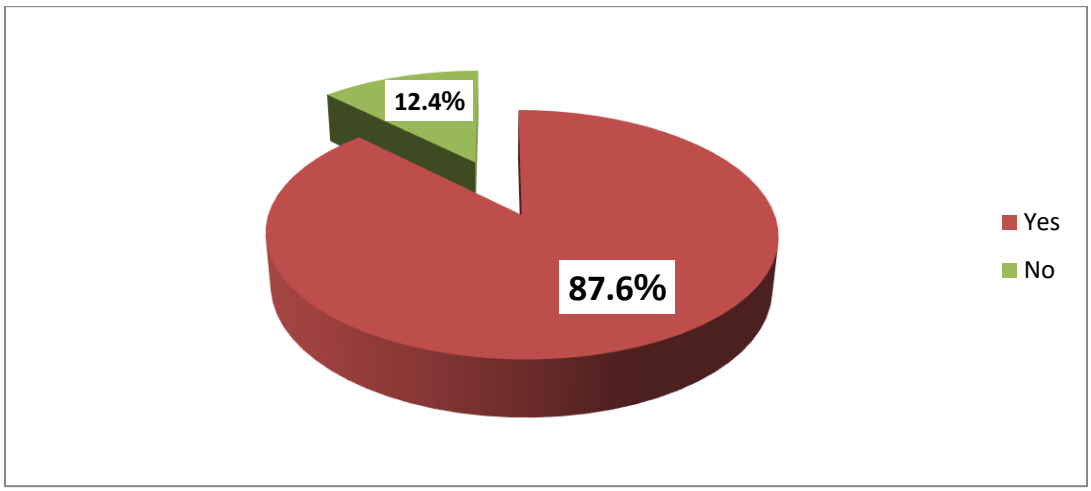
Figure 12 Do you know about the rule and regulations with regarding to medical solid waste management ?



The presented data illustrates that 71.4% (N=207) of the respondents confirmed their familiarity with the regulations and guidelines governing the management of medical solid waste, while 28.6% (N=83) revealed a lack of knowledge in this area. The results of this survey shed light on the level of awareness among the surveyed individuals regarding the legal framework and guidelines pertaining to the disposal of medical solid waste. It is imperative for organizations and

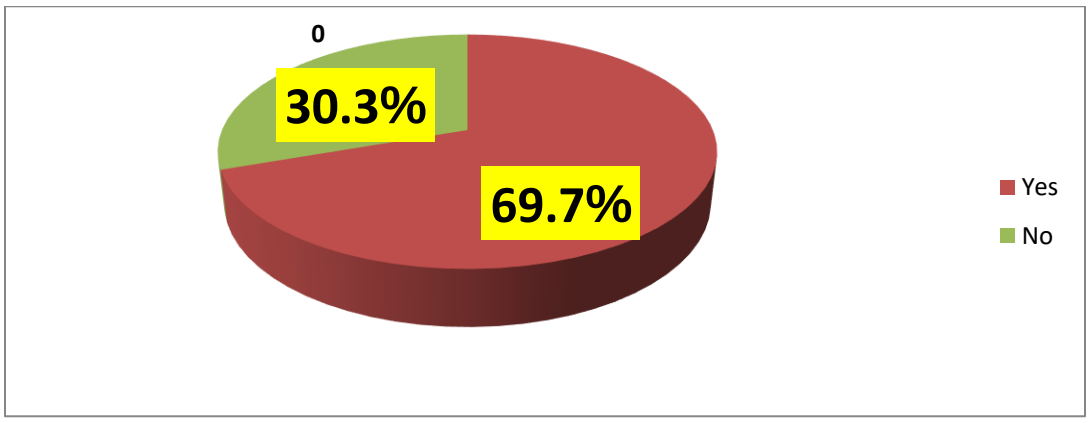
individuals handling medical waste to have a comprehensive understanding of the regulations to ensure compliance with the legal requirements and to promote safe and effective waste management practices

Figure 13The institutional arrangement of Werabe Hospital on medical solid waste management and disposal activity are effective ?



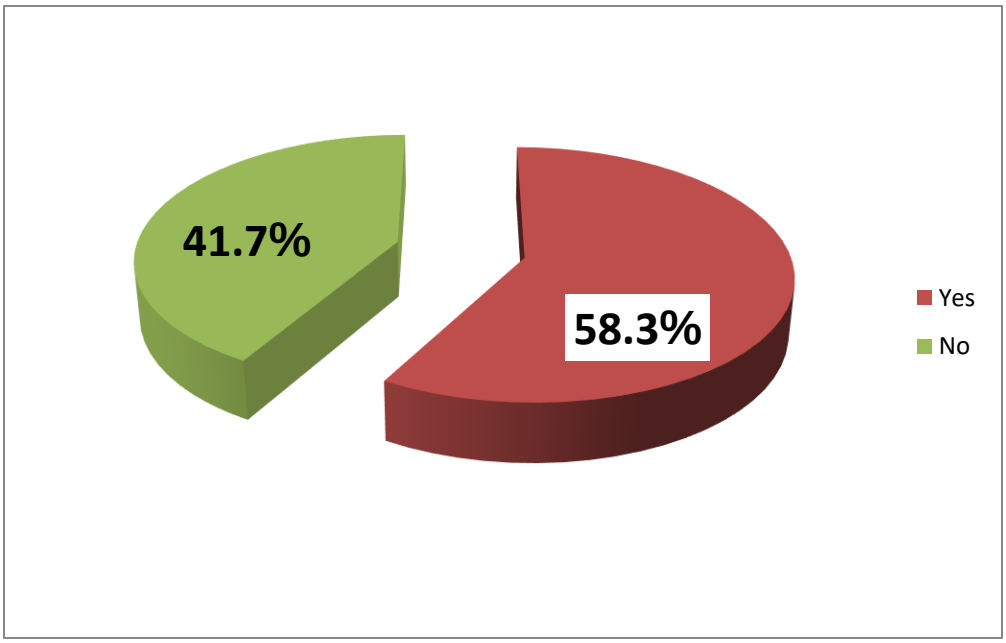
In the illustration presented in Figure 13, it is evident that 87.6% of the participants acknowledge the efficacy of the institutional framework at Werabe Hospital in handling and disposing of medical solid waste. Conversely, a minority of 12.4% (N=36) hold a differing perspective on this matter.

Figure 14 Do you know the workers about the rule and regulation medical solid waste disposal practices ?



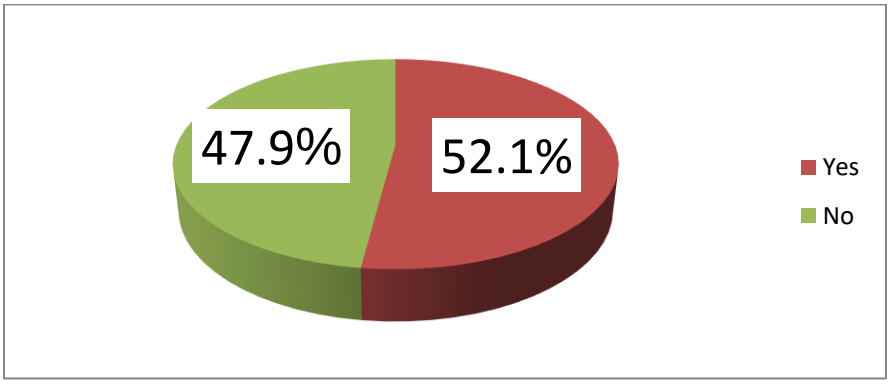
Based on the information provided in Fig 14, it is evident that 69.7% (N=202) of the respondents understand the rules and laws regarding the proper disposal of medical solid waste. On the other hand, 30.3% (N=88) do not understand these rules.

Figure 15 Do you believe that the werabe city municipality's environmental beauty and cleanliness parking offices are working in coordination with the hospital in terms of medical solid waste management and disposal ?



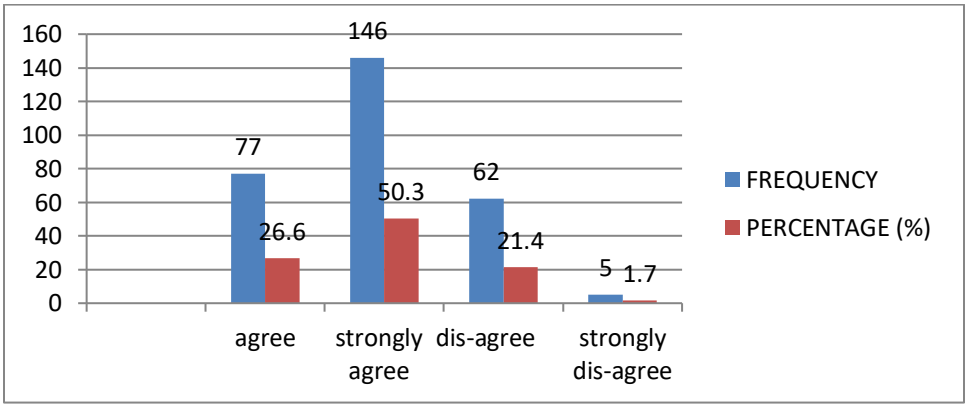
The findings indicate that a significant proportion of respondents, specifically 58.3% (169 individuals), expressed confidence in the alignment between the environmental aesthetics and cleanliness of parking facilities in the Warabe metropolis municipality and the corresponding infrastructure for managing and disposing of medical solid waste at the hospital. Conversely, 41.7% (121 individuals) did not subscribe to this perspective.

Figure 16 Do you know negative impact of the illegal medical solid waste disposal practices ?



In the illustration presented in Figure 16 above, it is observed that 52.1% (N=151) of the respondents demonstrate awareness regarding the adverse consequences associated with the improper disposal of medical solid waste, whereas 47.9% (N=139) indicate a lack of awareness on this matter.

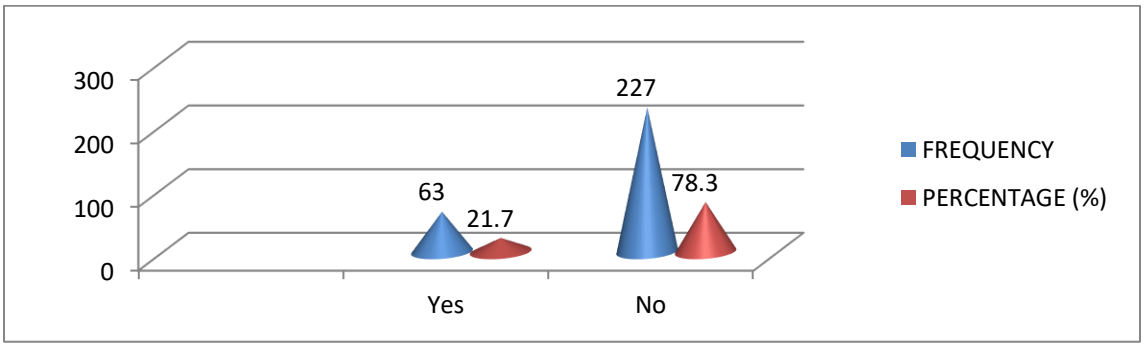
Figure 17 Do you agree the community participate in medical solid waste management and disposal practices are low ?



Source: Computed from survey data, 2023

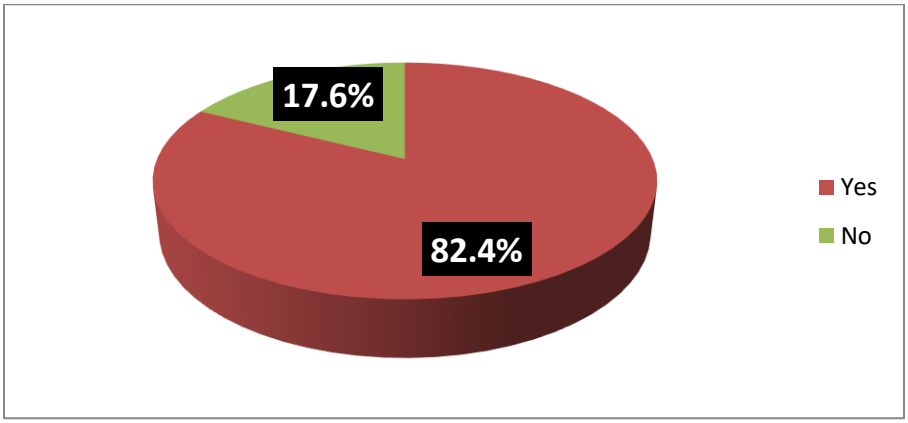
Based on the information presented in Figure 17 concerning community involvement in the management and disposal of medical solid waste, it is noted that a significant portion of the participants expressed strong agreement, with 50.3% (N=146) strongly concurring, 26.6% (N=77) in agreement, 21.4% (N=62) in disagreement, and a mere 1.7% (N=5) strongly expressing disagreement.

Figure 18 Is any private sector which is , participate on medical solid waste collection, transportation ,and dumping activity in Hospital ?



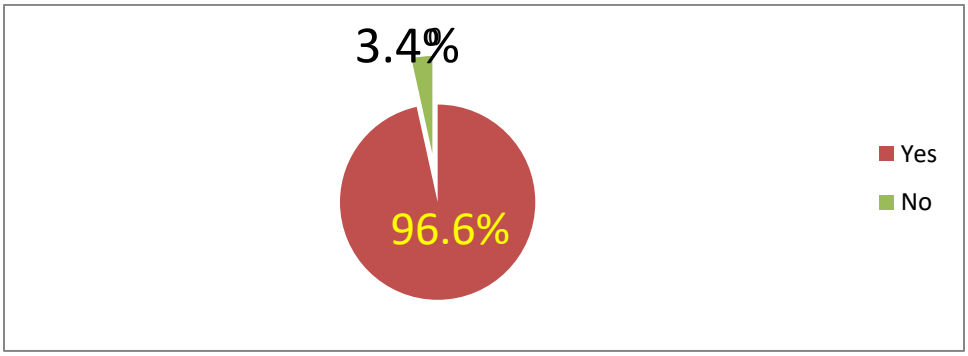
According to the information presented in Figure 18, a significant majority of respondents, comprising 78.3% or 227 individuals, expressed that there is no involvement of private sector entities in the management of medical solid waste within hospital premises. Conversely, 21.7% (63 individuals) held a differing viewpoint on this matter.

Figure 19 Are the following materials like transportation car, waste bins and other equipment's are available in your Hospital ?



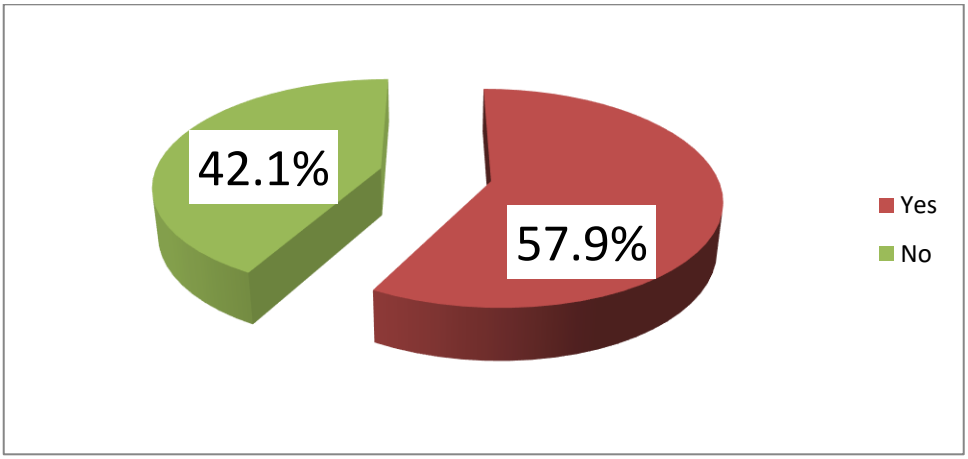
In Figure 20, respondents of the survey were inquired about the availability of materials such as transportation vehicles, waste receptacles, and other equipment within their healthcare facility. The data revealed that a significant majority, constituting 82.4% (N=239), affirmed the presence of these resources, whereas 17.6% (N=239) indicated their absence.

Figure 20 Is medical solid waste bins available in the departments of your Hospital?



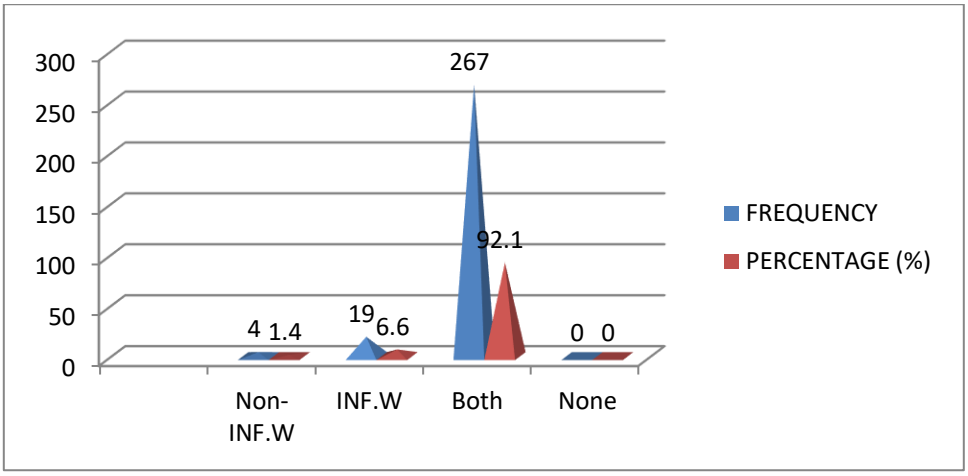
As per the data presented in Figure 20, respondents of the survey were queried regarding the presence of medical solid waste receptacles across different sections of the hospital. The results revealed that 96.6% (N=280) affirmed the availability, while 3.4% (N=10) negated its presence.

Figure 21 Does the Hospital's environmental Health care department enforce rules and regulations when solid waste is misplaced ?



Based on Figure 21, the data indicates that a majority of participants, precisely 57.9% or 168 individuals, provided affirmative responses. Conversely, 42.1% or 122 respondents expressed negative viewpoints. This dataset holds significance as it provides valuable insights into the perspectives and sentiments of the surveyed individuals.

Figure 22 What is the type of MSW generated in your Hospital ?



According to the survey results, 92.1% of the respondents indicated that both non-infectious and infectious wastes are generated to a great extent in WCSH. Additionally, 6.6% of the respondents reported that infectious waste is generated to some extent, while 1.4% indicated that non-infectious waste is generated to some extent. These findings clearly indicate that medical solid waste is generated in the Hospital.

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Table 13 The amounts of wastes generated in different wards of WCSH

Ward	Total amount waste	Date (From Sep 11up to Sep 17 2023)														Total	
		Monday Sep.11-2023		Tuesday Sep.11-2023		Wednesday Sep.11-2023		Thursday Sep.11-2023		Friday Sep.11-2023		Saturday Sep.11-2023		Sunday Sep.11-2023			
		Patient	Kg	Patient	kg	Patient	kg	Patient	kg	Patient	kg	Patient	kg	Patient	kg	Patient	kg
Emergency	General	36	12	48	10	45	11	37	9	26	9	39	13	40	14	271	78
	Infectious		4		2		4		4		3		4		5		26
	Hazardous		2		1		1		1		1		2		2		10
Medical Ward	General	47	9.5	46	8	46	10	57	11	53	8	55	12	58	13	362	71.5
	Infectious		2.5		3.5		3		3.5		2		4		5		23.5
	Hazardous		2.5		3		3		4.5		3		3		2		21
Surgical Ward	General	29	8	25	6	31	9	23	6	23	7	22	9	23	10	176	55
	Infectious		3		4		3		4		3		3		3		23
	Hazardous		7		5		8		7		6		5		3		41
Delivery	General	20	10	7	11	19	12	8	11	20	9	18	12	9	14	101	79
	Infectious		2.5		3		3		2		2		3		4		19.5
	Hazardous		6		5		7		7		5		6		5		41
Pediatrics Ward	General	30	14	31	12	33	15	27	13	21	13	17	16	12	17	171	100
	Infectious		5		5		5		4		4		6		6		35
	Hazardous		4		3		2.5		4		4		5		3		25.5
Gynecology Ward	General	14	23	17	18	16	21	20	25	24	21	28	26	22	27	141	161
	Infectious		10		9		11		10		9		11		12		72
	Hazardous		6		5		6		5		6		5		6		39
Orthopedics Ward	General	12	23	13	21	14	20	13	20	14	22	15	25	20	28	101	159
	Infectious		6		6.5		7		6		7		8		9		49.5
	Hazardous		3		2		5		4		3		3		3		23
Plastic Surgery Ward	General	16	7	21	5	25	4	25	6	23	5	21	9	21	10	152	46
	Infectious		4		5		3		4		4		6		7		33
	Hazardous		2		2		1		1		2		2		1		11

Ward	Total amount waste	Date (From Sep 11up to Sep 17 2023)														Total	
		Monday Sep.11-2023		Tuesday Sep.11-2023		Wednesday Sep.11-2023		Thursday Sep.11-2023		Friday Sep.11-2023		Saturday Sep.11-2023		Sunday Sep.11-2023			
		Patient	Kg	Patient	kg	Patient	kg	Patient	kg	Patient	kg	Patient	kg	Patient	kg	Patient	kg
Forensic Medicine	General	3	2	0	2	0	3	0	2	5	2	0	2	0	4	8	17
	Infectious		3		4		3		3		3		3		3		22
	Hazardous		2		3		4		3		2		1		2		17
OPD & cafe	General	570	16	663	14	581	18	671	16	56	15	640	12	457	12	4142	103
	Infectious		4		5		6		4		4		3		4		30
	Hazardous		2		2		1		2		2		0		0		9
OR	General	24	7	23	8	21	6	22	5	18	6	19	4	24	3	151	39
	Infectious		5		4		6		4		5		4		5		33
	Hazardous		4		4		5		5		5		4		3		30
Laboratory	General	137	2	144	3	152	2	125	4	166	4	140	1	185	1	1049	17
	Infectious		9.5		5	“	8		7		6		5		7		47.5
	Hazardous		10		8		8		9		7		7		6		55
Total		938	**242.5**	**1038**	**217**	**983**	**244.5**	**1028**	**236**	**953**	**219**	**1014**	**244**	**871**	**259**	6825	1662

4.1.3 Estimation of the HCSW quantities generated at WCSH

The data presented in Table 13 depicts the average quantity of medical solid waste that underwent incineration over the course of a week, encompassing seven consecutive days. The results show that the HCSW facility generated an overall average weight of 237.43 kg per day of waste generated at HCSW.. As illustrated in Figure 21, the minimum quantity of combustible waste produced during the week was 217 kg/day, while the maximum amount weighed in at 259 kg/day. It is worth noting that these figures were obtained by averaging the quantities of medical solid waste that were incinerated, and as such, they reflect the facility's overall waste generation trends.

Table 14 Average weight of waste produced by WCSH per day

Number of wards	Total amount waste	Date (From Sep 11up to Sep 17 2023)							Total	**Average**
		Monday	Tuesday	Wednesday	Thursd	Friday	Saturday	Sunday		
		kg	kg	kg	kg	kg	kg	kg	kg	kg
	General	133.5	118	131	128	121	141	153	925.5	132.214
	Infectious	58.5	56	62	55.5	52	60	70	414.0	59.143
	Hazardous	50.5	43	51.5	52.5	46	43	36	322.5	46.071
	total	242.5	217	244.5	236	219	244	259	1662	237.43

The above daily average weights could help to estimate the total average weight of medical solid waste produced per year. The following calculations are an estimation of the amounts of medical solid waste produced in a year:

Estimation of the amount of medical solid waste production in tons per year

237.43 kg of medical solid waste per day

365 days x 237.43 kg = 86,661.95 kg/year

L kg= O.OOl ton (metric)

86,661.95 kg= (86,661.95 x 0.OO1) ÷ l kg=86.662 tons/year of medical solid waste.

Results gave an approximate weight of 87 tons/year of medical solid waste.

4.1.4 The Waste Generation Rate of the Hospital.

During the data collection period (within one week), a total of 6,825 patients availed themselves of health services at Werabe Comprehensive Specialized Hospital's health service delivery units. Specifically, 817 patients, or 11.97% of visitors, were admitted to the inpatient department (IPD), while 6,008 patients, or 88.03% of visitors, were treated at the outpatient departments (OPDs).

Within the span of a week, a total of 1662 kg of biomedical solid waste was generated. Of this amount, 19.404% (322.5 kg) was classified as hazardous waste or risk waste, while 24.909% (414.00 kg) was designated as risk waste. The remaining 55.686% (925.5 kg) was categorized as general waste.

The Werabe Comprehensive Specialized Hospital generates various types of hazardous waste, including sharps, infectious, pharmaceutical, and pathological (placenta and blood) waste. The quantity of waste generated amounts to 0.244 kg per patient per day. It is imperative that the hospital adopts appropriate measures to manage and dispose of this waste safely and effectively, in accordance with relevant regulations and guidelines. Failure to do so may result in serious health and environmental consequences, as well as regulatory sanctions and reputational damage.

The present study sought to measure the daily, monthly, and annual total waste generation rates in a given context. Our findings indicate that the daily rate of waste generation was 0.244 kg/pt/day, while the monthly rate was 237.9 kg/pt/month. The annual total waste generation rate was 2854.80 kg/pt/year, and the monthly rate was consistent with this figure. These findings provide valuable insight into the waste management practices of the studied context and can inform future efforts to reduce waste production and improve sustainability. (Table 14)

Table 15The types of waste and their generation rate at WCSH

Waste category	(kg)	Percentage (%)
General	**925.5**	55.686
Pathologic	**299.5**	18.021
Infectious	414.0	24.909
Pharmaceutical	9.0	0.542
Sharp	14	0.842
Total	**1662.00**	**100**

Total type of hospital waste generated over the period of study

During the course of the researcher's study, it was observed that three distinct categories of hospital waste were generated, namely, general waste, infectious waste, and hazardous waste. These types of waste were segregated into black, yellow, and red bags, respectively. Of the three categories of waste, the black bag exhibited the highest volume of waste, followed by the yellow bag and the red bag. It is crucial to note that the proper disposal of hospital waste is of paramount importance to maintain a clean and safe environment.

Table 16 Total type of hospital waste generated over the period of study

Waste category	(kg)	Percentage (%)
General	**925.5**	55.686
Infectious	**414.00**	24.909
Hazardous	**322.5**	**19.404**
Total	**1662.00**	**100**

Regarding the categories or types of waste (general waste, infectious waste, and hazardous waste) generated using color coding (black, yellow, and red), it was observed that the percentage of total general waste generated over the period of study was higher than total infectious and hazardous waste (Table 16).

Table 17 Weekly distribution of Hazardous Waste and General Waste in Different Service Units.

Ward	Date-Time	Patient	Total amount of waste in kg			Total
			General	infectious	**Hazardous**	
Emergency	From Sep 11-		78	26	10	114
Medical Ward	From Sep 11-		71.5	23.5	21	116
Surgical Ward	From Sep 11-		55	23	41	119
Delivery	From Sep 11-		79	19.5	41	139.5
Pediatrics Ward	From Sep 11-		100	35	25.5	160.5
Gynecology Ward	From Sep 11-		161	72	39	272
Orthopedics Ward	From Sep 11-		159	49.5	23	231.5
Plastic Surgery Ward	From Sep 11-		46	33	11	90
Forensic Medicine	From Sep 11-		17	22	17	56
OPD & cafe	From Sep 11- 17/.2023		103	30	9	142
OR	From Sep 11-		39	33	30	102
Laboratory	From Sep 11-		17	47.5	55	119.5
Total			**925.5**	**414.0**	**322.5**	**1662**

The present study was designed to determine the amount of waste generated by various wards and units over a period of one week. Our findings indicate that the total amount of waste generated is primarily dependent on the number of patients present in the ward. The Gynecology and Orthopedics Wards were found to generate the highest amount of waste on a weekly basis, while the Forensic Medicine unit generated the least. Upon further analysis, it was observed that the Gynecology unit generated the highest share of pathological waste at 111 kg/week. Conversely, the lowest amount of hazardous waste was generated by the OPD & CAFE wards at 9 kg/week,

respectively, as detailed in Table 17. These results hold significant implications for healthcare facilities, as they underscore the importance of waste management practices inpromoting public health and safety. By carefully monitoring waste generation and implementing appropriate measures, healthcare facilities can significantly reduce environmental impact and ensure that waste disposal is performed in a safe and effective manner.

4.1.4 Estimation of the amounts of biodegradable waste generated by a WCSH

The amount of biodegradable waste was ascertained by computing the volumetric capacity of a collection of sacks in which the waste was disposed. The municipal truck is capable of collecting and loading approximately 6m3 of garbage, which equals the volumetric capacity of the truck. The HCW manager and observations revealed that this collection of sacks containing non-infectious biodegradable waste is evacuated by Werabe municipal four times per month and transported to a landfill for final disposal. Thus, based on the estimation, the total monthly volume is 24m3 (6m3 x 4)

Figure 23 Tied sacks prepared for disposal by municipal trucks from WCSH

Waste production

Hospital waste can be categorized into different types based on their source, type, and associated risk factors during handling, storage, and disposal. The European Union has made special efforts to standardize waste classification through the Waste European Catalogue (Alvim-Ferraz and Monso, 2005). This catalogue includes both infectious and non-infectious waste materials.

Research findings have revealed that solid waste classification at WCSH is based on two categories: Non-infectious and Infectious waste (Sharp and Non-Sharp.). (Figure2).

According to the World Health Organization (WHO) (BAN&HCWH, 1999), almost 85% of hospital waste is non-hazardous, 10% is infectious, and approximately 5% is non-infectious but hazardous. In the US, for instance, only 15% of hospital waste is considered infectious waste. A study conducted on WCSH revealed that 92.1% of the respondents mentioned that WCSH generated both Infectious waste (Sharp & Non-Sharp) and Non-Infectious waste. It is evident that WCSH generates a higher percentage of Non-infectious waste, as per the WHO study results. The internal medicine and gynecology-obstetrics departments were the largest producers of healthcare wastes. This could be because patients visiting these departments are receiving treatment services. Consequently, higher waste generation requires special treatment at all stages, starting with patients and ending at the disposal site (WHO, 1999)

In this study it has been found that the two types of HCSW generated at this Hospital, have been categorized into two classes by considering its bio-characteristics; Biodegradable waste and Non Biodegradable for easy collection for treatment. It was discussed that the landfill was the best treatment used for biodegradable solid waste and slurry disposal (Hamer, 2003).

However, during our interview with waste management staff in the hospital, they could not tell us the amount of waste generated in the hospital daily. They could not also provide information with respect to which departments generate the highest and lowest amounts of medical waste in the hospital. Our study showed that there is a high proportion of clinical waste at WCSH level, which is compatible with previous studies (Kuroiwa et al 2004, Da Silva et al 2005). Results

gave an overall average weight of 105.21 kg per day of Non-Biodegradable (combustible) waste generated at WCSH. This might be because most patients visiting WCSH are receiving treatment rather than consultation. Results gave an approximate weight of 0.0384 tons of Non-Biodegradable waste in a year. The amount of waste generated in hospitals depends upon various factors such as the number of beds, types of health services provided, economic, social and cultural status of the patients and the general condition of the area where the hospital is situated. For example, in hospitals located in low socioeconomic areas of the cities, most of the waste consists of residues from fruits which are voluminous and abundant, whereas in those located in high socioeconomic areas of the city, most of the wastes contain flowers, cans and single use

containers for food (Askarian et al, 2004). So far, studies have focused on measurement of HCW amount in kg/bed per day (Korowai et al 2004, Da Silva et al 2005).

4.1.5 Characterization of the HCSWM Practices at WCSH

Segregation, packaging, color coding and labeling

The present study examined the waste management practices at the Werabe comprehensive specialized Hospital (WCSH), with a focus on the segregation of Healthcare Waste (HCSW) at the source. All of the interviewees (100%) reported that there is a concerted effort to segregate

HCSW at the source, which is typically generated within hospital wards, and that this task is primarily the responsibility of the medical staff. The study further revealed that patients and visitors to the hospital are provided with color-coded labels to facilitate proper disposal of their waste. This finding suggests that the hospital has implemented an effective waste management program that is consistent with best practices in the healthcare industry.

The survey revealed that in some wards, nurses were observed to be segregating healthcare waste (HCW) improperly. This practice may lead to increased risks of injuries and infection for the waste handlers. The results indicated that while all medical staff correctly used colored polythene bags and placed them in buckets for HCW segregation, the cleaners used plastic containers instead (plate 3).

It is essential to emphasize that proper segregation of HCW using the appropriate method is crucial to minimizing the risks associated with HCW management. Therefore, it is imperative that all staff members follow the correct method to ensure the safe and efficient handling of HCW.

Recyclable waste segregation

Based on the findings of a survey, data analysis and observations indicate that segregating recyclable waste, such as paper and wrappers, involves the use of transparent polythene bags, which are then placed in a plastic bucket for collection. Notably, plastic bottles are collected separately by a private solid waste management company, COPED, which specializes in the recycling of plastic materials (as illustrated in Fig 24).

Figure 24 recycle bins used for recyclable waste in the wards at WCSH

WHO proposes that segregation must be done at the point of waste generation. To encourage segregation at the source, (reusable) containers or baskets with liners of the correct size and thickness must be placed as close to the point of generation as possible (WHO, 2000). The wastes produced within the hospital are generally segregated according to the color coding system of WCSH. The survey indicated that all the medical staff used colored polythene bags on buckets for HCW segregation.

But I have seen garbage incinerators struggling to separate the garbage when HCW segregation. But I have seen garbage incinerators struggling to separate the garbage when the cleaners are mixing it while taking it to the main waste incinerator.

According to the proposal by WHO, hospitals have to provide plastic bags and strong plastic containers for infectious waste such as empty containers of antiseptics used in the hospital. Bags and containers for infectious waste should be marked with the Biohazard symbol (Pruss et al., 1999). During the interview and as possible to see in person it was revealed that segregation of medical waste into infectious medical waste and non-infectious medical waste is not conducted according to definite rules and standards.

WHO proposes that segregation must be done at the point of waste generation. To encourage segregation at the source, (reusable) containers or baskets with liners of the correct size and thickness must be placed as close to the point of generation as possible (WHO, 2000). The wastes produced within the hospital are generally segregated according to the color coding

system of WCSH. The survey indicated that all the medical staff used the colored polythene bag onto buckets for HCW segregation, whereas the cleaners used the colored polythene bag onto plastic containers for HCW collection.

According to the proposal by WHO, hospitals have to provide plastic bags and strong plastic containers for infectious waste such as empty containers of antiseptics used in the hospital. Bags and containers for infectious waste should be marked with the Biohazard symbol (Pruss et al., 1999). During our interview it was revealed that the segregation of medical waste into infectious medical waste and non-infectious medical waste is not conducted according to definite rules and standards.

Collection, On-Site Transportation and Storage

Based on the interviews conducted with cleaners and observations made, it was found that the collection of Healthcare Waste (HCSW) from Werabe comprehensive specialized Hospital(WCSH) involves the use of dustbins for separating Biodegradable and Non-biodegradable waste.

All Non- Biodegradable waste, which is also considered as Combustible waste, is collected together in yellow polythene bags and is transferred to plastic wheelie bins. Similarly, Biodegradable waste, such as domestic waste, is collected in black polythene bags and is transferred to plastic wheelie bins. As per the proposal by WHO (2004), the waste must be collected on a regular basis to avoid accumulation and decomposition. The waste is transported on-site to the central storage area by the cleaners who are responsible for HCSW collection. Fig 24 displays the plastic wheelie bins utilized for the collection of HCSW from the generation point.

Figure 25 Wheelie bins (15 kg) used for collection of MCSW at WCSH

Fig 25 shows the means used by the cleaners to collect and transport solid waste to the treatment and disposal point. As the researcher understood from the cleaning staff in an interview and confirmed it by seeing the bags containing waste from different parts of the hospital are brought to the site by wheelie bins. The cleaners reported that they used wheelie bins for on-site transport of the segregated waste from generation point to disposal place, on a daily basis. Transport to the central storage area is usually performed using a wheelie bin or trolley. Wheelie bins or trolley should be easy to load and unload, have no sharp edges that could damage waste bags or containers and they should be easy to clean. Ideally, they should be marked with the corresponding coding color (WHO, 2004).

The researcher's findings reveal that no significant difference in manual collection waste was observed between cleaners who use gloves and those who do not. However, it is expected that a noteworthy proportion of waste is collected manually by the group of cleaners who use gloves. It is worth noting that the study has illustrated an insignificant variation in the amount of waste collection between the two groups.

The collection and disposal of biodegradable and non-biodegradable waste are imperative for the maintenance of a clean and hygienic environment. Municipal skip waste bags are utilized to collect biodegradable waste, which are transported once a week to a selected area for disposal. Non-biodegradable waste, on the other hand, is transported to the incinerator house. The Health Care Waste (HCSW) generated is loaded using the means indicated by the following figures from the generation point to the disposal place at WCSH. It is important to note that the bags are not secured or labeled with the site of generation, which may lead to potential complications. Consequently, the findings of the study revealed a lack of a specific HCSW collection point or central storage within WCSH, which is a matter of concern.

Figure 26 Means of collection and on-site transportation of HCSW at WCSH

Off-site transportation

Observations at WCSH have revealed that biodegradable waste is being disposed of in Sacs and removed only when full or at the request of hospital administration once a week to the designated Werabe Municipal dumpsite area. The transportation of waste from the hospital to the dumpsite is conducted by a municipal and WCSH team. Interviews with the HCW manager and the truck driver engaged in transporting the medical waste to the final disposal site have revealed that the truck used for this purpose is exclusively designated for the task. The vehicle, however, does not carry a consignment note from the point of collection. According to Johannessen et al. (2000), medical waste transportation on public roads must be carried out by trained staff in a dedicated vehicle with closed containers. However, it has been observed that the hospital's waste management practice is not in line with the recommendation of Johannessen et al. (2000). Instead of a dedicated vehicle with closed containers, the waste is loaded onto a truck, tied in a compost sack, and left open. It is, therefore, imperative that the hospital improves its waste management system to align with industry best practices. This will involve addressing the problem of waste disposal and adopting the recommended transportation practices for medical waste.

Environmental problems associated with the current HCWM at WCSH

An analysis of comparative data revealed that 70% of the interviewees (14/20) did not express any apprehensions regarding the present healthcare waste management (HCWM) system. However, 15% (3/20) of the interviewees reported injuries during their daily activities. Despite being protected and exposed to infectious waste, these injuries were accidental and put the interviewees at potential risk. The primary reason for these injuries was the improper segregation and collection of syringe needles and other sharps in safety boxes. A further 5% (1/20) of respondents reported sickness due to bad odors, which was also attributed to not wearing masks during work activities. Additionally, 10% (2/20) of interviewees reported insufficient equipment. It was observed that the bins used at WCSH were insufficient and inappropriate, as mentioned by 1% of the interviewees (see plate 3 & 4). The bins used to store HCW in WCSH were not in good condition and were open buckets. Therefore, these bins need to have an opening from the front (in addition to the top one) or be pedal bins to avoid exposing workers and patients to danger while unloading the bags from the bottom of the bins.

Out of all the interviewees, the largest percentage of those who reported injuries belonged to internal medicine, surgery and the gynecology-obstetrics departments. Upon observation, it was found that these departments had a higher number of patients and generated a significant amount of infectious sharp waste, which could puncture the bags and expose the workers to infection risks. This is due to the wrong practices being followed. The laboratory department, on the other hand, was observed to have a good condition of healthcare waste management, but most interviewees from this department reported that there was a lack of sufficient equipment.

In the context of sharp object injuries, it has been observed that nearly 85% of such injuries are attributable to their usage and subsequent disposal. Additionally, over 20% of those handling such objects encounter 'stick' injuries. Through research, it has become apparent that the current incineration practices are inadequate. Notably, the WCSH incinerator is lacking pollution control devices, also known as filters, and has a stack height of less than 2 meters. As a result, significant amounts of smoke and toxic gases are being released into the atmosphere, as evidenced by Plate 8. It is essential to adopt better incineration methods to ensure the safety of workers and mitigate the environmental impact of these activities

It was observed that one of the operators of the incinerator at WCSH was not adequately protected during the incineration process. This lack of protection could potentially result in acute effects such as eye and respiratory irritation, as well as other illnesses. This improper incineration practice is documented in Fig 28

Figure 27 Unsecured incineration practice observed at WCSH

Risks associated with incineration

Despite the fact that incineration is one of the only high technologies that can treat all types of HCW properly and has the advantage of reducing significantly the volume and weight of the waste treated. This treatment system can cause much concern. Some studies (Groundwork, 2002), have pointed out that incinerators have been associated with a wide variety of health problems in South Africa, such as disrupting the bodies hormonal, immune and reproductive systems, and even causing cancers.

During research time, it was observed that the current incineration practices were inappropriate. WCSH incinerator had no pollution control devices (filters) and the stack height is low (less than 2 meters), and releases important quantities of smoke (toxic gases) or air pollutants (PCI, heavy metals, etc...) that constitute an environmental health threat (see Plate 8). These gases emissions and ash from the incinerator contain high levels of toxic substances such as heavy metals, dioxins and furans that constitute an environmental health threat. If no proper filtering is done, the air can also be polluted causing illnesses in the nearby populations (Diaz et al, 2003).

During the course of the research, it was observed that the disposal of incinerator ashes was not conducted in a proper manner, as they were being dumped into overfilled wheeled containers without an impermeable cover. As per the guidelines of the United States Environmental Protection Agency (EPA), incinerator ash comprises of both fly ash and bottom ash (Plate 2), and it is known to contain elevated levels of hazardous substances such as heavy metals, dioxins, and furans.

This incinerator ash is potentially capable of causing disease and illness in humans, either through direct contact or indirectly by contamination of soil, groundwater, surface water and air. Windblown ash from these dumps also has the potential to carry pathogens and hazardous materials. Incinerator ash therefore poses a risk to communities and the environment if not carefully disposed of (Akter et. al., 1998).

4.2 DISCUSSION

Werabe Comprehensive Specialized Hospital is a major healthcare facility in the Silte zone, catering to a population of over 2 million people. At the time of data collection, the hospital housed a total of 306 beds. The services offered, such as outpatient department (OPD) and cafeteria, operating room (OR), gynecology ward, medical ward, surgical ward, laboratory, pediatric ward, delivery, orthopedics ward, plastic surgery ward, and forensic medicine, are expected to generate various types of medical waste, forming the focus of this study.

The amount of medical waste generated by various facilities varies depending on factors such as the country's income, waste management methods, hospital specialization, use of reusable items, proportion of day-care patients, and number of beds.The results obtained from this study revealed that Werabe comprehensive specialized hospital produces an average of 0.78 kg of biomedical solid waste per bed per day and 0.244 kg per patient per day. These findings indicate lower waste generation compared to figures reported in a WHO study for the USA (2.79 kg/bed/day) and Bahrain (1.177 kg/patient/day) (Al-thukair AA 2017)

The higher biomedical solid waste generation rate in high-income countries may be due to the higher per capita gross domestic product (GDP), that is, the developed nations due to more services than others, which tends to generate more waste in HCFs. However the current study results were higher when compared with the study conducted in public healthcare facilities in Bujumbura, Burundi(0.22kg/patient/day), (BesufekadMekonnen 2020) and Almost similar to the study conducted at the municipal hospital of Ghana(0.39kg/patient/day), and lower than the local study conducted in Mizan- Tepi University Specialized Hospital(0.073kg/bed/day (Nahom Solomon 2021)and lower than the Gondar teaching hospital(0.37kg/patient/day (Wondimagegn 2017)The differences in average waste generation rates could be speculated to result from the differences levels of healthcare facilities, types of service offered and, on a country to country basis, on the level of economic development.

The current study is lower than the study done in USA 2.79kg/bed/day, Bangladesh 0.934kg/bed/day , primary hospital in Ethiopia at national level 1.1 kg/bed/day, Gonder 0.95kg/bed/day, and greater than the study done at Mizen tape Hospital 0.073kg/bed/day .

Moreover, according to WHO, developed countries generate on average up to 0.5kg of hazardous Biomedical solid waste per hospital bed per day. In comparison, low-income countries generate on average 0.2kg of hazardous biomedical solid waste per hospital bed per day. However, the results from this study identified about 0.78 kg/bed/day of total biomedical (hazardous) waste generated from Werabe Comprehensive Specialized Hospital, which did not correspond to the stated WHO value. The major reason for the high percentage of biomedical solid waste generation may be due to no waste segregation practiced in the Werabe comprehensive specialized hospital, which probably may increase the biomedical solid waste generation rate.

The results of this quantitative and qualitative study confirmed that there was weak segregation of biomedical solid waste into different categories using color-coded containers and labels. This finding is consistent with a study done in Somaliland and Kenya (Ali M, 2018) and inconsistent with a study conducted in different hospitals in Mizan Primary Hospital Southwest, Ethiopia (Nahom Solomon,2020).

These indicated that the implementation of biomedical waste segregation strategies varied from hospital to hospital in Ethiopia and also varied from country to country. This may be due to a lack of training for healthcare workers on waste segregation. This idea is also supported by (WHO, 2005) and (Lars M.2014)stated that the priority among waste management practices is the segregation of waste at the point of generation. The current study showed that Werabe comprehensive specialized hospital waste mixed waste was collected and transported in cartons or open plastic bins and not labeled at the point of generation. The waste was scattered on the surrounding treatment and disposal sites due to the use of substandard waste containers. This also contributing to the risk of infections for health care providers, patients, visitors, and the neighboring community.

A result obtained at MTU Teaching Hospital revealed that healthcare wastes were not separated into different categories appropriately. During our observation time, mixed types of waste such as hazardous and general wastes were found together in black and yellow boxes Generally, segregation of medical waste at the point of generation was not properly practiced in all the studied departments. This result was similar to a finding obtained in Addis Ababa (Ethiopia) where almost all of the assessed hospitals reported that there was no segregation of waste into infectious, pathological, and pharmaceutical, and had no separate bins for the collection of infectious waste.

This may be associated with the inadequate distribution of appropriate boxes, poor attention given by the generators of waste such as doctors, nurses, paramedical staff, patients, and their attendants about the amount, quantity, and type of waste they generate and the way it is disposed of and insufficient enforcement to improve waste segregation practices by top management.

A temporary waste storage site is a place where medical waste is kept before it is transported to its final disposal place or it is a place to segregate wastes to search for the presence of any recyclable or reusable wastes.

The results from this study revealed that there was no separate place for waste storage in the hospital rather they stored healthcare wastes temporarily which were not sited in an appropriate place that was not secured and accessible for all visitors to the hospital, which was contrary to WHO regulations. This result was similar to a study conducted in Debre Berhan.

Medical waste may be disposed of using different methods which many countries have adopted. However, the disposal of medical waste needs to be carried out in a way that neither the environment nor the health conditions of people are put at risk as they are hazardous.

The common types of medical waste disposal methods used were open pit burning and open dumping in addition to other types of waste disposal methods including placenta pits. This result was not good in contrast to a study done in Addis Ababa where an incinerator was the main

disposal method in hospitals. Also it was not in coherent condition with a guidelines stated by the World Health Organization (WHO) for the disposal of healthcare wastes.

CHAPTER FIVE

5. FINDINGS, CONCLUSION AND RECOMMENDATIONS

In this concluding chapter, the key points from the study results are summarized. The study's conclusions are drawn from its findings, and valid suggestions and recommendations aligned with the thesis objectives are presented. Additionally, this chapter outlines potential directions for future research in the field.

5.1 FINDINGS

This study investigated the solid waste management systems and practices at Werabe Comprehensive Specialized Hospital to improve environmental management by promoting safe and proper waste management. The study had the following specific objectives :

A. To identify the type and nature of healthcare waste generated at Werabe Comprehensive Specialized Hospital.

B. Estimate health care waste generation rate in Werabe Comprehensive Specialized hospital.

C. To identify the current waste management systems and practices that exist at Werabe Comprehensive Specialized Hospital

The researcher made frequent visits to the hospital, taking note of how hospital solid waste is managed. Regular visits were made to the medical ward, Emergency, surgical ward, Delivery, Pediatrics Ward, operating theatres (OR), Gynaecology Ward, OPD & cafe, orthopedic Ward, Plastic Surgery Ward, and Laboratory department.

The researcher utilized both primary and secondary data. Secondary data was acquired from the hospital’s documents, as well as from published and unpublished books, journals, newsletters, periodicals, articles, and the Internet.

Primary data was gathered through questionnaire administration and interviews with hospital authorities, health workers, and personnel responsible for infection control and waste management.

Data analysis was conducted using Statistical Package for Social Science (SPSS) version 21. Descriptive statistics, including means and ranges, were calculated. Significance tests were carried out to assess the connection between socio-demographic variables and variables related to documents, knowledge, health workers' training, and practice concerning medical waste management. The discussions revolved around the current hospital waste management practices compared to recommended standards.

The study found that both general and medical waste are produced in the hospital. Medical waste is generated from practices such as chemotherapy, surgery, plastic surgery, forensic medicine, delivery, resection of gangrenous organs, and injections. The hospital does not regularly measure the amount of waste generated daily, and it is also unclear which departments generate the most and least medical waste. However, the study showed that the Gynecology Ward produces the highest amounts of medical waste. The segregation of hospital waste into infectious and non-infectious categories is not consistently done according to specific rules and standards. While the hospital does not label infectious waste with a biohazard sign, it is described in the local language. Manual transport methods and wheelbarrows are used to move waste from the production sites (different wards) to the treatment area. The staff employed for handling waste in the hospital use almost incomplete personal protective equipment, such as overall gowns,

protective boots, and gloves. Surveys had indicated that most WCSH care workers didn’t wear masks during daily activities; the greatest percentage was familiar with gloves and uniforms or aprons. The waste collectors were observed to wear uniforms, gloves, and boots while cleaning.

The study found that Werabe Municipal is responsible for transporting hospital waste off-site on a weekly basis. Municipalities mainly use big truck pickups to transport waste to an off-site location for treatment and disposal, with Werabe Municipal being responsible for the final disposal of medical waste. Incineration is the primary treatment method for infectious waste, while non-infectious waste is disposed of using land disposal. The hospital only recycles plastic bottles, which are collected separately by a private solid waste company (COPED).

The hospital provides training for its personnel on hospital waste management and potential hazards, but staff members are not annually trained on the health and environmental effects of infectious waste. WCSH does not offer continued formal training on hospital waste management, leaving hospital care workers unaware of the environmental and health impacts of medical waste

While the preparation and organization of rules and regulations are thorough, there are implementation gaps. These include issues such as combining hazardous waste with hospital household waste during separate waste collection and disposal, the inability to reliably measure the amount of waste generated, failure to use colored bags, and limiting the bags to only two colors. Additionally, there is a lack of participation from the committee overseeing hospital waste management, as well as insufficient education and training on hospital waste management

5.2 CONCLUSION

The average rate of biomedical solid waste generation in Werabe Comprehensive Specialized Hospital was 0.78 kg/bed/day and/or 0.244 kg/patient/day, exceeding the World Health Organization (WHO) threshold value for hazardous biomedical solid waste generation in low-income countries. Additionally, it was found to be poorly managed. Lack of appropriate biomedical solid waste segregation at the point of generation and insufficient waste collection equipment in most departments were observed. Age, sex, professional category, work experience, and biomedical solid waste were all factors influencing biomedical solid waste management practices.

The study confirmed that standard biomedical waste segregation was lacking in the hospital. As a result, all biomedical solid waste was mixed with general waste, leading to the generation of infectious and hazardous waste. The collection and transportation systems were ineffective, using non-standard encoded containers. The use of low combustion and poor single-chamber incinerators contributed to the release of large amounts of air pollutants. Overall, the biomedical solid waste management systems in Ethiopia were almost non-existent, leading to environmental pollution and potential health risks. Additionally, the incinerator and placenta pit were operated poorly. Low levels of awareness about the importance of implementing appropriate biomedical solid waste management systems are predominant in many developing countries.

It is crucial to increase the level of training and education regarding biomedical solid waste and environment-friendly health care with optimum priority, under rules and regulations. There is an urgent need to establish standard biomedical solid waste management in all healthcare facilities in developing nations.

5.3. RECOMMENDATIONS

Based on the above observations, the following recommendations are proposed to improve the management of Werabe Comprehensive Specialized Hospital. These recommendations aim to enhance the hospital's operating efficiency in terms of medical waste management:

5.3.1 Hospital administrators (service providers)

- It is essential to conduct regular measurements and quantifications of the medical waste generated in each hospital unit in order to ascertain the departments that produce the highest and lowest amounts of waste. This data could have significant implications for the allocation of resources for the management of medical waste.
- The waste producer should play an important role in ensuring the distinction between communicable and non-communicable diseases. Plastic bags and sturdy plastic containers need to be provided for the disposal of waste, such as containers containing antibiotics used in hospitals. Waste bags and containers should be marked with the biohazard symbol. The standard procedure for coded red bags for segregation of solid waste should be used and strictly followed. The use of isolation measures in hospitals will produce clean wastewater that can be managed easily, safely and cost-effectively.
- They should institute an efficient Sharps Management System, including proper equipment and containers at all sharps generating points, a secure accounting and collection system for transporting contaminated sharps for treatment and final disposal as well as the proper training of hospital staff on the handling and management of sharps.
- They should provide regular education and training to all staff, from doctors to church children, laborers, garbage collectors and employees of waste management companies. Appropriate training is required to develop awareness of health, safety and environmental issues. It is important for employees to recognize and understand the risks associated with medical waste.

- They should seek to promote ongoing cooperation between all key actors (government, hospitals and waste management) to implement health and safety management strategies not only in law and its development, but especially in their maintenance and work.
- Disposal should be careful and controlled, and needles, scalpel blades and other sharp objects that may cause harm should be stored in a waste container as close as possible to the area where they will be used. To prevent needlestick injuries, the needle should not be covered, deliberately bent, broken, or otherwise handled.
- must have a functional and accountable hospital biomedical waste management structure that meets on a regular basis and which is assigned the responsibility of evaluating progress in terms of the implementation of the biomedical waste management plan.

5.3.2 Researchers - Further research

Further studies should consider the impact of intervention on biomedical solid waste management systems were not studied; therefore, a study should be conducted on the evaluation of the effectiveness of measures taken on biomedical solid waste storage, collection, transportation, treatment disposal and other involvement in the improvement of biomedical solid waste management.

5.3.3 Strengths and limitations of the study

A/ Strength of the study

- ✓ The use of different approaches (semi structured interview and observation) to measure and recognize the problem was one of the study's primary strengths. Checking the weighing scale calibration before starting data collection.
- ✓ Since the study was the first in this zone, it can be baseline data and input for different stakeholders for better planning and management of health care waste in the hospital and the country as a whole.
- ✓ Supervision was made by more experienced professionals during waste collection and measurement.

B/ Limitations of the study

- ✓ The research was conducted at a single location, so it could not be practiced in other situations. Liquid waste management was not considered in this systematic study. Furthermore, biomedical recycling efforts for reusable products were not taken into account.
- ✓ Even if health care waste generation rates can be affected by seasonal variation, this research was done using cross-sectional methods.

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APPENDICES

Appendix I: Research Instruments

Estimation of the daily quantity of Health-Care Waste generated Kg/day

Estimation of the daily quantity of Health-Care Waste generated K/g day	WCSH
A assessment made by:	Date of assessment (week):

Source **Department**	Monday			Tuesday ~			Wednesday			Thursday			Friday			Saturday			Sunday		
S	C	N	W	C	N	W	C	N	W	C	N	W	C	N	W	C	N	W	C	N	W
Outpatient departments																					
Adult Emergency																					
Gynecology department																					
Xray/Imaging/Community																					
Medicine department																					
Operation theater																					
Pathology laboratories																					
samplecollection room																					
Oncology department																					
Kitchen																					
Medical Ward																					
Surgical ward																					
Gin/ward																					
Pedi ward																					
Labor ward																					
Orthopedics department																					
Psychiatry ward																					
Total weight																					
Total monthly weight																					
Explanations																					
S:source ; c : color coding bag ; N : number of bags ; W : weight (Kg) ; Y: Yellow ; R: Red ; W:white ; B:Black																					
Estimation of the volume of Biodegradable HCW generated during one week/Skip Container Volume(rn2)																					

HCW Skip Container_____	Total volume	Evacuation per week(Times)
Skip Container for Biodegradable waste		
Skip container for ash from Incinerator:		

Appendix II : Survey questionnaire for Hospital waste management in WCSH

This questionnaire is prepared for an academic purpose for the fulfilment of an MSc in Environmental Change Management studies. Specifically, the objective of the study is to explore the practices and challenges of MSW disposal practices in WCSH. Therefore, your response is very important for the success of the study because all the information that you provide determines the analysis and conclusion of the research. Hence, you are kindly requested to give your response by selecting (circling) your answer from the given alternative or describing your option. Please be informed that your response is kept confidential and you are not required to write your name. I would like to thank you for your cooperation.

1. Background information about the respondents

Instruction: - in order to answer the following questions, put a right sign (√) in the Boxes that located in front of your choice.

Age	18-26 ☐	27-38 ☐	39-50 ☐	51-60 ☐	Above 60 ☐
Sex	Male ☐	Female ☐			
Education level	No formal education ☐	1-8 Grades complete ☐	9-12 Grades complete ☐	Certificate and above ☐	
Marital status	Not married ☐	married ☐	Divorce ☐		
Family size	1-4 family member ☐	5-8 family Member ☐	9-12 family member ☐ and above		
Employment status	Permanent ☐	Temporary ☐			
Average monthly income	Low income below 1500 ☐	Medium income between 1500-6000 birr ☐	High income above 6000 birr ☐		
Work experience in the hospital	< 1 Year ☐	1-5 Year ☐	6-9 Year ☐		
Work experience in management	< 1 Year ☐	1-5 Year ☐	6-9 Year ☐		

2. Staff Survey Questionnaires

Questionnaire prepared for investigating households regarding Medical solid waste management awareness, and practice together with their attitude regarding the Hospital.

1. Where is dumped medical solid waste that is generated by the Hospital ?

1/ everywhere 2/ Land fill 3/ Open space 4/ Burning 5/ other

2. If your answer is everywhere what is the reason?

1/ lack of awareness 2/ lack of commitment 3/ lack of SWBs 4/all

3. Do you have medical solid waste and disposal strategies in your hospital ?

1/ yes 2/ no

4. If your answer is yes what are the means of collection and transportation mechanisms?

1/ by using a cleaner 2/ by using a donkey cart or car

3 burning in the compounds 4/ using other methods

5. Where are you incinerated the medical solid waste that is generated by your hospital?

1/ inside the hospital 2/ outside the hospital.

3/ municipality collect it 4/ dispose in open space, river side and drainage side

5/ use as an energy source

6. The frequency of medical solid waste burning practices is

1/ daily 2/ once a week 3/ weekly 4/ I do not know

7. How to manage or handle medical solid wastes which are generated by your hospital ?

1/ collect in closed containers 2/ collect in open containers

3/ collect by plastic bag 4/ collect by other mechanisms

8. Do you agree improper medical solid waste disposal practices affect the environment, human life and the environment? 1/ Yes 2/ No 3/ I do not know

9. Do you agree with creating awareness in the community to reduce illegal medical solid waste?

Disposal practices. ? 1/ agree 2/ strongly agree 3/ disagree 4/ strongly disagree

10. Do you know about the rules and regulations regarding medical solid waste management ?

1/ yes 2/ no

11. The institutional arrangement of Werabe Hospital for medical solid waste management and

Disposal activities are effective? 1/ Yes 2/ No

12. Do you know the workers about the rules and regulations of medical solid waste disposal practices? 1/ yes 2/ no

13. Do you believe that the Warabe city municipality's environmental beauty and cleanliness parking offices are working in coordination with the hospital in terms of medical solid waste management and disposal? 1/ yes 2/ no

14. Do you know the negative impact of illegal medical solid waste disposal practices?

1/ Yes 2/ No

15. Can you elaborate? _____

16. Do you agree that community participation in medical solid waste management and disposal practices is low? 1/ agree 2/ strongly agree 3/ dis-agree 4/ strongly dis-agree

17. Is there any private sector, which is, participate in medical solid waste collection, transportation and dumping activity in hospitals ? 1/ yes 2/ no

18. Are the following materials like transportation car, waste bins and other equipment's are available in your Hospital ? 1/ yes 2/ no

19. Are there Work units with Medical solid waste bins in your Hospital? 1/yes 2/ no

20. How to manage medical solid wastes that are generated by your work units, restaurants or cafes?_____.

21. Where are you disposing of medical solid waste that is generated by your work units, café or restaurants?_____.

22. If your answer is 'no' where are you disposing or dumped Medical solid wastes which are generated from your Hospital ?

Discuss it_____.

23. Does the hospital's environmental health care department enforce rules and regulations when solid waste is misplaced?

1/ yes 2/ no

24. What is the type of MSW generated in your hospital ?

1 / non infectious waste 2/ infectious waste 3/ both 4/ none

25. Is there any alternative which is reduce improper MSW dumping and disposal

Practices _____Other

Suggestion: _____

If you have any additional comments, suggestions, or would like to elaborate on any of your previous answers, please include them here, or attach a separate sheet.

Appendix III

1. Interview Questionnaires

Attention: All the information obtained through this questionnaire shall be used for academic purposes only. Anyway, the data collected will be stored, handled and kept confidentially and could not have any effects on the respondents' privacy, and the researcher is fully responsible.

A. Interview questionnaires for hospital managers.

1. What are the main causes of poor MSWM and disposal practices?

2. If there is a poor medical solid waste management and disposal system in the hospital, what are the main causes?

3. Is it Staff and Work units participating in MSWM and disposal practices?

4. Is it allocated for medical solid waste management and transportation activity enough budget and other equipment?

5. What are the challenges for medical solid waste management practices in the hospital ?

6. What methods do you think can be used to alleviate if workers or work units create problems with waste management and disposal?

7. What else should be done? Or if you have an opinion

B. Interview for Hospital Directors

1. Do you have a strategic plan for a solid waste management and disposal system?_____

2. Can you elaborate? _____

_____

3. Do you believe that a weak institutional structure and the use of inappropriate technologies will harm the solid waste management and disposal system?

4.If you believe that, how? List it_____

5. Is it illegal MSWM and disposal practices affect human beings & the environment? _____

6. If they have an impact, how? List it

7. Solid waste storage containers or waste bins are found in the Hospital?

8. Briefly discuss the rule, regulation, its implementation, and monitoring that have been proposed by your bureau for the efficient practice of MSWM in Werabe Hospital.

9. Discuss the situation of public awareness and involvement. Existing trends and practices in solid waste management and disposal practices at Werabe Hospital?

10. What are the main challenges for MSWM and disposal practices in Werabe Hospital?

11.Whatdo you think should be done to make the medical solid waste management, disposal and management system more effective in the hospital?

12. . Are you involved in the MSWM activity at the hospital?

Appendix IV

Focus group discussion questionnaires

Attention: All the information obtained through this questionnaire will be used for academic purposes only. Always, the data collected will be stored, handled, and kept confidentially and could not have any effects on the respondents' privacy and the researcher is fully responsible. To verify this, please do not give your name and any address anywhere in the questionnaire.

A. Health Worker Members

1. How do you see the existing situation of medical solid waste management & disposal practices?

2. Is poor institutional structure and use of inappropriate technologies affecting MSWM?

3. Is it participating Staff and Work units in MSWM and disposal practices?

4. What is the cause of illegal medical solid waste dumping? In addition, what are the consequences of the social, environmental and human impacts of improper medical solid waste disposal practices?

5. Who is responsible for illegal MSWM and disposal practices everywhere?

6. Are the staffs and communities know the rules and regulations of environmental laws?

8. Medical solid waste storage containers or waste bins are found in the Hospital?

B. Purposely selected directorates and staffs

1. Medical solid waste disposal site selection is appropriate for disposal activities? Elaborate?

2. Staff involvement in MSWM and disposal practices is effective or not?

3. Is the hospital and sanitation beautification creating awareness about MSWM and disposal practices? Elaborate

4. Do you know the rules and regulations of MSWM and environmental law?

5. How to handle medical solid waste that generates from your hospital. Is it the best way?

6. What are the challenges for MSWM and disposal practices in your hospital ?

7. Do you know the impact of illegal medical solid waste management and disposal practices?

Appendix V

Structured observation

The practices and challenges of medical solid waste management and disposal practices at Werabe Hospital

1. Presence of medical solid waste containers_____

2. Existing practices for medical solid waste management and disposal practices

_____

3. Existing trends in medical solid waste management and disposal practices

_____

4. Medical solid waste disposal site and transportation equipment _____

5. Other visual practices in the hospital.

_____

END OF QUESTIONS. THANK YOU