ASSESSMENT OF BIOMEDICAL WASTE MANAGEMENT PRACTICES AMONG HEALTH CARE WORKERS OF TANGA REGIONAL REFERRAL HOSPITAL: A CASE OF TANGA REGION, TANZANIA.

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CERTIFICATION

The undersigned certifies that he has read and here by recommends for acceptance by The Open University of Tanzania a dissertation entitled, **Assessment of Factors Influencing Biomedical Waste Management among healthcare workers at Tanga regional referral hospitals.** In partial fulfillment of the requirements for the award of Degree of Master's in environmental studies.

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DECLARATION

I, **Walter David Mwai** declare that, the work presented in this dissertation is original. It has never been presented to any other University or Institution. Where other people's works have been used, references have been provided. It is in this regard that I declare this work as originally mine. It is hereby presented in partial fulfillment of the requirement for the Degree of Master's in environmental studies.

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Signature

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Date

DEDICATION

This research report is dedicated to my late beloved brother Silas David Mwai. I also dedicate this piece of work to my parents Mr. and Mrs. Mwai, my lovely family without forgetting all of my friends around me who’s love, support and interest in what I was doing fueled and enabled me endure and carry on, still remains a source of inspiration in my heart. I Love you all and God bless you

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ABSTRACT

Addressing the underlying drivers of biomedical waste management practices at Tanga Regional Referral Hospital (TRRH) is essential for protecting healthcare workers and the wider community. This study characterized types and quantities of biomedical solid waste generated, assessed the BMW management practices and identified key drivers influencing adherence to recommended practices. A cross-sectional design was employed with quantitative research methods, seventy-four (74) healthcare workers were sampled. Data were collected through structured questionnaires, direct observation, and document review. Data were analyzed using descriptive statistics and multivariate logistic regression to identify predictors of proper BMW management. Research was guided by Health Belief model (HBM) and Waste Management Hierarchy theories (WMH). TRRH generates 1,313 kg of biomedical waste weekly 60.8% (798 kg) highly infectious and 39.2% (515 kg) infectious. The study reveals gap in adherence to BWM practices. 81% (n=60) of staff received BMW training, training alone was not a significant predictor of compliance ($p>0.05$). Instead, full-time employment ($OR=4.9$, $p<0.05$) and age 41–50 years ($OR=12.9$, $p<0.05$) were statistically significant. These findings indicates that institutional role and experience, drive compliance. The study recommends to implement a color-coded segregation system aligned with WHO standards, maintain bins, gear, and storage facilities, and digitize record-keeping. Apply Inservice practical training and mentor younger ones and part-time staff and develop a hospital Waste management plan to bridge the gap between knowledge and practice.

Keywords: Drivers, Biomedical waste, Waste management.

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LIST OF ABBREVIATIONS AND ACRONYMS

BMW	Bio Medical Waste
PPE	Personal Protective Equipment
WHO	World Health Organization
HCW	Health Care Waste
HCWM	Health Care Waste Management
HCF	Health Care Facility
WMT	Waste Management Theory
3Rs’	Reuse, Recycle and Recover
MSW	Municipal Solid Waste
SPSS	Statistical Package for Social Sciences
HIV	Human Immunodeficiency Virus
AIDS	Acquired Immunodeficiency Syndrome
TRRH	Tanga Regional Referral Hospital
LMICs	low- And Middle-Income Countries

CHAPTER ONE

INTRODUCTION

1.1 Background Information of the Study

Bio-medical waste (BMW) is one of the emerging pollutants generated by healthcare facilities, such as medical diagnosis, treatment, or immunization of human beings, animals, and biological research activities supported by Datta *et al*., (2018); Shaida & Singla, 2019). BMW is infectious and hazardous waste. It includes wastes of sharps, non-sharps, pathological/anatomical, synthetic substances, personal protective equipment (PPE), pharmaceuticals, and other infectious wastes reported by Ilyas *et al*., (2020);

Bio-medical waste means any waste generated during the diagnosis, treatment, and care of human beings or waste generated in research activities. All such waste that has an impact on the environment or health of a person is considered infectious and has to be managed as per Biomedical Waste Management Rules as according to , WHO, (2016).

Biomedical waste (BMW) is a significant concern in healthcare facilities, comprising both non-hazardous (85%) and hazardous (15%) components. The hazardous portion includes infectious waste (10%) and chemical/radioactive waste (5%) (World Health Organization, 2014). Globally, it's estimated that over 5.2 million people, including 4 million children, die each year due to diseases linked to improper medical waste management reported by Rahman *et al.*, (2020). The COVID-

19 pandemic has further exacerbated the issue, leading to a sudden surge in healthcare waste generation. This excessive BMW has become a serious threat to public health and the environment.

Biomedical waste management (BMW) is seen as a necessity in health care facilities. Hospitals and nurses are interdependent aspects of biomedical waste management. Regarding the safe management of biomedical waste management, there is role conflict among the generators, operators, decision-makers, and the general community due to a lack of awareness said by Choudhary *et al.*, (2020). Based on these facts, an integrated biomedical waste management system for hospitals and health care facilities should be incorporated suggest by Nema *et al*., (2011).

In developing countries particularly, the Sub-Saharan Africa where many health concerns are competing for inadequate resources, the management of medical wastes has received less attention and the priority it deserves Al-Khatib *et al*., 2009; Emmanuel & Stringer, (2007).

Among the practices that have been reported in many developing countries include plenty of medical waste that are deposited openly in waste dumps and neighboring environments and from time to time together with nonhazardous solid waste this was observed by Manyele & Lyasenga, (2010) but also by Mgimba and Sanga, (2016).

In Tanzania, harmful and medical solid wastes are still managed and disposed as one with domestic wastes, This makes a potential public health danger and an environmental burden suggested by Manyele & Lyasenga, (2010). The Ministry of

Health (MoH) and the World Health Organization (WHO) carried out a study in the year 2000 to find out the management of the syringes and needles used during immunization programs in Tanzania (Emmanuel *et al.,* 2008). This was accompanied by a similar survey on the management of all medical waste types in 2001. From these two studies, it was determined that medical facilities did not have the proper means of managing medical waste as reported by Emmanuel & Stringer, (2007). Improper waste management causes Hospital Acquired Infections and poses public health hazards by polluting air, water and soil as mentioned by Ghimire & Dhungana, (2018). To prevent occupational hazards Biomedical waste must be managed properly to protect the environment, the general public, and workers who are involved in handling and management. To improve biomedical waste management in health facilities in a country, the development and implementation of a national waste management policy are needed as suggested by Datta, Mohi & Chander, (2018).

This study aimed to determine the factors influencing biomedical waste management practices that is effective in managing and handling biomedical waste in manners that promote public health as well as occupation health and safety to the workers working on the line of waste management.

1.2 Statement of Research Problem

Biomedical waste (BMW) management is a critical global issue due to its potential to harm public health and the environment if not handled properly. This waste includes infectious materials, hazardous chemicals, and radioactive substances, requiring careful management through proper segregation, treatment, and disposal. However, in many developing countries, healthcare systems are burdened by limited resources and insufficient infrastructure, making effective BMW management a significant challenge Kagonji & Manyele, (2016).

In Tanzania, biomedical waste management is often neglected, despite its public health risks. WHO, 2019 assessment of 22 developing countries found that between 18% and 64% of healthcare facilities were still using outdated and unsafe waste disposal methods Jovanović, Matić, & Đonović, (2016). The 2007 Tanzania Health Policy recognized the inadequacies in BMW management as a key issue in the healthcare sector, but progress remains slow. Limited funding, infrastructure, and trained personnel continue to hinder improvements.

Tanga City, home to the Tanga Regional Referral Hospital, faces particular challenges in BMW management. Reports from supportive supervision activities in 2014 across 15 Tanzanian regions, including Tanga, highlighted significant gaps, such as the absence of waste management plans, trained coordinators, and proper disposal infrastructure Msuya, (2003). In many cases, medical waste is improperly handled through practices like open burning or burying, posing risks of environmental contamination and the spread of infectious diseases. Healthcare workers, lacking adequate training, further exacerbate the issue.

A 2023 study confirmed that healthcare facilities in Tanga continue to struggle with improper waste segregation and outdated disposal methods. Most facilities do not have access to modern waste treatment technologies like incinerators or autoclaves, relying instead on unsafe practices. The lack of financial resources further hampers efforts to improve BMW management Mndeme & Kilima, (2023).

Given these ongoing challenges, this study aims to assess the drivers influencing BMW management practices at Tanga Regional Referral Hospital. By evaluating healthcare workers' knowledge, the availability of resources, and existing waste infrastructure, the study identifies gaps and propose actionable solutions. Improving waste management at the hospital could serve as a model for other healthcare facilities in the region, reducing the risks posed by biomedical waste and enhancing public health outcomes.

This research at Tanga Regional Referral Hospital (TRRH) is essential for understanding the drivers that influences BMW management in resource-limited settings. By offering practical solutions, it aims to improve waste management practices, thereby reducing health and environmental risks in Tanga and beyond.

1.3 Research Objectives

1.3.1 General Objective

The general objective of this study is to assess drivers influencing biomedical waste management practices among health care workers at TRRH referral hospital in Tanga region, Tanzania.

1.3.2 Specific Objectives

i. To characterize biomedical solid wastes generated at TRRH
ii. To assess biomedical waste management practices among healthcare personnel.
iii. To identify the drivers influencing adherence to recommended biomedical waste management practices.

1.4 Research Questions

i. At what rate does biomedical solid waste generated by TRRH hospital?
ii. How are biomedical waste handled at TRRH hospital?
iii. What drivers influence biomedical waste management practices at TRRH hospital?

1.5 Significance of the Study

The significance of this research can be observed in diverse ways. The study provides bases for the effective handling of wastes in health facilities to benefit the health facilities and service users. The findings provide the opportunity for the health facilities to develop specific ways of managing wastes in health facilities in a proper approach. It also provides bases for supporting institutions in the provision of education concerning waste management in health facilities including health department in the local governments. The recommendations be useful to medical waste management stakeholders in the formation of effective measures to handle wastes and improved health service delivery.

The findings can be used as reference material for policy maker in making decisions concerning waste management to the health facilities and it can contribute to the body of literature for the academicians and researchers. But also, it gives a broad spectrum of ideas and research gap to be field with other researchers in such study to close gaps in some areas that were not focused by this studies that could help in improving medical waste management but also in reduction of the risk encountered by the health care workers in the course of performing such risk activity.

More over the study help to raise awareness to public and the health care workers on the risk and impact of poor medical waste management, but also in eliminating or avoiding and problems that may arise due to improper medical waste management and create a better working environment to health care workers and the environment not to forget making a world a better place free from ant infection or diseases that may be caused but improper waste management.

1.6 Scope of the Study

This study was conducted at Tanga Regional Referral Hospital (TRRH) in the Tanga Region of Tanzania, with a specific focus on the assessment of solid biomedical waste management practices. The research concentrated on solid waste materials generated from healthcare procedures, including sharps, contaminated disposables, pathological waste, and other potentially infectious or hazardous items. Guided by three objectives, the study aimed to (1) characterize the types and volume of solid biomedical waste produced across various departments, (2) assess how healthcare personnel manage this waste from generation to disposal, and (3) determine the demographic, occupational, and institutional drivers influencing proper waste handling behavior among staff. The study population included doctors, nurses, laboratory technicians, pharmacists, environmental health officers, and support staff, selected purposively for their involvement in waste-generating activities.

The scope was confined to in-hospital solid biomedical waste management processes, including segregation, internal storage, handling, and treatment, particularly incineration. It did not extend to the management of liquid biomedical waste or the external transportation and final disposal of waste outside hospital grounds. Departments studied included emergency, ICU, operating theatres, maternity, dialysis, wards, and laboratories, as these are primary waste-generating units. Additionally, the study was cross-sectional, capturing practices at a single point in time and may not reflect seasonal or long-term variations. While the research findings are specific to TRRH and may not be generalizable to all healthcare facilities in Tanzania, they offer important insights into practical gaps and inform targeted interventions for improving solid biomedical waste management systems in similar resource-limited hospital settings.

1.7 Limitations of the Study

One major limitation of this study is its reliance on self-reported data from healthcare workers through questionnaires. Such data are susceptible to social desirability bias, where respondents may overstate their adherence to proper biomedical waste management practices, especially when they are aware that their responses are being evaluated. Furthermore, the advance knowledge of the ongoing interviews may have influenced participants to modify their behavior temporarily or prepare rehearsed responses, potentially compromising the authenticity of the data collected.

Additionally, the study used a simplified and outdated waste categorization system, classifying biomedical waste into only two categories: “infectious” and “highly infectious.” This deviates from the comprehensive classification recommended by WHO (2017), which includes multiple categories such as sharps, pathological waste, pharmaceutical waste, chemical waste, and general healthcare waste. As a result, the study may have underrepresented or misclassified certain types of waste, leading to an incomplete characterization of the actual biomedical waste generated at TRRH. This limitation may affect the accuracy of waste generation estimates and hinder comparison with international standards or other healthcare facilities applying WHO-recommended frameworks.

Lastly, while the study involved diverse staff categories, there was limited exploration of interdepartmental differences in training exposure, workload, or resource availability. Given the multidimensional nature of waste management, future studies could benefit from stratified analysis to capture nuanced differences across units such as maternity, surgery, and outpatient departments

CHAPTER TWO

LITERATURE REVIEW

2.1 Definitions of Key Concepts

2.1.1 Health facility

According to WHO (2006), health-care facilities encompass a range of establishments such as hospitals, primary health-care centers, isolation facilities, units for burn patients, feeding centers, and various others. These facilities can be divided into higher and lower levels. Higher-level facilities consist of district hospitals, designated hospitals, and referral hospitals, while lower-level facilities include health centers, dispensaries, laboratories, and specialized clinics like eye clinics, HIV/Sexually Transmitted Diseases clinics, Reproductive Child Health clinics, and dental clinics.

2.1.2 Bio-Medical Waste Management

Medical waste management (MWM) encompasses all the processes involved in generating, sorting, transporting, storing, handling, and ultimately disposing of waste generated within medical facilities, each stage requiring careful attention. This ensures that the resources (financial, equipment, and facilities), procedures, and outcomes (safe staff, a clean environment, and the health of personnel) necessary for the safe management and disposal of medical waste are maintained at an optimal level (MOHSW, 2006).

2.1.3 Medical Waste

According to the Tanzania Medical Waste Management Monitoring Plan, medical waste is defined as all the waste harmful or not, produced by health organizations throughout medical actions, precautionary, curative and/or analytic (Manyele and Lyasenga, 2010).

2.1.4 Bio-medical Waste

Biomedical Waste (BW) refers to any waste produced during the diagnosis, treatment, or immunization of humans or animals in research endeavors. Biomedical waste management has become a significant concern for hospitals, nursing homes, and the environment alike. The amount of biomedical waste generated by healthcare facilities depends on various factors including waste management practices, the nature of healthcare services provided, the occupancy rate of these facilities, their specialized services, the proportion of reusable items in use, and the availability of infrastructure and resources (Mandal *et al.*, 2009).

Waste characterization refers to the systematic process of identifying, categorizing, and quantifying the types of waste generated within a specific facility or operation—such as a healthcare institution. It includes determining the physical composition, risk level (e.g., infectious, hazardous), source department, and volume of each type of waste produced. This process is critical for designing effective waste management strategies, selecting appropriate treatment methods, and minimizing environmental and occupational health risks.

According to Eshete et al. (2023) in their study on hospital waste management practices in Ethiopia, "waste characterization involves not only the classification of biomedical waste into categories like sharps, pathological, or infectious, but also assessing the generation rate and determining the specific hospital units responsible for their production, which is essential for targeted interventions."

Similarly, Windfeld and Brooks (2015) emphasize that, "accurate waste characterization enables facilities to implement risk-based segregation and treatment systems, and avoid over-classifying general waste as hazardous, which inflates treatment costs and increases the risk of exposure."

2.2 National Policy Guidelines Statement for Health Care Waste Management in Tanzania (2017)

Ever health care facility and other institutions that in the course of their activities generate HCW shall have the responsibility to minimize, segregate, collect, store, label, transport, treat and dispose of all HCW in the manner prescribed in this policy and other laws and regulation regarding HCWM so as to safeguard public health and the environment.

Provided the "proximity principle" is observed, HCFs in the same vicinity may share treatment and disposal facility in order to minimize public health risks and the environment.

The ministry of health, community development, gender, elderly and children shall collaborate with all stake holders to develop information, education and communication strategies to educate the public on the importance of the proper health care waste management and the role of community.

The ministry of health, community development, gender, elderly and children shall collaborate with VPO-DoE, PO-RLG and other stake holders to promote centralized biomedical waste treatment facilities and ensure an effective management of health care waste.

The ministry shall facilitate and collaborate with other stake holders to conduct Monitoring and Evaluation and operational research on priority areas for the health care waste management.

2.3. Characterization of Biomedical Waste

Biomedical waste (BMW) is broadly classified into several categories, each with distinct characteristics, generation patterns, and implications for public health and the environment. Studies from both developing and developed countries have revealed that the type and quantity of waste generated vary significantly across departments and healthcare facility levels. Understanding how each waste type contributes to health hazards, environmental degradation, and resource strain is critical for developing effective biomedical waste management strategies. The Following empirical literature provides a comprehensive overview of different BMW types, their generation rates, and associated impacts as documented in recent studies.

2.3.1Pathological Waste

Pathological waste consists of body parts, tissues, organs, and blood-soaked materials, typically generated from surgical units, maternity wards, and pathology laboratories. Although not always infected, such waste is treated as hazardous due to its biological origin and potential for contamination. A study by Demissie et al. (2018)

in Ethiopia found that tertiary hospitals generated approximately 0.45 kilograms of pathological waste per bed per day. In Indian urban hospitals, Chatterjee et al. (2021) estimated an average generation of 75–100 kilograms per week, with surgical theatres being the largest contributors. These wastes, if not properly managed, pose both psychological and physical risks. Demissie et al. reported that residents living near hospitals experienced emotional distress when exposed to visible pathological waste during open dumping practices. Similarly, in Tanzania, Manyele and Lyasenga (2010) observed that unsegregated disposal of tissues and blood products in unlined pits resulted in soil and groundwater contamination, creating conditions conducive to the spread of infectious diseases and environmental degradation.

2.3.2 Non-Hazardous Waste

Non-hazardous waste is composed of materials that have not come into contact with infectious agents or hazardous chemicals. It includes food scraps, packaging materials, and office waste typically originating from kitchens, outpatient departments (OPD), and administrative offices. Although generally safe, this waste poses serious risks when mixed with infectious or hazardous waste due to poor segregation. WHO (2017) estimates that about 75–85% of all healthcare waste is non-hazardous. However, Njiru (2014), in a study at Kenyatta National Hospital in Nairobi, found that up to 30% of non-hazardous waste bins contained contaminated materials, increasing the volume of hazardous waste requiring costly and complex treatment. The study also found that poor segregation practices led to a 20–30% increase in the quantity of waste sent to incineration, thereby inflating operational costs and causing unnecessary exposure to incineration emissions. This highlights the importance of proper classification and training to prevent the transformation of benign waste into hazardous streams.

2.3.3 Hazardous Waste

Hazardous waste encompasses a wide range of waste types, including infectious, pathological, sharp, and chemical wastes. It is typically generated in large volumes in laboratories, surgical departments, labor wards, and diagnostic units. A study conducted by Mndeme and Kilima (2023) in Tanzanian referral hospitals found that hazardous waste accounted for approximately 60% of total hospital waste, with an average generation rate of 0.8 kilograms per bed per day. Similarly, Sharma and Sharma (2019) reported a slightly higher rate of 1.1 kilograms per bed per day in Indian hospitals. These wastes are associated with a range of occupational and environmental risks. Mndeme and Kilima noted that 16% of hospital support staff, particularly cleaners, had experienced direct exposure to hazardous fluids and materials due to a lack of personal protective equipment (PPE). Inadequate containment and disposal infrastructure further compound these risks, increasing the likelihood of nosocomial infections and workplace injuries. These findings affirm that hazardous waste mismanagement poses significant dangers not only to staff and patients but also to surrounding communities.

2.3.4 Infectious Waste

Infectious waste includes materials contaminated with blood, body fluids, or microorganisms capable of causing diseases. These are commonly generated from dressing changes, diagnostic procedures, laboratories, and surgical operations. Eshete et al. (2023) investigated infectious waste handling in Ethiopian hospitals and recorded a generation rate of 0.6 kilograms per bed per day. They noted that infectious waste was frequently stored in unsealed containers close to patient areas, creating a high risk of disease transmission. The study reported that nearly 7.2% of healthcare workers experienced occupational exposure within one year, largely due to improper handling or insufficient training. In Nigeria, Adogu et al. (2020) found that primary health centers lacked secure systems for the disposal of infected gauze, bandages, and gloves. Many facilities resorted to open-air burning, which not only released harmful airborne pollutants but also led to recurring respiratory illnesses in nearby communities. These findings highlight the urgent need for improved infrastructure and regular training to ensure safe handling of infectious materials.

2.3.5 Sharps Waste

Sharps waste comprises needles, syringes, scalpels, broken glass, and other objects capable of cutting or puncturing the skin. These are among the most dangerous biomedical wastes due to their potential to transmit bloodborne infections such as HIV and hepatitis B and C. According to Felicia et al. (2008), unsafe disposal of sharps causes an estimated 66,000 hepatitis B, 16,000 hepatitis C, and 1,000 HIV infections among healthcare workers each year. A local study by Manyele and Anicetus (2006) at Bugando Medical Centre in Tanzania reported that only 58% of sharps were properly segregated into puncture-resistant containers. Alarmingly, one-third of the hospital’s nurses reported having experienced a needlestick injury within the past month. This situation was attributed to poorly marked disposal bins, lack of training, and absence of supervision. The consequences of unsafe sharps disposal are profound, both in terms of worker safety and institutional liability.

2.3.6 Chemical Waste

Chemical waste is generated from cleaning processes, laboratory tests, pharmaceutical use, and diagnostic activities. It includes disinfectants, reagents, solvents, and expired medications, many of which are corrosive, flammable, or toxic. WHO (2017) emphasizes that chemical waste is often overlooked in routine waste audits, even though it can cause lasting harm to ecosystems and human health. In Tanzania, Hamoda (2016) found that 94% of hospitals in Arusha and Moshi discharged chemical waste directly into open drains or septic tanks without treatment. The average daily output was estimated at 0.2 kilograms per bed. This practice leads to contamination of water sources, disrupts aquatic ecosystems, and contributes to antimicrobial resistance. Similarly, the Institute for Environmental Chemistry (2011) in Germany demonstrated that pharmaceutical residues—such as painkillers, antibiotics, and hormones—remained active in hospital wastewater and were detected in downstream drinking water supplies. These studies reveal that chemical waste, while less visible, can have long-term environmental consequences that are costly and difficult to reverse.

2.3.7 Highly Infectious Waste

Highly infectious waste includes microbial cultures, infected body fluids, and materials used in treating patients with highly contagious diseases such as Ebola, tuberculosis, or COVID-19. This waste is predominantly generated in isolation wards, medical laboratories, and intensive care units. During the COVID-19 pandemic, Heir and Asadi (2021) documented a dramatic increase in the production of highly infectious waste in hospitals across low- and middle-income countries, with daily generation rates rising from 0.7 to 2.5 kilograms per bed. These facilities, already burdened by limited resources, resorted to open burning and shallow burial due to overwhelmed incineration capacity. This led to the emission of dioxins and furans, both classified as carcinogenic by the WHO. Additionally, Rahman et al. (2020) highlighted the poor labeling and misclassification of highly infectious waste in many African hospitals, which resulted in exposure of frontline workers to disease-causing agents. Such conditions underscore the urgent need for specialized handling, transportation, and treatment protocols for this dangerous waste category.

This empirical review shows that biomedical waste is not a monolithic issue but rather a complex interplay of categories, each requiring tailored management approaches. From sharps that directly injure healthcare workers to chemical waste that disrupts ecological balance, the literature consistently emphasizes the need for proper segregation, adequate infrastructure, and continuous training. Furthermore, the generation rates vary significantly, ranging from 0.1 kg/bed/day for sharps to over 2.5 kg/bed/day for highly infectious waste during disease outbreaks, indicating that waste volumes are highly sensitive to hospital type, function, and crisis contexts. These findings offer a valuable reference point for evaluating practices at Tanga Regional Referral Hospital and framing local challenges within the broader global experience.

Thank you for the clarification. Based on your request, here is the Theoretical Literature Review section for your proposal, written as a standalone component of your research before data collection. It explains how each theory/model can be applied in a study on biomedical waste management and reviews its effectiveness in other studies, without referencing your specific findings or discussion.

2.4 Biomedical Waste Management Practices

According to WHO, (2017). Biomedical waste management (BMWM) involves various steps such as sorting, gathering, storing, treating, transporting, and disposing of waste in healthcare facilities. Effective BMWM entails crucial processes like segregating, collecting, storing, transporting, treating, and ultimately disposing of waste generated within healthcare settings.

As per (Vishal *et al.,* 2012), the process entails four main steps : sorting various components, identifying reusable items and securely storing them in appropriate containers, transporting them to designated waste handling and disposal sites, and finally treating and disposing of the waste.

Furthermore, according to (Mesfin *et al.*,2013), another study found that the standard practice of waste management follows a well-defined procedure. This study identifies key steps in medical waste management, including handling, sorting, breaking down, disinfecting, storing, transporting, and ultimately disposing of the waste in a safe and scientifically sound manner in all institutions.

2.4.1 Collection and Segregation

Segregation is a very important aspect and a first step in waste management, as segregation errors create a threat to those stuffs managing wastes. Effective segregation initiates at the source or at collection point is a key factor in the waste management strategy and it enable hospital authorities to save money on waste disposal of all waste generated by the health care facility or hospital (Vorapong, 2009).

Based on the study carried at Pravara Rural Hospital, Loni and Maharashtra with an aim to characterize and quantify the waste generated at the hospital, it was found that there was no segregation of the waste starting from generation source to final disposal (Arvind and Girish, 2010). Studies in Uttar Pradesh the results indicated that segregation of biomedical waste was not properly carried out, and disposal was unscientific; Waste is segregated at source and stored in plastic bins of the same color, with plastic covers of different colors inside (Hanumantha, 2009).

2.4.2 Storage of Hospital Waste

(Vijaya *et al.,* 2007) noted that segregated healthcare waste storage was located away from patient and nursing areas. However, the storage lacked secure bins to prevent access by flies, rodents, and dogs. Furthermore, there was no designated storage area, resulting in haphazard dumping. Healthcare waste wasn't kept onsite for more than 24 hours.

To prevent waste accumulation and decomposition, it should be collected daily. The area where larger containers are stored before being taken to central storage should be close to wards but inaccessible to unauthorized individuals like patients and visitors. Storage time shouldn't exceed 24-48 hours, especially in warm and humid climates (WHO, 2005).

2.4.3 Transportation of Hospital Waste

Njiru, 2015) suggests that transportation of medical waste on public infrastructure should be carried out by trained personnel using suitable vehicles equipped with sealed containers. Non-reusable plastics should be shredded before being sent to the vendor. The final disposal of medical waste can be accomplished using machinery such as incinerators, autoclaves, hydroclaves, or microwaves (Sharma, 2010).

(Verma, 2010) revealed that infected waste was being transported using wheelbarrows. Verma suggested that air-conditioned vans with suitable compartments would be necessary for transporting infected waste. Despite the inclusion of this provision in the Municipal Solid Waste (MSW) Rules, covered vans are not supplied for transporting municipal waste, and enforcement of this rule remains lacking.

2.4.4 Treatment and Disposal

Based on study carried by institute of environmental chemistry German suggested that improper disposal of pharmaceutical waste not only poses a threat to the environment but also presents significant health hazards, as these substances can persist and remain active in aquatic environments for extended periods. A survey involving randomly selected participants was conducted to investigate how households dispose of unused and expired pharmaceuticals (Institute for Environmental Chemistry-Germany, 2011).

In developing nations, the unhygienic disposal of waste puts millions of lives at risk, as local residents often scavenge at dumping sites. African healthcare facilities face significant challenges in disposing of sharps (such as needles, scalpel blades, blood vials, and glassware) contaminated with infectious agents. The high cost of safety boxes for proper sharps disposal limits their widespread use (News Analysis, 2010).

2.5 Drivers Influencing Biomedical Waste Management.

2.5.1 Education Level

Education level has consistently been identified as a foundational factor influencing biomedical waste handling. Inadequate formal education, especially among auxiliary staff such as cleaners and waste handlers, limits their ability to interpret and follow waste management protocols. Magwe (2020) found that while many healthcare workers in Dodoma were aware of biomedical waste hazards, limited educational qualifications among lower-cadre staff restricted their capacity to engage in proper segregation and disposal. Moreover, those with secondary or tertiary education were more likely to comply with guidelines compared to those with only primary education. The knowledge gap arising from educational disparities undermines the efficiency of waste management systems, especially in low-resource settings.

2.5.2 Employment Status

The employment status of healthcare workers also shapes waste management outcomes. Manyele and Anicetus (2006), in a national assessment of Tanzanian hospitals, emphasized that temporary or contract workers were often deployed for waste collection and disposal. These workers typically lacked institutional affiliation, formal induction, and long-term investment in hospital policy. The transient nature of their employment reduced accountability and increased instances of poor segregation, handling without protective gear, and unsafe final disposal. This study highlighted that sustainable biomedical waste management requires stable staffing with formal employment arrangements.

2.5.3 Department

The department in which healthcare staff work plays a significant role in shaping their exposure to and handling of biomedical waste. In a study at a national referral hospital in Tanzania, Isangula et al. (2021) reported that segregation compliance varied significantly across departments. Clinical units like surgical and maternity wards demonstrated better adherence to protocols, attributed to their frequent interaction with high-risk waste. Conversely, administrative or outpatient departments showed lower compliance levels. This suggests that waste management behavior is influenced not only by individual knowledge but also by departmental priorities and routines.

2.5.4 Years of Experience

Experience in healthcare service has been associated with improved biomedical waste handling. More experienced professionals often possess greater familiarity with institutional policies and are more attuned to the risks of improper disposal. Although not always numerically quantified, Manyele and Anicetus (2006) observed that long-serving staff demonstrated greater consistency in waste segregation and use of personal protective equipment compared to recently recruited or rotated staff. Informal learning through observation and participation in institutional culture contributes to this trend. However, newer staff, particularly those recently trained, may sometimes outperform older workers in applying current guidelines.

2.5.5 Age

Age as a variable intersects with training exposure and institutional culture. In the study by Isangula et al. (2021), the mean age of respondents was approximately 32 years. It was observed that younger healthcare workers, who had often undergone more recent pre-service training, displayed better understanding of updated waste management practices. However, older staff showed better adherence to hospital norms and policies, suggesting that experience and age may reinforce behavioral compliance, even if technical knowledge may be less current. This dynamic suggests that both younger and older staff contribute positively but differently to waste management systems.

2.5.6 Sex

Gender has been noted to influence roles and behaviors in biomedical waste handling. Isangula et al. (2021) found that female healthcare workers were more frequently involved in waste segregation and handling activities, especially within nursing and supportive roles. This gendered task distribution places women at greater risk of exposure to hazardous waste, while also giving them more influence over day-to-day compliance. The study implies that waste management strategies must take gender into account, ensuring equitable distribution of responsibilities and provision of protective measures for all genders.

2.5.7 Occupation

Occupational role within a healthcare facility shapes one’s knowledge and practice regarding biomedical waste. Clinical staff, such as nurses and laboratory technicians, generally display higher levels of compliance due to their direct engagement with waste-producing procedures. In contrast, auxiliary staff like cleaners or waste porters may lack the same level of training and institutional support. Magwe (2020) emphasised that while clinicians had better knowledge and safer practices, support staff were often overlooked in training programs. This occupational stratification of knowledge and behavior creates gaps that can compromise the overall waste management system.

2.5.8 Awareness

Awareness of biomedical waste hazards and proper disposal procedures is a critical behavioral driver. In the Dodoma City study, Magwe (2020) found that 96.5% of healthcare workers were aware of the health and environmental risks posed by poor waste management. Despite this, awareness alone was insufficient to guarantee compliance, as many staff lacked the resources or institutional support to translate knowledge into practice. This finding aligns with the understanding that awareness must be accompanied by other enablers such as training, supervision, and infrastructure.

2.5.9 Training

Training is among the most powerful influencers of proper biomedical waste management. Several studies highlight that trained healthcare workers are more likely to segregate waste correctly, use personal protective equipment, and comply with disposal protocols. In a study conducted in northern Tanzania, Njau et al. (2015) observed that although healthcare workers were knowledgeable about injection safety, lack of waste management training led to poor practices such as unprotected handling and inadequate disposal. Similarly, Manyele and Anicetus (2006) reported that institutions that incorporated regular BMWM training programs observed improvements in waste handling, reduced open burning, and increased compliance with national guidelines**.**

2.6 Waste Management Theory (WMT)

Waste Management Theory (WMT) provides a structured framework for understanding the design and function of waste systems across multiple sectors. Rooted in the principles of Industrial Ecology and environmental engineering, WMT aims to organize the diverse components of waste systems—such as waste types, sources, processes, and outcomes—into a unified body of knowledge Gavannavar, Shantharam, & Kulkarni, (2014). In the context of biomedical waste, WMT facilitates a systems-level understanding of how healthcare institutions generate and process waste and how these systems can be optimized to reduce harm.

Studies have used WMT to design waste systems that are both efficient and compliant with environmental regulations. For example, Manyele and Lyasenga (2010) applied WMT to analyze medical waste practices in Tanzanian hospitals and identified institutional gaps such as poor waste container design and inadequate transport schedules. Their work showed that when system components are well-coordinated—such as through defined workflows and logistical planning—waste handling improves. In research proposals, WMT is effective for structuring investigation into how the technical and institutional aspects of waste management influence outcomes.

2.6.1 Waste Management Hierarchy Theory

The Waste Management Hierarchy (WMH) is a foundational theory in sustainable waste management. It ranks waste handling practices in order of environmental desirability—starting with reduction, reuse, and recycling, and ending with disposal, which is considered the least favorable option as stipulated several writers as Plesea & Visan, (2014), Yakubu & Zhou, (2018). The hierarchy is often used as a policy and planning tool, guiding healthcare institutions toward minimizing waste generation and promoting sustainability.

In biomedical waste research, WMH has been used to assess whether hospitals are following best practices for waste minimization. For instance, Gupta et al. (2017) used the hierarchy to evaluate Indian hospitals and found that due to poor segregation, most waste was incinerated or dumped rather than recycled, which increased environmental and financial burdens. Applying WMH in a study proposal enables researchers to evaluate not only the quantity of waste but also how closely institutions align with sustainable practices. It is particularly effective in identifying systemic inefficiencies and guiding recommendations for policy improvement.

Figure 2.1: Waste Management Hierarchy

2.7 Biomedical Waste Management Model

The Biomedical Waste Management Model is a practical framework used to analyze the lifecycle of biomedical waste—from generation and segregation to treatment and final disposal. This model considers technical parameters (e.g., waste categories and volume), economic constraints, and compliance with national or international guidelines. BMWMM is particularly useful in settings where waste generation rates are increasing and infrastructure is limited Gavannavar et al., (2014).

In a study by Rahman et al. (2020), a waste flow model was applied to hospitals in South Asia to estimate the increase in biomedical waste during the COVID-19 pandemic. The model helped identify bottlenecks in treatment capacity and proposed practical interventions, such as mobile autoclaves and improved storage protocols. In a research proposal, adopting a BMW management model supports the development of data collection tools (e.g., waste quantification sheets) and enables structured analysis of how biomedical waste is generated and managed across departments. It is particularly helpful for comparing institutional performance against established standards.

2.7.1 Health Belief Model

The Health Belief Model (HBM) is a behavioral theory that explains why individuals engage—or fail to engage—in health-related behaviors. It posits that behavior is influenced by factors such as perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (Rosenstock, 1974). In biomedical waste management, HBM is particularly relevant for examining why healthcare workers may or may not follow proper waste disposal procedures despite having adequate knowledge.

HBM has been effectively used in several studies to understand behavioral outcomes. Mndeme and Kilima (2023) found that healthcare workers who believed they were at risk of infection were more likely to use PPE and segregate waste correctly. Similarly, Chisholm et al. (2021) observed that workers with higher self-efficacy were more compliant with BMWM protocols, regardless of the availability of resources.

2.8 Conceptual Frame Work

The conceptual frame work serves as a spring board for theory development, theoretical and context the importance of the study, where a model symbolically represents a phenomenon. The conceptual framework for this study based on the health belief model from Rosenstock, (1974). Beckers Health Belief model addressed relationship between the person belief and behavior. If people understand the ways or have knowledge on something then they most likely to adopt to the ways of the knowledge, that people with bio-medical waste management awareness they are most likely to practice the knowledge to the extent of their understanding and believe and vice versa. Therefore, from this study socio demographic behaviors, believes and knowledge are the independent variables but the application of the knowledge (biomedical waste management practices) depends upon the behavior and the personal belief of the hospital health care workers. In this conceptual framework, indicates the variables under independent and dependent variables.

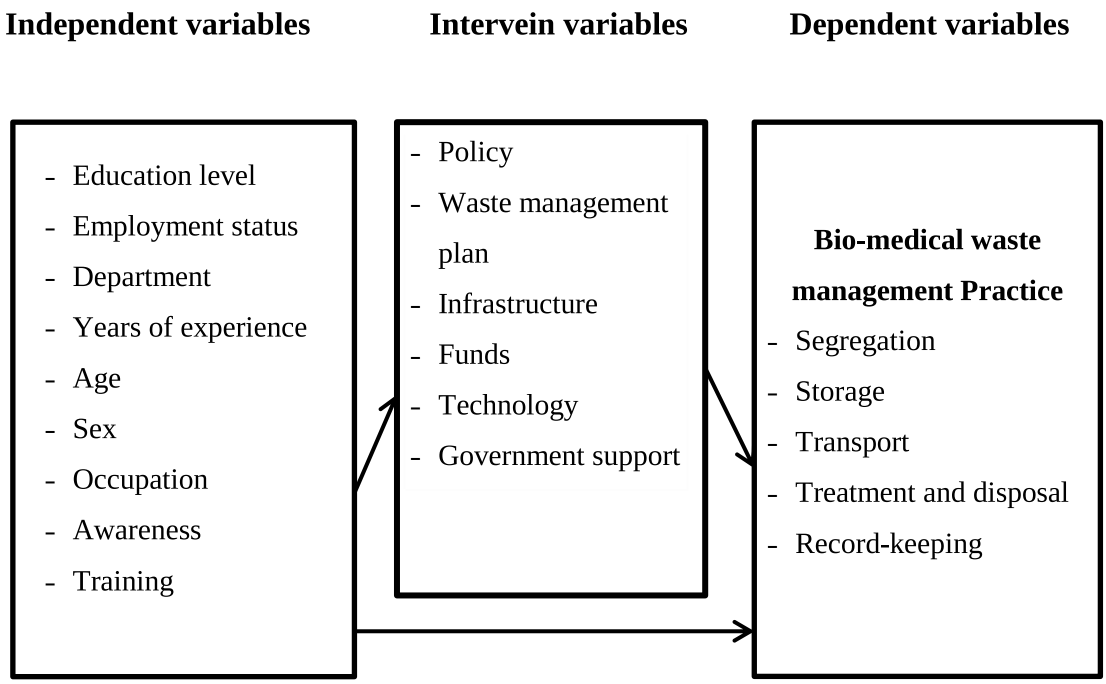


Figure 2.2: Conceptual Framework

2.9 Research Gap Identified

Biomedical Waste Management (BMWM) plays a critical role in safeguarding public health, ensuring environmental protection, and maintaining the safety of healthcare professionals. Effective management depends on systematic segregation, safe treatment, and final disposal guided by clear policies and consistent facility-level implementation. While significant studies have been made globally and nationally, healthcare facilities in resource-constrained settings like Tanzania still face persistent challenges due to inadequate infrastructure, insufficient training, and unsafe handling practices. Recent evidence from Dodoma, Tanzania James and Tarimo, (2023) revealed that although many healthcare workers understand the risks associated with biomedical waste, their actual compliance with recommended handling protocols remains low. The study identified systemic issues such as the absence of adequate waste containers, lack of practical training, and irregular supervision, which collectively contribute to poor waste management behavior. Similarly, a nationwide WHO-supported assessment in Tanzania (WHO, 2021) found that, despite national waste management guidelines, over one-third of health facilities lacked reliable segregation systems, and many continued to rely on open burning and mixed waste disposal practices. At Tanga Regional Referral Hospital (TRRH), internal observations confirm that gaps persist in segregation, documentation, and resource allocation, despite basic training being provided. These findings echo regional patterns. In Kenya, for example, Otieno et al. (2021) reported that healthcare workers in Kajiado County often failed to follow BMWM procedures due to a lack of training materials, PPE shortages, and insufficient institutional support. Meanwhile, in Ethiopia, Tadesse and Kumie (2021) highlighted that while waste handlers had awareness of infection risks, poor infrastructure and workload pressures frequently led to unsafe disposal practices. Mishra et al. (2022) argue that many existing models of waste management overlook crucial behavioral and contextual variables such as staff motivation, work environment, and demographic characteristics. This limitation has led to policy frameworks that do not fully align with the operational realities in low-resource health settings.

Therefore, this study aims to fill the research gap by moving beyond simple assessments of awareness and instead exploring the behavioral and institutional drivers that influence BMWM practices. By investigating how factors such as age, training level, years of experience, departmental assignment, and organizational support affect compliance, the study will offer deeper insights into barriers and enablers of effective waste management.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area Description

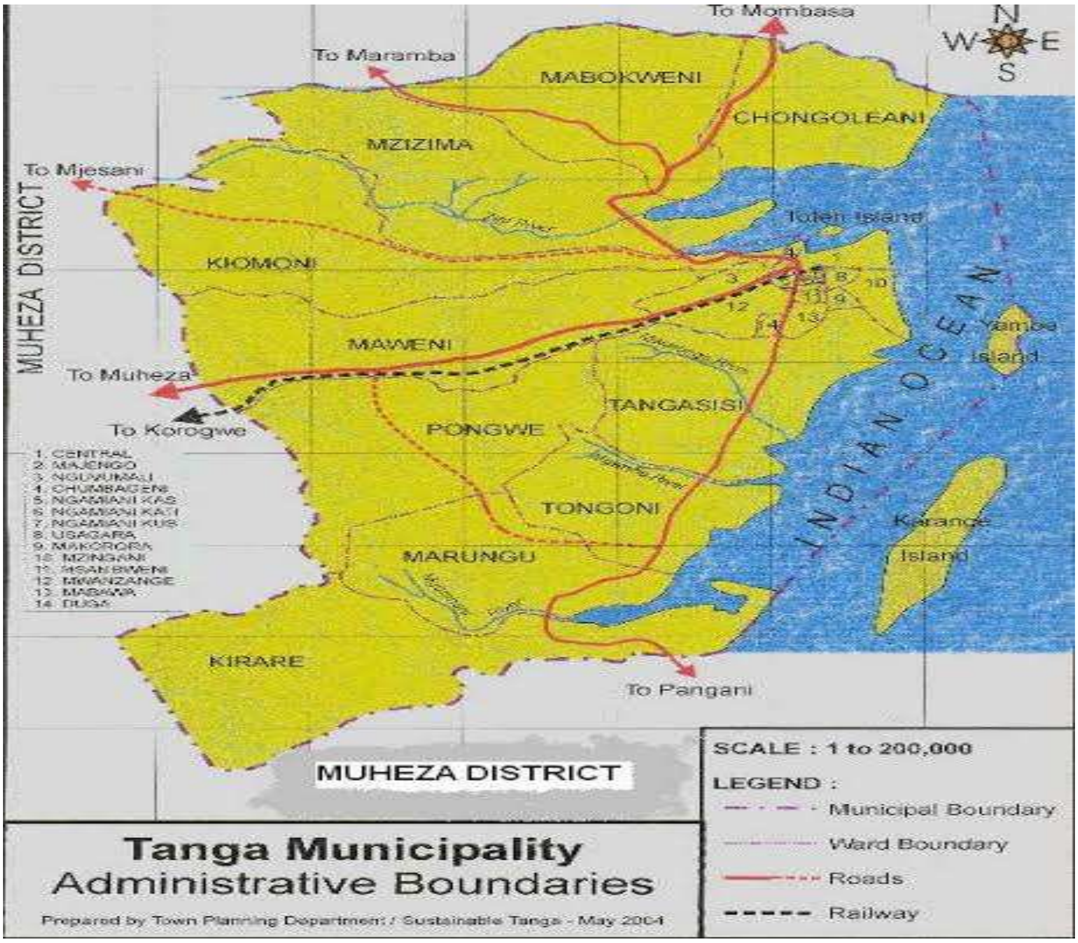


Figure 2.3: A map of Tanga Regional Tanzania

3.1.1Tanga Regional Referral Hospital (TRRH)

TRRH is a tertiary-level public healthcare facility situated in Tanga Region, north-eastern Tanzania with geographical coordinates of 5°03′47″N 39°06′44″E. As per the 2022 National Census, Tanga Region has a population of approximately 2.6 million. Established in 1901 by the German colonial administration, TRRH is recognized as one of the earliest hospitals in East Africa. It serves as a referral center for peripheral health facilities and provides diverse services including surgery, maternity care, dialysis, and infectious disease treatment. It is co-located with the National Institute for Medical Research (NIMR), enabling a unique environment for health systems research.

TRRH was selected for this study due to its high patient load, comprehensive departmental structure, and its role as a major generator of biomedical waste in the region—making it an ideal setting for evaluating BMW management practices and influencing factors.

3.2 Research Design

A facility-based cross-sectional study design was employed. This design is widely used in environmental health and hospital-based studies (Setia, 2016) to assess the prevalence of behaviors and conditions at a specific point in time. It enables the researcher to establish associations between variables without manipulating the study environment. The cross-sectional approach was particularly suitable for identifying BMW practices and related determinants within a complex hospital setting without requiring longitudinal follow-up.

In alignment with best practices in BMW studies (e.g., Windfeld & Brooks, 2015; Sharma & Sharma, 2019). With quantitative-research methods (questionnaires and document reviews) provided measurable patterns.

3.3 Study Objectives and Data Collection Approach

The data collection strategy was explicitly designed to match the three research objectives.

3.3.1 Objective 1: To Characterize the Types and Volume of Solid Biomedical Waste Generated at TRRH

Primary Data: Direct observation using structured checklists was conducted in key departments (e.g., surgery, maternity, laboratory) to identify waste types and volumes. This aligns with methodologies in Patwary et al. (2021), who emphasized real-time observation as essential for accurate waste characterization.

Secondary Data: Waste generation records and facility-level annual reports were reviewed to validate and triangulate observational findings. These included logs from incinerator operations and departmental disposal summaries.

3.3.2 Objective 2: To Assess the Existing Biomedical Waste Management Practices Among Healthcare Personnel

Primary Data: Semi-structured questionnaires (Appendix 1) were administered to healthcare workers to capture reported practices in waste segregation, storage, transport, and disposal. The questionnaire was adapted from WHO (2017) standards and prior studies in hospital waste management by Manyele & Lyasenga, (2010).

Observational Data: A structured checklist (Appendix 2) was used to observe actual behaviors in waste handling, enabling comparison with self-reports and reducing bias.

3.3.3 Objective 3: To Identify key Drivers Influencing Biomedical Waste Management Practices Among Healthcare Personnel

Primary Data: Demographic and employment-related information (e.g., age, occupation, employment status, training history) was collected through questionnaires and analyzed against observed waste handling practices.

3.4 Study Population and Sampling

3.4.1 Study Population

The population included all healthcare workers at TRRH involved in biomedical waste generation or handling. This comprised doctors, nurses, laboratory technicians, pharmacists, environmental health officers, and trained support staff such as hospital cleaners.

3.4.2 Sampling Frame and Technique

From a total of 314 staff at TRRH, a purposive sampling technique was applied to select 74 respondents, focusing on individuals with direct roles in waste handling. Purposeful sampling is widely applied in qualitative and mixed-method studies where expert insight or exposure to the phenomenon is essential (Palinkas et al., 2015). Sample size adequacy was balanced against logistical constraints and aligned with the concept of information-rich cases.

3.5 Data Collection Instruments

Questionnaires: Designed based on WHO BMW management standards and prior validated tools. They included both closed and open-ended questions to gather data on knowledge, awareness, and self-reported practices.

Observation Checklists: Developed using guidelines from WHO (2017) and Waste Management Journal studies to assess real-time practices, infrastructure availability (e.g., bins, PPE), and compliance with segregation protocols.

Document Review Template: Used to extract secondary data from hospital records, including incinerator logs and waste tracking forms.

All tools were pre-tested for clarity and relevance at a similar facility before full deployment at TRRH.

3.6 Data Analysis

Quantitative data were analyzed using SPSS. Descriptive statistics (frequencies, percentages) were used to summarize demographic data and practice prevalence. To identify determinants of good BMW practices, binary logistic regression was used—appropriate for dichotomous outcomes (good vs. poor practice) as also employed in studies by Eshete et al. (2023) and Sharma & Sharma (2019).

The regression model estimated odds ratios (OR) and 95% confidence intervals (CI), with a p-value < 0.05 considered statistically significant. Independent variables included age, sex, occupation, training, awareness, and employment status. Categorization of BMW practices was based on combined observation scores and WHO criteria.

3.7 Ethical Considerations

The copy of approval letter and proposal was presented to the Hospital administration (Medical Superintendent) who cleared the researcher to carry out the study in the Hospitals. Respondents were assured that their participation is voluntary and that they are free to withdraw from the study at any time and informed consent was obtained before administration of questionnaires.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Description of Sample

In this chapter the researcher has presented result-of the data in-terms of tables, figures and simple interpretations Table 4.1 narrates the demographic data of the respondents in terms of age, sex, education level occupation and their departments.

Table 4.1: Sample Description

Age categories	
18-30	17
31-40	18
41-50	19
51-60	20
Sex	
Male	34
Female	40
Education	
O level	10
A level	15
Certificate	15
Diploma	18
Higher Education	16
Occupation	
Doctor	21
Nurse	19
Lab technician	15
Cleaners	11
Pharmacists	5
Environmental health officer	3
Department	
Emergency	13
Laboratory	8
Dialysis	8
Labor	16
Theatre	14
Ward/ICU	15

4.2 Characterization of Biomedical Wastes Generated

The primary objective of this section was to comprehensively characterize the types, quantities, sources, and segregation practices of biomedical waste generated by TRRH Hospital, highlighting key findings for effective waste management strategies.

From the observations it was identified that TRRH generates different types of biomedical waste, the hospital generalized them into two main categories namely highly infections for which have highly infectious rate and infectious biomedical waste for the less infectious biomedical waste category. It was also observed that, the generation rate of biomedical waste is primarily due factors like Single-use Items: Dialysis procedures often require numerous single-use items such as tubing, filters, syringes, and gloves, contributing significantly to the waste generated.

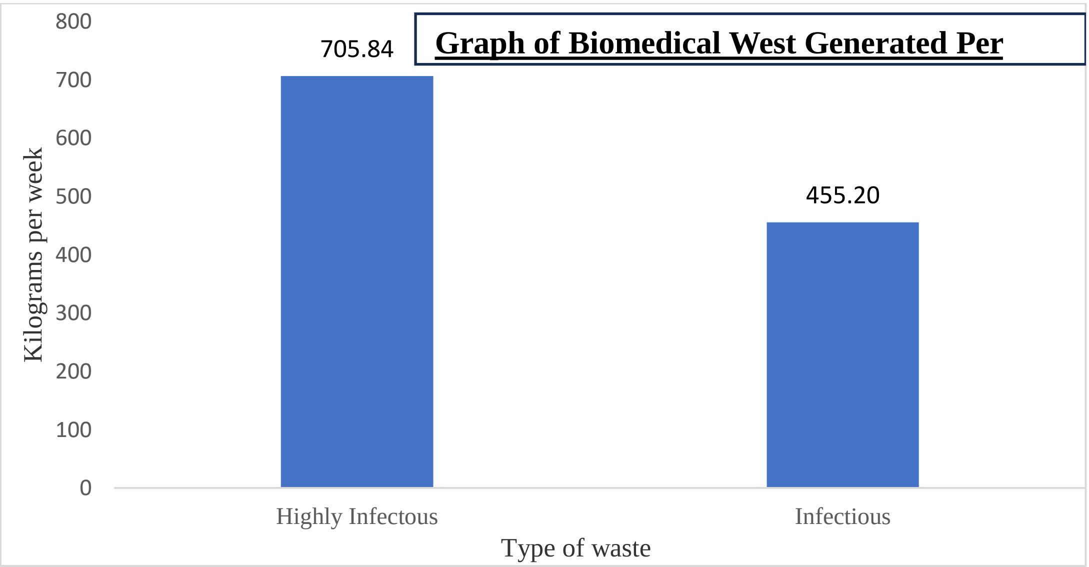


Figure 4.1: Waste Generation Rate

This study assessed the biomedical waste generation rate at Tanga Regional Referral Hospital (TRRH) over a 14-week period and revealed a total average of 1,313 kg of biomedical waste per week. The hospital classifies its waste into two broad categories: highly infectious biomedical waste, generated at 705 kg/week, and infectious biomedical waste, recorded at 455 kg/week as shown in **Figure 4.1**. This categorization reflects the hospital's internal classification system based on infection risk. A significant finding is that highly infectious waste forms the majority of the total waste generated, suggesting the prevalence of high-risk procedures or a potential overclassification due to limited waste segregation practices.

When examined through the lens of the Waste Management Hierarchy (WMH) Theory, this predominance of highly infectious waste reflects a system operating predominantly at the lowest tier—disposal—which is considered the least preferred option. According to WMH, the most desirable approaches are waste prevention, minimization, reuse, and recycling, with treatment and disposal being last-resort strategies. The high proportion of waste directed to incineration at TRRH, especially due to classification issues, suggests that waste reduction and segregation—the upper tiers of the hierarchy—are not being optimally achieved.

The predominance of highly infectious waste can be explained by the use of disposable medical items, particularly in procedures such as dialysis. These procedures typically require single-use items like tubing, filters, gloves, and syringes, all of which must be disposed of after one use due to contamination risk. This practice, though essential for infection prevention, contributes significantly to the high volume of hazardous waste (World Health Organization, 2004). While disposal is necessary for infection control, WMH Theory encourages facilities to explore upstream interventions, such as product substitution or more efficient use of single-use items, to reduce total waste generation.

To place these findings into context, the results from TRRH can be compared with those from other referral hospitals in Tanzania and beyond. For example, Mwaria (2020), in a study titled “Assessment of Healthcare Waste Management Practices in Five Referral Hospitals in Tanzania”, conducted at major hospitals including Muhimbili National Hospital and Bugando Medical Centre, reported biomedical waste generation rates ranging from 232 to 2,345 kg/day. In comparison, TRRH’s waste generation rate of 1,313 kg/week is relatively lower in absolute terms. However, it is important to note that Mwaria’s findings predominantly documented infectious waste, while the current study identified highly infectious waste as the dominant type. This variation may stem from differences in waste classification protocols, the nature of health services provided, and patient throughput.

These differences are further supported by the work of Manyele et al. (2010) in their study titled “The Status of Healthcare Waste Management in Tanzania: A Case of Three Regional Hospitals.” This research highlights that variations in biomedical waste quantities are strongly influenced by hospital capacity, patient volume, and the types of clinical services offered. Larger hospitals with specialized departments such as surgical units, intensive care, or dialysis centers tend to generate higher volumes of hazardous waste due to their complex procedures and higher patient turnover. In contrast, TRRH may have a lower capacity and patient load, which could explain its comparatively lower overall waste generation, despite the high proportion of highly infectious waste. However, in the framework of WMH, even lower-volume hospitals like TRRH are encouraged to emphasize segregation and reduction strategies to avoid unnecessary classification of general waste as hazardous, thereby reducing reliance on final disposal methods like incineration.

In addition, the World Health Organization (2004) underscores the importance of proper segregation at the point of waste generation. Failure to separate general waste from hazardous and infectious categories often results in overclassification, where a larger portion of waste is mistakenly treated as hazardous. This may be a contributing factor at TRRH, where the volume of highly infectious waste appears disproportionately high. This suggests a potential gap in the implementation of standardized waste segregation protocols or limited training among hospital staff on proper waste categorization. This segregation weakness indicates a shortfall at the second tier of the WMH—sorting and preparing waste for recovery or safe treatment, which in turn causes an avoidable shift toward incineration and burial.

Expanding the comparison beyond Tanzania, a study by Da Silva et al. (2005) titled “Medical Waste Management in Developing Countries: A Case Study in Brazil” analyzed data from over 200 hospitals in Latin America. It found that hospitals with specialized units, such as ICUs and dialysis centers, produced between 1.5 to 2.5 kg of hazardous waste per bed per day. Although TRRH’s data are not reported per bed, its weekly generation of 1,313 kg suggests a significant per-bed rate, especially if the hospital has a smaller bed capacity. This aligns with the global trend that complex healthcare services led to higher waste generation, particularly of the hazardous category. However, as per WMH guidance, the focus should not only be on quantity but also on ensuring that waste is accurately classified and minimized at the source, to reduce the pressure on treatment infrastructure.

Additionally, Windfeld and Brooks (2015), in their global review titled "Medical Waste Management – A Review," observed that low- and middle-income countries (LMICs) tend to exhibit poor segregation practices, resulting in inflated volumes of infectious or hazardous waste. They note that while total waste volumes in LMICs may be lower than in high-income countries, a larger proportion of their waste is treated as hazardous, often due to inadequate training and infrastructure. TRRH's situation reflects this pattern and indicates the need for capacity building, investment in waste treatment technology, and policy reinforcement to reduce the over-classification of biomedical waste. These insights support the WMH model, which emphasizes moving practices upward in the hierarchy by investing in training, segregation systems, and waste minimization strategies to reduce reliance on the bottom-tier incineration methods.

4.3 Assessment of Biomedical Waste Management Practices

4.3.1 Waste Segregation

Segregation Practices, found to be inconsistent across various departments, affecting proper sorting and disposal of biomedical waste streams.

This wide-ranging perception indicates a potential inconsistency or variance in awareness, implementation, or evaluation of biomedical waste management practices among the respondents. Healthcare workers demonstrated a reasonably good theoretical understanding of biomedical waste management protocols. However, there were notable gaps in the practical implementation of these protocols in day-to-day activities.

Plate: 4.1 Waste Segregation Bins

Plate: 4.2 Segregation Practices

At TRRH, waste segregation is designed to begin at the point of generation, with red bins designated for highly infectious waste and yellow bins for infectious waste. However, observational data revealed that improper segregation was common. Containers were frequently found unlabeled, or contained mixed waste streams including sharps, pharmaceuticals, and general waste as shown in **plate 1** and **plate 2** respectively. This improper handling increases occupational hazards, complicates treatment processes, and weakens regulatory compliance.

These observations are consistent with findings from Millanzi (2023), who assessed segregation practices in various Tanzanian health facilities. In his study "Assessment of Perceived Practices in Biomedical Waste Segregation Among Health Workers in Tanzanian Health Facilities", it was noted that despite most health workers possessing adequate theoretical knowledge of waste segregation protocols, practical application was poor. The author attributed this to lack of reinforcement mechanisms, limited oversight, and shortages of labelled containers—factors also evident at TRRH.

Further, Manyele et al. (2010), in their study "Assessment of Medical Waste Management in Tanzania Hospitals", found that over 60% of public hospitals in Tanzania exhibited non-compliance with WHO-recommended color-coding systems. They concluded that hospitals often relied on individual departments to manage waste without centralized enforcement. The case of TRRH reflects a similar decentralized weakness: although staff are generally aware of procedures, no strong supervisory or feedback mechanism ensures consistent compliance.

4.3.2 Waste Storage

From observations, TRRH store biomedical waste that was generated by the hospital for not more than 24 hours, the hospital stores 100 % of all generated waste as there is no waste that is transported outside the hospital, total.

Hospital waste including biomedical waste have been left outside the laboratory facility see **plate 3,** this Improper storage methods for biomedical waste within healthcare settings, it presents immediate risks to the environment, public health, and the safety of healthcare workers. When waste is not stored and transported correctly, it increases the likelihood of cross-contamination between different waste types, potentially exposing individuals to hazardous materials or infectious agents. Poor or unacceptable storage practices were also observed. Open unsecured waste bins in healthcare facilities amplify the risks associated with biomedical waste as observed in **plate 4**. These bins are prone to unauthorized access, spillage, or exposure to external elements, further exacerbating the hazards associated with biomedical waste.

Plate: 4.3 Waste Storage and Transport

Plate: 4. 4 Waste Storage

At TRRH, waste is typically stored in open bins outside laboratory buildings, some without covers or designated rooms as shown in **plate 3 and 4** This practice exposes waste to environmental elements and increases the risk of disease transmission. However, TRRH adheres to the WHO (2005) guideline of not storing waste beyond 48 hours, often managing to incinerate waste within 24 hours. Manyele et al. (2010) also documented poor storage conditions in their national assessment, reporting that in over half of the hospitals surveyed, storage areas were not enclosed, lacked ventilation, or were situated close to patient care areas—circumstances that mirror what was observed at TRRH. These findings reinforce the need for dedicated, well-ventilated, secure storage areas, which remain a major infrastructural gap across the Tanzanian healthcare system.

In contrast, Caniato et al. (2015) identified case studies from Kenya and South Africa where hospitals had invested in integrated waste handling units, complete with labeled trolleys, scheduled pick-ups, and monitored storage. These facilities reported a significant reduction in spillage and exposure incidents, pointing to the value of combining infrastructure investment with strict protocols.

4.3.3 Treatment and Disposal

Through direct observation it was found that TRRH predominantly relies on the incineration technology powered by gas as a fundamental method for treating and disposal of biomedical waste, which is the most common in developing countries but also to overlook more environmentally sustainable alternatives. Depending on the amount of waste generated and stored, TRRH usually incinerates and dispose total of biomedical waste generated by TRRH within 24 hours on daily basses by aid of modern incineration method that utilizes gas as fuel and the remaining ash is disposed in a pit-hole.

Plate: 4. 5 Incinerator

TRRH uses a gas-based incinerator for final treatment, which offers a cleaner, more controlled burn compared to the crude oil or charcoal-based incinerators commonly found in many facilities. According to WHO guidelines, gas-powered incineration helps reduce waste volume by up to 90% while minimizing emissions, a crucial step toward sustainable waste management. This places TRRH at the lower tier of the Waste Management Hierarchy (WMH), which prioritizes waste prevention, reduction, and recovery before resorting to final disposal. While incineration is often necessary in healthcare settings, WMH theory underscores the need to first minimize the volume of waste requiring incineration through upstream strategies such as segregation and source reduction.

Mwaria (2020) reported that most referral hospitals in Tanzania still use outdated incinerators that lack air filters and pose environmental risks due to unregulated emissions. In this respect, TRRH appears relatively advanced. However, the final disposal method—burying residual ash in pits on hospital grounds—still raises concerns about soil contamination and long-term environmental impact, especially if pits are unlined or unmonitored. From a WMH perspective, this practice emphasizes the urgent need to invest in better post-treatment residue management, such as secure landfilling or ash stabilization, which aligns with the model's guidance to reduce environmental risks at the final disposal stage.

The findings from TRRH align closely with national trends in biomedical waste management in Tanzania, as highlighted in the works of Millanzi (2023), Mwaria (2020), and Manyele et al. (2010). Across these studies and the current research, similar themes emerge: awareness among healthcare workers exists, but consistent practice, infrastructure, and supervision remain lacking. The limited implementation of waste minimization and recovery strategies further indicates that biomedical waste systems in these hospitals remain concentrated at the lowest rungs of the WMH, reinforcing the call for comprehensive waste planning that includes upstream and midstream interventions.

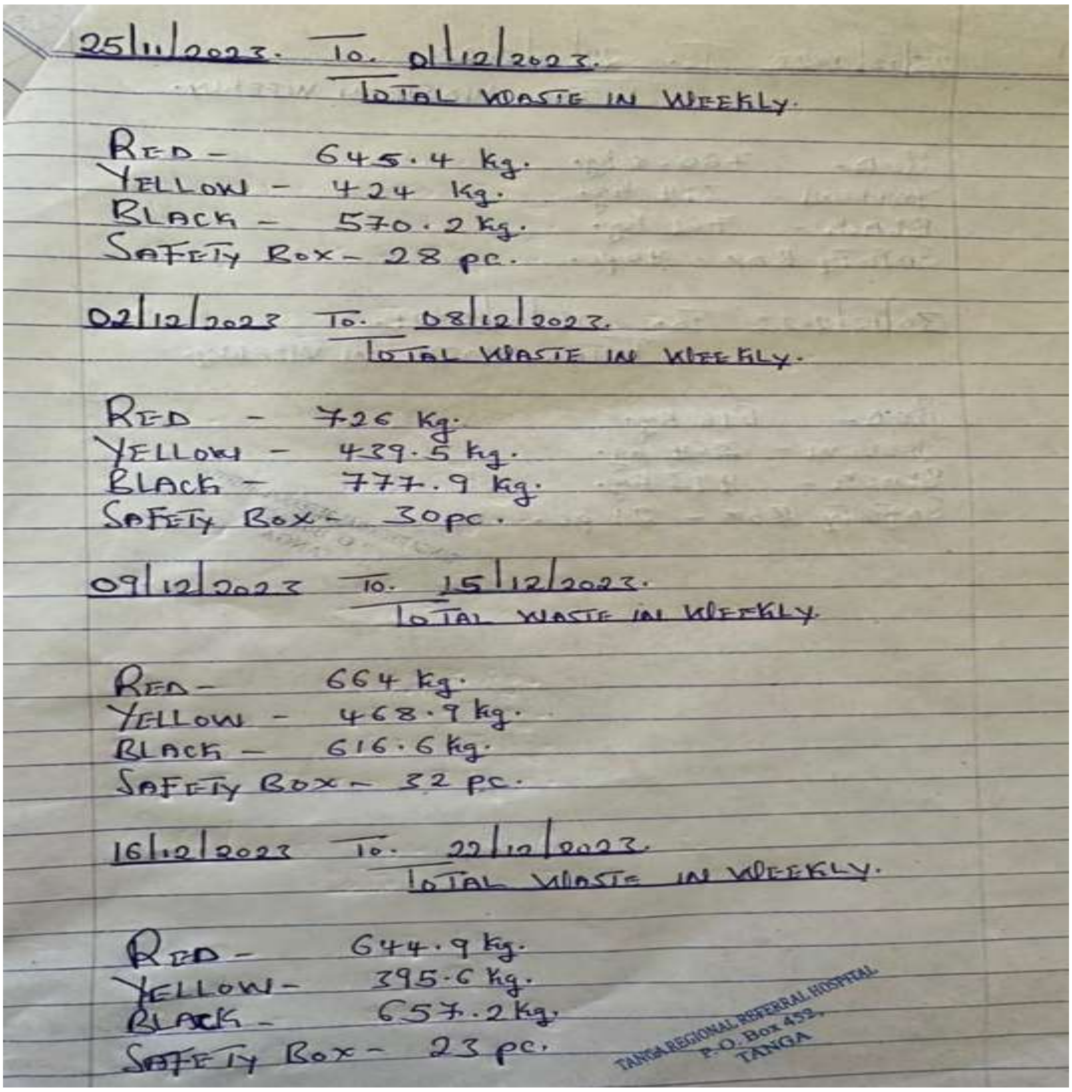
When viewed in the broader context of international literature such as Caniato et al. (2015) and Chisholm et al. (2021), it becomes evident that TRRH's challenges are part of a larger systemic issue facing many developing countries. Adding to the global perspective, Chisholm et al. (2021), in their study "Sustainable Waste Management of Medical Waste in African Developing Countries", argued that although incineration remains the most practical option in resource-limited settings, poor design and lack of emissions control often negate the benefits. The authors emphasize the importance of investing in post-treatment residue handling, including ash solidification and secure landfilling, areas where TRRH still requires development and which are essential for compliance with the final steps of the Waste Management Hierarchy, ensuring that even waste disposed of is managed in an environmentally responsible manner.

Despite its shortcomings, TRRH shows promise, particularly through its use of cleaner incineration technology, its adherence to timely waste disposal, and the partial application of segregation protocols. To further improve its system and act as a model for regional hospitals, TRRH must:

4.3.4 Record-Keeping.

During field observation at Tanga Regional Referral Hospital (TRRH), it was noted that the system used for recording biomedical waste was entirely manual. Data entries were made in a handwritten format in exercise books, with no use of electronic systems or structured templates (see plate 4.5). Waste types were categorized into red, yellow, and black bins, with weight measurements recorded weekly.

Plate: 4. 6 Record Keeping


25/11/2023. To. 01/12/2023.
TOTAL WASTE IN WEEKLY.
RED - 645.4 kg.
YELLOW - 424 kg.
BLACK - 570.2 kg.
SAFETY BOX - 28 pc.
02/12/2023 To. 08/12/2023.
TOTAL WASTE IN WEEKLY.
RED - 726 kg.
YELLOW - 439.5 kg.
BLACK - 777.9 kg.
SAFETY BOX - 30pc.
09/12/2023 To. 15/12/2023.
TOTAL WASTE IN WEEKLY.
RED - 664 kg.
YELLOW - 468.9 kg.
BLACK - 616.6 kg.
SAFETY BOX - 32 pc.
16/12/2023 To. 22/12/2023.
TOTAL WASTE IN WEEKLY.
RED - 644.9 kg.
YELLOW - 395.6 kg.
BLACK - 657.2 kg.
SAFETY BOX - 23 pc.
TANGA REGIONAL REFERRAL HOSPITAL
P.O. Box 452,
TANGA

Another critical issue at TRRH is the inadequate documentation of waste generation volumes and categories. Inconsistencies in measurements and reporting make it difficult to plan for infrastructure needs, track trends, or ensure regulatory compliance. This mirrors findings from Mwaria (2020) in the study "Assessment of Biomedical Waste Generation and Management in Tanzanian Referral Hospitals", which emphasized that the absence of systematic waste quantification methods severely impairs data-driven decision-making in most referral hospitals. Mwaria noted that only a few hospitals maintained regular logs, and even fewer could use their data to forecast supply needs or evaluate cost-efficiency of disposal systems.

On a broader scale, Caniato et al. (2015), in their comprehensive review "Healthcare Waste Management in Developing Countries: A Systematic Review", reported that across most low- and middle-income countries, record-keeping is the most underdeveloped aspect of biomedical waste management. They argue that poor data culture stems from the absence of national electronic systems, low policy enforcement, and insufficient human resource allocation to waste management. The case of TRRH aligns well with this broader trend, suggesting that record-keeping weaknesses are not institution-specific but reflect systemic national and regional gaps.

4.4 Identification of the Drivers Influencing Adherence ti Recommended Bio-medical Waste Management

4.4.1 General Awareness

Figure general awareness of biomedical waste was measured using questions on whether a worker had knowledge of what kind of wastes were infectious and the ability to mention the categories of hospital waste. Results indicate that 59.5 % of the respondents possessed general awareness of biomedical waste, thus they could identify and categorised BMW.

A Graph of General Awareness on Biomedical Waste Management

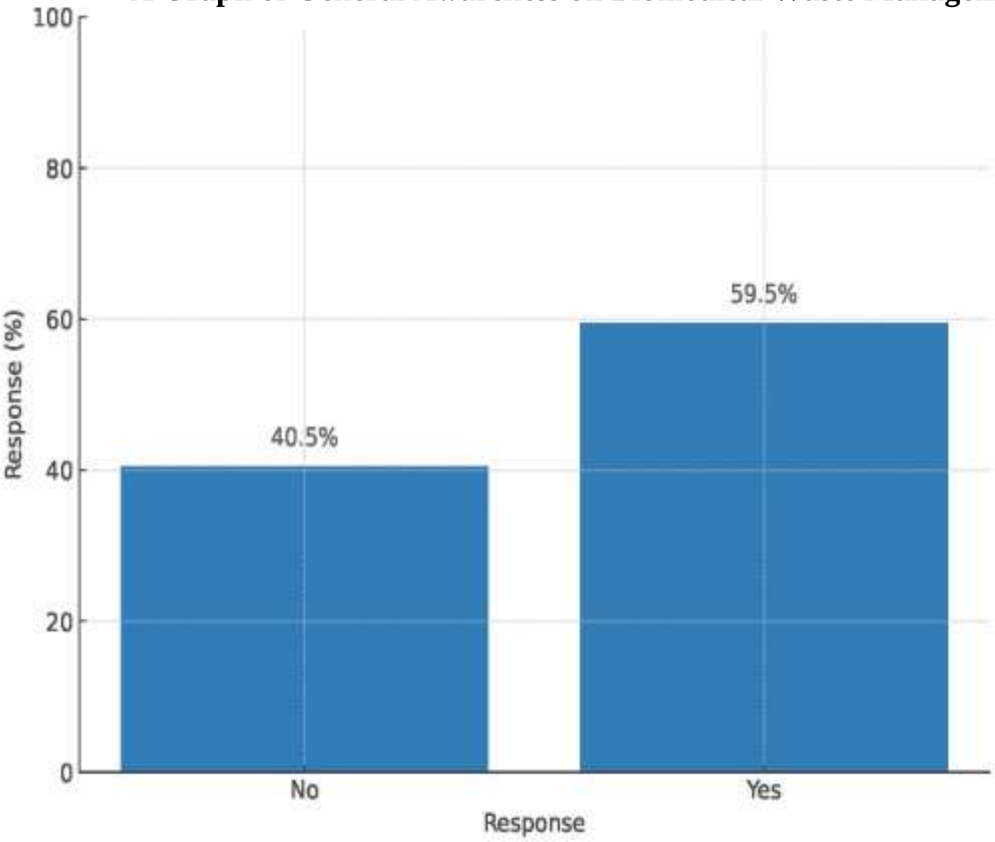


Figure 4.2; General Awareness on Biomedical Waste Management

At TRRH, 59.5% of healthcare staff demonstrated general awareness of biomedical waste types, associated risks, and handling requirements. This indicates a fair level of understanding across the workforce. However, despite this awareness, observations revealed common lapses, including improper classification, poor labeling, and the mixing of general and hazardous waste in the same containers.

This disconnects between awareness and behavior mirrors the findings of Eshete et al. (2023) in their study titled "Healthcare Waste Management Practice and Associated Factors Among Healthcare Workers in Ethiopia." In that study, although 87% of respondents were knowledgeable about BMW risks, fewer than half practiced proper waste segregation. The gap was attributed to institutional barriers, such as lack of materials, weak supervision, and an unsupportive workplace culture. Similarly, Windfeld and Brooks (2015), in their global review titled "Medical Waste Management – A Review," found that in many low-income countries, staff awareness does not translate into compliance due to underdeveloped support systems. For TRRH, this suggests that enhancing institutional reinforcement may be more impactful than focusing on knowledge alone.

4.4.2 Occupation and Training

The results indicate that majority (81 %) of the respondents received formal training on bio medical waste management. **Table 4.2** presents the percentage of those who got training on BWM

Table 4.2: Percentage of Respondents who Received Training on BWM Across Occupation Category

Occupation	Number	Percent	Total
Doctor	17	81.0	21
Nurse	16	84.2	19
Lab technician	14	93.3	15
Cleaners	10	90.9	11
Pharmacists	3	60.0	5
Environmental health officer	3	100	3
Total	63	85.1	74

From **Table 4.2**, the study found that 85.1% of workers at TRRH had received occupational training in BMW management. Training rates were particularly high among environmental health officers (100%), laboratory staff (93.3%), and cleaners (90.9%). This high training coverage demonstrates the hospital's investment in capacity-building for its workforce.

However, despite these efforts, observations highlighted that many staff still failed to consistently apply what they had learned—with ongoing issues such as incorrect bin usage, poor personal protective equipment (PPE) adherence, and misclassification of waste. This is consistent with Millanzi (2023), in his study titled "Assessment of Perceived Practices in Biomedical Waste Segregation Among Health Workers in Tanzanian Health Facilities." Millanzi reported that even trained workers often performed poorly in real-world settings due to a lack of practical supervision and inconsistent resource availability.

Supporting this, Eshete et al. (2023) also noted in their Ethiopian study that training without institutional follow-up had limited impact. In contrast, Nyangwe and

Tarimo (2023), in their study titled “Practices on Biomedical Waste Management Among Healthcare Workers at Benjamin Mkapa and Dodoma Regional Hospitals,” found that where training was reinforced through leadership support and regular monitoring, it led to improved compliance. The contrast implies that TRRH may benefit from integrating post-training support and supervision to ensure training outcomes are sustained.

Table 4.3: Results for Logistic Regression Analysis

	Odds ratio	Std. error	p-value	[95% conf.]	
Age categories					
18-30	1				
31-40	1.37	1.17	0.715	0.26	7.28
41-50	12.95	14.25	**0.020**	1.50	111.96
51-60	2.31	1.95	0.319	0.44	12.05
Gender					
Male	1				
Female	1.29	0.80	0.682	0.38	4.35
Education					
O level	1				
A level	2.36	2.65	0.445	0.26	21.38
Certificate	5.78	7.46	0.174	0.46	72.58
Diploma	0.35	0.28	0.197	0.07	1.74
Higher Education	0.31	0.27	0.174	0.06	1.68
Employment					
Part-time	1				
Full-time	4.89	3.92	**0.048***	1.02	23.56
Training					
Not trained	1				
Trained	1.11	1.01	0.910	0.19	6.64
General Awareness					
Insufficient	1				
Sufficient	1.16	0.78	0.822	0.31	4.33
Segregation awareness					
Insufficient	1				
Sufficient	0.65	0.57	0.619	0.12	3.62
Treatment awareness					
Insufficient	1				
Sufficient	1.41	0.88	0.581	0.42	4.80

*Significant level at $p < 0.05$

This study used a binary logistic regression model to assess how selected factors influenced biomedical waste (BMW) management practices among healthcare workers at Tanga Regional Referral Hospital (TRRH). The outcome variable was categorized into good and poor practices, while predictors included socio-demographic variables (such as age, gender, education, and employment type) and institutional aspects (like training, general awareness, and knowledge of segregation and treatment procedures). The results not only provide statistical insight but also highlight behavioral patterns that can inform future interventions. These findings align with the Health Belief Model (HBM), which explains health-related behaviors based on an individual's beliefs about risks, benefits, barriers, and their confidence in taking action as shown in **Table 4.3**

Age: Experience Enhances Compliance among the examined factors; age showed a strong association with proper BMW practices. Healthcare workers aged between 41 and 50 years were nearly 13 times more likely to adhere to recommended practices than those aged 18–30 (OR = 12.95; p = 0.020). This suggests that with age comes greater familiarity with protocols, institutional routines, and possibly a stronger internalization of safe practices.

These findings are consistent with earlier research by Manyele et al. (2010), which emphasized that more experienced professionals are more likely to follow waste management standards. Vishal et al. (2012) also observed similar trends, noting that repeated exposure to routines improved compliance. At the regional level, Chisholm et al. (2021) argued that age often reflects depth of professional development, which translates into greater procedural awareness.

Within the HBM framework, older workers may demonstrate stronger perceived severity regarding the consequences of improper waste handling and higher self-efficacy, meaning they feel more capable of carrying out the right procedures. These beliefs likely motivate more consistent behavior.

Employment Status: The study also found a statistically significant link between employment status and good BMW practices. Full-time employees were almost five times more likely to follow appropriate procedures compared to their part-time counterparts (OR = 4.89; p = 0.048). This could be due to greater accountability, more frequent exposure to institutional standards, or a stronger sense of belonging. These outcomes align with Millanzi (2023), who reported that permanent staff typically showed better compliance with segregation protocols. Nyangwe and Tarimo (2023) also noted that hospitals with structured staffing and clear incentives tended to have more consistent waste handling behaviors. From an HBM perspective, full-time staff likely receive more cues to action—such as routine training or supervision—and perceive greater benefits from following procedures, including job security or professional recognition. Their long-term engagement in the system may also reduce perceived barriers that hinder waste compliance among temporary staff.

Gender and Education: While gender and education level were included as predictors, neither showed a significant impact on waste management behavior. Female staff were slightly more likely to engage in proper practices (OR = 1.29; p = 0.682), and those with certificate-level education were five times more likely to follow procedures than those with only O-level qualifications (OR = 5.00; p = 0.174), but neither result reached statistical significance. These findings reflect those of Amita et al. (2017), who found no clear link between gender or education and BMW practices. Their study suggested that institutional culture, supervision, and hands-on experience play a larger role than formal qualifications. Under the HBM, this could indicate that knowledge alone is not enough to influence behavior. Without strong perceived susceptibility or effective cues to action, educational background may have limited influence on day-to-day practices. Practical barriers and workplace culture may outweigh the influence of personal attributes like gender or academic attainment.

Training and Awareness: Although many participants reported having been trained and were generally aware of waste protocols, these factors did not significantly influence their practice. Trained individuals were only slightly more likely to perform proper BMW procedures (OR = 1.11; $p = 0.910$), and knowledge of general, segregation, and treatment procedures also had no significant effect. This finding highlights a common issue: the gap between knowledge and practice. A similar trend was noted in Ethiopia by Eshete et al. (2023), where despite 87% of staff being aware of proper disposal practices, fewer than half actually followed them. The authors attributed this to resource shortages, inadequate supervision, and a weak institutional culture around compliance. Interestingly, Nyangwe and Tarimo (2023) reported a different outcome at Benjamin Mkapa Hospital, where knowledge strongly correlated with practice. This suggests that the presence of institutional support, consistent monitoring, and leadership commitment can help translate awareness into action.

The disconnect at TRRH can be viewed through the HBM lens as a case of low perceived benefits or high perceived barriers. Even when individuals are trained, they may not act unless they believe the behavior will make a difference and feel confident in their ability to perform it consistently. If resources or support are lacking, training alone is unlikely to change behavior.

The regression model explained only 21.5% of the variance in BMW practices, suggesting that other, unmeasured factors—likely institutional or environmental—play a substantial role. These may include the availability of equipment, administrative oversight, consistent enforcement, or supportive infrastructure. This view aligns with WHO (2004) guidelines, which identify institutional shortcomings—such as weak leadership, poor infrastructure, and inadequate monitoring—as key contributors to unsafe waste practices in low-resource settings. Addressing these systemic issues is essential for improving compliance.

From an HBM standpoint, these institutional factors act as external cues to action and can influence perceived barriers. Without consistent reinforcement or institutional commitment, even motivated individuals may struggle to maintain proper waste practices.

In summary, the analysis revealed that age and employment status were significant predictors of proper biomedical waste management, while education, gender, training, and awareness were not. These results suggest that practical experience, organizational integration, and system-level support play a more important role in shaping behavior than individual knowledge alone. This supports the core principle of the Health Belief Model, which states that behavior is driven by both internal perceptions (such as risk and confidence) and external factors (like barriers and prompts). For real improvement, interventions must go beyond training to address motivation, environment, and institutional reinforcement.

Finally, aligning TRRH's waste practices with those of higher-performing facilities like Benjamin Mkapa Hospital can serve as a model of cross-institutional learning and policy diffusion.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Firstly, in characterizing biomedical solid waste, the study found that TRRH generates approximately 1,313 kg of waste per week, with 60.8% categorized as highly infectious. This dominant proportion indicates potential over classification and weak segregation practices, compounded by the hospital's use of a limited two-tier classification system. Inadequate record-keeping and lack of waste tracking tools further hinder effective auditing, leading to inefficiencies in waste processing and possible environmental hazards.

Secondly, the assessment of current BMW management practices revealed a significant gap between knowledge and practice. While staff displayed high theoretical awareness of waste handling procedures, actual adherence was inconsistent. Observations identified unsafe segregation, open storage, inadequate transportation methods, and manual documentation as common shortcomings. Although the use of a gas-powered incinerator reflects progress, the lack of proper ash disposal and emissions monitoring remains a concern. These findings underscore the importance of not just training, but also practical supervision, adequate infrastructure, and policy enforcement.

Thirdly, the analysis of drivers influencing BMW practices showed that employment status and age group (41–50 years) were statistically significant predictors of safe practices. This suggests that experience and institutional attachment are more influential than training or educational background. Surprisingly, variables such as gender, awareness, and formal education showed no significant correlation with good practice, reinforcing the idea that behavioral adherence is shaped more by institutional culture and stability than by individual knowledge.

This study primarily addressed solid biomedical waste management at TRRH; however, future research should explore the handling of liquid biomedical waste in departments like laboratories and dialysis units, and assess the environmental risks of incinerator ash disposal. These areas are vital for improving comprehensive, sustainable waste management in low-resource healthcare settings.

5.2 Recommendations

Based on the findings drawn from the three specific research objectives, the following recommendations are proposed to enhance biomedical waste management practices at Tanga Regional Referral Hospital (TRRH). These recommendations aim to address the existing gaps in waste characterization, operational practices, and the behavioral drivers influencing compliance.

- Adopt a More Detailed Waste Classification System: TRRH should revise its current biomedical waste categorization system to align with World Health Organization (WHO) and Tanzania National Healthcare Waste Management Guidelines. This should include clear identification of sharps, pathological, pharmaceutical, chemical, and general waste categories, beyond just “infectious” and “highly infectious” classifications.

- Conduct Periodic Waste Audits: TRRH should carry out biannual waste audits to assess the types and quantities of waste generated. These audits will help identify specific departments with high waste output and improve classification accuracy.
- Strengthen Segregation at Source: To improve compliance, TRRH should ensure that all healthcare units are equipped with clearly labeled, color-coded bins in accordance with national standards. Waste segregation should begin at the point of generation to minimize health risks and reduce treatment costs.
- Enhance Treatment Infrastructure: While the gas-powered incinerator is a strength, the hospital should consider adopting additional treatment methods such as autoclaving or shredding for specific types of waste. This diversification would improve safety and environmental compliance.
- Standardize Record-Keeping Systems: TRRH should introduce structured logbooks or digital tracking tools for daily documentation of biomedical waste types, volumes, and disposal methods. These records should be regularly reviewed to inform planning and improve accountability.
- Establish Continuous and Targeted Training Programs: All staff involved in waste handling, including temporary and newly recruited workers, should undergo regular training focused on practical waste management skills, safety procedures, and institutional policies. Training sessions should be reinforced with real-life demonstrations and simulations.
- Design Tailored Support for High-Risk Groups: Targeted support strategies should be implemented for younger and part-time workers, who were ob-

served to have lower compliance levels. These may include peer mentoring, department-level supervision, or incentives for safe practices.

Develop and Implement a Hospital Waste Management Plan: A formal waste management policy tailored to TRRH should be developed, outlining standard procedures, roles and responsibilities, waste minimization strategies, and monitoring mechanisms. This plan should be updated annually to reflect changes in national policy and institutional needs.

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APPENDICES

APPENDIX 1:

QUESTIONNAIRE FOR HEALTH FACILITY WORKERS

Part A: Socio demographic information

1. ID
2. Age…………………………………………………………………
3. Gender
    a. Male
    b. Female
4. Education Level
    a. O level
    b. A level
    c. Certificate
    d. Diploma
    e. Higher Education level
5. Occupation
    a. Doctor
    b. Nurse
    c. Lab technicians
    d. Cleaners
    e. Pharmacists
    f. Health officer
6. Department…………………………………………………………………
7. Years of experience……………………………………………………………

8. Employment status

    a. Full-time

    b. Part-time

Part B – Knowledge and Practice of BMW management

Please answer the following questions.

#	Main category	Sub-category	Yes	No	No comment
1	General awareness of biomedical waste	**1.** Are all biomedical wastes hazardous?			
		2. Are you familiar with the categories of biomedical waste? Mention			
2	Adherence to segregation and color-coding system	**3.** Do you adhere to segregation of highly infectious and infectious waste from non-hazardous waste effective in a safe disposal of waste?			
		4. Does you color code waste containers for effective in a safe waste control?			
3	Waste storage, disposal and treatment scheme				
		5. Is landfilling a good way to dispose of biomedical waste?			
		6. Is incineration a good way to dispose of waste?			
		7. Should all waste generated in health care centers be mixed and disposed of as infectious waste?			
4	Transportation	**8.** Does transportation of biomedical waste do regularly? If so, how frequent?			
		9. Does biomedical waste transportation comply with regulations?			

APPENDIX 2

OBSERVATION CHECKLIST

The outcome of interest, thus assessment of BMW practices was done by the researcher through observation of each individual participant in the study. The overall percentage score of 90 or above would mean the categorization of that individual's working station as Good practice. Otherwise, it was assigned as bad practice.

variable	observation	comment
Waste segregation	Segregation at point Types of waste Color coding and labeling Appropriate container Enough containers Empty at when 1/3 full	
storage	Adhere to storage guidelines. Cleanness of storage area Containment of waste bins	
Treatment and disposal	Method used for treatment and disposal. Technology used. Maintenance of treatment and disposal facility	
Emergency preparedness	Availability of spill kit	
Record keeping	Training records Waste type Amount of waste generated. Waste transport	
Regulatory compliances	Waste management policy Waste management plan Waste management procedure Waste disposal permits. Minimum PPE used	
Infrastructure evaluation	Biomedical waste management infrastructure Condition of Equipment's used.	
Behavior observation	Adherence to waste management practices • Segregation • Storage • Treatment and disposal	

APPENDIX 3

ETHICAL CLEARANCE

THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

THE OPEN UNIVERSITY OF TANZANIA

Ref. No OUT/PG202000271

14th November, 2023

Medical Officer in Charge,
Tanga Regional Referral Hospital,
P.O Box 452,
TANGA.

Dear Medical Officer in Charge,

RE: RESEARCH CLEARANCE FOR MR. WALTER DAVID MWAI, REG NO: PG202000271

2. The Open University of Tanzania was established by an Act of Parliament No. 17 of 1992 which became operational on the 1st March 1993 by public notice No.55 in the official Gazette. The Act was however replaced by the Open University of Tanzania Charter of 2005, which became operational on 1st January 2007. In line with the Charter, the Open University of Tanzania mission is to generate and apply knowledge through research.

3. To facilitate and to simplify research process therefore, the act empowers the Vice Chancellor of the Open University of Tanzania to issue research clearance, on behalf of the Government of Tanzania and Tanzania Commission for Science and Technology, to both its staff and students who are doing research in Tanzania. With this brief background, the purpose of this letter is to introduce to you **Mr. Walter David Mwai, Reg. No: PG202000271)**, pursuing **Master in Environmental Studies Health Stream (MES-HEALTH)**. We here by grant this clearance to conduct a research titled

"Applicability of Biomedical Waste Management Models at Bombo Referral Hospital in Tanga Region, Tanzania". He will collect his data at your office from 15th November 2023 to 30th December 2023.

4. In case you need any further information, kindly do not hesitate to contact the Deputy Vice Chancellor (Academic) of the Open University of Tanzania, P.O.Box 23409, Dar es Salaam. Tel: 022-2-2668820.We lastly thank you in advance for your assumed cooperation and facilitation of this research academic activity.

Yours sincerely,

THE OPEN UNIVERSITY OF TANZANIA

Prof. Magreth S.Bushesha

For: VICE CHANCELLOR

Kinondoni Biafra, Kawawa Road; P.O 23409; Dar es Salaam; Tel: +255 22 2668 445;
E-Mail:vc@out.ac.tz|| Website:www.out.ac.tz

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TANGA REGIONAL REFERRAL HOSPITAL LABORATORY
Document Title: Declaration of Confidentiality
Document Number: TRRH/Lab/M/FM 02
Effective Date: 01/07/2023
Version 04

DECLARATION OF CONFIDENTIALITY

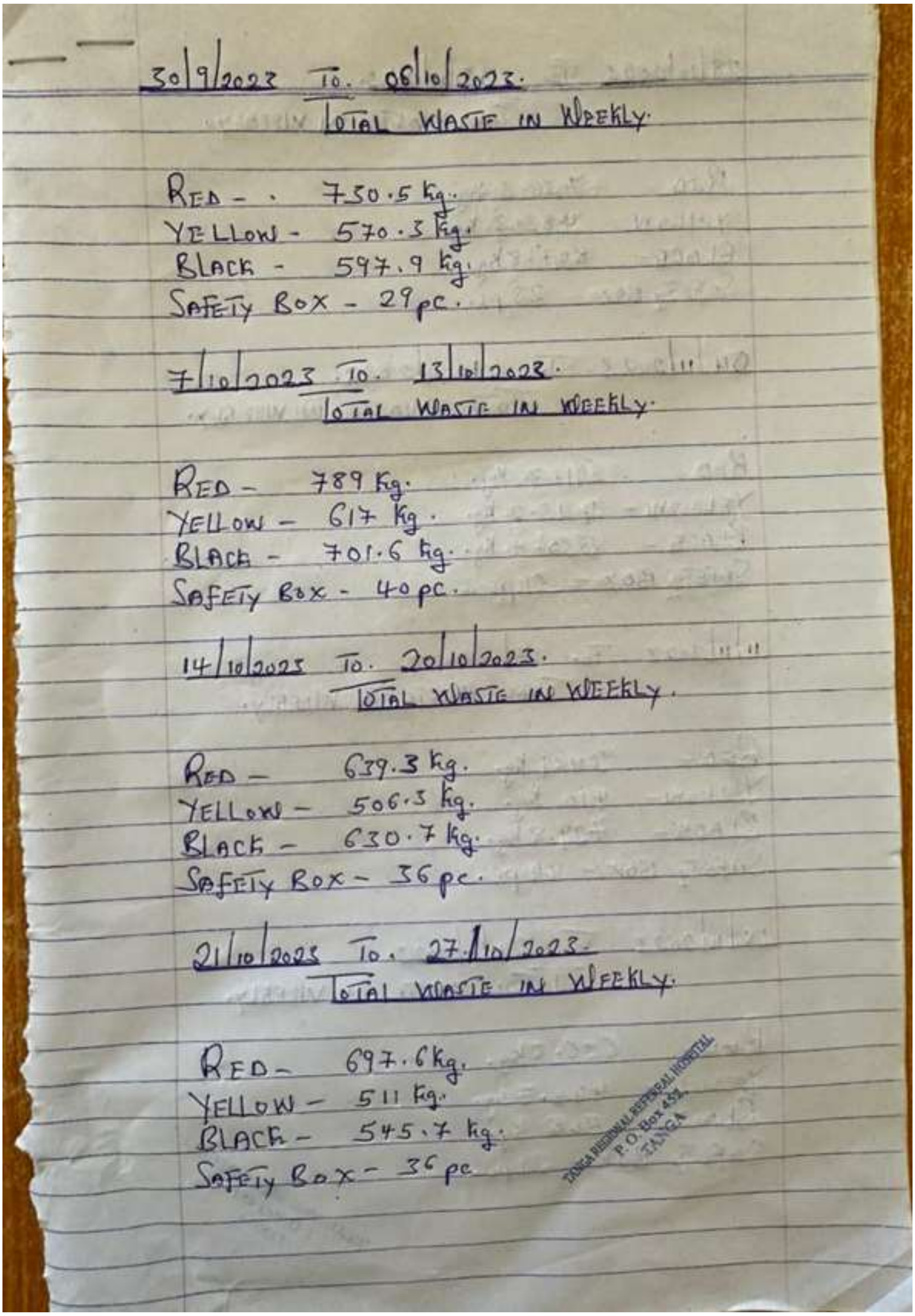
I, Walter David Mwai, hereby declare that I fully understand the patient's right to confidentiality with regards to identity and laboratory test results and will adhere to this **principle as a member of lab staff of Tanga Regional Referral Hospital staff, as a visitors or Guest** of the Tanga Regional Referral Hospital Laboratory at all times.

Signature: ____________ Date: 01st DEC 2023

Witness 1: ZUHURA KIVASU Sign ______ Date: 01st DEC 2023.
Quality Officer

Witness 2: SINDE MTOBU Sign ______ Date: 01/12/2023
Laboratory Manager

APPENDIX 4



30/9/2023 TO. 06/10/2023.
TOTAL WASTE IN WEEKLY.

RED - . 750.5 kg.
YELLOW - 570.3 kg.
BLACK - 597.9 kg.
SAFETY BOX - 29pc.

7/10/2023 TO. 13/10/2023.
TOTAL WASTE IN WEEKLY.

RED - 789 kg.
YELLOW - 617 kg.
BLACK - 701.6 kg.
SAFETY BOX - 40pc.

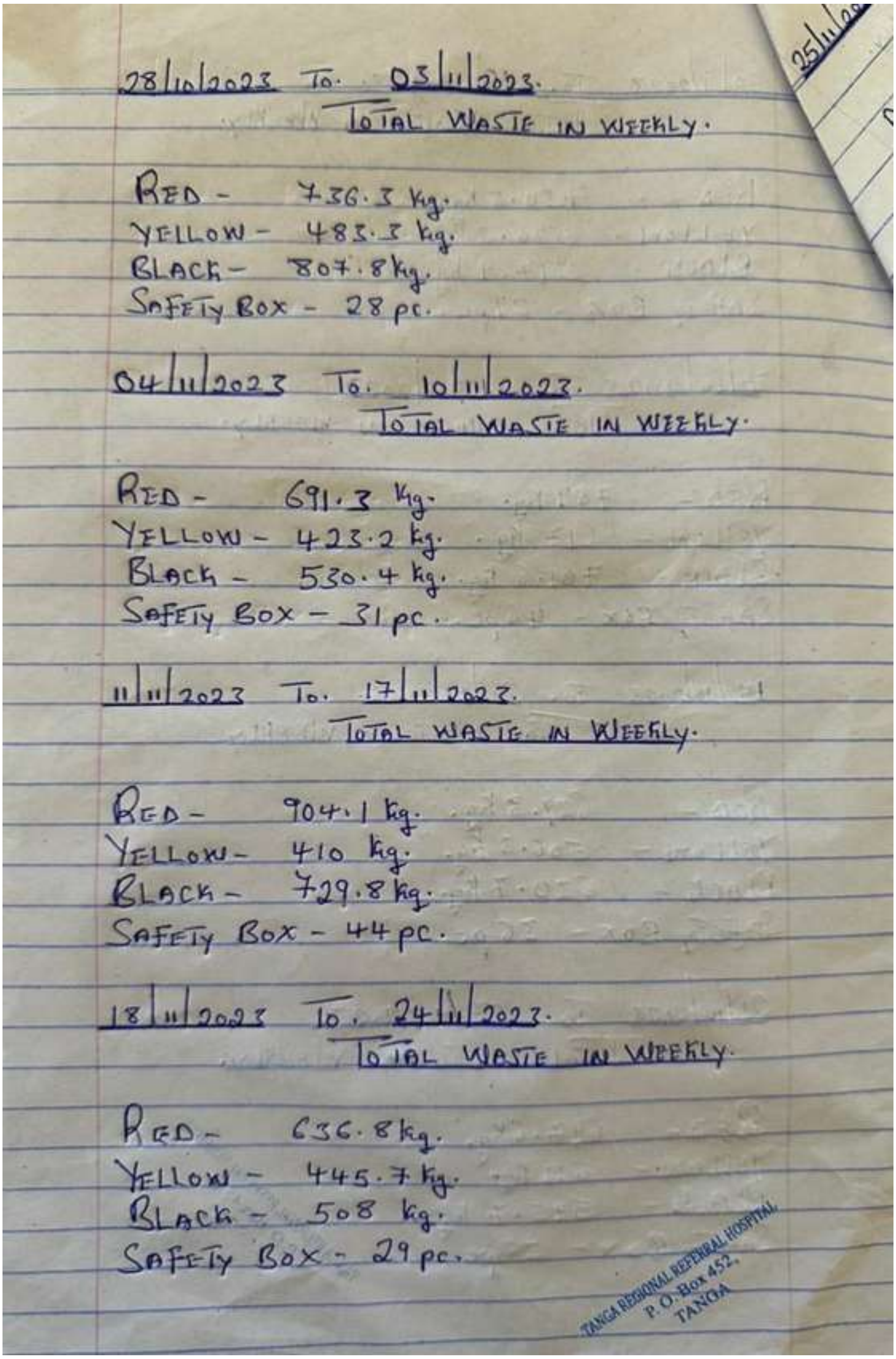
14/10/2023 TO. 20/10/2023.
TOTAL WASTE IN WEEKLY.

RED - 639.3 kg.
YELLOW - 506.3 kg.
BLACK - 630.7 kg.
SAFETY BOX - 36pc.

21/10/2023 TO. 27/10/2023.
TOTAL WASTE IN WEEKLY.

RED - 697.6kg.
YELLOW - 511 kg.
BLACK - 545.7 kg.
SAFETY BOX - 36pc

TANGA REGIONAL REFERRAL HOSPITAL
P.O. Box 452,
TANGA



28/10/2023 To. 03/11/2023.
TOTAL WASTE IN WEEKLY.

RED - 736.3 kg.
YELLOW - 483.3 kg.
BLACK - 807.8 kg.
SAFETY BOX - 28 pc.

04/11/2023 To. 10/11/2023.
TOTAL WASTE IN WEEKLY.

RED - 691.3 kg.
YELLOW - 423.2 kg.
BLACK - 530.4 kg.
SAFETY BOX - 31 pc.

11/11/2023 To. 17/11/2023.
TOTAL WASTE IN WEEKLY.

RED - 904.1 kg.
YELLOW - 410 kg.
BLACK - 729.8 kg.
SAFETY BOX - 44 pc.

18/11/2023 To. 24/11/2023.
TOTAL WASTE IN WEEKLY.

RED - 636.8 kg.
YELLOW - 445.7 kg.
BLACK - 508 kg.
SAFETY BOX - 29 pc.

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TANGA

25/11/2023. To. 01/12/2023.

TOTAL WASTE IN WEEKLY.

RED - 645.4 kg.
YELLOW - 424 kg.
BLACK - 570.2 kg.
SAFETY BOX - 28 pc.

02/12/2023 To. 08/12/2023.

TOTAL WASTE IN WEEKLY.

RED - 726 kg.
YELLOW - 439.5 kg.
BLACK - 777.9 kg.
SAFETY BOX - 30pc.

09/12/2023 To. 15/12/2023.

TOTAL WASTE IN WEEKLY.

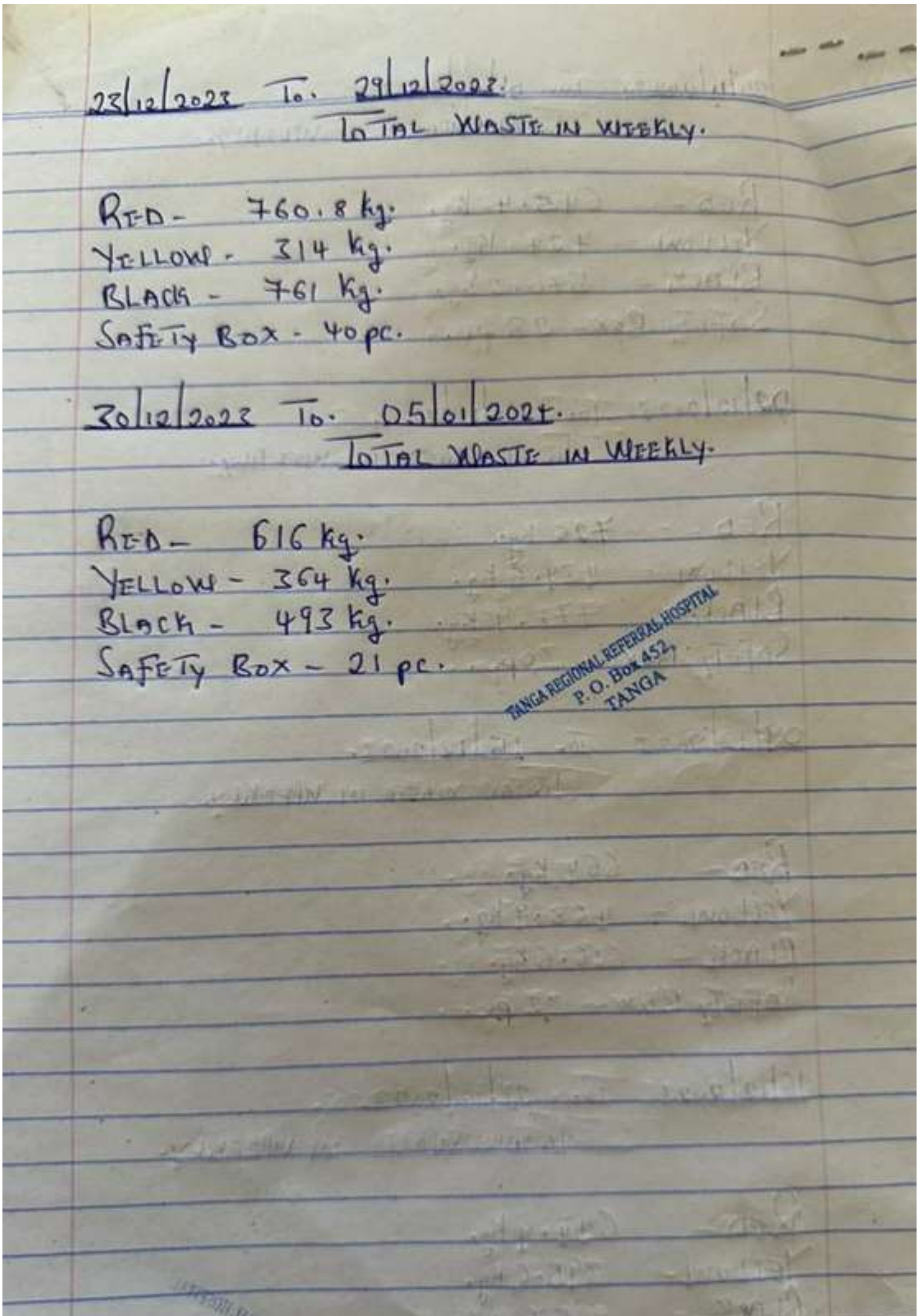
RED - 664 kg.
YELLOW - 468.9 kg.
BLACK - 616.6 kg.
SAFETY BOX - 32 pc.

16/12/2023 To. 22/12/2023.

TOTAL WASTE IN WEEKLY.

RED - 644.9 kg.
YELLOW - 395.6 kg.
BLACK - 657.2 kg.
SAFETY BOX - 23 pc.

TANGA REGIONAL REFERRAL HOSPITAL
P.O. Box 452,
TANGA



23/12/2023 To. 29/12/2023.

TOTAL WASTE IN WEEKLY.

RED - 760.8 kg.
YELLOW - 314 kg.
BLACK - 761 kg.
SAFETY BOX - 40 pc.

30/12/2023 To. 05/01/2024.

TOTAL WASTE IN WEEKLY.

RED - 616 kg.
YELLOW - 364 kg.
BLACK - 493 kg.
SAFETY BOX - 21 pc.

TANGA REGIONAL REFERRAL HOSPITAL
P.O. Box 452,
TANGA

MANUSCRIPT

ASSESSMENT OF BIOMEDICAL WASTE MANAGEMENT PRACTICES AMONG HEALTH CARE WORKERS OF REGIONAL REFERRAL HOSPITAL: A CASE OF TANGA REGION, TANZANIA.

Biomedical waste management remains a pressing public health and environmental challenge, particularly in low-resource settings. Addressing the underlying drivers of management practices at Tanga Regional Referral Hospital (TRRH) is essential for protecting healthcare workers and the wider community. This study identified key drivers influencing adherence to recommended biomedical waste management (BWM) practices. A cross-sectional design was employed with quantitative research methods, seventy-four (74) healthcare workers were purposively sampled from various departments. Data were collected through structured questionnaires, and document review. Quantitative data were analyzed using descriptive statistics and multivariate logistic regression to identify predictors of proper BMW management. The research was guided by Health Belief model (HBM) and Waste Management Hierarchy theories (WMH). 81% (n=60) of staff received BMW training, training alone was not a significant predictor of compliance ($p>0.05$). Instead, full-time employment (OR=4.9, $p<0.05$) and age 41–50 years (OR=12.9, $p<0.05$) were significantly associated with better practices. These findings support the HBM, indicating that institutional role and experience, rather than knowledge alone, drive compliance, and highlight gaps in applying WMH principles at TRRH. The study recommends to Apply Inservice practical training and mentor younger ones and part-time staff and develop a hospital Waste management plan to bridge the gap between knowledge and practice.

Keywords: Drivers, Biomedical, Waste management, practices

INTRODUCTION

1.1 Background information of the study

Bio-medical waste (BMW) is one of the emerging pollutants generated by healthcare facilities, such as medical diagnosis, treatment, or immunization of human beings, animals, and biological research activities as it was said by several scholars Datta *et al*. ,(2018); Shaida & Singla, (2019). Bio-medical waste means any waste generated during the diagnosis, treatment, and care of human beings or waste generated in research activities. All such waste that has an impact on the environment or health of a person is considered infectious and has to be managed as per Biomedical Waste Management Rules, as stipulated by WHO, (2016). BMW is a significant concern in healthcare facilities, comprising both non-hazardous (85%) and hazardous (15%) components. The hazardous portion includes infectious waste (10%) and chemical/radioactive waste (5%) World Health Organization, (2014). Globally, it's estimated that over 5.2 million people, including 4 million children, die each year due to diseases linked to improper medical waste management Rahman *et al.*, (2020). The COVID-19 pandemic has further exacerbated the issue, leading to a sudden surge in healthcare waste generation. This excessive BMW has become a serious threat to public health and the environment. Biomedical waste management is seen as a necessity in health care facilities. Hospitals and nurses are interdependent aspects of biomedical waste management. Regarding the safe management of biomedical waste management, there is role conflict among the generators, operators, decision-makers, and the general community due to a lack of awareness Choudhary *et al.*, (2020). In developing countries particularly, the Sub-Saharan Africa where many health concerns are competing for inadequate resources, the management of medical wastes has received less attention and the priority it deserves as it was reported by Al-Khatib *et al*., (2009), Emmanuel & Stringer, (2007).

Among the practices that have been reported in many developing countries include plenty of medical waste that are deposited openly in waste dumps and neighboring environments and from time to time together with nonhazardous solid waste said Manyele & Lyasenga, (2010) as well as Mgimba and Sanga, (2016). In Tanzania, harmful and medical solid wastes are still managed and disposed as one with domestic wastes. This makes a potential public health danger and an environmental burden Manyele & Lyasenga, (2010). The Ministry of Health (MoH) and the World Health Organization (WHO) carried out a study in the year 2000 to find out the management of the syringes and needles used during immunization programs in Tanzania as it was mentioned by Emmanuel *et al.,* (2008). Improper waste management causes Hospital Acquired Infections and poses public health hazards by polluting air, water and soil to prevent occupational hazards Biomedical waste must be managed properly to protect the environment, the general public, and workers who are involved in handling and management. To improve biomedical waste management in health facilities in a country, the development and implementation of a national waste management policy are needed Datta, Mohi & Chander, (2018).

1.2 Research objective

To identify the drivers influencing adherence to recommended biomedical waste management practices.

2.0 Conceptual frame work

The conceptual frame work serves as a spring board for theory development, theoretical and context the importance of the study, where a model symbolically represents a phenomenon. The conceptual framework for this study is based on the health belief model, Rosenstock, (1974). Beckers Health Belief model addressed relationship between the person belief and behavior. If people understand the ways or have knowledge on something then they most likely to adopt to the ways of the knowledge, that people with bio-medical waste management awareness they are most likely to practice the knowledge to the extent of their understanding and believe and vice versa. Therefore, from this study socio demographic behaviors, believes and knowledge are the independent variables but the application of the knowledge (bio-medical waste management practices) depends upon the behavior and the personal belief of the hospital health care workers. In this conceptual framework, indicates the variables under independent and dependent variables.

Independent variables **Intervening variables** **Dependent variable**

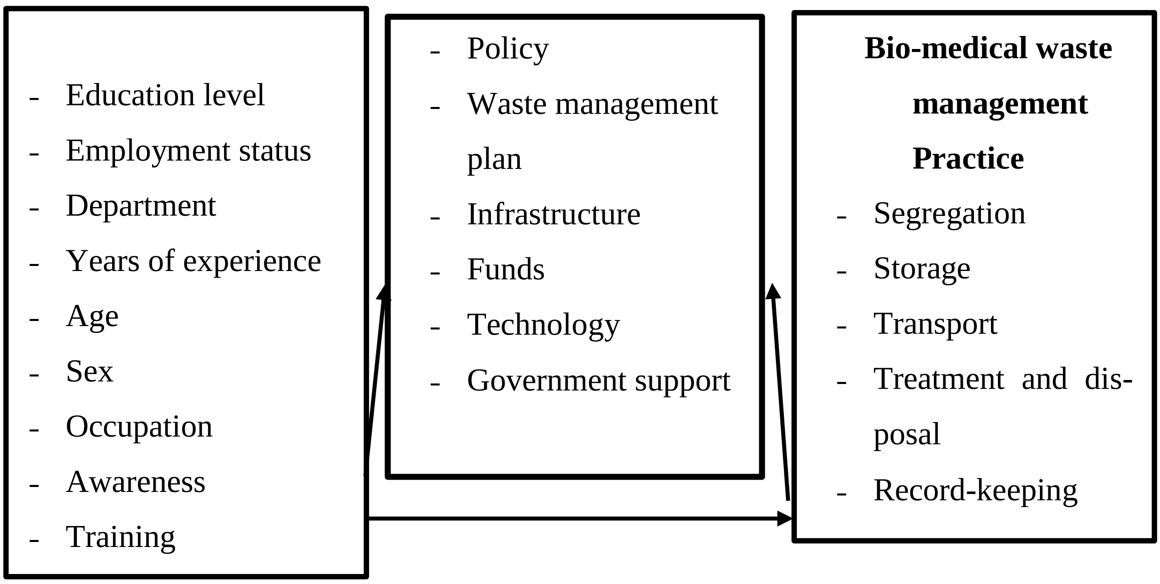
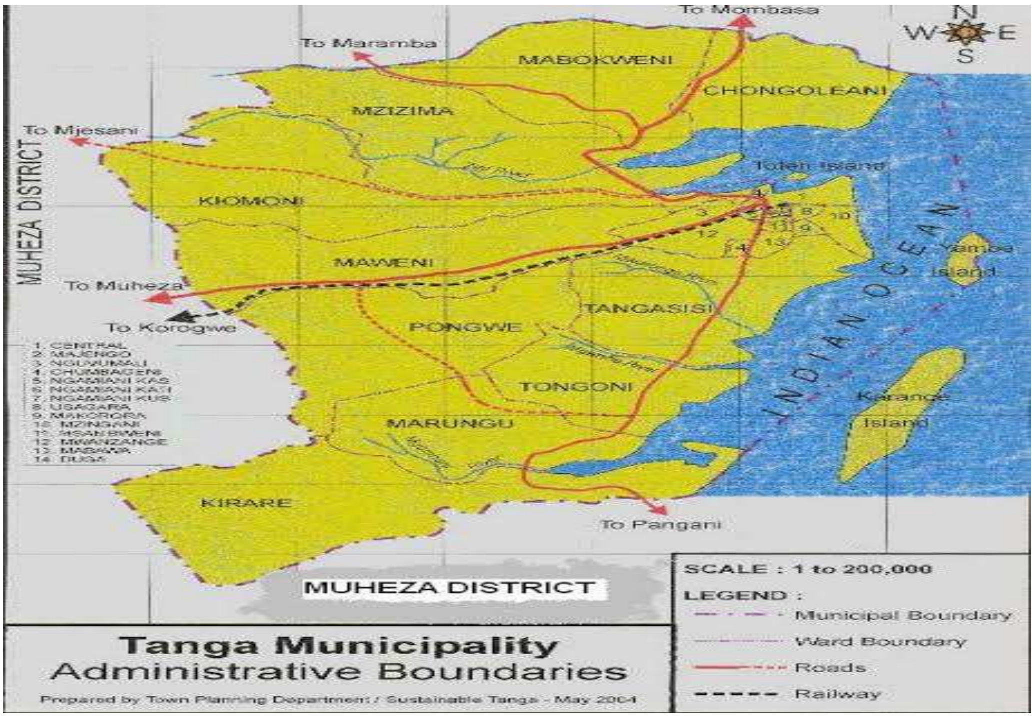


Figure 1: Conceptual framework.

RESEARCH METHODOLOGY

3.1Study Area Description



<u>Figure 2: A map of Tanga</u>

3.1.1Tanga Regional Referral Hospital (TRRH)

TRRH is a tertiary-level public healthcare facility situated in Tanga Region, north-eastern Tanzania with geographical coordinates of 5°03′47″N 39°06′44″E. As per the 2022 National Census, Tanga Region has a population of approximately 2.6 million. Established in 1901 by the German colonial administration, TRRH is recognized as one of the earliest hospitals in East Africa. It serves as a referral center for peripheral health facilities and provides diverse services including surgery, maternity care, dialysis, and infectious disease treatment. It is co-located with the National Institute for Medical Research (NIMR), enabling a unique environment for health systems research.

TRRH was selected for this study due to its high patient load, comprehensive departmental structure, and its role as a major generator of biomedical waste in the region—making it an ideal setting for evaluating BMW management practices and influencing factors.

3.2 Research Design

A facility-based cross-sectional study design was employed. This design is widely used in environmental health and hospital-based studies Setia, (2016) to assess the prevalence of behaviors and conditions at a specific point in time. It enables the researcher to establish associations between variables without manipulating the study environment. The cross-sectional approach was particularly suitable for identifying BMW practices and related determinants within a complex hospital setting without requiring longitudinal follow-up.

In alignment with best practices in BMW studies e.g., Windfeld & Brooks, (2015), Sharma & Sharma, (2019), a mixed-methods approach was adopted. Quantitative research methods (questionnaires and document reviews) provided measurable patterns.

3.3 Study objectives and data collection approach

Primary Data: Demographic and employment-related information (e.g., age, occupation, employment status, training history) was collected through questionnaires and analyzed against observed waste handling practices.

3.4 Study Population and Sampling

3.4.1 Study Population

The population included all healthcare workers at TRRH involved in biomedical waste generation or handling. This comprised doctors, nurses, laboratory technicians, pharmacists, environmental health officers, and trained support staff such as hospital cleaners.

3.4.2 Sampling Frame and Technique

From a total of 314 staff at TRRH, a purposive sampling technique was applied to select seventy four (74) respondents, focusing on individuals with direct roles in waste handling. Purposeful sampling is widely applied in qualitative and mixed-method studies where expert insight or exposure to the phenomenon is essential Palinkas et al., (2015). Sample size adequacy was balanced against logistical constraints and aligned with the concept of information-rich cases.

3.5 Data Collection Instruments

Questionnaires: Designed based on WHO BMW management standards and prior validated tools. They included both closed and open-ended questions to gather data on knowledge, awareness, and self-reported practices.

Document Review Template: Used to extract secondary data from hospital records, including incinerator logs and waste tracking forms.

All tools were pre-tested for clarity and relevance at a similar facility before full deployment at TRRH.

3.6 Data Analysis

Quantitative data were analyzed using SPSS. Descriptive statistics (frequencies, percentages) were used to summarize demographic data and practice prevalence. To identify determinants of good BMW practices, binary logistic regression was used—appropriate for dichotomous outcomes (good vs. poor practice) as also employed in studies by Eshete et al. (2023) and Sharma & Sharma (2019).

The regression model estimated odds ratios (OR) and 95% confidence intervals (CI), with a p-value < 0.05 considered statistically significant. Independent variables included age, sex, occupation, training, awareness, and employment status. Categorization of BMW practices was based on combined observation scores and WHO criteria.

3.7 Ethical considerations

The copy of approval letter and proposal was presented to the Hospital administration (Medical Superintendent) who cleared the researcher to carry out the study in the Hospitals. Respondents were assured that their participation is voluntary and that they are free to withdraw from the study at any time and informed consent was obtained before administration of questionnaires.

1.1 RESULTS AND DISCUSSIONS

4.1 Description of sample

In this chapter the researcher has presented result-of the data in-terms of tables, figures and simple interpretations Table 1 narrates the demographic data of the respondents in terms of age, sex, education level occupation and their departments.

Table 1: Sample Description

Age categories	
18-30	17
31-40	18
41-50	19
51-60	20
Sex	
Male	34
Female	40
Education	
O level	10
A level	15
Certificate	15
Diploma	18
Higher Education	16
Occupation	
Doctor	21
Nurse	19
Lab technician	15
Cleaners	11
Pharmacists	5
Environmental health officer	3
Department	
Emergency	13
Laboratory	8
Dialysis	8
Labor	16
Theatre	14
Ward/ICU	15

4.4 Drivers Influencing Biomedical Waste Management

1.1.1.1 4.4.1 General Awareness

General awareness of biomedical waste was measured using questions on whether a worker had knowledge of what kind of wastes were infectious and the ability to mention the categories of hospital waste. Results indicate that 59.5 % of the respondents possessed general awareness of biomedical waste, thus they could identify and categorised BMW.

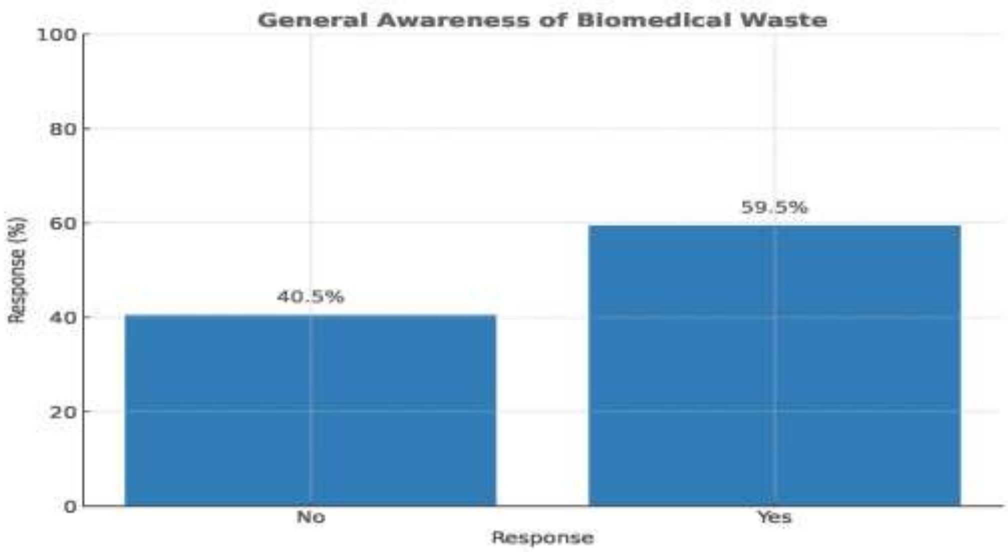


Figure 3: General Awareness of Biomedical Waste Management.

At TRRH, 59.5% of healthcare staff demonstrated general awareness of biomedical waste types, associated risks, and handling requirements. This indicates a fair level of understanding across the workforce. However, despite this awareness, observations revealed common lapses, including improper classification, poor labeling, and the mixing of general and hazardous waste in the same containers.

This disconnects between awareness and behavior mirrors the findings of Eshete et al. (2023) in their study titled “Healthcare Waste Management Practice and Associated Factors Among Healthcare Workers in Ethiopia.” In that study, although 87% of respondents were knowledgeable about BMW risks, fewer than half practiced proper waste segregation. The gap was attributed to institutional barriers, such as lack of materials, weak supervision, and an unsupportive workplace culture.

Similarly, Windfeld and Brooks (2015), in their global review titled “Medical Waste Management – A Review,” found that in many low-income countries, staff awareness does not translate into compliance due to underdeveloped support systems. For TRRH, this suggests that enhancing institutional reinforcement may be more impactful than focusing on knowledge alone.

1.1.1.2 4.4.2 Occupation and training

The results indicate that majority (81 %) of the respondents received formal training on bio medical waste management. **Table 2** presents the percentage of those who got training on BWM

Table 2: Percentage of respondents who received training on biomedical waste management across occupation category

Occupation	Number	Percent	Total
Doctor	17	81.0	21
Nurse	16	84.2	19
Lab technician	14	93.3	15
Cleaners	10	90.9	11
Pharmacists	3	60.0	5
Environmental health officer	3	100	3
Total	63	85.1	74

From **Table 2**, The study found that 85.1% of workers at TRRH had received occupational training in BMW management. Training rates were particularly high among environmental health officers (100%), laboratory staff (93.3%), and cleaners (90.9%). This high training coverage demonstrates the hospital's investment in capacity-building for its workforce.

However, despite these efforts, observations highlighted that many staff still failed to consistently apply what they had learned—with ongoing issues such as incorrect bin usage, poor personal protective equipment (PPE) adherence, and misclassification of waste. This is consistent with Millanzi (2023), in his study titled "Assessment of Perceived Practices in Biomedical Waste Segregation Among Health Workers in Tanzanian Health Facilities." Millanzi reported that even trained workers often performed poorly in real-world settings due to a lack of practical supervision and inconsistent resource availability.

Supporting this, Eshete et al. (2023) also noted in their Ethiopian study that training without institutional follow-up had limited impact. In contrast, Nyangwe and Tarimo (2023), in their study titled "Practices on Biomedical Waste Management Among Healthcare Workers at Benjamin Mkapa and Dodoma Regional Hospitals," found that where training was reinforced through leadership support and regular monitoring, it led to improved compliance. The contrast implies that TRRH may benefit from integrating post-training support and supervision to ensure training outcomes are sustained.

Table 3: Results for logistic regression analysis

	Odds ratio	Std. error	p-value	[95% conf.]	
Age categories					
18-30	1				
31-40	1.37	1.17	0.715	0.26	7.28
41-50	12.95	14.25	**0.020**	1.50	111.96
51-60	2.31	1.95	0.319	0.44	12.05
Gender					
Male	1				
Female	1.29	0.80	0.682	0.38	4.35
Education					
O level	1				
A level	2.36	2.65	0.445	0.26	21.38
Certificate	5.78	7.46	0.174	0.46	72.58
Diploma	0.35	0.28	0.197	0.07	1.74
Higher Education	0.31	0.27	0.174	0.06	1.68
Employment					
Part-time	1				
Full-time	4.89	3.92	**0.048***	1.02	23.56
Training					
Not trained	1				
Trained	1.11	1.01	0.910	0.19	6.64
General Awareness					
Insufficient	1				
Sufficient	1.16	0.78	0.822	0.31	4.33
Segregation awareness					
Insufficient	1				
Sufficient	0.65	0.57	0.619	0.12	3.62
Treatment awareness					
Insufficient	1				
Sufficient	1.41	0.88	0.581	0.42	4.80

*Significant level at $p < 0.05$

This study used a binary logistic regression model to assess how selected factors influenced biomedical waste management practices among healthcare workers at Tanga Regional Referral Hospital, see **Table 3**. The outcome variable was categorized into good and poor practices, while predictors included socio-demographic variables (such as age, gender, education, and employment type) and institutional aspects (like training, general awareness, and knowledge of segregation and treatment procedures). The results not only provide statistical insight but also highlight behavioral patterns that can inform future interventions. These findings align with the Health Belief Model, which explains health-related behaviors based on an individual's beliefs about risks, benefits, barriers, and their confidence in taking action.

Age: Experience Enhances Compliance. Among the examined factors, age showed a strong association with proper BMW practices. Healthcare workers aged between 41 and 50 years were nearly 13 times more likely to adhere to recommended practices than those aged 18–30 (OR = 12.95; p = 0.020). This suggests that with age comes greater familiarity with protocols, institutional routines, and possibly a stronger internalization of safe practices. These findings are consistent with earlier research by Manyele et al. (2010), which emphasized that more experienced professionals are more likely to follow waste management standards. Vishal et al. (2012) also observed similar trends, noting that repeated exposure to routines improved compliance. At the regional level, Chisholm et al. (2021) argued that age often reflects depth of professional development, which translates into greater procedural awareness. Within the HBM framework, older workers may demonstrate stronger perceived severity regarding the consequences of improper waste handling and higher self-efficacy, meaning they feel more capable of carrying out the right procedures. These beliefs likely motivate more consistent behavior.

Employment Status: The study also found a statistically significant link between employment status and good BMW practices. Full-time employees were almost five times more likely to follow appropriate procedures compared to their part-time counterparts (OR = 4.89; p = 0.048). This could be due to greater accountability, more frequent exposure to institutional standards, or a stronger sense of belonging. These outcomes align with Millanzi (2023), who reported that permanent staff typically showed better compliance with segregation protocols. Nyangwe and Tarimo (2023) also noted that hospitals with structured staffing and clear incentives tended to have more consistent waste handling behaviors. From an HBM perspective, full-time staff likely receive more cues to action—such as routine training or supervision—and perceive greater benefits from following procedures, including job security or professional recognition. Their long-term engagement in the system may also reduce perceived barriers that hinder waste compliance among temporary staff.

Gender and Education: While gender and education level were included as predictors, neither showed a significant impact on waste management behavior. Female staff were slightly more likely to engage in proper practices (OR = 1.29; p = 0.682), and those with certificate-level education were five times more likely to follow procedures than those with only O-level qualifications (OR = 5.00; p = 0.174), but neither result reached statistical significance.

These findings reflect those of Amita et al. (2017), who found no clear link between gender or education and BMW practices. Their study suggested that institutional culture, supervision, and hands-on experience play a larger role than formal qualifications. Under the HBM, this could indicate that knowledge alone is not enough to influence behavior. Without strong perceived susceptibility or effective cues to action, educational background may have limited influence on day-to-day practices. Practical barriers and workplace culture may outweigh the influence of personal attributes like gender or academic attainment.

Training and Awareness: Although many participants reported having been trained and were generally aware of waste protocols, these factors did not significantly influence their practice. Trained individuals were only slightly more likely to perform proper BMW procedures (OR = 1.11; p = 0.910), and knowledge of general, segregation, and treatment procedures also had no significant effect. This finding highlights a common issue, the gap between knowledge and practice. A similar trend was noted in Ethiopia by Eshete et al. (2023), where despite 87% of staff being aware of proper disposal practices, fewer than half actually followed them. The authors attributed this to resource shortages, inadequate supervision, and a weak institutional culture around compliance. Interestingly, Nyangwe and Tarimo (2023) reported a different outcome at Benjamin Mkapa Hospital, where knowledge strongly correlated with practice. This suggests that the presence of institutional support, consistent monitoring, and leadership commitment can help translate awareness into action. The disconnect at TRRH can be viewed through the HBM lens as a case of low perceived benefits or high perceived barriers. Even when individuals are trained, they may not act unless they believe the behavior will make a difference and feel confident in their ability to perform it consistently. If resources or support are lacking, training alone is unlikely to change behavior. The regression model explained only 21.5% of the variance in BMW practices, suggesting that other, unmeasured factors—likely institutional or environmental play a substantial role. These may include the availability of equipment, administrative oversight, consistent enforcement, or supportive infrastructure.

This view aligns with WHO (2004) guidelines, which identify institutional shortcomings—such as weak leadership, poor infrastructure, and inadequate monitoring as key contributors to unsafe waste practices in low-resource settings. Addressing these systemic issues is essential for improving compliance. From an HBM standpoint, these institutional factors act as external cues to action and can influence perceived barriers. Without consistent reinforcement or institutional commitment, even motivated individuals may struggle to maintain proper BWM practices.

1.2 CONCLUSION

This study investigated the factors influencing BMW management practices among healthcare workers at TRRH the analysis of drivers influencing BMW practices showed that employment status and age group (41–50 years) were statistically significant predictors of safe practices. This suggests that experience and institutional attachment are more influential than training or educational background. Surprisingly, variables such as gender, awareness, and formal education showed no significant correlation with good practice, reinforcing the idea that behavioral adherence is shaped more by institutional culture and stability than by individual knowledge. This study primarily addressed solid biomedical waste management at TRRH; however, future research should explore the handling of liquid biomedical waste in departments like laboratories and dialysis units, and assess the environmental risks of incinerator ash disposal. These areas are vital for improving comprehensive, sustainable waste management in low-resource healthcare settings.

1.3 RECOMMENDATIONS

Based on the findings drawn from the three specific research objectives, the following recommendations are proposed to enhance biomedical waste management practices at TRRH the study recommends

Establish Continuous and Targeted Training Programs: All staff involved in waste handling, including temporary and newly recruited workers, should undergo regular training focused on practical waste management skills, safety procedures, and institutional policies. Training sessions should be reinforced with real-life demonstrations and simulations.

Design Tailored Support for High-Risk Groups: Targeted support strategies should be implemented for younger and part-time workers, who were observed to have lower compliance levels. These may include peer mentoring, department-level supervision, or incentives for safe practices.

Develop and Implement a Hospital Waste Management Plan: A formal waste management policy tailored to TRRH should be developed, outlining standard procedures, roles and responsibilities, waste minimization strategies, and monitoring mechanisms. This plan should be updated annually to reflect changes in national policy and institutional needs.

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