

**AN EVALUATION OF CLINICAL WASTE MANAGEMENT IN GABORONE CITY
COUNCIL HEALTHCARE FACILITIES.**

by

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DECLARATION

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I declare that the dissertation titled “AN EVALUATION OF CLINICAL WASTE MANAGEMENT IN GABORONE CITY COUNCIL HEALTHCARE FACILITIES” is my own research work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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ABSTRACT

The management of clinical waste is of great importance due to its infectious and hazardous nature that can cause risks on environment and public health. The study was conducted to evaluate clinical waste management practices and to determine the amount of waste generated in five purposively selected healthcare facilities in Gaborone City Council. The surveyed healthcare facilities were of different size, specialization and category and included a referral hospital, two clinics and two health posts. To examine clinical waste management practices the study employed a range of methods including questionnaire survey which targeted 105 stratified randomly selected healthcare workers and ancillary staff, formal interviews with facility managers, field observations and literature reviews. Compliance with the Botswana Clinical Waste Management Code of Practice, 1996 and Waste Management Act, 1998 and other related documents were used as standards to assess clinical waste management practices. The waste management practices were analysed for a week in each healthcare facility to capture the daily management practices.

The generated clinical waste was weighed to compute the generation rates and was followed through the various management practices to the final disposal. Findings of the study revealed that clinical waste generation rates were: 0.75kg/patient/day for Princess Marina Hospital and 0.1 - 0.3kg/patient/day for clinics and health posts. Numerous aspects of clinical waste management were found to comply with the expected rules and standards at Princess Marina Hospital, but the clinics and health posts had less appropriate practices. Clinical waste generated at Princess Marina Hospital is quantified in reliable records and dedicated Infectious Control Officers are responsible for monitoring the management of clinical waste. The study revealed that clinics and health posts do not quantify clinical waste and there are no officers responsible for monitoring clinical waste and there are no documents for monitoring the management of clinical waste. The main treatment method of clinical waste for the surveyed healthcare facilities is incineration and it is being done properly. The study established that at least 80% of healthcare workers and ancillary staff have been vaccinated against hepatitis B and have received training in clinical waste management. Recommendations are given with the aim of improving clinical waste management practices in Gaborone City Council healthcare facilities.

Key words: Evaluation; Clinical waste; Waste management; Waste generation; Health risks; Environmental risks; Health facilities; Gaborone City Council; Botswana.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immune deficiency syndrome
AZT	Zidovudine
CSO	Central Statistics Office
EPA	Environmental Protection Agency
GCC	Gaborone City Council
GHG	Green House Gases
GoB	Government of Botswana
HIV	Human Immuno-deficiency virus
ICO	Infection Control Officer
MoH	Ministry of Health
MWTA	Medical Waste Tracking Act
PMH	Princess Marina Hospital
PPS	Probability Proportional to Size
RCRA	Resource Conservation and Recovery Act
SPSS	Statistical Packages for Social Science
UK	United Kingdom
UNCED	United Nation Conference on Environment and Development
UNEP	United Nation Environment Program
UNISA	University of South Africa
USA	United States of America
WHO	World Health Organisation

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CHAPTER 1 INTRODUCTION

1.0 Introduction

The evolution of a separate category of medical waste within the municipal waste stream dates back to the late 1970s, when medical waste including syringes and bandages were washed up on the Eastern United States coast (Frost and Sullivan, 2009). The public outcry that followed led to the formation of the United States Medical Waste Tracking Act (MWTAA), which came into force on November 1, 1988 (Holmes, 2009). Much of the outcry ignored the specificity of medical waste, its small quantities and its nature. The first solution adopted to solve this problem was reflected in the installation of 6500 onsite small and unregulated medical waste incinerators at healthcare facilities. It was soon realized that these small burners were not only causing more pollution than the medical waste, but they also provided license to create more waste, much of it disposable plastics since it could be easily burned (Frost and Sullivan, 2009).

The risks associated with healthcare waste and its management has gained attention across the world in various events, local and international forums and summits. The Agenda 21 of the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, June 1992 also identified healthcare waste as being amongst the environmental issues of greatest concern to the global community. Cheng *et al.* (2009) noted that although medical waste presented a relatively small portion of the total waste in a community; its management is considered an important issue worldwide. During the past two decades the world experienced a dramatic increase in the amount of hazardous waste generated. This period also witnessed a vigorous drive for sustainable development and increased awareness and concern of the environment (Ketlogetswe *et al.*, 2004). The United Nations Environmental Program (UNEP) argues in their International Source book on Environmentally Sound Technologies for Municipal Solid Waste Management that among these waste, healthcare waste is one of the most problematic types.

The growing affluence and increasing population concentrated in urban areas have increased the generation of all types of waste including clinical waste. Mbongwe *et al.* (2008) noted that as

the demand for more healthcare facilities increases, there is also an increase in medical waste generation in Botswana. Ramokate (2007) added that in developing countries, high HIV/AIDS prevalence, high morbidity amongst the general population has resulted in high hospital admissions and the management of the medical waste generated as a result, has become a major challenge in most healthcare facilities. Healthcare waste continues to present an array of challenges, as its generation from healthcare facilities has greatly increased and healthcare waste management has become a concern. Poor conduct and inappropriate disposal methods exercised during the handling and disposal of medical waste is increasing significant health hazards and environmental pollution due to the infectious nature of the waste. Access to a clean environment has been recognized as being essential to the improvement of a healthy and social environment. The Government of Botswana (GoB) has rapidly embarked on programs for delivery of good sanitation to most cities, towns and village (Jamu *et al.*, 2009).

In recognition of the significance of clinical waste management, the GoB in co-operation with the German Agency for Technical Co-operation undertook a study on the management of medical waste in 1995, to assess how clinical waste could be managed within referral and primary hospitals in Botswana (Kangethe, 2008). Consequently, in 1996 the GoB adopted the Clinical Waste Management Code of Practice to address the concerns that had been expressed by the study. The Clinical Waste Management Code of Practice set out the best practice for segregation, handling, storing, transporting and disposal of clinical waste (GoB, 2007). Furthermore in 1998, the Waste Management Policy was formulated to have an over arching vision to raise the environmental sustainability, human health and natural resources awareness to meet the needs of current and future generations (GoB, 2007).

From 2000, sanitary landfills were constructed throughout the country, in order to ensure that clinical waste residuals and ashes among other wastes are efficiently disposed off, so that the environment and natural resources are not at risk (Jamu *et al.*, 2009). Between 2003 and 2005 the GoB undertook a performance audit in three referral hospitals, namely Princess Marina Hospital, Nyangwabgwe Hospital and Lobatse Mental Hospital. The aim of this audit was to assess whether medical waste generated by the three hospitals was appropriately managed and disposed of through safe and environmental sound methods to protect employee's health, the

environment and the communities in which the hospital operate (GoB, 2007). The significant observations made were in regard to planning, compliance and evaluation of Botswana Clinical Waste Management Code of Practice, risk management and clinical waste management information (GoB, 2007).

Despite all the efforts to provide good sanitation and sound clinical waste management, Jamu *et al.* (2009) noted that numerous aspects of clinical or healthcare waste management are found to be haphazard and challenging to hospitals. Clinical waste is increasingly becoming a problem particularly in Gaborone healthcare facilities (Kgosiesele and Zhaohui, 2010). Indiscriminate dumping of clinical waste, clinical waste mixed with household waste and this waste being conveyed using bare hands and transported in open trucks from some healthcare facilities have been observed (Gob, 2007). Mbongwe *et al.* (2008) noted that the environmental quality in Botswana has deteriorated due to improper clinical waste segregation, collection, transportation and disposal methods used in healthcare facilities. Kgosiesele and Zhaohui (2010) also added that improper management practices are still evident from point of initial generation, collection to final disposal. This research has been motivated by these challenges noted in the medical waste management practices in Gaborone City Council healthcare facilities. It is hoped that the findings of this study will be used to bridge the knowledge gap and improve on the medical waste management practices in Gaborone.

1.1 Statement of the problem

Botswana is a landlocked country in Southern African, which exhibited the typical characteristics of a developing nation with rapidly growing economy in the 1990's (Kangethe, 2008). Kangethe (2008) revealed that the HIV/AIDS breakout in the 1990's, which escalated to levels that placed Botswana at the top of the list of countries with highest infection rate in the world, has threatened to reverse the country's economic gains. In response to the nation's health needs including the HIV/AIDS problem, the GoB mounted perhaps the most aggressive counteraction in the developing world, which includes crash programs of upgrading and building new clinics and hospitals (Ministry of Health (MoH), 2011). The upgrading and building of healthcare facilities was also necessary to accommodate population growth subsequent to

economic diversification, the expanding manufacturing, tourism, mining and business service sectors. As a result of a growth in the healthcare sector, there has been an increase in the amount of clinical waste generated (Mbongwe *et al.*, 2008).

Against this background, it is important to recognize the priority in clinical waste management which must be directed to the protection of human health, the environment and natural resources. GoB (2007) revealed that Botswana is producing an estimated 2 400 tonnes of healthcare risk waste per year, equating to 1.71kg per capita. The reason for the high clinical waste generation is due to a rising population that is outweighing the country's capacity to deal with the increased volume of clinical waste (Kangethe, 2008). The situation has been worsened by lack of adequate technical, technological and human resources to deal with the problem. GoB (2007) revealed that despite concerted efforts towards management of clinical waste, cases of clinical waste left uncontrolled for a long time are still quite prevalent.

Poor waste management practices at healthcare facility level, including failures in waste segregation and errors in waste disposal colour coding may result in hazardous waste not only being disposed inappropriately, but also in members of the community gaining access to such waste (Holmes, 2009). Mbongwe *et al.* (2008) noted that in training sessions with healthcare workers in Lobatse and Kgatleng District Council Municipalities, healthcare workers indicated that some members of the community used some of the waste receptacles, such as sharps containers to store food commodities while others including healthcare workers used red waste bags for other purposes other than storage of infectious waste. Due to lack of understanding of the importance of colour coding and segregation in clinical waste management, some healthcare workers were reported to be giving out red bags to patients when they were discharged from the hospital to carry their personal belongings and clothes (Mbongwe *et al.*, 2008). This poses a great risk for members of the public who may encounter red bags containing medical waste. Sharp containers that are often placed in less secure storage facilities may also result in containers containing equipments being scavenged and reused (Mochungong, 2010).

Previous studies reported that handling of waste at some facilities is haphazard, with use of unacceptable methods of transport such as mortuary trolleys (Holmes, 2009). Inadequate

management and disposal of medical waste in hospitals, clinics and private practices in Gaborone has also been reported (GoB, 2007). This suggests that waste management systems for clinical waste generated in Gaborone seem to be inadequate for sufficient and sustainable medical waste management. When dealt with incorrectly, clinical waste presents risks to hospital staff, rag pickers, municipal workers, the community at large and the environment. Mbuyi (2010) also added that clinical waste has the potential to cause damage to most aspects of the environment, especially to land, water, air and wildlife. It therefore requires that medical waste be managed in a safe manner using suitable treatment and disposal methods (Sharma, 2007). It is against this background, that the researcher evaluated the clinical waste management systems or practices in Gaborone City Council (GCC) healthcare facilities, Botswana.

1.2 Rationale and motivation

Healthcare services, in pursuing the goals of reducing health problems and eliminating potential human health risks, inevitably create waste that may itself pose health hazards (Pruss *et al.*, 1999). Mohee (2005) noted that healthcare waste worldwide have sharply increased in recent decades due to increased population, numbers and sizes of healthcare facilities as well as the use of disposable medical products. Incorrect management of healthcare waste has direct impacts to individuals working in healthcare facilities, the community and natural environment (Goddu *et al.*, 2007). Risks associated with clinical waste and clinical waste management have gained attention across the world in various summits, locally and internationally. Despite the magnitude of the problem, practices, capacities and policies on dealing with clinical waste management in many countries, especially in developing nations, is inadequate and requires intensification (Jang, 2011).

In Gaborone, clinical waste management systems seem not to be properly followed and there seem to be minimum control of waste (GoB, 2007). Proper clinical waste management strategies are necessary in GCC healthcare facilities and as the Agenda 21 identified clinical waste as an environmental issue of great concern to the global community.

An article from Mmegi Newspaper (Maipelo, 28 March 2011) revealed that there is a growing public awareness and media concern about clinical waste in Botswana. The concern is over inappropriate segregation, collection, handling, storage, transportation, treatment and ultimate disposal of clinical waste. A large part of clinical waste consists of solids and liquid waste. Both are important sources of physical and natural environmental degradation and constitute a health hazard. Due to these concerns, this study was conducted in order to evaluate the clinical waste management practices in GCC healthcare facilities.

It is hoped that this study will provide information regarding clinical waste management in healthcare facilities and will generate interest in the systematic control effort for effective medical waste management. The findings will help to supplement and complement the existing knowledge on clinical waste management systems used in GCC healthcare facilities. It is also hoped that the research may help the government departments, and local authorities to improve their existing waste management policies and planning measures in order to mitigate the likely impacts of ineffective clinical waste management methods.

1.3 Aim of the research

The aim of this study was to evaluate clinical waste management practices at selected GCC healthcare facilities.

1.4 Objectives of the research

The following were the study objectives:

- a. To determine the amount of clinical waste generated at GCC healthcare facilities.
- b. To assess clinical waste management practices employed at GCC healthcare facilities.
- c. To determine the extent to which the GCC implement and comply with Clinical Waste Management Code of Practice, 1996 and all other related national waste management strategies.
- d. To determine the level of knowledge and awareness of individuals involved in clinical waste management.

- e. To discuss potential risks of clinical waste management to both human health and the natural environment.
- f. To make recommendations on effective clinical waste management systems.

1.5 Research questions

- a. What are the different types and quantities of clinical wastes generated in GCC healthcare facilities?
- b. How is clinical waste managed at the different healthcare facilities?
- c. To what extent are health workers familiar with clinical waste management policies and procedures?
- d. To what extent do facilities implement and comply with Clinical Waste Management Code of Practice?
- e. What are the likely risks related to clinical wastes that are occurring in GCC healthcare facilities?
- f. What recommendations can be made to improve the efficiency of clinical waste management systems used?

1.6 Significance of the study

The study is considered significant for the following reasons.

- It provides insight into prevailing clinical waste management practices at the healthcare facilities in GCC.
- The information and recommendations from the study can be used to help ensure effective management of medical waste in healthcare facilities which could in turn help to reduce risks to healthcare workers, the community at large and the environment.
- It is hoped that the research may help the Government departments and local authorities in improving the existing policies and planning measures in order to mitigate risks of improper management of medical waste.
- Findings of the study could enable the GoB through the MoH to address identified gaps and strengthen proper management of clinical waste.

1.7 Study area

This research focused on the evaluation of clinical waste management practices at selected healthcare facilities in GCC, further details are described in the methodology section (chapter 3). Gaborone is the capital and largest city of Botswana with a population of 231 626, about 10% of the total population of the country (Central Statistics Office (CSO), 2011). Gaborone was named after chief Gaborone who led his tribe from Magaliesburg around 1880. The city is situated at 24°39'29"S 25°54'44"E between Kgale and Oodi hills on the Notwane River in the southern corner of Botswana, and is 15 km from the South African border (Seith, 2008). It is a vibrant cosmopolitan city although it is small in size with an area of 169km² (Figure 1.1) (Lekorwe, 2010).

Gaborone has a hot semi- arid climate. Most of the year, it is very sunny, with hot summers and very cold winters. Annual precipitation is scanty and erratic. Most of it falls during the summer, between October and April. Rainfall varies between 250mm to 750mm (Bauer, 2010).

According to CSO (2011), the population growth rate of Gaborone is 3.4 % being the highest in the country. This is because the city has more developed infrastructure, making it more livable. It is one of the fastest growing administrative cities in the world. Much of the growth is based on migration from the rest of Botswana. Gaborone is the centre of national economy and is the headquarter of important financial institutions such as Bank of Botswana and Botswana Stock Exchange. Gaborone is controlled by GCC, the wealthiest council in Botswana (Nyeru, 2009). The city is governed by a mayor and several committees run by councilors, for example the public health committee.

The healthcare system is well organized, although trained staff is in short supply (MoH, 2011). Provision of healthcare services is Botswana's long term pillar of vision 2016, whose overall goal is to have a health nation that is fully involved and can contribute meaningfully to the country's development (Jamu *et al.*, 2009). As of 2008, (Mmereki, 2009) cited that Gaborone had a network of healthcare facilities operated by Government and private practitioners. These facilities include referral hospital, private hospitals, clinics, health posts and health stops.

According to World Health Organization (2007) it is estimated that 84% of Batswana live within a 5 kilometer radius of the nearest healthcare facility and 95% of the population lives within 8 kilometer radius of the nearest healthcare facility. The majority of Batswana living outside the 5-8 kilometer radius of the nearest health facility are reached by health services through net work of mobile health units operated by clinics and health posts.

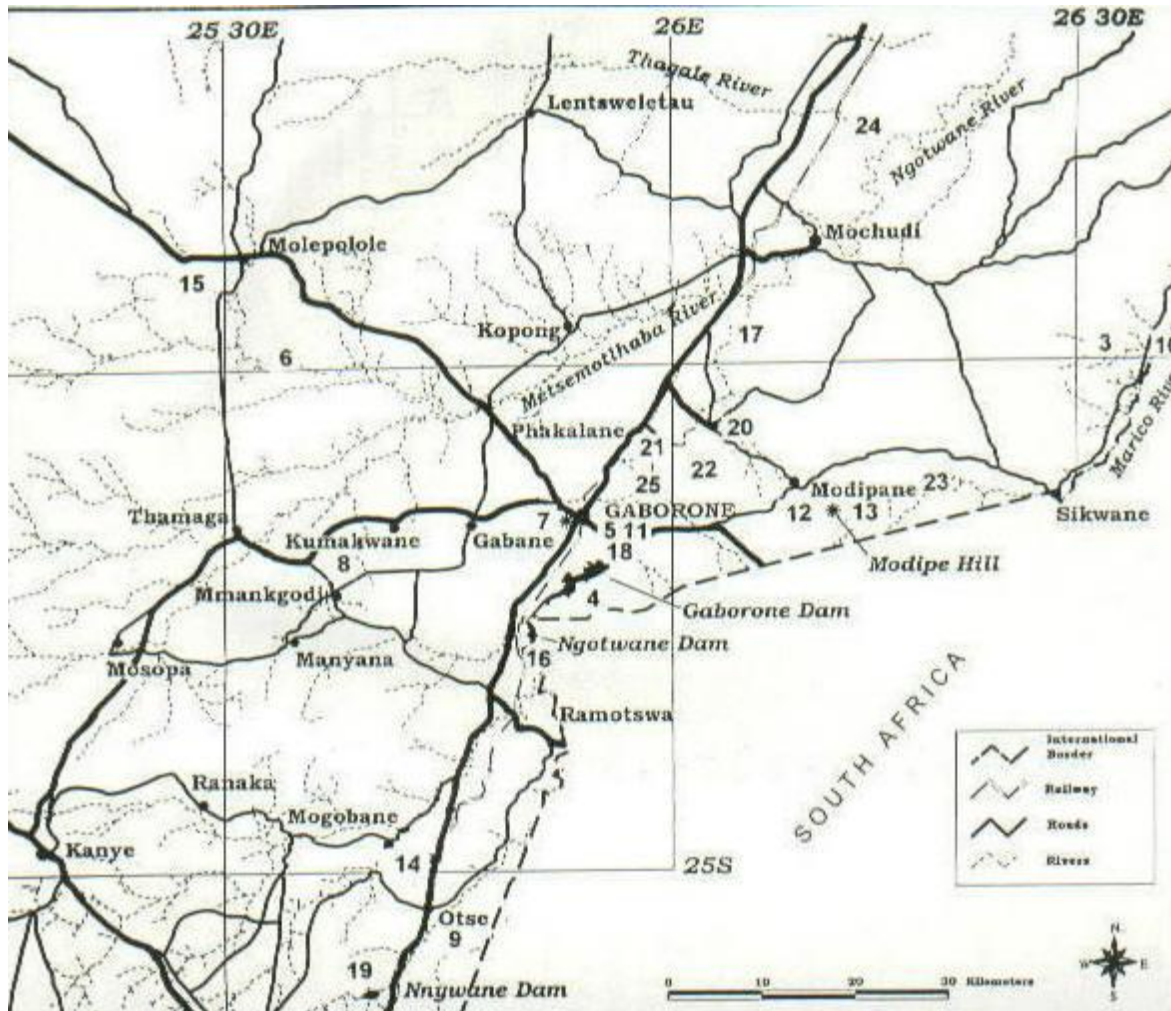


Figure 1.1: Map showing location of Gaborone (Department of surveys and mapping, 2011)

CHAPTER 2 LITERATURE REVIEW

2.0 Introduction

One of the long standing and most challenging tasks for human beings have been to live on a piece of land without spoiling it. Hospitals are known for the treatment of sick persons, and communities seem to be unaware of the adverse effects of the garbage and filth they generate. Sharma (2007) added that it is ironic that health facilities which provide succor to the ailing can also generate various types of medical wastes. From time immemorial, medical facilities have needed to find ways of managing and disposing their waste. In 18th century England and France carters were paid by medical facilities to carry out and discard waste on the outskirts of towns. Disposal in open pits became a routine and Benjamin Franklin initiated the first municipal cleaning program in Philadelphia in 1957 (Clarke, 2008). Since then society has evolved and developed types of clinical waste that cannot be simply be dumped into a pit (Frost and Sullivan, 2009). Moving on to the 20th century, the advent of complicated diseases and ailments led to more complicated medical waste being generated, which required more organized methods of waste management. Poor management of medical waste exposes healthcare workers, waste handlers and the community to infections, toxic effects and injuries in addition to environmental damages (Pruss *et al.*, 1999).

2.1 Nature of clinical waste

Crick (2012) defines clinical waste very broadly, as being any solid or liquid that is used in the diagnosis, treatment or immunization of human beings or animals in research pertaining thereto, or in the production or testing of biological matter. This definition includes a number of waste material such as blood soaked bandages, culture dishes and other glassware, discarded surgical gloves and instruments, discarded needles and lancets, cultures and stock and removable body organs (Jang, 2011). Clinical waste is a type of waste which is commonly generated in medical facilities. Agumuth (2010) also defines clinical waste as waste arising from medical, nursing, dental, veterinary, pharmaceutical or similar investigative, treatment care or research practice. Holmes (2009) adds that clinical waste is a healthcare waste that may prove hazardous to those

that come into contact with it. The term clinical waste has often been used interchangeably with other terms such as medical waste, hospital waste, healthcare waste, biomedical waste or bio-hazardous waste around the world (Jang, 2011). In Botswana, this waste is generally known as clinical waste, while World Health Organisation (WHO) and other international bodies refer this waste as healthcare waste, recognizing that not all waste generated from healthcare facilities is clinical (Mbongwe *et al.*, 2008). Lee *et al.* (2002) used the term medical waste to deal with all types of waste produced by healthcare facilities.

According to Agumuth (2010) clinical waste is a small fraction of urban municipal waste and there should be a greater consensus on how much of the waste generated is infectious or hazardous. Infectious hospital waste in turn presents only a small part of total clinical waste which cannot be ignored. According to Rappe and Nyregen (2009), large quantities of clinical wastes are produced everyday from a wide range of sources. Most hazardous and toxic healthcare waste comes from healthcare facilities. Only a small amount is from domestic or industrial sources.

Pruss *et al.* (1999) classified sources of medical waste sources according to quantities produced. Major sources are hospitals and healthcare establishment such as emergency medical care services, healthcare centers and dispensaries, obstetric and maternity clinics, out-patient clinics, dialysis centers, first aid posts, hospices and transfusion centers. Laboratories, research centers dealing with animal research and testing are also considered as major centers. According to Sharma, (2007) minor and scattered sources produce some health care waste in categories similar to hospital waste but their composition is different. Minor sources include convalescent nursing homes, psychiatric hospitals, disabled persons' institution and physicians' office. Non healthcare activities like cosmetic ear- piercing and tattoo parlour are also minor sources including funeral services, ambulance services and home treatment (Pruss *et al.*, 1999).

Rappe and Nyregen (2009) highlighted that the composition of medical waste is often a characteristic of the type of source. For example different units within the healthcare facility generate waste of different characteristics. According to the WHO between 10% and 25% of waste generated in health facilities is regarded as hazardous due to its composition. The

remaining 75% to 90% poses no risk of infection transmission, as it is comparable to domestic waste. This mainly comprises waste produced in the administration and housekeeping sections of the facilities. The WHO further classifies healthcare waste into two major categories (Pruss *et al.*, 1999):

1. Healthcare general waste, which is the proportion of healthcare waste that is not hazardous and is comparable to household waste.
2. Healthcare risk waste, which is the proportion of healthcare waste that is likely to contain pathogenic organisms in sufficient quantities to cause disease. This waste is also commonly referred to as clinical waste or biomedical waste in certain quarters and falls under a general cluster known as hazardous waste.

Healthcare risk waste is further classified into the various other types according to specific composition (Diaz *et al.*, 2008; Clover, 2009):

- a) Infectious waste refers to waste which is suspected to contain pathogens, such as excreta from infected patients and wound dressings.
- b) Pathological waste consists of tissues, body parts, human foetuses, blood and body fluids.
- c) Sharps are a category of healthcare waste comprising of items which can cause cuts and injuries. These include needles, scalpels and broken glass.
- d) Chemical waste contains residues of chemicals used in hospitals such as disinfectants and reagents used in laboratories.
- e) Pharmaceutical waste contains remains of pharmaceutical products such as expired drugs.

Figure 2.1 shows how Hossain *et al.* (2011) classified clinical waste.

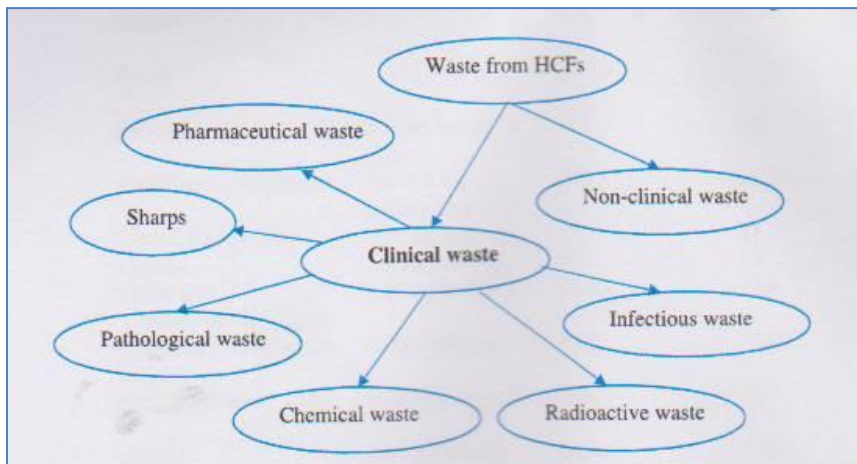


Figure 2.1: Categories of waste from healthcare facilities (Hossain *et al.*, 2011)

2.2 Clinical waste management

Waste management consists of various activities from generation of waste to final disposal. It involves strategic measures taken in the generation, characterization, quantification, storage, handling, collection, transportation and disposal of waste. It also covers managerial, technological and remediation measures involved in the corrective actions of existing waste practices as well as the continuous plan towards ensuring sustainable waste management within a locality (Olatoye, 2009). Samarakoon and Gunawardena (2011) define healthcare waste management as an integral part of the hygiene and infection control within a healthcare facility, which helps in controlling nosocomial infections. According to Insa *et al.* (2010) medical waste management includes all the actions necessary for collection, transportation and treatment of this waste to recover recyclable or valuable fractions before its final disposal at a landfill or before incineration. The term waste management usually relates to materials produced by human activities and the process is generally undertaken to reduce their effect on health, the environment or aesthetics. According to Crick (2012), the process of waste management comprises key stages which are all very important and interrelated. These stages include segregation, collection, storage, handling, transportation, treatment and disposal.

Clinical waste management has become a critical issue and has taken a central place in national health policies of many countries (Bdour *et al.*, 2007). Unless clinical waste is properly segregated, handled, transported and disposed, it can present risks to the health and safety of people at work, members of the public and the environment (Abor, 2007; Clarke, 2008). All individuals exposed to improper management of healthcare waste are potentially at risk of being injured or infected. The most vulnerable groups include medical staff namely doctors, nurses, sanitary staff and hospital maintenance personnel. Patients receiving treatment in healthcare facilities, their visitors and the general public are also at risk of being injured through healthcare waste (Pruss *et al.*, 1999; Cheng *et al.*, 2009; Hossain *et al.*, 2011).

Improper waste management can lead to environmental pollution (water, air, soil), unpleasant smells, can foster the growth and multiplication of insects, rodents, cockroaches, vermin and may lead to transmission of diseases like typhoid, cholera, human immunodeficiency virus and

hepatitis (B and C), as well as contamination of underground water table by untreated medical waste landfills (Nemathaga *et al.*, 2008; Taghipour and Mosaferi, 2009; Abd El-Salam, 2010).

In order to minimize impacts of clinical waste, a proper and workable waste management system is a pre-requisite in hospitals. The safe management of clinical waste may be achieved by ensuring care in dealing with clinical waste. Hence it is the ethical responsibility of management of hospitals and healthcare establishments to ensure proper medical waste management. This involves the determination of sources, waste characterization, generation rate, safe handling practices, segregation, storage, transportation and final disposal (Goddu *et al.*, 2007). According to Kagonji and Manyela (2011), effective medical waste management should also include clear definitions of medical waste and the scope of legislation concerning it, basic principles to promote the reduction of the amount of waste generated at source and homogeneous classification of waste and the implementation of environmentally friendly waste management technologies.

2.3 Clinical waste generation

Clinical waste is generated from various activities performed in healthcare facilities and these include infectious and non infectious waste. Infectious or hazardous waste is a by-product of diagnostic and experimental activities and therapeutic methods such as surgery, dialysis, labor and delivery, biopsies injections and chemotherapy (Diaz *et al.*, 2008). Generation of healthcare waste differs not only from country to country but also within the country. Figure 2.2 shows the generation rates of medical waste in different countries. Waste generation depends on numerous factors such as established waste management methods, type of healthcare establishment, hospital specialization, proportion of reusable or disposable medical devices employed in healthcare, occupancy rate and proportion of patients treated on daily basis and the degree of regulation enforcement at national and local levels, definitions of medical waste, training of medical waste management and medical waste treatment and disposal policy type (Taghipour and Mosaferi, 2009; Jang, 2011).

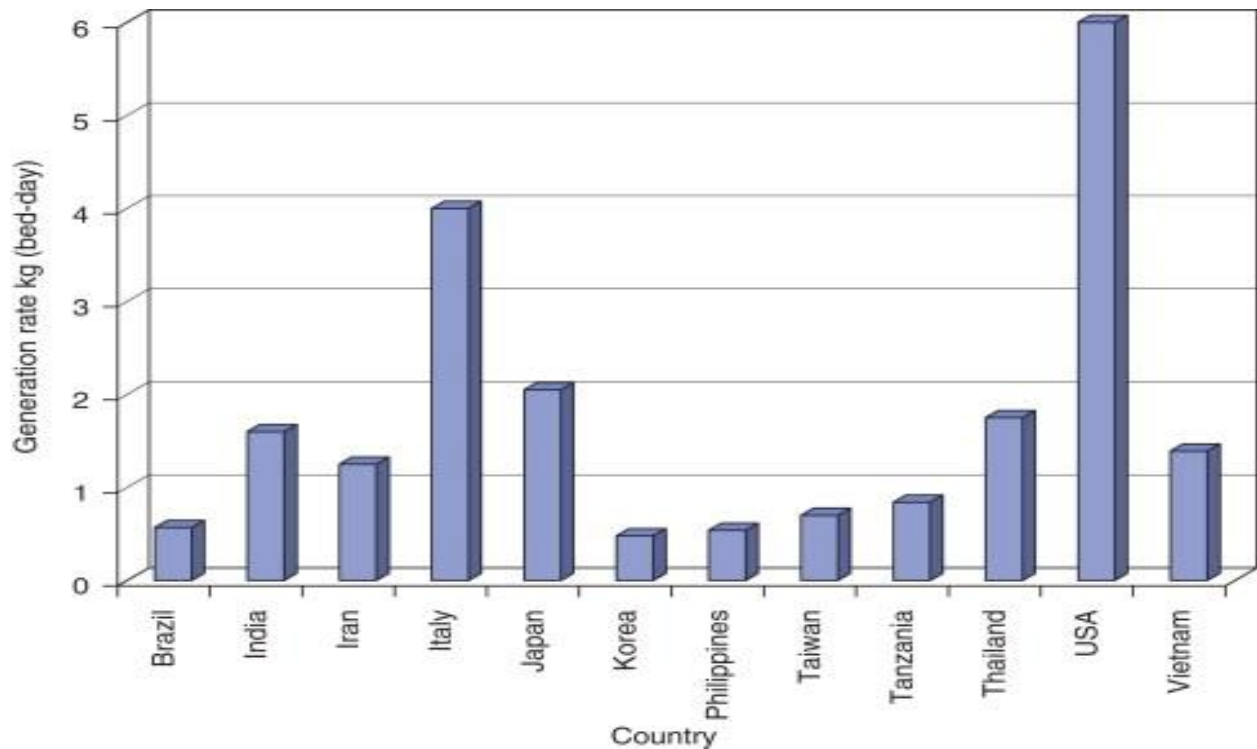


Figure 2.2: Generation rates of medical waste in different countries (Jang, 2011)

Nemathaga *et al.* (2008) also noted that the quantities of medical waste generated also depend on level of instrumentation at the healthcare facility, number of beds, types of health services provided, economic, social and cultural status of patients and the general condition of the area where the hospital is situated. A study in Tanzania hospitals revealed that hospitals with modern facilities and good services are found to have higher waste generation rates than the rest. For example Aga Khan one of the best hospitals in Tanzania was found to have a waste generation rate of 1.3kg/patient/ day, and this value was nine times that of Temeke Hospital with generation rate of 0.15 kg/ patient/day. Aga Khan Hospital was reported to have high generation rates because it has modern facilities and offers good services (Mato and Kassenga, 1997).

Generation rate in developed countries such as Italy, USA and Portugal is greater than the rates found in developing countries such as Thailand, Vietnam, India and Iran (Diaz *et al.*, 2005). The generation rate for Canada and USA were reported to range from 4.3-5.8 kg per day (Nemathaga *et al.*, 2008). According to Cheng *et al.* (2009) the total amount of medical waste generated from medical establishment is associated with the type or size of the institution. The generation rate

of medical waste is also dependent on the regulations and economic status of a country with large variation when expressed as the amount of waste per bed/day or per capita/day. The number of day care patients has significant effect on waste generation rate (Bdour *et al.*, 2007; Patwary *et al.*, 2009). For example Bdour *et al.* (2007) reported that due to higher number of daycare patients, public healthcare facilities produce larger amount of healthcare waste than private healthcare facilities. Patwary *et al.* (2009) argue that due to the high numbers of patients care, public hospitals produce more waste than private hospitals but total waste and proportion of clinical waste per bed is similar in both public and private hospitals.

2.3.1 Clinical waste generation in developing countries

According to Kagonji and Manyela (2011), one of the first and most important steps in development of risk or cost analysis in the field of medical waste management involves understanding the generation rates and quantities of materials that need to be managed. Ramokate (2007) noted that in Sub Sahara Africa many countries are still collecting and establishing data on amount of waste generated per bed, information that is useful for planning purposes.

Artiola (2010) revealed that an average amount of waste generated in developing countries including India ranges from approximately 1 to 4.5kg per bed per day and estimates of clinical waste generated can be made from a number of beds in any facility and an average amount of waste generated per bed. The range varies widely per bed generation and method of estimate used. Mbuyi (2010) also noted that in Kenya hospitals generate about 1 500 tonnes of clinical waste per year with a mean generation rate of 0.51 kg per occupied bed per day. In middle and low income countries, healthcare waste generation is usually lower than in high income countries. However the range of values for countries of similar income level is probably as wide in high income countries as in less wealth countries (Pruss *et al.*, 1999; Diaz *et al.*, 2005). A Dar es Salaam city study conducted by Kagonji and Manyele (2011) showed that medical waste generation in the surveyed hospitals was 0.3 to 1.8 kg/bed/day. However total generation rate differs from one country to another. A study carried out in Kuwaiti showed that generation rate ranges from 3.65 to 5.4 kg/patient/day (Cheng *et al.*, 2009).

Botswana generates both domestic and infectious waste during delivery of healthcare services comparable to waste generated in developing countries (Jamu *et al.*, 2009). The compositions of such waste include non-infectious (domestic) waste, infectious sharps and non sharps (anatomical body parts, cultures and stock of infectious agents, blood stained swabs), pharmaceutical, chemical, radioactive and geno-toxic wastes. The GoB (2007) estimated that 2400 tonnes of clinical waste are produced per year. Constrained with lack of data, estimates painted a picture of the amount of waste being generated in public facilities basing on 1995 data to be 5 200.7 tonnes by end of 2009 (this was likely an underestimate of the true tonnage of waste to date (Jamu *et al.*, 2009).

According to Kgosiesele and Zhaohui (2010), referral hospitals are major generators of medical waste in Botswana followed by district hospitals and other levels of healthcare facilities. However, exact amounts of waste per each stream are not known because of lack of data. The CSO (2007) estimates suggested that Botswana will produce 19 078.4 metric tonnes of healthcare waste, comprising of 13 825 metric tonnes of domestic waste, 5 200.7 metric tonnes of infectious and hazardous waste and 52.6 metric tonnes of sharps waste by end of 2009. By 2016, healthcare waste metric tonnage would increase to more than 27 914.8 metric tonnes (20 211.5 domestic waste, 7 627 infectious waste and 76.2 sharps) (Jamu *et al.*, 2009). At community level, no data is available for home based care. However, Kangethe (2008) reported that the amount of medical waste might have declined due to the national expansion of anti-retroviral therapy, which has drastically reduced the number of bed-ridden patients. Sharps waste generated from communities is estimated to be 3.1 million needles and syringes (CSO, 2007).

2.3.2 Clinical waste generation in developed countries

Developed countries generate higher amounts of medical waste than of developing countries (Nemathaga *et al.*, 2008; Hossain *et al.*, 2011). Data from WHO (1999) also revealed that North America produce 7-10kg of healthcare waste per bed/day, whereas South America produce 3kg

of waste per bed/day. This difference was also found in Europe and Asia. Western Europe produces 3-6kg whereas Eastern Europe produces 1.4-2kg of waste per day/bed. In Asia, richer countries produce 2.5kg per bed/day and poor countries produce 1.8-2kg per bed/day (Hossain *et al.*, 2011). From the available data, it is evident that the amount of healthcare waste generation depends on the level of economic development of the region. Due to higher level of economic development, North America produces largest amount of waste (Jang, 2011). This can be attributed to the developed nation's life style demands, consumption of high amount of goods and services which tend to generate large amounts of waste.

Abdulla *et al.* (2008) revealed that in a study carried out in Northern Jordan, hospitals' waste generation rates ranged from 0.6 to 2.6 kg/bed/day with weighted average of 0.83kg/bed/day. In the United Kingdom clinical waste generation varies from 0.6 to 5.9 kg/bed/day with most studies reporting rates of production in the range 0.3-3.5kg per bed per day. Larger volumes arise from teaching hospitals and from surgical and maternity departments (Blenkharn, 2011).

Mbuyi (2010) also revealed that two million tonnes of medical waste are produced each year in America. Most of it comes from hospitals and other sources are doctor's offices, dental practices, research facilities, laboratories and veterinarian offices. Companies that manufacture pharmaceuticals also generate high amounts of this waste. WHO (1999) states that approximately 15 percent of medical waste generated in healthcare facilities is infectious and has the potential to cause harm to people and environment.

2.4 Clinical waste management practices

2.4.1 Segregation

The United Nation Environmental Programme (UNEP) has established that only 10% of the healthcare waste is considered to be potentially infectious. The proportion can be further reduced to 1-5% with proper segregation practiced at the sources (UNEP, 2002). According to Cheng *et al.* (2009), segregation refers to separation of waste into designated categories. Blenkharn (2008) also defined waste segregation as a process of dividing garbage and waste products in an effort to reuse and recycle material. In the context of healthcare facilities it is the

first important process in clinical waste management. The safe management of healthcare waste requires that clinical waste should be separated from general waste at source of generation for example from all patient care activity areas, diagnostic service areas, operation theaters, labour rooms and treatment rooms. Segregation of waste happens at the point of generation so that it can be sent through the appropriate route for disposal (Abor *et al.*, 2007; Clover, 2009). The reason being that clinical waste presents greater risks and needs to be handled with care. Segregation is useful for safe disposal of risk waste. The risk waste is separated from non risk waste which account for 20% of medical waste (Sim, 2009). The responsibility of segregation should be with the generator of biomedical waste for example doctors, nurses, technicians (medical and paramedical personnel).

Waste segregation is emphasized as a means of ensuring that healthcare risk waste and healthcare general waste are separated and stored in appropriate containers. This enables those who handle the containers outside the hospital wards to identify and treat them appropriately (Pruss *et al.*, 1999). Segregation also ensures that the various classes of healthcare risk waste are placed in their appropriate containers and treated accordingly. Segregation at source minimise the chances of infection, injury to the persons who handle waste and lesser amount of waste to be incinerated and is critical to safe management of healthcare waste (Mato and Kassenga,1997). Segregation of different waste categories is critically important to enable proper disposal. Without source segregation, hospitals are forced to dispose general waste along with infectious waste there by resulting in unwanted disposal costs (Ananth *et al.*, 2010).

Segregation does not only help to reduce the management cost associated with medical waste, but ensures that the correct pathways are adapted for storage, transportation and ultimate disposal of medical waste. Moreover, medical waste is also segregated from each other because certain medical wastes need to be handled, treated and disposed of differently and appropriately. For instance, sharps/syringes, needles, cartridges, broken glass and any other contaminated disposal of sharp instruments or items are to be handled differently. For segregation to work efficiently, Holmes (2009) advises that hospital staff must be provided with colour coded and labeled waste receptacles and sack holders. These receptacles should be positioned in locations as close to the

point of production as possible and replaced when three quarter full, securely tied and appropriately labeled.

Failure to separate the various healthcare waste according to the risk they pose, results in complex stream of waste which is very difficult to manage. Poor segregation practices defeat the principle of waste minimization, resulting with all types of waste being disposed together. According to Weir (2002), if segregation does not take place properly, two scenarios which arise have far reaching implications on public and environmental health. The scenarios are:

1. Healthcare risk waste gets mixed up with healthcare general waste. This results in a situation where the former ends up at landfills and cause injuries to scavengers, municipal workers, children and the general population.
2. Healthcare general waste is subjected to special treatment to disinfect it such as incineration or autoclaving thereby imposing unnecessary costs on the health system. Infectious waste requires very expensive treatment before disposal. By all means it should only be infectious waste that is subjected to such treatment.

2.4.2 Handling

Handling procedures of clinical waste follows after waste has been segregated and placed in plastic bag or rigid containers. According to Rappe and Nyregen (2009) handling of medical waste takes place in all the stage and it is through handling that different groups get into direct contact with the medical waste. Medical waste operatives and all other people involved with waste handling are to handle it appropriately with caution bearing in mind the risks that may occur. In order to prevent injuries from sharps, porters and other operatives are to wear overalls, heavy duty or industrial gloves and sturdy shoes including goggles and mask for incineration. These protective clothing are to be worn when handling, transporting or incinerating medical waste (Mato and Kassenga, 1997). According to the GoB (2007), all cuts abrasion and other injuries sustained during the handling are to be reported to the Infection Control Officer (ICO). Healthcare workers, operatives and all other personnel involved in handling clinical waste are to be given Hepatitis B vaccination as a means of protection from viral hepatitis B infection.

Personnel responsible for health and safety are to ensure that all persons including contractor for handling wastes are suitably protected (Pruss *et al.*, 1999).

2.4.3 Storage

Waste has to be stored before collection and final disposal, and should not accumulate in corridors, wards or places that are accessible to the general public. There is a wide range of containers designed to store different types of waste. These include plastic bags and rigid containers in a variety of sizes. When containers are full to the required capacity, the waste is removed from the collection points on a 24 hourly basis of its generation. Waste is not supposed to be stored for more than 48 hours (GoB, 1996; Hassan *et al.*, 2008; WHO, 2010).

According to Pruss *et al.* (1999) the place where the hospital waste is kept before being transported to final disposal sites is termed temporary waste storage. Location and size of any waste storage depends upon the quantity and type of clinical waste produced and the frequency of collections. Bulk storage areas should be kept locked and access to these areas should be limited to personnel responsible for the handling, transportation, incineration and ultimate disposal of the waste, but kept securely from wild and domestic animals, birds, rodents and insects by means of a locked wire mesh cage. All internal and external storage containers are to be kept clean and disinfected and they should be easily drained. Disinfectants should be placed in close proximity to the waste in case a spill occurs.

According to Pruss *et al.* (1999) and Sim (2009), the following are characteristics of an appropriate area for storage of medical waste:

- Identified as being for only medical waste.
- Well lit and ventilated area.
- Away from food preparation or storage area.
- Vermin free.
- Away from pedestrian and private or public transportation routes.
- Totally enclosed and secure space with only authorized access.
- Clearly marked with warning signs.

- Has access to first aid washing facilities.
- Should allow for any spillage of contents.

2.4.4 Transportation

As noted by Insa *et al.* (2010) medical waste must be transferred from the place where it is generated to the installations where it will be treated and/or disposed of. Collection and transportation of medical waste must be carried out by trained personnel from authorized waste collection companies. Transportation of medical waste depends on the category of waste. Abdulla *et al.* (2008) reported that at all times transportation of medical waste should be controlled via a document that shows at least the amount and type of waste, place of origin of waste and waste collection date, and place of destination.

Where waste is transported within the facility, Singh (2001) established that all containers should be covered and labeled as being bio-hazard according to WHO specifications. GoB (2007) added that bags and rigid containers need to be labeled 'clinical waste', the place of production indicated and conveyed by red wheelie bins, trolleys and carts, which are made especially for carrying clinical waste. The containers to be easily cleaned, drained and allow waste to be handled without difficulty. Kumari *et al.* (2012) also state that transportation routes within a hospital must be specifically designated to avoid passage through patient care areas. Separate times should be dedicated for the transportation of bio-medical waste to minimize chances of it mixing with general waste. Where waste is transported from the healthcare facilities to disposal places by respective local authorities or contractors, there has to be a liaison between waste producers and those responsible for collection and disposal. Purpose designed vehicles are to be used solely for the transportation of such waste.

2.4.5 Treatment and disposal

Several core technologies are available for treatment of clinical waste. Waste treatment leads to a decrease in volume, weight, risk of infectivity and organic compounds in the waste (Pruss *et al.*, 1999). Treatment methods include incineration, autoclaves and retorts, microwave and

disinfection systems (Diaz *et al.*, 2008; Nemathaga *et al.*, 2008; Shinee *et al.*, 2008; Bendjoudi *et al.*, 2009; Al-Khatib and Sato, 2009; Coker *et al.*, 2009; Sawalem *et al.*, 2009; Abd El-Salam, 2010). It has been found from literature that the most common disposal methods of solid clinical waste, particularly in developing countries, are dumpsites, controlled landfill, sanitary landfill and pits (Sharma, 2007; Sawalem *et al.*, 2009; Abd El-Salam, 2010).

According to Ananth *et al.* (2010), different waste categories have to be treated differently. Healthcare waste treatment technologies, especially for infectious waste are often classified into burn and non burn technologies and have their inherent merits, demerits and application criteria (Hossain *et al.*, 2011). The most commonly proclaimed treatment technology for healthcare waste is incineration. Incineration is considered the gold standard treatment process though there is a trend towards its use for only the most difficult waste fraction (Blenkharn, 2011). Mato and Kassenga (1997) define incineration as the controlled combustion process for reducing solid, liquid or gaseous waste primarily to carbon dioxide, other gases and relatively non combustible residue or ash. The gases are released into the atmosphere (through a chimney) and the residue is disposed of in sanitary land fill. The WHO (2010) suggested incineration as a viable interim solution especially for developing countries where options for waste treatment such as autoclaves, shredders or microwaves are limited. A properly designed and constructed incinerator should completely burn the waste leaving a minimum amount of residuals in the form of ashes and it should be equipped with scrubber to trap toxic air pollutants emitted (Nemathaga *et al.*, 2008).

Environmentalists consider incineration to only change the form of waste, while retaining the hazards (Mmereki, 2009). Incinerators burn the waste and leave behind toxic ash and noxious gases that can be harmful air pollutants. These emissions are claimed to have serious consequences on worker safety, public health and the environment (Ketlogetswe *et al.*, 2004). Healthcare waste incinerators are a leading source of dioxins and mercury in the environment. Non burn technologies appear to emit fewer pollutants, are cost effective, compact and reliable, and avoid secondary pollutants (Jamu *et al.*, 2009).

Autoclaving of clinical waste is considered as an alternative technology to incineration, but it is viewed as a more costly method than incineration (Jang *et al.*, 2006; Al-Khatib and Sato, 2009). Autoclaves are generally used to treat sharps, items contaminated with blood, residues from surgery and from isolation wards, bandages, gauzes, linen, gowns and other similar materials and non-chemical laboratory wastes. However, autoclaving cannot treat a variety of chemical and hazardous substances such as wastes from chemotherapy treatment, mercury, volatile and semi-volatile organic compounds, radioactive wastes, and other hazardous chemical wastes (Lee *et al.*, 2002). It is not suitable to treat large body parts, animal carcasses, or other large items in an autoclave because of their mass and other characteristics, which make it difficult or time consuming for the entire material to reach the prescribed temperatures (Pruss *et al.*, 1999).

Open pit dumping is the most common method of clinical waste disposal in developing countries (Al-Khatib and Sato, 2009; Coker *et al.*, 2009). This is probably because it is less expensive and no other alternative methods are available at reasonable costs. Though, it is the least cost option, open dumping has long been recognized as a potential infection source of public health and environmental pollution hazard (Al-Khatib and Sato, 2009). It is an uncontrolled and inadequate disposal option for clinical waste, since the waste is accessible to scavengers and animals (Pruss *et al.*, 1999; Coker *et al.*, 2009). Therefore, clinical waste should not be deposited on or around open dumps. This is because this uncontrolled clinical waste transmits infectious pathogenic micro-organisms to the environment either via direct contact through wounds, inhalation, or ingestion, or indirect contact through the food chain or a pathogenic host species (Pruss *et al.*, 1999). Also wind easily blows over the dumped waste, dispersing air pollutants into nearby communities (Nemathaga *et al.*, 2008; Coker *et al.*, 2009).

In general, landfilling is also an easy and low cost waste disposal method. However, if a landfill is improperly managed, it raises human health risk and environmental pollution concern (But *et al.*, 2008; Narayana, 2009). Landfilling is however considered an unsophisticated disposal method, which requires careful segregation of waste so that it does not pose significant health effects on public health and the environment (Moritz, 1995; Visvanathan, 1996). In developing countries, landfills are operated like an open dump sites. The clinical waste is dumped in the landfill mixed with non-clinical wastes, and later burned (Nemathaga *et al.*, 2008). Landfills

produce waste products in three phases during the waste degradation process. These are solid (degraded waste), liquid (leachate, which is water polluted with waste), and gas (usually referred to as landfill gas) (But *et al.*, 2008).

It can be seen therefore, that landfilling is not a safe solution to the treatment of the clinical waste. This is because landfills can produce harmful gases and contaminate underground water bodies, as well as wind-blown litter and dust. Landfills also attract vermin. In addition, landfill disposal of clinical solid waste is often done in low lying areas of open land, which may be prone to flooding, increasing the possibility of surface water contamination during the rainy season (Narayana, 2009). The main potential impacts on health arise from inhaled landfill gas and exposure to groundwater contaminated by landfill leachate (UNEP, 1996; Williams, 2005). Although landfill gas consists mainly of methane and carbon dioxide, it can contain a large number of other gases at low concentrations, some of which are toxic (Williams, 2005). The major components of landfill gas, methane and carbon dioxide, are Greenhouse gases (GHGs). Both gases are major constituents of the world's problem GHGs; however while carbon dioxide is readily absorbed for use in photosynthesis, methane is less easily broken down, and it is considered 20 times more potent as a GHG (Johannessen, 1999).

2.4.6 Training and education

A smooth running of any clinical waste management system requires regular training programmes. Proper training must be carried out with hospital employees to develop awareness of health, safety and environmental issues (Mohee, 2005; Kumari *et al.*, 2012). Staff members who are involved in handling waste should be provided with training in handling, segregation, storage and disposal procedures. This group of people should be provided with protective equipment and should receive certificates of proficiency after successful completion of appropriate training (Pruss *et al.*, 1999).

According to GoB (2007) Staff should be trained in the following:

- Checking that the storage bags are effectively sealed before and after they handle them.
- Handling bags by neck and never throwing or drop them.

- Knowing what to do if there is an accidental spillage.
- Reporting accidents and incidents.
- Making sure that the source and origin of the waste are clearly marked on the bag.
- Understanding the risks associated with disposal.

Abdulla *et al.* (2008) reported that 29% of hospitals in Northern Jordan had not provided training to doctors and other personnel regarding medical waste management, 57% of the hospitals studied provided limited training for support staff (maintenance, engineers and cleaning workers). From a survey by Yong *et al.* (2009) in Nanjing city hospitals in China, the following problematic areas were found in the field of training: there was lack of sufficient training and education programs for all hospital staff. In some hospitals training and education was focused on the doctors and nurses while cleaning workers and technicians did not receive any training (Yong *et al.*, 2009). In some of the hospitals, training and education mechanisms had not been developed. Yong *et al.* (2009) further added that there is lack of effective organization, control and evaluation of the performance of the training and education programs for medical waste management. Coker *et al.* (2009) noted that in Ibadan, Nigeria, health facilities, 59% of health workers were not trained in medical waste management. In Ibadan tertiary hospitals, where some level of training is given, their programmes are not updated. Askarian *et al.* (2004) reported that 60% of hospitals in Iraq provided some training for cleaners, but newly hired waste management personnel were not trained properly.

2.5 Clinical waste management practices in developed countries

Waste management practices differ from developed to developing nations, from urban to rural areas. It is the ethical responsibility of the management of hospitals and healthcare establishments to have concern for public health. In a study at King George Hospital in England, Blenkharn (2008) observed that staff were handling medical waste with appropriate health and safety measures using impervious gloves and mouth masks although they were not aware of potential hazards of the material they were handling as prescribed in the Biomedical Waste Management and Handling Rule, 1998. Goddu *et al.* (2007) reported that the management of healthcare waste in England is very stringent.

In USA medical facilities, it was found out that medical waste items were generally segregated according to respective colour coded bags and storage of segregated healthcare waste was away from the patients and nursing station (Sim, 2009). Askarian *et al.* (2004) also reported that in New York State health facilities there were effective training programs and educational plans related to medical waste management. The waste management in Malaysia was reported to be somehow efficient and systematic (Artiola, 2010). The Malaysian government's commitment to provide an effective and economical means of waste disposal has been achieved through modern technology and privatization. In Malaysia it was reported that three private consortiums were currently handling the management of clinical waste in 133 government hospitals (Clarke, 2008). The bulk of the clinical waste is incinerated and the resulting residue is deposited in landfills. There are 16 incinerators with capacities ranging from 25 to 500kg in Teluk Intan a town in Perak State in Malaysia (Artiola, 2010). Clinical waste management in Teluk Intan hospital is systematic and efficient with minimal impacts on environment and safety and health aspects of all the personnel involved in waste handling are also adhered to strictly (Clarke, 2008).

In developed countries legislation and good practice guidelines define medical wastes and state the various possible ways for collection, transportation, storage and disposal of such waste. Also the best available technologies are used for the development of alternatives for proper disposal of medical wastes with minimal risks to human health and the environment (Bdour *et al.*, 2007).

2.6 Clinical waste management practices in the developing countries

Clover (2009) stated that the convectional healthcare waste management approach based on collection and disposal has to provide efficient and effective services in all countries. Healthcare waste management systems in many cities, towns and villages in developing countries cannot cope with increased volume of healthcare waste generated (Visvanthan and Adhikari, 2006). In developing countries medical waste management has not received sufficient attention; this is because very often health issues compete for very limited resources (Taghipour and Mosaferi, 2009). In many countries hazardous and medical wastes are still handled and disposed of together with domestic wastes thus creating a great health risk to municipal workers, the public and the environment (Visvanthan and Adhikari, 2006; Bdour *et al.*, 2007). Abor *et al.* (2007)

identified the following main problems facing the hospitals in developing countries in terms of medical waste management:

- a) Lack of necessary rules, regulations and instructions on different aspect of collections and disposal of waste.
- b) Mixing of hazardous waste with domestic waste of the hospital.
- c) Failure to quantify the waste generated in reliable records.
- d) Failure to use appropriate of coloured bags thereby limiting the bags used to one colour for all waste.
- e) Absence of a dedicated waste manager and committees responsible for monitoring medical waste management practices.
- f) Lack of education and training on medical waste management.

Some researchers (Bdour *et al.*, 2007; Hassan *et al.*,2008; Nemathaga *et al.*, 2008; Coker *et al.*,2009) argued that successful clinical waste management presents a challenge in their countries due to insufficient financial investment, lack of awareness and effective control, lack of trained clinical staff within a waste management framework. In addition, absence of healthcare waste management guidelines and legislation in country level and unavailability of suitable treatment and disposal options further obstruct the waste management effort.

Assessment studies on medical waste management in developing countries have detected several problems and defaults such as segregation, handling and storage not being appropriately conducted. Practices for waste minimization are poor, hazardous and common waste are mingled and disposed in the open dumps or landfills, waste incinerators are not equipped with an emission control apparatus, chemical waste is disposed through the public sewage system and there are no staff training programs (Moreira and Gunther, 2013). Mbuyi (2010) added that in developing countries, on-site incineration, autoclaving and steam disinfection are a few of the processes currently in use for treating a very small amount of hazardous waste. Clinical waste incinerators often operate under suboptimal conditions.

A study in Bangladesh (Hassan *et al.*, 2008) and Egypt (Abd El-Salam, 2010) revealed that there was no proper systematic management of medical waste except in a few private healthcare

establishments that segregate their infectious waste. Some cleaners were found to salvage used sharps, saline bags, blood bags and test tubes for resale or reuse. Ananth *et al.* (2010) noted that in Bangladesh, waste is not segregated in many hospitals and is disposed off together with municipal solid waste and that medical waste segregation, recycling and reuse is done by rag pickers. In a similar research Agumuth (2010) discovered that in Bangladesh all types of waste generated in most urban and rural areas are disposed of by open dumping in either low depression or high areas. Waste decomposition occurs by means of natural degradation. Clinical waste is treated in poorly managed incinerators. Sharps are collected and reused without sterilization.

According to Hassan *et al.* (2008) proper medical waste management is a new phenomenon in healthcare facilities in Dhaka city, Bangladesh. The Government of Bangladesh developed new and modern approaches in training relevant personnel of different healthcare establishments to increase awareness on proper in-house management of medical waste. The government of Bangladesh provided training to more than 3000 personnel in 185 healthcare facilities and public awareness programmes for proper management of medical waste (Hassan *et al.*, 2008). The awareness was essential to solve the problem of reuse of syringes and needle and other sharps contaminated with human blood or body fluids.

In India, Holmes (2009) reported that medical waste management in most healthcare facilities is very poor. Medical waste was observed mixed with general waste, it was found out that there was no segregation in 27 out of 40 government hospitals surveyed and there was usage of some wheel barrows for transportation of all categories of waste. In a study by Coker *et al.* (2009) in Idaban, Nigeria, it was observed that the secondary and primary healthcare centers do not practice any scientific disposal of clinical waste; the clinical waste is often mixed with municipal waste. Hospital waste is often thrown in open garbage dumps or in nearby open dumps. Where waste is segregated by hospital staff, it is done for the purpose of retrieving useful items. This gives way to malpractices as waste recycling by rag pickers and possible reuse of used syringes has become accepted way of life. Hospitals are currently burning waste or dumping in bins which are transported to unsecured dumps.

Yong *et al.* (2009) discovered that of the surveyed hospitals in China, 93.3% provide training for staff at some point, while 20% of the hospitals had ongoing training and education. The survey indicated that training programs regarding medical waste management for doctors, nurses and technicians were limited in Nanjing hospital. Birpinar *et al.* (2009) also reported that in Istanbul, Turkey, 98% of hospitals organize courses for their collection personnel and healthcare services organize training programs regarding medical waste management for doctors, nurses and technicians; almost 63% of healthcare services organize courses at least once a month, while 31% organize courses at least twice a year.

In Tabriz the largest city in Iran research by Taghipour and Mosoferi (2009) revealed that medical waste in state healthcare facilities is poorly managed and there are no suitable environmental measures available. Medical waste is handled by poorly educated workers, without sufficient quality control. Medical waste is currently disposed in municipal dumpsites or burned in onsite incinerators that have operational maintenance problems.

In many African countries, hazardous and medical wastes are still handled and disposed together with domestic waste and is collected along with the rest of waste stream, thus creating a great health risk to municipal workers, the public and the environment (Taru and Kuvarega, 2005; Abor, 2007). Studies have constantly shown that in the majority of hospitals there is no segregation of wastes. In hospitals where there is segregation, medical waste is handled so casually that infectious waste and sharps are dumped along with waste. Colour coded bags are not used due to unavailability, or doctors and nurses are not aware of the need to segregate waste (Coker *et al.*, 2009).

According to Mato and Kassenga (1997), 21.7% of surveyed hospitals in Tanzania receive refuse collection services from private companies engaged in refuse collection. However the collection services offered by the private companies are unreliable. Frequency of refuse collection in most hospitals served by the private companies ranges between 2 to 3 times per week. Medical waste should normally be collected every day due to its hazardous nature. Hospitals which do not receive refuse collection services have to devise their own means of refuse disposal. Common methods of disposal employed are onsite dumping, open pit dumping (burning and burying)

which account for 70% of the surveyed hospitals. Due to unreliable refuse collection services, individual hospitals are forced to look for their own means of solid waste disposal, most of which are inappropriate.

Kagonji and Manyela (2011) reported that in Tanzania most incinerators are constructed from cement and sand blocks. Since cement and sand blocks have low temperature tolerance some of the incinerators have cracked as the material passes through cycles of heating and cooling. Some hospitals face problems of disposal of ash from the incinerators. Whereas some hospitals bury the ashes within their premises and others transport and bury offsite.

Tsiko and Togarepi (2012) reported that overall healthcare delivery in Zimbabwe has significantly deteriorated in terms of quality and patient care, coupled with improper management of medical waste. At some healthcare facilities, medical waste also finds its way into large plastic bins outside the hospital, which are meant for domestic waste. Medical waste including syringes, needles and dirty gloves, are often seen in domestic bins located at the entrance of accident and emergency sections.

Taru and Kuvarega (2005) reported that at Parirenyatwa hospital in Zimbabwe, medical waste is often disposed together with the rest of other waste streams. Only 2% of medical staff was reported to separate medical waste from other refuse due to their experience of the dangers of sharp objects. Majority of healthcare waste is not sorted before disposal. Tsiko and Togarepi (2012) reported that medical waste could go for days without being collected for incineration mainly due to fuel shortages, which were crippling services delivery at most medical facilities in Harare. Medical waste brought for incineration was observed scattered all over the incinerator location. Taru and Kuvarega (2005) reported that people who brought the waste for incineration tore open the bins as they scavenged for usable items. The incinerator was reported to be very inefficient following the collapse of its furnace lining (Tsiko and Togarepi, 2012). The diesel pump was reported to be not working and waste was being ignited using paper (Taru and Kuvarega, 2005). Tsiko and Togarepi (2012) reported that incinerators in Harare were overloaded with waste from unauthorized external parties and rats and flies were a nuisance due to the delayed incineration.

Coker *et al.* (2009) reported that there was no proper segregation in the Nigerian healthcare facilities they surveyed. The study team had to implement waste sorting and segregation at source by providing coded separate receptacles for each identified component of medical waste. The management practices for dealing with medical waste at Ibadan hospital were ineffective (Coker *et al.*, 2009). This cut across waste storage, handling, collection, transportation and disposal practices. Wastes were collected at point of segregation into metal dustbins, drums, plastic bins, baskets, pans, cartons, buckets or bowls before transference into larger or final disposal containers as shown in Plate 2.1. Waste handlers in some healthcare facilities in Ibadan opt to carry waste containers on their shoulders or with their bare hands, which indicated a possible lack of awareness or training about the potential risks involved (Coker *et al.*, 2009).



Plate 2.1: Medical waste storage media in Ibadan, Nigeria (Coker *et al.*, 2009)

According to Mokuolu (2009) waste collection frequency varies between healthcare facilities and from unit, ward or within each healthcare facility. The enormity of waste generated by health facilities may have been responsible for a trend in which units wait to have their bins full before collection or have no definite or regular time of collection. Coker *et al.* (2009) reported that waste handlers claimed to take anti tetanus vaccines as a further precaution and were seen right inside temporary waste depots without being mindful of the hazards of possibly being pierced by syringes and other sharps (Plate 2.2).



Plate2.2: Waste handlers inside temporary storage deport (Coker *et al.*, 2009)

In Botswana concern has been raised over unsatisfactory clinical waste management. Kgosiesele and Zhaohui (2010) reported that in Botswana most hospitals attempt to segregate clinical waste. Storage of waste and the improper handling is done by staff that often lacks proper training on waste handling. Disposal of medical waste is unregulated and dealt with in a haphazard manner. According to Mbongwe *et al.* (2008) in Botswana waste collection and transportation is limited by inadequate equipment, personnel and financial resources facing all local authorities. Hazardous waste and healthcare waste is mostly incinerated. Incinerators in Botswana are located within hospitals and they expose pollutants to the hospital community and the communities near or around the hospital.

2.7 Potential impacts associated with clinical waste

As more people become sick and seek help from hospitals, clinics and private medical practitioners, more waste is generated in these facilities. This brings about several questions in terms of who is affected by this waste, who handles it and how well prepared are the waste handlers (Mbongwe *et al.*, 2008). Infectious or hazardous hospital waste represents a small part of clinical waste, which contains different kinds of pathogens that have potential for infection if the waste is not managed properly. According to WHO (2010), the incorrect management of healthcare waste can have direct impact on communities, individuals working in healthcare facilities, patients and the natural environment. Health risks associated with clinical waste

include injuries, infection or death, either by inappropriate handling or inadequate disposal at poorly controlled dumpsites or by inadequate incineration or open burning which may release dangerous compounds to the environment, pollution of water and air may have serious repercussion in turn for public health (Abor, 2007).

Infections from healthcare waste to waste handlers can be spread through contact and then the transfer of contagious diseases to families, friends, neighbours and close associates can occur. Infections can also spread through unchecked disposal of contaminated waste water into the public drains and also via movement from dumpsites to other areas, through surface and underground movement that is horizontal and vertical transmission of vector and disease causing agents, which will eventually impact humans, animal and plants (Olatoye, 2009). According to GoB (2007) risks to the general public is secondary and occurs in three ways which are:

- a) Accidental exposure from contact with waste at municipal disposal bins.
- b) Exposure to chemical or biological contaminants.
- c) Exposure to chemical pollutants like mercury and dioxins from incinerations.

Environmental workers, including ward boys, janitors, municipal workers and rag pickers along with nurses are the group at most risk from infected clinical waste. They are at risk because of lack of priority on basic worker safety when dealing with waste with healthcare facilities and installing end of pipe disposal technologies does little to minimize their risks (Ramokate, 2007). Some of the problems arising from poor collection, storage and disposal of medical waste include environmental nuisances of foul odors, flies, cockroaches, rodents and vermin. Diseases like diarrhea, leptospirosis, typhoid and cholera can be transmitted through mismanagement of medical waste (Mato and Kassenga, 1997).

Abor, (2007) reported that it is estimated that 45% of healthcare waste generated in KwaZulu-Natal in South Africa cannot be accounted for indicating that it is being illegally dumped, buried or burnt somewhere, thus affecting the people and the environment. There have been numerous instances where medical waste has been dumped in residential areas thus posing serious risks to the community and the environment (Abor, 2007). The illegal dumping of medical waste in

disadvantaged residential areas has resulted in situations where children have been found playing with medical wastes such as syringes. For example 48 children were treated with Zidovudine (AZT) after being pricked with needles and ingesting potentially lethal pills they found in a field in Elsies River in South Africa (Waldner, 2011).

Clover (2009) reported incidents of injuries (10 cases out of 17) due to exposure to medical waste inside or outside hospital premises in Kabul Medical Centre. Some of the incidents were hand cuts due to handling of broken glass, injuries by needle and fingers being permanently damaged as a result. Clarke (2008) added that sharps which include syringes and needles, have the highest disease transmission potential amongst all categories of medical waste. Almost 85% of sharp injuries are caused between usage and subsequent disposal. Goddu *et al.* (2007) noted that there is strong epidemiology evidence from Canada, Japan and USA that the main concern of infectious hospital waste is transmission of HIV virus and hepatitis B and C viruses through injuries caused by syringes contaminated by human blood.

Incineration of medical waste has also caused much concern. Studies carried out by Abor (2007) have pointed out that incinerators have been associated with wide variety of health problems in South Africa such as disrupting the bodies hormonal, immune and reproductive system and have caused cancer.

In Afghanistan medical waste was found to pose risks in urban areas (Agumuth, 2010). Waste sites in urban areas across the country are full of medical waste. Visvanathan and Prashanthin (2009) reported that medical waste produced in the healthcare facilities in Kabul and other major cities is not being properly managed and poses a serious health risk. Medical waste including syringes, soiled dressing, body parts, diagnostic samples, blood, chemicals, pharmaceuticals and medical devices were found lying in open rubbish dumps near hospitals (Agumuth, 2010). The study reported that tonnes of vaccination waste resulting from an exercise to immunise about 1.6 million children against polio between 21 and 23 September, 2008 were thrown away in the open (Visvanathan and Prashanthin, 2009). Kabul municipality expressed that it had little experience of safe waste disposal and few tools with which to separate and dispose of medical waste. Kabul is reeling under increasing mountains of rubbish with waste management apparently slipping out

of control. Afghanistan does not have by laws on safe management of medical waste, and over 60 public and private hospitals in Kabul do not have incinerators or equipment to deal with the problem (Visvanathan and Prashanthin, 2009).

While only 10-25% of healthcare waste is hazardous and may pose hazards and risks to healthcare workers, many healthcare workers in Botswana are not aware of such hazards or associated risks (Mbongwe *et al.*, 2008). A training need assessment on healthcare workers carried in 2004 showed that a number of professional personnel in the healthcare facilities were not familiar with associated risks of healthcare waste (Jamu *et al.*, 2009). The well known type of hazardous waste was sharps in particular used needles. Most of the healthcare workers were aware of the close association of used needles to risk of HIV transmission through needle stick injuries (Mbongwe *et al.*, 2008).

2.8 Acts and legislation on clinical waste management

Policies, laws and guidelines provide a legal framework for the protection of the environment and public health. There are various laws, guidelines and policies that have been developed over the years at international, national and facility levels to protect the public against the adverse health effects of healthcare waste (UNEP, 2002). If these laws are properly implemented the risks associated with healthcare waste can be significantly reduced (Moritz, 1995). However, for them to be effective, hospitals need to put in place proper structures to facilitate their implementation. Abd El-Salam (2010) noted that these structures should include measures to ensure that healthcare professionals and other employees of the hospitals have sufficient knowledge, not only about the existence of such documents but also about their requirements. They would then be able to engage in practices that prevent infections and injuries within and outside the hospitals.

Many countries have devised codes of practice and made recommendations for handling and disposal of medical waste from hospitals. All categories of solid waste need to be, transported and disposed of in a controlled manner to safeguard public health and prevent environmental

pollution. This can be achieved only by the use of enforced code of practice and guidelines for all aspects of handling, storage, transport and disposal of this waste (Bdour *et al.*, 2007).

Medical waste is potentially dangerous since it may contain pathogenic agents. As a result medical waste management requires that institutions take decisions, and implement a wide range of measures in order to reduce health risks (Insa *et al.*, 2010). In developed countries, definite rules and regulations exist at national, regional and hospital level (Abor, 2007). Many European countries have enacted legislation and good practice guidelines to define, classify and treat medical waste management. According to Insa *et al.* (2010), 13 of European countries' regional governments have adopted regulations concerning medical waste management to guarantee health and environmental protection. In UK safe disposal of clinical waste has received much attention over many years. Emphasis is placed mainly on proper handling, segregation and disposal of healthcare waste, with the implementation of Hazardous Waste Regulations, 1996 (Blenkharn, 2006). There exist a wide array of legislation, codes of practice and licensing conditions that dictate the standards for operation for both waste producers and those providing merchant clinical waste disposal (Blenkharn, 2011).

Blenkharn (2008) noted that in England the management of medical waste is very stringent. The main drivers that have resulted in the stringency in medical waste are: the introduction of the concept of "Duty of Care" under the Environment Protection Act of 1990, which states that all waste producing organization had an obligation to ensure safe treatment, carriage and disposal and strict policies governing clinical waste management. These include the European Union Landfill Directive of 1999 which reduces the amounts of non-biodegradable waste to landfills, Waste Incineration and Pollution Prevention Control Regulation and the Proximity Principle and Producer Responsibility, which govern the handling and treatment of medical waste from arising to final disposal (Sim, 2009). Frost and Sullivan (2009) revealed that America's medical waste disposal is regulated by the Resource Conservation and Recovery Act (RCRA), 1976. Most of the regulated medical waste goes to one of the 2 400 incinerators in the United States.

According to Ananth *et al.* (2010) few Asian countries have integrated healthcare waste specific polices. Where regulations address healthcare waste, they are either a subset of other existing

regulations or part of the powers vested on departments related to the issue. Visvanathan and Prashanthin (2009) noted that in South Asian countries greater attention is now given to improving legislation and guidelines of healthcare waste. Legislation exists in India and Pakistan, while Bangladesh and Bhutan use Guidelines in some form and Sri Lanka uses a Draft National Policy. Countries are moving towards better technology in management of clinical waste.

The Government of India implemented the Biomedical Waste Management and Handling Rule, 1998, which specified that hospital waste management is part of hospital hygiene and maintenance activities such as collection transportation, treatment, operation of processing systems and appropriate disposal of waste is liable for hospital management (Guddu *et al.*, 2007). The implementation of the Biomedical Waste Management and Handling rules, 1998 also made it mandatory for hospitals, clinics, other medical institution and veterinary institutions to dispose of biomedical solid waste (Goddu *et al.*, 2007)

In recognition of the need to protect the public's health and environment, Jamu *et al.* (2009) noted that the Government of Botswana enacted the Waste Management Act, 1998, Strategy for Waste Management, 1998 and the Clinical Waste Management Code of Practice, 1996. At international level, Botswana acceded to the Stockholm Convention on Persistent Organic Pollutants and the Basel Convention on the Control of Trans-boundary Movement of Hazardous waste. For instance, in Botswana there is a clinical waste management policy which lays the ground for training of healthcare workers on healthcare waste management (Botswana Clinical Waste Management Plan, 1998).

Waldner (2011) noted that South Africa's medical waste is currently governed by a number of pieces of legislation including Hazardous Substance Act, 1983 and National Waste Management Act, 2008 amongst others. The National Health Act, 2003 and the Hazardous Substance Act, 1983 monitor the disposal of medical waste by hospitals and related centers in South Africa. According to Coker *et al.* (2009) in Nigeria the management of infectious waste is normally governed by activates of largely untrained and uneducated waste handlers. This is reflected by lack of specific policies to address the menace of healthcare facility waste, some which is

deemed hazardous. There is no current formal policy to regulate the generation and management of medical waste in Nigeria. Waste management policy in Nigeria is embodied in the National Policy on Environment, formulated in 1989, and revised in 1999. The act only alludes to hazardous waste and does not even refer to medical waste (Mokuolo, 2009).

Tsiko and Togarepi (2012) also expressed that as in many other developing nations Zimbabwe has no regulations or systems specifically designed to manage potentially hazardous medical waste. Magadzire and Maseva (2006) added that currently Zimbabwean municipal councils make use of parts of the Public Health Acts. This does not afford them adequate powers and as a result there are very few instances that have lead to prosecution of those who are instigating public health hazards through handling and dumping of medical waste.

2.9 Conclusion

Clinical waste management has become a major health and environmental concern worldwide. The awareness to manage and dispose clinical waste effectively is also on the rise. Appropriate clinical waste management is a vital requirement as it ensures protection of human health and the environment. It is therefore, important to understand that improper clinical waste management may cause adverse health effects by spreading infections and diseases, leading to environmental problems.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

3.0 Introduction

The methodology for this study was determined by the study aims and objectives. This chapter outlines in detail how the research was conducted. It describes the research design, subjects, data collection process and instruments. It also gives the data analysis and presentation plan. Furthermore limitations and ethical considerations are also outlined.

3.1 Research design

Sekaran (2009) defined a research design as a master plan specifying the methods and procedures which are used to guide and conduct a research. It is a strategic plan for a research project, setting out the broad outline and key features of the work to be undertaken, including the methods of data collection and analysis to be employed and showing how the research strategy addresses specific aims and objectives of the study (Gordon, 1998). Polit and Beck (2008) added that a research design provides the basic strategies that are necessary for the development of empirical evidence. The research focused on an evaluation of clinical waste management in five selected healthcare facilities in GCC. The types of research designs which were adopted are both qualitative and quantitative approaches (mixed method approach). Van Maanen (2007) explained mixed method approach as a type of research design which combines elements of qualitative and quantitative approaches and is a third paradigm in educational research.

According to Johnson *et al.* (2007) a paradigm is an interpretative frame work, which is guided by a set of beliefs and feelings about the world and how it should be understood and studied. The mixed method approach presents the middle ground on the paradigmatic continuum and is allied with pragmatic philosophy that utilizes induction, deduction and adduction (Johnson *et al.*, 2007). The mixed method approach involves both collecting and analyzing qualitative and quantitative data and is practical in the sense that the researcher is free to use all methods possible to address a problem (Creswell, 2003). Qualitative and quantitative approaches helped

the researcher to lay out the research questions, methodologies and data collection and analysis needed to conduct a research.

The qualitative approach is a systematic subjective approach used to describe life experiences and give them a meaning (Gwimbi and Dirwai, 2003). Its main goal is to gain insight, explore depth, richness and complexity inherent in the phenomenon (Burns and Grove, 2005). Qualitative methods encompass a variety of methodologies which include observations, interviews and document analysis. In this research qualitative approach consisted of interviewing environmental officers from GCC, facility or health and safety officers from selected healthcare facilities and the contractors involved in clinical waste collection. The respondents were interviewed to find out their views on clinical waste generation, its management practices, risks of clinical waste and knowledge of waste management. The use of a qualitative approach allowed the researcher to obtain a rich set of data that was not easily obtainable using a quantitative approach. A qualitative approach also involved site visits or walks through the healthcare facilities to access working conditions, and gather basic information about the institutions and issues relating to medical waste management. A camera was used in the design to capture some scenes in the field of study. Photograph variables were used as evidence in the research. Hot spots for the onsite check up, inpatient rooms, nursing station, laboratories, dialysis rooms, radiology rooms, waste disinfection and storage, handling and treatment rooms were observed. The qualitative approach was subjective, using language and descriptions mostly (Creswell, 2003).

Quantitative research refers to the systematic empirical investigation of social phenomena via statistical, mathematical or computational techniques. The process of measurement is central to quantitative research because it provides the fundamental connection between empirical observation and mathematical expression of a quantitative relationship (Van Maanen, 2007). De Vos *et al.* (2010) explained that quantitative research methods endeavor to provide answers to questions about relationships between measurable variables. It is also possible to explain causation among variable, generalise research and predict relationships between variables. Weight of clinical waste was the measured variable. The quantitative approach involved precise measurements of the amount and types of clinical waste generated per day in the selected

healthcare facilities. This approach was also used to find out how many people visit the selected healthcare facility per day. A measurement/observation sheet was used to record weight of clinical waste, number of red plastic bags and number of people who visit the healthcare facilities. The quantitative approach was more objective and statistical, involving the use of figures (Gwimbi and Dirwai, 2003).

3.2 Study setting

The setting for this study was one referral hospital, two clinics and two health posts. The names of the healthcare facilities selected were Princess Marina Hospital, Extension 2 Clinic, Broadhurst 2 Clinic, Nkaikela Health Post and Gabane Health Post. Gaborone City Council has twenty one (21) healthcare facilities which are in following categories: one (1) referral hospital, eighteen (18) clinics and two (2) health posts. These healthcare facilities are few; they operate under different conditions and are located in different areas of the city. The researcher used a purposive sampling technique to select a sample of healthcare facilities. Purposive sampling technique is a non probability sampling technique where the researcher chooses a sample with a purpose to include predetermined category of healthcare facility of interest (Van Maanen, 2007). Since the purposive sampling technique is a non probability approach, it is subject to bias and error.

The main site was Princess Marina Hospital (PMH) which is Botswana's first hospital situated in the heart of Gaborone City 24°39'22"S 25° 55'28"E (Figure 3.1). The hospital was established in 1966 when the country gained independence and started operating on 4 April 1967 (MoH, 2011). It now has advanced medical facilities and is a referral hospital for all public healthcare facilities in the city and villages around. The Hospital has an estimated capacity of 540 beds. It is a public facility and also the main teaching hospital for the University of the Botswana, Faculty of Health Sciences. Numerous services provided by the facility include dental, maternity and delivery, medical, pediatric, oncology, orthopedic, physiotherapy and others. Due to the high quality of specialized services offered, PMH serves not only the city but the whole country as well as neighboring countries.

The hospital generates huge amounts of healthcare wastes. The management of the hospital has outsourced clinical waste collection and cleaning services to private companies. The hospital has a unit dedicated for infection control. Its mandate encompasses management of healthcare waste within the hospital. Among other things, the unit is responsible for conducting training of hospital staff. The members of this unit also represent the hospital in key committees on clinical waste management at the district and national levels to ensure that the hospital is compliant with national and district regulations. The researcher worked with this unit for the duration of the research.

Extension 2 Clinic is situated about 3km from PMH. The clinic operates daily and is open 24 hours; it performs outpatient activities and has an X-ray department and a laboratory. Broadhurst 2 clinic is situated in Broadhurst suburb and it is approximately 6km from the referral hospital. Health posts are the smallest units, which serves an area with a population of less than 500 people. The two health posts studied were Nkaikela and Gabane Health Posts. Nkaikela health post is situated in Tlokweng village and it is about 8km from PMH. Gabane Health Post is located in Gabane village and is approximately 12km from PMH. Both clinics and health posts provide primary healthcare and they generate clinical waste.

3.2.1 Location plan for Princess Marina Hospital

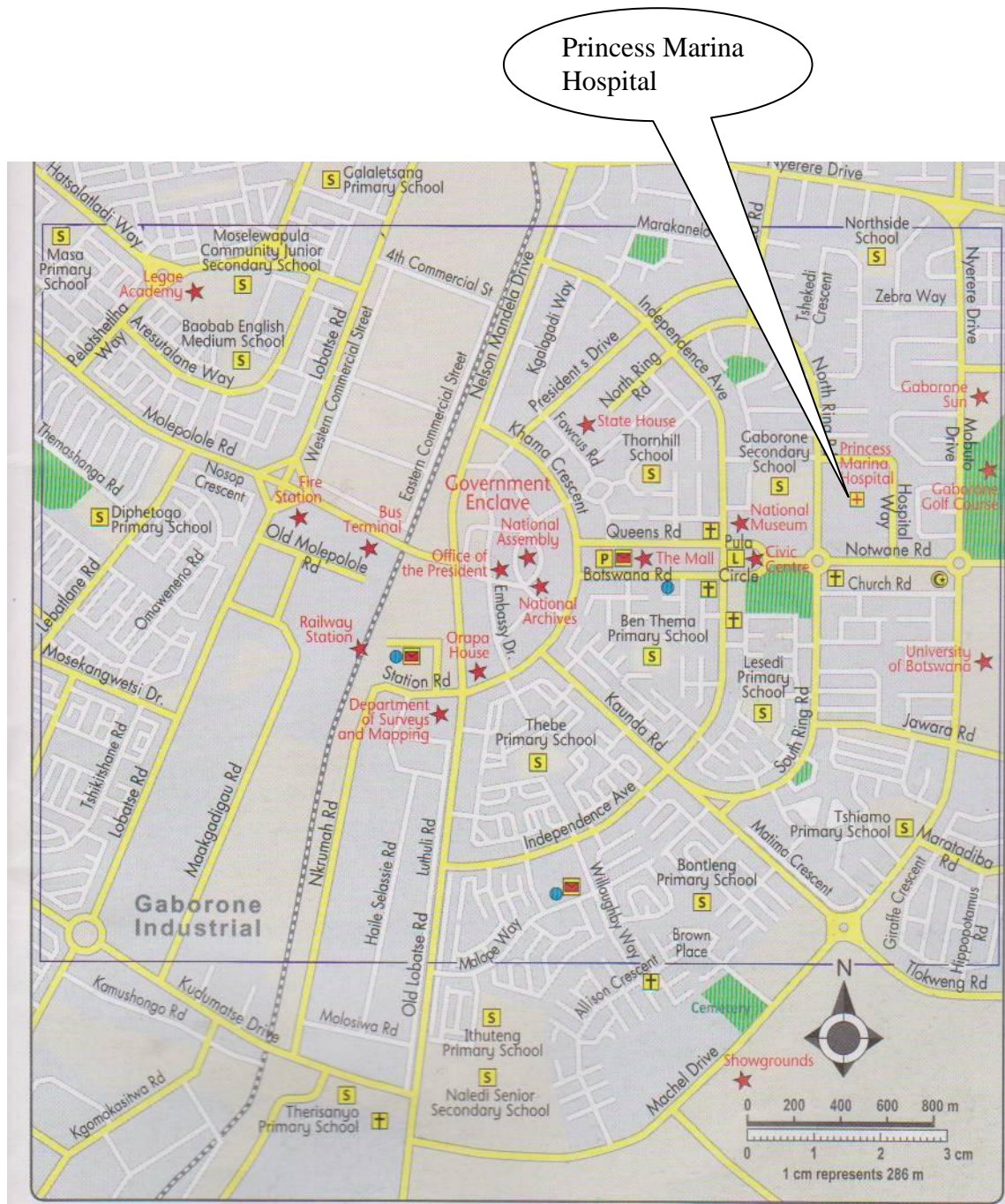


Figure 3.1: Location map for Princess Marina Hospital (Department of surveys and mapping, 2011)

3.3 Sample and sampling procedure

By virtue of their numbers, the referral hospital and the two health posts automatically were included into the sample. Therefore five (5) healthcare facilities were used in this study. To select the sample (healthcare facilities), the researcher used purposive sampling which is a non probability sampling technique where the researcher chose a sample with a purpose to include a predetermined category of healthcare facility of interest. The list of names of clinics, where the sampling framework was developed from, was obtained from the Department of Clinical Services in Gaborone. The sample was made up of five healthcare facilities: one referral hospital, two clinics and two health posts. The names of healthcare facilities selected were Princess Marina Hospital, Extension 2 Clinic, Broadhurst 2 Clinic, Nkaikela Health Post and Gabane Health Post.

3.3.1 Study population

A study population comprises the entire aggregation of cases that a researcher is interested in (Creswell, 2003). The respondent population was the healthcare workers and ancillary staff in the five healthcare facilities which were sampled. These included doctors, nursing staff, laboratory staff, and pharmacists. The ancillary staff consisted of cleaners, porters and operatives for handling waste. Table 3.1 shows the distribution of the healthcare workers in the selected healthcare facilities.

Table 3.1 Number of healthcare workers in surveyed healthcare facilities

Health facility	No of health workers	Ancillary staff
Princess Marina Hospital	720	198
Extension 2 Clinic	32	24
Broadhurst 2 Clinic	25	17
Nkaikela Health Post	11	5
Gabane Health Post	12	6
Total	800	250

Probability Proportional to Size (PPS) was used to select the sample size of 105 respondents as indicated in Figure 3.2. This method allows each and every stratum to be equally represented and the larger the strata the more the samples to be taken. A total of 105 questionnaires were distributed to the surveyed healthcare facilities. However, only 93 questionnaires were usable. This is because the researcher considered those questionnaires which were 75% answered and the rest of the incompletely answered questionnaires were excluded. Stratification ensured representation of each category of healthcare workers and produced improved estimators with less variation. Lists of healthcare workers and their positions were obtained from the selected healthcare facilities. A sample size of 80 healthcare workers and 25 ancillary staff was decided upon for the five healthcare facilities. According to Polit and Beck (2008), in quantitative studies large samples are advised. The larger the sample the more representative of the population it will be and the smaller the chance of producing less accurate estimates. The overall target population was 1050 made up of 620 nurses, 180 doctors, laboratory staff, and pharmacists and 250 ancillary staff as shown on the stratified random sampling plan in figure 3.2.

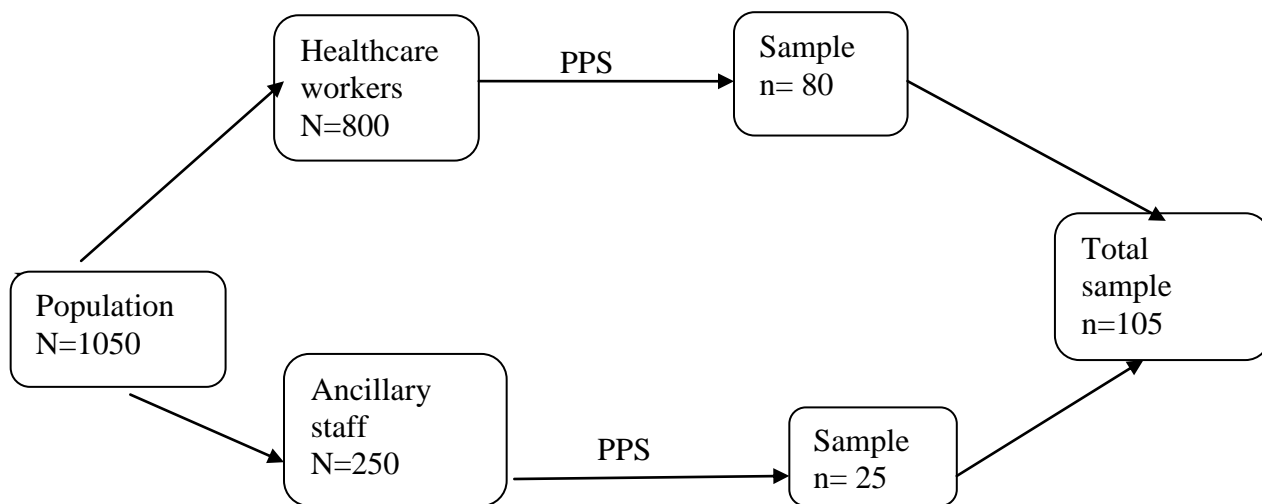


Figure 3.2: Stratified random sampling plan (Polit and Beck, 2008)

3.4 Data collection and research instruments

Various research instruments were used to ensure reliability and validity of data that was to be collected. Reliability refers to the extent to which an instrument yields similar results each time

it is administered by independent persons under comparable conditions (De Vos *et al.*, 2010). The researcher took much care to ensure that the research procedure was the same at each healthcare facility included in the study sample. The use of various research instruments was likely to improve the quality of the research findings and conclusions from one instrument were checked against those from another hence the enhancement of validity of data.

3.4.1 Questionnaires

Questionnaires were used to collect primary data from sampled healthcare workers and ancillary staff from selected GCC healthcare facilities. Questionnaires were used mostly to solicit information from key respondents on their views concerning the type of clinical waste generated, disposal methods, collection patterns and risks relating to clinical waste management systems, sample questionnaire is in Appendix I. A questionnaire survey was used because it allowed participants to give their views anonymously and this reduced bias from the researcher's own opinion and also with no verbal or visual clues to influence the respondents (Sekaran, 2009).

A deliberate effort was made to give questionnaires to the following categories of professionals: doctors, pharmacists, radiologist, laboratory staff and the general nursing staff. These professionals form the majority of professional staff in healthcare facilities who deal with waste at point of production and they also spend most of their time with patients thus increasing their risk of exposure to infections and injuries that are inherent in a healthcare facility environment. Questionnaires were also administered to cleaners, porters and waste handling operatives. The purpose of the study was explained to all the healthcare workers and the ancillary staff. All the participants participated on voluntary basis. These questionnaires were administered by the researcher through the drop and pick method at sampled healthcare facilities. The researcher collected completed questionnaires on site after an agreed time period. Language used was English only and with translation depending on the respondent's grade, educational level and understanding of English.

3.4.2 Semi structured interview guide

According to Sekaran (2009), interviews involve direct interaction between an investigator and research subjects. The researcher spoke directly with respondents asking questions related to a specific topic area. Semi structured interviews allow for more freedom of discussion with subjects and aim for a greater understanding of the subjects (Gwimbi and Dirwai, 2003). Questions were prepared to prompt topical areas of dialogue. This allowed the subjects to expand upon the questions and revealed information that could not be achieved with a structured interview. Interviews were conducted based on a written list of questions (Appendix II). The order of questions varied and the researcher also followed new leads arising during the course of the interview. Personal interviews were used to get in depth and comprehensive primary data on clinical waste management systems. Personal interviews are flexible and allow the researcher to collect non verbal data simultaneously and can also probe for more specific answers in case questions are misunderstood or misinterpreted (De Vos *et al.*, 2010). The following subjects were interviewed: the contractors involved in the collection and disposal of clinical waste, facility waste managers or health and safety officers of the selected healthcare facilities and the Environmental Officer from GCC. The researcher designed structured questions for each subject to collect primary data. The researcher asked questions from a written interview guide and record answers on verbatim. Prior consent and appointments were made with the key informants who were to be interviewed in their designated offices.

3.4.3 Field observation and measurements

Observation involves the examination of research subjects in a natural social environment with particular attention paid to the subjects' behavior and actions (Polit and Beck 2008). The observations were made first hand by the researcher. The researcher used unobtrusive observation where she was not directly involved in the activities observed. This prevented the researcher from influencing the subject's behavior. Human activity was observed without filtering effects of subjects' interpretation of their interaction. The researcher observed processes from cradle to the grave to obtain first hand information. Types of clinical waste generated in the selected healthcare facilities, places where clinical waste is stored and designated waste

collection points were observed. Observation can reveal habits the subjects are unaware of and can help place behavior in context (De Vos *et al.*, 2010). Observations were done through continuous monitoring and through spot checks. Places like inpatient rooms, nursing stations, laboratories, clinical waste storage and treatment rooms within the selected healthcare facilities were considered.

The researcher spent one week at each healthcare facility, observing how clinical waste is managed daily then proceeded to the incinerators and landfill where clinical waste is treated and disposed of. The reasons for observations were to see whether segregation, handling, collection and storage were being done accordingly and if clinical waste receptacle were provided, waste deposited in appropriate containers, transported appropriately, incinerated according to the manufacturer's instruction/Botswana Clinical Waste Management Code of Practice, 1996 and disposed of in a safe manner. Measurements were used to express observations numerically in order to investigate casual relationships. Aspects which were measured were quantity of clinical waste generated and the number of patients who visited the selected healthcare facilities per day. To measure waste generated, the researcher ensured that the waste type generated was put into pre-weighed separate bags for example red plastics for infectious waste and yellow containers for sharps. A digital weighing scale was used to measure clinical waste at all sampled healthcare facilities. The researcher asked for the assistance from waste handling operatives to help with measuring of clinical waste. A camera was used to collect primary data from observations in the field of study. A measurement/observation sheet was used to record data obtained (Appendix III).

3.4.4 Review of records

Record analysis involves reviewing all readily available material (Van Maanen, 2007). Data from existing records help the researcher to come up with background information of work done and medical waste management practices. Record analyses also help to gather information that is not publicly available, or that is too new to be found in the literature (Kimberlin and Wintersterin, 2008). The following documents were reviewed to gather secondary data regarding administrative procedures and policy frame work of clinical waste management

processes and strategies: Botswana Strategy for Waste Management, 1998, Botswana Clinical Waste Management Code of Practice as adopted in 1996, Guidelines for Disposal of Waste by Landfill, 1997 and Clinical Waste Management plan April, 1998. Data on the past and current clinical waste management was obtained from Department of Waste Management and Pollution Control, Department of Clinical Services and waste management records of the medical establishments. These departments are responsible for implementing regulations on healthcare waste management, ensuring safe disposal of clinical waste and setting standards of clinical waste licensing and monitoring of clinical waste management facilities.

3.5 Pilot study and questionnaire validation

To ensure validity and reliability of the questionnaire, the researcher conducted a pilot testing of the questionnaire to a small group of healthcare workers and ancillary staff at Gabane Clinic which is 4km from Gabane Health Post before actual data collection. The pilot was performed with the same sampling procedures and techniques as in the larger sample. The pilot test was conducted to develop, adapt and check feasibility of the questionnaire and after which amendments were made.

Validity is the ability of an instrument to measure the concept under study and to be able to measure it accurately so that any observed differences are true and not the result of random or constant error (De Vos *et al.*, 2010). Instrument validity determines whether an instrument accurately measures that which it is supposed to measure (Brink *et al.*, 2006). In this study the issue of external validity was considered. Kimberline and Winterstein (2008) noted that external validity of a study is said to exist when results obtained in a study can be generalized to other people and settings. Generalization is made considering the degree of confidence which the sample findings can be conferred on the population and whether similar findings would be obtained at other times and places. External validity may be affected in cases where subjects behave in an unnatural way due to the fact that they are aware that they are being observed by the researcher (Brink *et al.*, 2006). External validity is influenced by the sampling method used. Findings of this research will not be generalized to other healthcare facilities in Botswana because of the purposive sampling technique used in the selection of surveyed healthcare

facilities. Internal validity refers to the extent to which the results of an experiment can be said to be wholly due to the manipulated independent variables as opposed to any other factor that has not been controlled for (Kimberline and Winterstein, 2008). Experiments were part of this study as clinical waste generated was measured and numbers of patients visiting the selected healthcare facilities daily were recorded. Therefore issues of internal validity influenced the outcome of this study.

A good research design should be valid and be able to produce reliable results. Gwimbi and Dirwai (2003) defined reliability as the repeatability and consistency of the findings. A reliable measure does not fluctuate randomly and is used to discover relationships between variables.

3.6 Data presentation and analysis tools

Data analysis is a practice in which raw data is ordered and organized so that useful information can be extracted from it (Polit and Beck, 2008). In this research raw data took a variety of forms including measurements, questionnaire responses and observation. Charts, graphs and textual write ups of data were used to analyse data. These methods are designed to refine and distill the data so that readers can glean interesting information without needing to sort through all data on their own. Statistical Package for Social Science (SPSS) was used to present and analyse the data that was collected. The services of a statistician were sought during this phase of the research process. The raw data was presented in tables, bar graphs, and pie charts. Microsoft Excel was also used to produce various graphs. Plates were used to present collected data. Comments were made on findings. Data from existing documents was analysed to enable certain themes and trends to be identified. Descriptive statistics which include measures of central tendency and measures of dispersion were used to analyse data from measurements and observations. Correlation coefficients for the amount of waste generated versus the number of people who visited the healthcare facilities surveyed were calculated. The methods of data presentation used helped to clarify data and draw new conclusions.

3.7 Limitations

Clinical waste is generated in all healthcare facilities in GCC. However it was not possible for the researcher to examine clinical waste management systems at all healthcare facilities in Gaborone. Rather the researcher examined the clinical waste management systems of a selected sample from GCC healthcare facilities. This was due to financial, human resource and time constraints. The other constraint was that the native language in Botswana is Setswana, which the researcher could not speak and most participants felt comfortable to speak in Setswana which reduced the credibility of results. The researcher employed a Setswana research assistant to help with the interpretation. The other limitation was that Botswana lacks documented local reference sources on the topic of study.

3.8 Ethical consideration

3.8.1 Permission for the study

The research went through the University of South Africa (UNISA) ethical clearance process and permission to conduct research was granted. The researcher secured permission, ethical clearance and consent to conduct the research from GCC, the MoH, PMH and the clinics that were involved in the research. Permission to conduct the research at the incinerators and landfill was also obtained from Kweneng District Council. To gain a smooth entrance to the study sites the researcher visited the selected healthcare facilities for introductory purposes and also obtained permission letters to carry out the study, thereafter rapport was established. A formal consent from the respondents was also obtained, after the respondents had read and understood the content of the consent form and also had a verbal discussion with the researcher. The purpose of the research was explained through informal discussions with the respondents.

3.8.2 Respect for self determination/autonomy and human dignity

Respect refers to an individual's right to voluntarily take part in a study (Gwimbi and Dirwai, 2003). Study subjects should be given full disclosure on the nature of the study to enable them

to make informed choices on whether to participate in the study or not. In addition their decisions should not be coerced or influenced by other people or factors. Only when these conditions are satisfied should informed consent be obtained from them (Polit and Beck, 2008). As was indicated, a participation information leaflet was available on the front page of the questionnaire. The purpose and benefits of the study were clearly stated for respondents to read. The information provided the basis for respondents to either agree to participate in the study or decline. In addition the researcher verbally explained the reasons why the study had to be carried out and this was done in an effort for the respondents to appreciate the need for the study and their participation.

3.8.3 Anonymity and confidentiality

Anonymity refers to a situation where even the researcher cannot link the data collected to the respondents. Privacy, especially with regard to personal lives should be respected and identities kept anonymous (Polit and Beck, 2008). Questionnaire numbers were used and no names of respondents were required. Respondents were also verbally advised not to indicate their names or any other form of identity on the questionnaire. The results were therefore confidential with no possibility of names being detected. Names of respondents were not recorded anywhere to ensure confidentiality. Participants were identified with numbers and healthcare facility. The researcher made it clear to respondents that there were no individual benefits from the study and they were assured confidentiality. To encourage participation and to protect the privacy of survey respondents, the researcher designed the survey in such a way that when the results are published it will not be possible to match any participant's individual response with any data published in the results. Data collected was stripped of information which allows identification of sources of data.

3.8.4 Risks

Infectious or hazardous clinical waste was the potential risk to the researcher and the waste handling operatives during measuring of the quantities of clinical waste. To minimize the risks the researcher and operatives wore protective clothing when handling clinical waste. To reduce

psychological risks to respondents, the respondents were assured that the information they provide will not be used to exploit them. The respondents were informed that after the study has been completed; the results will be presented to the Ministry of Health Research Unit, Princess Marina Hospital Research and Ethics Committee, and will be also available from UNISA library in the form of a copy of the dissertation which can be used for further reference.

CHAPTER 4 RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter presents results and discussions from completed questionnaires, individual interviews, field measurements and observations from the study. A total of 93 out of 105 questionnaires were completed by the study participants, translating to a response rate of 88.5%.

4.1 Demographic information of respondents

Results from Table 4.1 indicate that amongst the respondents who participated in the study across all the sampled healthcare facilities, 67% were female whilst the other 33% were male. 66.7% of the respondents were from PMH.

Table 4.1: Respondents' distribution and gender at the surveyed healthcare facilities

Gender	Princess Marina Hospital	Extension 2 Clinic	Broadhurst 2 Clinic	Gabane Health Post	Nkaikela Health Post	Total	Percentage
Male	22	2	4	2	1	31	33
Female	40	8	7	4	3	62	67
Total	62	10	11	6	4	93	100

Table 4.2 shows that the majority of the respondents (61.3%) were within the age group 21-40 years while 38.7% were within the age group 41-60 years. These results depict that, there are many young people managing clinical waste at various healthcare facilities.

Table 4.2: Age distribution of respondents

Age group	Percentage %
21-30	29.0
31-40	32.3
41-50	19.4
51-60	18.3
60+	1.0
Total	100

Results in Figure 4.1 show that most of the respondents were the nurses, making up 37.6% and ancillary staff making up 22.6%. Doctors made up 11.8%, pharmacists 8.6%, laboratory staff 9.6%, and radiographers 3.2% of the respondents. The category “Others” which made up 6.5% include porters, ambulance drivers and orderlies. It should be pointed out again that it had been indicated earlier in the report that, nurses make the highest proportion of healthcare staff at various healthcare facilities followed by ancillary staff, while radiographers make up the least number of employees.

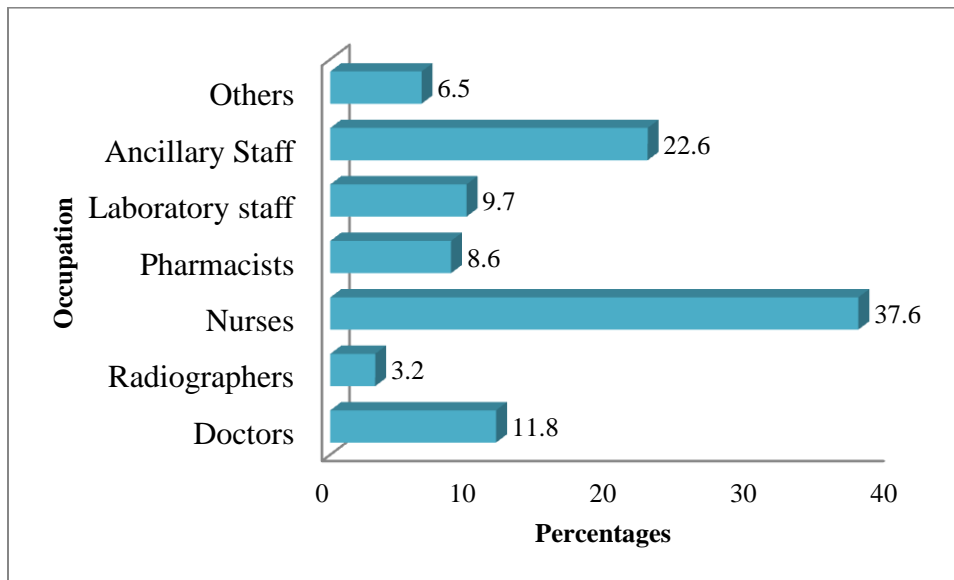


Figure 4.1: Percentage of respondents by occupation

Results from Table 4.3 revealed that 35% of questionnaire respondents have been working at the surveyed healthcare facilities for a period of 5 years or less, while 22% have 6-10 years working experience. Moreover, 43% of the respondents had been working at the healthcare facilities for over ten years. More years of service and a longer time at a healthcare institution might indicate that most of the respondents have knowledge and experience of how clinical waste is managed at the healthcare facilities.

Table 4.3: Period of working experience at surveyed healthcare facilities

Period of working experience	Percentage
0-5	35
6-10	22
11-15	17
16-20	14
21+	12
Total	100

4.2 Types of clinical waste generated

The nature and types of clinical waste generated in the surveyed healthcare facilities are shown in table 4.4. The common types of clinical waste mentioned by respondents were sharps (96.7%), dressing swabs (86%), human tissue and organs (32.3%) and body fluids (24.7%).

Table 4.4: Types of clinical waste generated daily at the surveyed healthcare facilities

Type of clinical waste	Percentage of respondents
Dressing swabs, genital swabs/absorbents	86.0
Used sanitary pads	43.0
Used gloves	26.8
Fluids	24.7
Used bandages	17.0
Human tissue and organs	32.3
Excreta	33.8
Sharps (used cannulas, needles, surgical blades, vials, Injections, syringes)	96.7
General waste or non infectious	98
Used toilet paper	13.2

Table 4.4 depicts that the majority of the respondents at the surveyed healthcare facilities indicated that dressing swabs, genital swabs/absorbents, sharps and general waste/non-infectious waste are the most generated waste at the healthcare facilities. In a similar study, Hassan *et al.*

(2008) confirmed that non-hazardous medical waste, hazardous waste, needles and sharps are the most generated clinical waste in surveyed healthcare establishments in Bangladesh.

4.2.1 Sources of clinical waste

Interviews and observation results revealed the principal sources of clinical waste in the surveyed healthcare facilities as shown in table 4.5.

Table 4.5: Sources of clinical waste

Health Facility	Sources
Hospital	Wards (male, female and children), maternity and delivery units, laboratories, theatres, mortuary, X-ray, outpatient clinics (dental, eye, surgical, medical), infection unit, .surgery, dispensaries and pharmacy, ambulances, emergency and accidents unit, blood bank, laundry rooms.
Clinics	HIV testing room, injection room, dressing rooms, consultation rooms, doctors' rooms, laboratory, X-ray room, dispensaries, antenatal rooms.
Health Posts	General outpatient, antenatal rooms, dressing rooms, injection rooms, HIV testing room, dispensaries.

Identified sources of clinical wastes show that PMH has many sources of infectious waste than clinics and health posts surveyed because it is a referral hospital and there are many services offered at the hospital. The common sources of clinical waste at the surveyed healthcare facilities are: outpatient rooms, dressing/injection rooms and dispensaries. Literature revealed that the principal sources of clinical waste are hospitals and clinics, due to services they offer such as: operating theatres, maternity, accident and emergency services, intensive care, pathology, pharmacies, laboratories and research facilities (Blenkharn, 1995; Bendjoudi *et al.*, 2009). Other sources of clinical wastes reported are immunization/vaccination clinics, blood banks, nursing homes, practice centers of doctors and dentists (Pruss *et al.*, 1999).

4.2.2 Clinical waste generation quantities in surveyed healthcare facilities

Clinical waste generation quantities in the surveyed healthcare facilities were obtained by actual measurements. The amount of clinical waste generated from each of the healthcare facilities was determined by weighing on a daily basis for a week and the total and average amount of waste generated is shown in table 4.6.

Table 4.6: Summary of the total and average clinical waste amounts generated at surveyed healthcare facilities

Healthcare facility	Total average waste generated, kg/day	Average number of patients per day	Generation rate kg/patient/day
Princess Marina Hospital	595.4	790	0.75
Extension 2 Clinic	24.3	182	0.13
Broadhurst 2 Clinic	11.2	108	0.10
Gabane Health Post	11.4	94	0.12
Nkaikela Health Post	6.7	61	0.11
Total	649	1235	
Total average	129.8	247	0.24

The generation rate of clinical waste generated was computed to be 0.75kg/patient/day and 1.1kg/bed/day at PMH, 0.13kg/patient/day, 0.10kg/patient/day, 0.12kg/patient/day and 0.11/patient/day at Extension 2 Clinic, Broadhurst 2 Clinic, Gabane Health Post and Nkaikela Health Post respectively. This resulted in an average of 129.8kg per day for the five healthcare facilities (Table 4.6). From the results in Table 4.6 the highest generation rate on average basis was found at PMH with 595.4kg/day, 24.3kg/day was found at Extension 2 Clinic and Nkaikela

Health Posts had the lowest generation rate of 6.7kg/day. As expected by facility size and diversity of services, it was also observed during collection of clinical waste in the surveyed healthcare facilities that more clinical waste (Plate 4.9) is collected at PMH than at the clinics and health posts (Plate 4.8).

This study revealed that Extension 2 Clinic had the second highest clinical waste generation rate with an average of 0.13kg/patient/ day (Table 4.6). It is a clinic that operates daily and is open for 24 hours and it offers services which other clinics do not offer. It has a laboratory and X-ray department; many people visit the clinic because of its operating hours which are flexible and convenient. An average of 180 people visits Extension 2 Clinic daily. Therefore these factors explain the higher generation rate than Broadhurst 2 Clinic.

Gabane Health Post generates more clinical waste as compared to Broadhurst 2 Clinic and Nkaikela Health Post. It was reported by the facility manager that many people visit Gabane Health Post because of its accessibility. It is near the main road and the terminal for public transport. An average of 94 people visits the health post per day. The facility manager for Nkaikela Health Posts commented that Nkaikela Health Post generates the lowest amount of clinical waste because it offers the least number of services and it is situated where there is less population. Although hospital and clinics produce larger amounts of clinical waste than health posts, results, reveal that clinical waste generated is proportional to the number of people who visit each healthcare facility (Tables 4.7.1 to 4.7.5).

From the study, quantities of waste generation rate in surveyed healthcare facilities depend on type and size of the healthcare facility, number of patients who visit the healthcare facility and type of services provided. PMH accommodates the largest number of patients as compared to other healthcare facilities in the study. It is a referral hospital which receives a lot of patients from other healthcare facilities in Gaborone and surrounding districts and villages. This has a significant effect on the generation rate. It is also a teaching facility with many services offered. It also has the largest maternity department and the whole hospital houses an average of 540 beds.

Cheng *et al.* (2009) also confirmed that the amount of medical waste generated from medical establishments is associated with the type or size of the institution. According to Pruss *et al.* (1999), the generation rate of medical waste is dependent on regulations and the economic status of a country, with large variation expressed as the amount of waste per bed/day or per capita/day. Any increase in number of beds and services might change the waste generation rates. Such an increase was confirmed by the findings of the study by Abd El-Salam (2010) in El-Beheira in Egypt, where 2.07kg/bed/day was found to be generated from one of the surveyed hospitals which had a large number of beds (590), services (26 departments) and a high occupancy rate (104%).

In a similar study in Jordan, Abdulla *et al.* (2008) revealed that at surveyed healthcare facilities waste generation ranged from 0.5-2.2kg/bed/day and in Bangladesh 1.28kg/bed/day (Alam *et al.*, 2008). The average medical waste generation rate of 2.79- 3.86kg/bed/day was reported in Taiwan and 2.6kg/bed/day in Poland (Gluszynski, 1999; Sharprio *et al.*, 2003) which was much greater than results obtained for this study. Jang *et al.* (2006) reported a low generation rate of 0.48 kg/bed/day in Korea. Abdulla *et al.* (2008) reported that generation rate of clinical waste in Northern Jordan healthcare facilities was influenced by bed occupancy, size of healthcare facility and types of services provided. Jang (2011) added that geographic location, the amount of disposable or reusable medical devices and the degree of regulation enforcement at national and local level also influence generation rate of medical waste.

It is evident from studies at some hospitals in developing countries that developing countries in Africa (South Africa 0.6kg/patient/day, Nemathaga *et al.*, 2008), (Algeria 0.7-1.22kg/bed/day, Bendjoudi *et al.*, 2009), Libya 1.3kg/patient/day, Sawalem *et al.*, 2009) generate lower amounts of clinical waste. Nemathaga *et al.* (2008) reported that the studied hospitals in South Africa have low generation rates because they lack modern medical facilities and they are not situated in highly urbanized environment and most patients do not represent affluent communities. Nemathaga *et al.* (2008) reported that the clinical waste generation rate for developed countries is higher than for developing countries. Canada and USA were reported to have high generation rates that range from 4.3-5.8kg per bed per day. This is because developed nations have modern facilities and good services. Hossain *et al.* (2011) commented that clinical waste have not yet

been fully appreciated in developing countries, often it is still handled and disposed together with non clinical waste.

The relationship between generated waste quantities versus patients is approximately linear. The amount of clinical waste generated increases with the increase in the number of patients who visit the healthcare facility. The generation rates for clinics and health posts in this study are less comparable to those obtained from a survey conducted in Dar es Salaam, Tanzania of 0.255kg per patient per day (Mato and Kassenga, 1997). The study in Tanzania further revealed that healthcare facilities with modern medical facilities and good services were found to have higher waste generation rates than the rest. Results of the study by Dasimah *et al.* (2012) also confirm that bigger healthcare facilities generate more medical waste than small healthcare facilities.

Table 4.7.1 Number of patients visiting Nkaikela Health Post versus clinical waste generated per day for a week

Patients at Nkaikela Health Post	85	60	57	49	53	82	43
Clinical waste generated in kg	11.35	6.7	5.8	4.45	5.1kg	8.4	4.8

Table 4.7.2 Number of patients visiting Gabane Health Post versus clinical waste generated per day for a week

Patients at Gabane Health Post	90	105	120	79	92	82	88
Clinical waste generated in kg	10.4	12.9	14.35	9.4	11.65	10.8	9.95

Table 4.7.3 Number of patients visiting Broadhurst 2 Clinic versus clinical waste generated per day for a week

Patients at Broadhurst 2 Clinic	125	93	90	115	89	109	133
Clinical waste generated in kg	12.0	8.65	10.45	11.75	10.15	11.25	14.1

Table 4.7.4 Number of patients visiting Extension 2 Clinic versus clinical waste generated per day for a week

Patients at Extension 2 Clinic	189	185	169	205	198	149	178
Clinical waste generated in kg	22.6	24.5	20.5	26.45	28.70	21.95	25.3

Table 4.7.5 Number of patients (outpatients and inpatients) versus clinical waste generated per day for a week at Princess Marina Hospital

Patients at Princess Marina Hospital	679	825	767	810	912	645	897
Clinical waste generated in kg	425.45	645.9	453.64	599.1	890.35	359.95	793.2

Tables 4.7.1 to 4.7.5, show that the amount of clinical waste generated increases with the daily increase of patients in the surveyed healthcare facilities. The time spent at a healthcare facility also affects the amount of clinical waste generated. PMH offer both inpatient and outpatient services, while clinics and health posts offer only outpatient services. This implies that more people spent more time at the PMH than at clinics and health posts, thus more waste is generated. The calculated correlation coefficients (r) for surveyed healthcare facilities are as follows: Nkaikela Health Post, $r = 0.946678698$, Gabane Health Post, $r = 0.948997304$, Broadhurst 2 Clinic, $r = 0.892399814$, Extension 2 Clinic, $r = 0.727160878$ and Princess Marina Hospital $r = 0.960046742$. The correlation coefficients are positive and this shows a linear relationship between patients and the amount of clinical waste generated.

When asked to provide data on the amount of clinical waste generated per day, 27% of questionnaire respondents were able to provide information on amount of clinical waste generated per day in kilograms. About 6% of questionnaire respondents provided data on amount of clinical waste generated in terms of numbers of plastic bags collected per day and 67% of healthcare workers indicated that they did not know the amount of clinical waste generated per day. Results also revealed that those who were able to quantify (volume) clinical waste were cleaners. This was because they are the ones responsible for collection of clinical waste to storage places. It was also observed that at PMH every time cleaners/waste handlers bring clinical waste to the storage room, the number of bags brought are counted, weighed and recorded on Clinical Waste Monitoring Tools (Appendix IV). Interview results also revealed that the healthcare facility managers for the surveyed clinics and health posts could not provide data on daily generation of clinical waste. These managers were also unable to provide information with respect to the amount of clinical waste generated by the different departments and which departments generated the highest and lowest amount of clinical waste. It was reported that facility managers for clinics and health posts do not keep records of waste generated but check if clinical waste is collected from every room. In all clinics and health posts clinical waste is not weighed but it is segregated from general waste. Dasimah *et al.* (2012) reported good record keeping regarding clinical waste generation at studied big hospitals in Malaysia namely Batu Pahat and Taiping hospitals. A small hospital Tumpat could not provide information on clinical waste generated.

Information on the amounts of waste generated was well documented at PMH. The Infection Control Unit within the hospital keeps records/register of clinical waste generated (Appendix IV). Scales are used to measure clinical waste generated daily at PMH (Plate 4.1 and plate 4.2). Similar practices were reported by Kumari *et al.* (2012), where records regarding quantity of different categories of medical waste generated are kept at a medical school hospital in China. Interview results established that the contracted private company for clinical waste collection collects an average of 600kg per day from PMH. They could constantly quantify the weight of clinical waste generated because they are paid per kilogram of collected waste. Interview results from GCC clinical waste collection manager indicated that they do not know how much they collect from each healthcare facility per day. They are not part of those paid per kilogram for the

job at each healthcare facility. GCC waste collection operatives just collect without weighing the waste. Weight of clinical waste that is brought by GCC waste collectors from different healthcare facilities is measured at Weigh Bridge at incinerators (plate 4.20).



Plate 4.1 and Plate 4.2: Scales used to measure clinical waste at Princess Marina Hospital

4.3 Clinical waste management practices

4.3.1 Clinical waste segregation

In the light of Botswana Clinical Waste Management Code of Practice, 1996, clinical waste must be separated from household waste at source of generation using coloured bags and containers. It was observed that coloured receptacles were used to store various types of hazardous waste at generation point. It was also observed that waste segregation start at point of generation in all the surveyed healthcare facilities as shown on Plate 4.3, Plate 4.4, Plate 4.5, Plate 4.6 and plate 4.7.



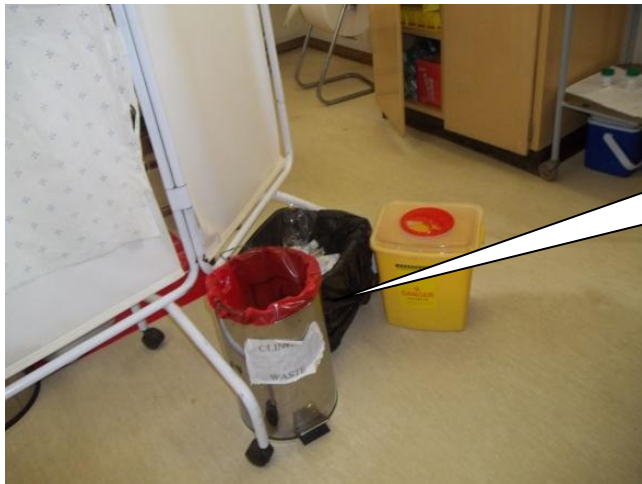
Coloured receptacles for segregating waste at Broadhurst 2 Clinic

Plate 4.3: Segregation at Broadhurst 2 Clinic



Coloured receptacles for segregating waste at PMH.

Plate 4.4: Segregation at Princess Marina Hospital



Coloured receptacles for segregating waste at Extension 2 Clinic.

Plate 4.5: Segregation at Extension 2 Clinic



Coloured receptacles for segregating waste at Nkaikela Health Post.

Plate 4.6: Segregation at Nkaikela Health Post



Coloured receptacles for segregating waste at Gabane Health Post.

Plate 4.7: Segregation at Gabane Health Post

About 96.8% of questionnaire respondents mentioned that clinical waste generated from surveyed healthcare facilities is segregated while only 3.2% did not confirm. Although clinical waste was found to be segregated and collected in recommended receptacles in all healthcare facilities about 43% of questionnaire respondents rated segregation as being poor, 33.3% good, 19.4% very good while 4.3% rated it excellent. Interview results with facility managers also revealed that separation of medical waste was not practiced to a satisfactory extent. Poor segregation was also observed at the surveyed health posts where black receptacles were not used to store domestic waste. Contractors responsible for clinical waste collection and incinerator operators also reported that segregation of clinical waste from general waste was not precise as waste in the incinerator was not wholly clinical. This anomaly was also observed from residuals/ash that showed a mixture of tins for soft drinks and bottles. Practices of poor segregation were observed at PMH where visitors of the admitted patients were observed throwing domestic waste into clinical waste receptacle during visiting times.

Results of this study are similar to those of a survey done by Abdulla *et al.* (2008) in Jordan, who reported that the main problem encountered in hospital waste management was inappropriate segregation. A study in Bangladesh by Hassan *et al.* (2008) revealed no proper and systematic segregation of medical waste. Few private healthcare establishments were reported to segregate their infectious waste. In the studied healthcare facilities in Bangladesh, all infectious waste was found to be separated from non-infectious waste streams at point of generation, but during

treatment, medical waste was found mixed with general waste. Hassan *et al.* (2008) reported that in Dhaka healthcare facilities, some cleaners were found salvaging used sharps, saline bags, blood bags and test tubes for resale. In a similar survey Nemathaga *et al.* (2008) reported that sharps were found to be the only type of waste collected in recommended containers infectious, pathological and chemical wastes were all collected in red plastic bags at studied hospitals in South Africa. Abd El-Salam (2010) reported that in studied healthcare facilities in El-Beheira in Egypt segregation of medical waste types was carried out in all healthcare facilities, but none of them were conducted properly according to consistent rules and standards. Dasimah *et al.* (2012) also reported segregation which is not conducted according to definite rules and standards in three District hospitals studied in Malaysia. Clinical waste deposited in yellow bins exceeded the specific limit of less than 3/4 full (Dasimah *et al.*, 2012). A similar research to this study by Kumari *et al.* (2012) revealed that segregation of medical waste is done appropriately in every department at each work station at a Medical University in India. Information displaying colour coding and appropriate segregation is disseminated through charts bedside stickers, pamphlets and hoardings.

4.3.1.1 How clinical waste is segregated

The proper packaging of clinical wastes prior to their ultimate distribution or disposal is the most crucial element of any waste management program to prevent contamination of handlers or the environment (WHO, 2000). Generally, clinical waste items were segregated according to the respective colour coded receptacles as prescribed in the Botswana Clinical Waste Management Code of Practice, 1996. About 92% of questionnaire respondents from clinics and health posts were able to explain how segregation of clinical waste is applied and 8% did not know how segregation is done. Results from questionnaires respondents show that among those who were not able to explain the segregation process were nurses, cleaners, ambulance drivers and porters. Results reveal that these healthcare workers have not yet received training concerning how clinical waste is managed.

According to questionnaire respondents, segregation processes for clinics and health posts were similar and has been applied as follows: needles, sharps and broken capsules are collected in

yellow sharps containers, clinical and infectious waste is collected in red plastic bags and general waste is collected in black plastic bags as shown in plate 4.3.

All of questionnaire respondents from PMH reported that clinical waste is put in red plastic bags which are clearly labeled with date, ward or place of origin and hospital, domestic waste is put in black plastic bags clearly labeled with hospital name, ward and date. Sharps are collected in rigid yellow containers which are clearly labeled with date opened and closed, name of the ward and hospital. It was reported that all waste bags are sealed when they are $\frac{3}{4}$ full and labeled before leaving the place of generation. These results were similar to a study in Egypt where Abd El-Salam (2010) reported that 62.5% of surveyed healthcare facilities were following WHO (2000) recommendations which stated that bags or sharps containers should be replaced when it is $\frac{3}{4}$ full. Kumari *et al.* (2012) also reported appropriate segregation and labeling of clinical waste storage receptacles at the studied hospital in China and a bar coded tracking system for clinical waste is under construction.

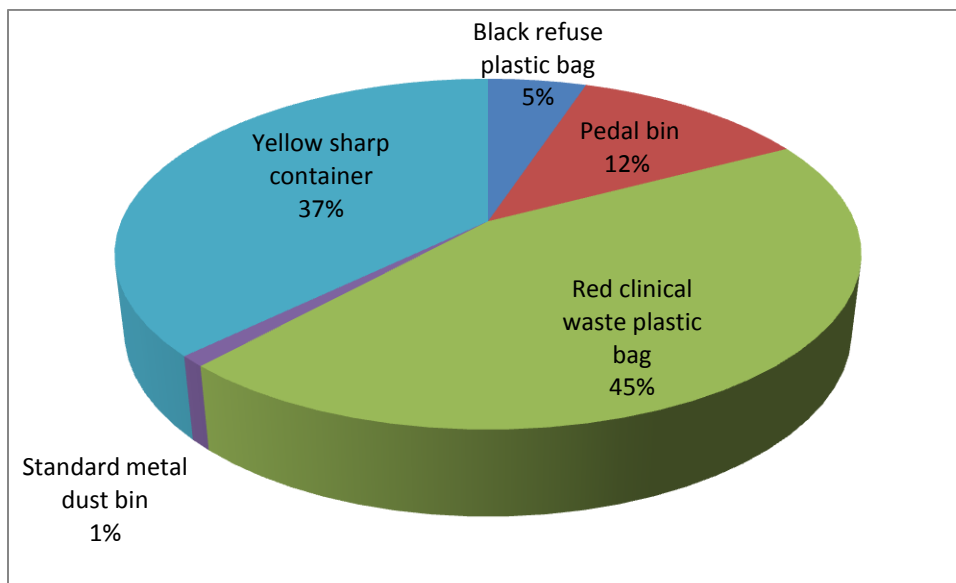


Figure 4.2: Receptacles where hazardous clinical waste is stored

According to the information provided by the respondents (figure 4.2), the common storage receptacle are red plastic bags (45%) and yellow sharp container 37%, other receptacles included pedal bins, black refuse plastic bags and standard metal dust bin, 12%, 5% and 1% respectively. Clinical waste from these receptacles were weighed as segregated separately. A study in Jordan

also revealed that all studied hospitals used colour coded receptacles to store clinical waste (Abdulla *et al.*, 2008). Sharps are segregated in yellow sharp containers, yellow bags are used to store infectious waste and red bags are used to store highly infectious waste (Abdulla *et al.*, 2008). In USA, all medical wastes are put in red bags while in Canada segregation of waste is done in red, yellow or blue bags according to the MoH's classification (Blenkharn, 2011). Shinee *et al.* (2008) reported that in Mongolia most of the healthcare institutions do not have appropriate colour coded receptacles for sorting the different types of waste. Some healthcare centers in Nigeria were also reported to use inappropriate receptacles like any plastic bags, paper bags or card board to collect clinical waste (Coker *et al.*, 2009).

4.3.2 Handling of clinical waste

4.3.2.1 Use of protective clothing

A total of 92.5% of the respondents across all the sampled healthcare facilities use protective clothing when handling clinical waste while about 7.5% do not use protective clothing (table 4.8). Gloves and masks were the common protective clothing mentioned by 92.5% of questionnaire respondents. Most of the respondents (90.3%) from clinics and health posts indicated that protective clothing like: aprons, boots, overalls and overshoes are in short supply. It was reported by the ICO that disposable gloves, musk, apron, overshoes, laboratory coats and protective goggles are adequately provided at PMH. The contracted company for cleaning services at PMH is responsible for provision of protective clothing and receptacles for cleaners and waste handlers. Similar results were reported by Birpinar *et al.* (2009) where medical waste collection personnel in surveyed healthcare facilities in Istanbul, Turkey wore appropriate uniforms and apparatus.

Table 4.8 Use of protective clothing when handling clinical waste

Health Facility	Percentage respondents' response Yes	Percentage respondents' response No
Gabane Health Post	5.38	1.08
Nkaikela Health Post	3.22	1.08
Extension 2 Clinic	8.60	2.15
Broadhurst 2 Clinic	9.68	2.15
Princess Marina Hospital	65.59	1.08
Total	92.47%	7.54%

On the other hand, interview results revealed that there is a shortage of supply for protective clothing for cleaners (waste handlers) at clinics and health posts. Since the MoH took over the management of all healthcare facilities from GCC in 2010 there has not been continuity in the provision of protective clothing like overalls aprons and boots. Facility managers for surveyed clinics and health posts reported that waste handlers use complete personal protective clothing that is overall, gowns and boots. Clinical waste handlers responsible for collection of clinical waste from both contracted company and GCC were observed wearing complete protective clothing (Plate 4.8 and Plate 4.9).

Muchungong (2010) reported similar results to this study, where 77% of clinical waste handlers in surveyed healthcare facilities lacked protective equipments. Gloves, overall gowns and masks to protect workers were not provided in studied healthcare facilities in the Northwest region of Cameroon. Incinerator operators were reported to lack proper protective clothing especially foot wear and overalls in studied healthcare facilities in the Northwest region of Cameroon (Muchangong, 2010).



Collected clinical waste from clinics and health posts

GCC's clinical waste handler, wearing appropriate protective clothing

Plate4.8: Waste handler for Gaborone City Council



Collected waste from PMH.

Private company's clinical waste handler, wearing appropriate protective clothing

Plate 4.9: Waste handler for a contracted private company

4.3.2.2 Handling of clinical waste

When asked to rate the handling of clinical waste, questionnaire respondents rated the handling of clinical waste as follows: 22.6% poor, 21.5% good and 30.1% very good while 26.9% rated it excellent. However it was observed that handling of clinical waste in clinics and health posts was haphazard. Cleaners were observed carrying clinical waste with their bare hands to storage containers, without complete protective clothing as shown on Plate 4.12.

At PMH staff members were observed handling clinical waste whilst observing appropriate health and safety measures by using impervious gloves and mouth masks. The facility manager commented that healthcare workers are aware of the potential hazards of material they were

handling as prescribed by the Botswana Clinical Waste Management Code of Practice, 1996. It was reported that incinerator operators use a variety of protective clothing which include: face mask, heavy duty gloves, plastic apron, overall, heavy duty boots, helmet, safety goggles, respiratory masks and heavy duty heat resistance gloves. Dasimah *et al.* (2012) reported that waste handlers for the three studied District hospitals in Malaysia handled medical waste using appropriate protective clothing. In a similar research to this study at Kotuba hospital in South Africa, Abor (2007) reported that staff employed for handling waste in the hospital use almost complete personal protective equipment, including overall, gown, gloves and protective boots.

4.3.3 Storage of clinical waste

The place where clinical waste is kept before transporting to final disposal site is called a temporary waste storage area. According to WHO (2000) central storage rooms are locations in special areas or in the grounds of a hospital where larger containers (1.1m³) for wheeled bins should be used to store clinical waste until it goes for final disposal either on or off-site. This area must be well sanitized and secured in such a way that it should be only accessible to authorized personnel (Pruss *et al.*, 1999). Generally in all the surveyed healthcare facilities medical wastes are collected and stored in a common area awaiting disposal/treatment. It was observed that waste was not allowed to accumulate within the wards or treatment rooms, which is a good thing since Botswana has very hot summers, which cause waste to decompose very fast thus producing unwanted odors.

According to results from a similar survey in China, Yong *et al.* (2009) reported that 93% of hospitals had temporary storage locations and in some hospitals, the temporary storage facilities were not satisfactory and were close to the municipal waste storage areas. In some hospitals in China, the storage areas were not sufficiently cleaned after medical waste was transported to disposal facilities (Yong *et al.*, 2009). Birpinar *et al.* (2009) also reported similar results, where in Istanbul 63% of the hospitals have temporary storage depots and 94% of these satisfy WHO requirements.

From the observation results, PMH had a secure, well sanitized and ventilated temporary storage location. Receptacles were located within the buildings (interior bins), they were in good

condition, had proper leads, which were securely tied and labeled. Clinical waste is kept in this area on storage shelves until it is time for offsite transportation (Plate 4.10). The storage room is isolated; it is located away from patients and nursing station. The central storage room is connected to sewerage system and a water source. It had limited access, being accessible only to personnel responsible for waste handling. The storage room doors were labeled as being a hazardous area. The place is open for clinical waste storage from 7:30am to 3:30pm daily and is always locked after these times. It was reported by the ICO that clinical waste is stored for a minimum of eight hours before disposal. Pedal bins which are used to transport clinical waste from point of generation to storage room are always cleaned and disinfected after use (Plate 4.11). In another healthcare facility similar to PMH, Nemathaga *et al.* (2008) reported at Tshilidzini hospital in South Africa, that the central storage room does not have any locking system, meaning that any person could go there anytime, which could be dangerous considering the types of wastes stored.



Clinical waste
on storage
shelves at PMH.

Plate 4.10: Clinical waste kept on storage shelves at Princess Marina Hospital



Cleaned and disinfected pedal bin after use

Plate 4.11: Cleaned pedal bin after use at Princess Marina Hospital

Surveyed clinics use external temporary storage containers for medical waste storage. The storage containers are located outside the buildings as shown in Plate 4.12 and Plate 4.13. At Broadhurst 2 Clinic the storage container is placed on the way to patient’s public toilets and the laundry room. At both Extension 2 and Broadhurst 2 Clinics, the storage containers are not secure. Storage containers in these facilities lack fencing and surveillance. It was reported that sometimes patients lean on them because they do not know what is contained inside. It was observed that the storage containers for both clinics are not labeled Bio-hazardous. Interview results revealed that at these clinics there are no personnel responsible for clinical waste storage locations. Anyone could have access to medical waste from these locations. Storage containers at the clinics were not cleaned after medical waste was transported to disposal/treatment places.



Cleaner disposing clinical waste at Extension 2 Clinic storage container

Plate 4.12: Extension 2 Clinic storage container



Broadhurst 2
Clinic storage
container
placed outside

Plate 4.13: Broadhurst 2 Clinic storage container

Pedal bins were used as temporary storage containers at both surveyed health posts. The locations of the temporary storage receptacles are not secure and are accessible to both people and animals. At Gabane Health Post the two pedal bins used as temporary storage were placed at the entrance of one wing of a public toilet and patients use the other wing as shown in Plate 4.15. The place was well ventilated. The waste inside the pedal bins was smelling, flies and ants were observed. It was observed that at Gabane Health Post clinical waste had been stored in the pedal storage bins for two days. At Nkaikela Health Post the two pedal storage bins are placed outside in the bush next to the public toilets (Plate 4.14). The second pedal bin's lid was off and domestic refuse was observed. Patients were also observed throwing litter in the open pedal bin after using the nearby toilet (Plate 4.16). Outside where the pedal storage bins were placed flies, worms and ants were observed. Water was observed in the open pedal bin because of rains that occurred during the sampling period (on 03 February 2013). This made the waste inside wet and smelly. The pedal storage containers for both healthcare facilities were not cleaned after collection of clinical waste. The location of storage containers for both surveyed clinics and health posts were contrary to WHO recommendations. Pruss *et al.* (1999) recommended the following specification for location of storage containers: containers should be inaccessible to unauthorized people, animals, insects, and birds. They should be placed where there is good lighting, good ventilation and be protected from the sun.

The clinical waste storage patterns in this study were partially different from those applied in Turkey's hospitals, where two chambers are used for hospital waste storage (Birpinar *et al.*, 2009). The first is designed for domestic waste and is cleaned with running or pressurized water and its drain is connected to the city sewage system. The second chamber is for clinical waste, it is dry cleaned and had a drainage system connected to an impermeable tank, it is located in a closed space. Containers which are appropriate to WHO requirements are also used as temporary deports (Birpinar *et al.*, 2009).



Storage pedal bins placed outside next to the public toilet

Plate 4.14: Nkaikela Health Post storage pedal bins



Gabane storage pedal bins kept at entrance of closed toilet

Plate 4.15: Gabane Health Post storage pedal bins



Clinical waste mixed with general waste in open pedal storage bin

Plate 4.16: Clinical waste mixed with general waste at Nkaikela Health Post

Table 4.9: Response to storage of clinical waste awaiting transportation

Health facility	Percentage respondents: Secure	Percentage respondents: Insecure
Gabane Health Post	0	100
Nkaikela Health Post	0	100
Extension 2 Clinic	0	100
Broadhurst 2 Clinic	0	100
Princess Marina Hospital	100	0

When asked about the security of the storage of clinical waste awaiting transportation, all questionnaire respondents for PMH reported that the storage of clinical waste was secure while all respondents for clinics and health post did not agree with its security as shown in table Table4.9. A study by Coker *et al.* (2009) reported unsecure location of storage clinical waste in Nigeria. Most of the hospitals in Nigeria have no special place for storage of clinical waste prior to disposal (Coker *et al.*, 2009). Alagoz and Kocasoy (2008) also reported unsecure location of storage depots at Ibn- Nafis Hospital in Istanbul, Turkey. Storage containers are located at the shoulder of the street outside the hospital building and the area is fully accessible to animals and people.

4.3.4 Collection of clinical waste for treatment

Gaborone City Council Sanitation Department is responsible for collection and transportation of clinical waste at all surveyed clinics and health posts to Gamodubu incinerators for treatment. A contracted private company is engaged in clinical waste collection services at PMH.

Table 4.10: Respondents' response on frequency of clinical waste collection services at surveyed healthcare facilities

Daily	Twice per day	Weekly	Fortnightly	Don't Know
40.9%	39.8%	5.4%	0%	13.9%

Table 4.10 above shows that most of clinical waste, 40.9% is collected daily and 39.8% is collected twice a day. About 13.9% of respondents indicated that they do not know the frequency of clinical waste collection. Some indicated that their work schedule is too busy that they don't have time to check if clinical waste is collected or not. Others also indicated that clinical waste management is not their core business, so they have never considered clinical waste collection pattern.

These results were supported by interview results from facility officers who reported that at Nkaikela Health Post waste is collected 1-2 times per week, at Gabane Health Post collection is three times per week, Broadhurst 2 Clinical waste is collected daily but there are times when it is collected twice a week because of shortage of transport. At Extension 2 Clinic, it was reported by the facility manager that clinical waste is collected daily and at PMH collection is twice a day at 8:00am and 3:00pm. Clinical waste collection practices at Extension 2 Clinic and PMH comply with Botswana Clinical Waste Management Code of Practice, 1996 and WHO specifications for daily and frequency of collection and transportation of clinical waste. It was observed that a hospital staffer was involved in the verification process of clinical waste collection as a required by the Botswana Clinical Waste Management Code of Practice. There was no verification of waste collection at all surveyed clinics and health posts. Similar collection practices were reported in surveyed healthcare facilities in Jordan. Bdour *et al.* (2007) reported that collection is done by a private company at the beginning of each shift at 7:00am, 2:00pm and 11:00pm. In Ibadan, Nigeria the studied healthcare facilities had no definite or regular

collection time, medical waste was always over spilling from receptacles because of not being collected (Coker *et al.*, 2009).

The ICO reported that collection of clinical waste by a private contracted company is reliable and it is consistently twice a day at PMH. The facility managers for the surveyed health clinics and health posts reported that collection by GCC is not reliable and consistent and ranges from 2-3 times per week. The waste collection manager for GCC reported that the local authority fails to collect all generated waste because of inadequate equipments, personnel and financial resources faced by local authority. According to the schedule provided by clinical waste collection officers, clinical waste should be collected daily from healthcare facilities. If clinical waste is not collected as per schedule all healthcare facilities reported that they keep it in their respective storage containers until collection is carried out. This challenge, also faced by GCC has been reported in other developing countries including Zimbabwe (Taru and Kuvarega, 2005). Tsiko and Togarepi (2012) reported that Harare City Council is struggling to offer clinical waste collection services on constant basis due to fuel shortage and inadequate financial resources, which are crippling most medical centers in Harare.

4.3.5 Transportation of clinical waste

4.3.5.1 Onsite transportation

From this study, it can be seen that healthcare facilities have the responsibility of providing onsite transportation of clinical waste, while offsite transportation to final disposal/treatment site is handled by disposal companies. According to Botswana Clinical Waste Management Code Practice, 1996 onsite transportation of clinical waste is supposed to be conveyed by red wheelie/pedal bins. The regular mode of transport observed for transportation of clinical waste to storage room at PMH was indeed by red pedal bins as shown on Plate 4.17. This was also supported by questionnaire respondents as shown in Figure 4.3. It was reported by the ICO at PMH that pedal rigid plastic bins are used to facilitate easier and safer waste transfer to the temporary storage room. Similar onsite transportation practices were reported in studied healthcare facilities in Malaysia and China, where medical waste is transported to storage room

using rickshaw trolleys (Dasimah *et al.*, 2012; Kumari *et al.*, 2012). Abor (2007) also reported that at Kotuba Hospital in South Africa, wheeled trolleys are used for onsite transportation of waste from the site of production to temporary storage areas.



Waste handler wearing protective clothing and transporting clinical waste using pedal bin.

Plate 4.17: Pedal bin used at Princess Marina Hospital for onsite transportation



Designated vehicle for clinical waste collection

Plate 4.18: Pick up used for clinical waste collection to incineration

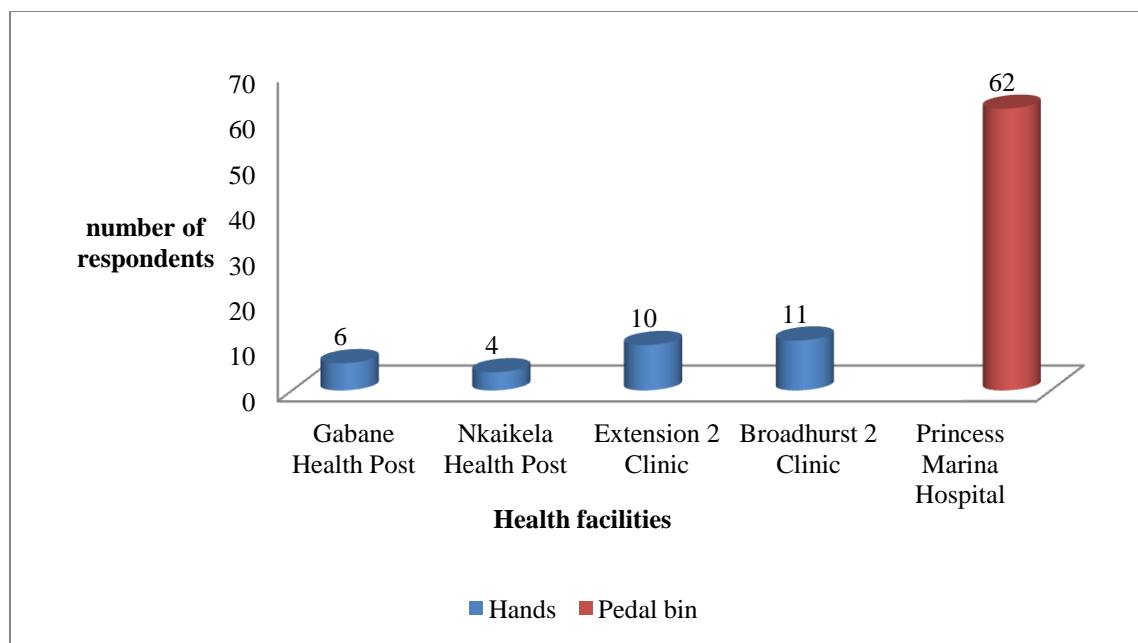


Figure 4.3: Methods of onsite clinical waste transportation

All respondents from clinics and health posts indicated that the common mode of transporting clinical waste to storage containers is by use of hands as shown in Figure 4.3. Waste handlers at Gabane Health Post carry waste with their bare hands without protective clothing which indicates a possible lack of awareness or training about potential risks involved such as personal injuries and accidents. Cleaners at Extension 2 Clinic were observed carrying clinical waste to storage containers with their hands and without adequate protective clothing as shown in Plate 4.12. This was contrary to the recommendations of Botswana Clinical Waste Code of Practice, 1996 which recommends the use of rubber gloves and aprons when handling clinical waste. Similar results were reported by Abd El-Salam (2008) in Bangladesh where internal transport to temporary storage areas is carried out manually by waste handlers without protective clothing, increasing the potential risks of accidents, personal injuries from protruding sharps and strain of the back due to weight. Dehghani *et al.* (2008) reported similar results where 46% of healthcare facilities in Iran transfer medical wastes to temporary stations manually using hands. Bdour *et al.* (2007) reported that clinical waste collected in studied hospitals in Jordan is transported by hands to the temporary storage areas, which are located within the hospitals. Because of poor collection practices, all waste collected manually by workers are then transported to the incinerator using uncovered trolleys.

4.3.5.2 Offsite transportation

The Botswana Clinical Waste Management Code Practice, 1996 recommends that transportation of medical waste on public roads must be carried out by trained staff using dedicated vehicles with closed containers. Small secure pickups labeled “CLINICAL WASTE FOR INCINERATION ONLY” were used by both, the contracted waste collection company for PMH and GCC waste collectors for offsite transportation of clinical waste to Gamodubu landfill for incineration as shown on Plate 4.18. Safe transportation of clinical waste to treatment area was reported by clinical waste collectors in all cases. The problem cited was that the landfill is far, 40km from Gaborone; sometimes vehicles for transporting clinical waste break down on the way, a lot of time is spent transporting waste, cost in terms of fuel and in addition to wear and tear. Collection and off-site transportation in surveyed health facilities in Bangladesh were conducted by a private company with little experience in management of medical waste and vehicles used fail to meet safety requirements (Abd El-Salam, 2008). Abor and Bouwer (2008) also reported that at Kotuba hospital in South Africa, offsite transportation of clinical waste is outsourced by a private waste management company and small pickups are mainly used to transport clinical waste. Abor and Bouwer (2008) further reported that using small pickup vehicles, wastes are usually heaped and they usually fall off the road during transportation and there is no supervision from hospital. This poses a serious health risk as well as nuisance to healthcare workers and patients.

4.3.6 Treatment of clinical waste

The treatment practices for clinical waste generated in surveyed healthcare facilities were investigated. The survey results indicated that all healthcare facilities incinerate clinical waste and this is done offsite. Interview results reveals that centralized treatment of medical waste has been implemented by all healthcare facilities in Gaborone. Clinical waste from all healthcare facilities both private and government facilities in Gaborone and Kweneng District are incinerated at Gamodubu landfill situated in Kweneng District, 40km from Gaborone. In agreement with this study (Abdulla *et al.*, 2008; Ananth *et al.*, 2010) found that the most frequently used treatment practice for solid medical waste was incineration. It has been reported in literature (Yong *et al.*, 2009; Dasimah *et al.*, 2012) that the studied hospitals in Nanjing, China

and District Hospitals in Malaysia practice centralized treatment of medical waste. Medical waste collected at Batu Pahan Hospital is incinerated 120km away from the hospital and takes about 2 hours transportation time. It was reported by the ICO at PMH that the incinerator at the hospital was closed in 2010 due to pollutants which were emitted during incineration which were polluting the hospital environment and surrounding areas. The Botswana Clinical Waste Code of Practice, 1996 recommends that onsite incinerators should be housed in an incinerator house which is at least 50m away from buildings and areas which are not accessed by the general public. The incinerator at PMH was reported not to comply with required standards. Similar problems were experienced at Tumpat Hospital in Malaysia where the incinerator at the hospital was closed in May 2011 due to leakages in its operating system (Dasimah *et al.*, 2012).

When asked where clinical waste is incinerated, about 55.9% of the respondents were aware that clinical waste is incinerated at Gamodubu landfill while 11.8% mentioned PMH and 9.7% Lobatse incinerator, 22.6% of questionnaire respondents (nurses and doctors) from clinics and health posts had no idea of where clinical waste is incinerated because they have never taken management of clinical waste as a part of the center's core business.

Although incineration was the treatment method applied in this study, WHO (2010) also suggest other treatment methods which include microwaves, autoclaving, sterilization and landfilling. Visits to the clinical waste disposal site incinerator at Gamodubu revealed regulated, systematic treatment and disposal of medical waste. There are two incinerators built in a big spacious storage room which is well ventilated and has washing facilities which include a shower, toilet and washing basin. The incinerators are secure and are not accessible to unauthorized people and no scavengers were found at incinerators as shown in Plate 4.19. The storage room is cleaned and disinfected twice a day. Clinical waste is burnt using diesel and electricity with temperature that ranges from 600⁰C to 800⁰C. During treatment, the incinerator door is periodically opened and waste materials turned for complete combustion. The incinerators are equipped with scrubbers to trap toxic air pollutants emitted as a result of the incineration. Loading and dishing operations were performed manually. Each incinerator has a capacity of 270kg and an average of 176kg of clinical waste is incinerated per hour. Clinical waste is weighed first before incinerating and the register for incinerated waste is kept. Emissions from

the incinerator chimney were colourless. Incinerator operator reported that they do not conduct emission testing for emitted gases.

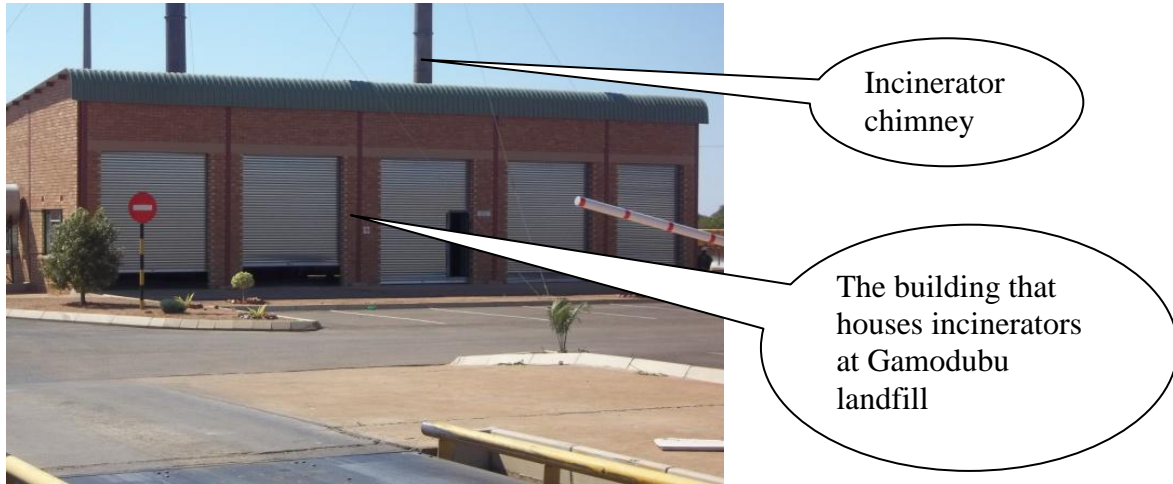


Plate 4.19: Incinerators at Gamodubu landfill in Kweneng District

Although the incinerators were reported to be overloaded with clinical waste from different places, the capacity of the incinerators was just enough to treat all the clinical waste brought in for incineration. Interview results reveal that there was no regular maintenance program for incinerators. Maintenance was conducted only when there was need or when an operational problem occurred. The Gamodubu landfill has facilities such as weighbridge (Plate 4.20) which is used to calculate the amount of waste a vehicle carries into the landfill.



Plate 4.20: Weighbridge at Gamodubu landfill in Kweneng District

In contrast to the results of this study Abd El-Salam (2010) reported that in El-Beheira, the incinerators operate below the recommended temperature. This means that the waste was not completely destroyed and the ash moves to a collar portion of the incinerators where it hardens into slag. Studies in several developing countries' healthcare facilities reported that incinerators are poorly designed and often have operational problems (Da Silva *et al.*, 2005; Coker *et al.*, 2009; Sawalem *et al.*, 2009; Ruoyan *et al.*, 2010). Nemathaga *et al.* (2008) reported that in a survey in South Africa, the incinerators burn clinical waste using coal as fuel, which cannot produce the required temperature to properly burn the waste.

4.3.7 Disposal of clinical waste

The incinerator operator at Gamodubu landfill reported that the requirements for clinical waste residual disposal are adhered to. Ash residues are removed every morning before incineration of a new day's load. The residue is carried by a front end loader truck from incinerator to the landfill. The incinerator operator cleans the girt from settling chamber, removes ash, weighs the ash and records the weight in a register. The plant operator transports the ash to the landfill for disposal. Residuals and ash observed were buried in a special excavation and covered with soil immediately after deposit. The location of the ash/residual disposal place is clearly identified. It was observed that ash/residuals at the closed incinerator at PMH have not yet been disposed of since 2010 (Plate 4.22). Nemathaga *et al.* (2008) reported that incineration residues from surveyed healthcare facilities were openly dumped at sites close to incinerators. This was contrary to the recommendation from WHO (2010), where incinerator residues are to be disposed in a designated place in a landfill. Moreira and Gunther (2013) also reported similar noncompliance disposal of clinical waste residuals at studied healthcare facilities in Sao Paulo, Brazil.

4.3.8 Training on clinical waste management

Proper handling of different types of waste is of paramount importance for health and safety at workplace in order to minimize risks (WHO, 1999). It is therefore imperative for healthcare workers and operatives to be conversant with dangers and hazards that may occur during the course of the duty. They need to be trained or oriented on the health and safety measures.

Questionnaire results indicated that 86% of respondents have received training on clinical waste management and 14% did not receive any training. Facility managers for surveyed clinics and health posts reported that there are no scheduled programs for in service training or workshops on clinical waste management. Only on job induction on clinical waste management was reported at Nkaikela Health Post when new employees join the organization. It was reported that the last training was done in 2008 when clinics and health posts were still under the administration of GCC, since then there has been no occupational healthcare programs in place for waste handlers.

Interview results indicated that, although there are limited or no formal training programs in clinics and health posts, healthcare workers have a good knowledge of clinical waste management due to long service and experience which would have given them on job-training opportunities. MoH is responsible for provision of training but for a long time no training has been done due to shortage of human and financial resources.

It was reported that at PMH training is offered upon first appointment of healthcare workers and later conducted periodically to ensure continuity as well as impart new knowledge to employees as it becomes available. Training and education programs were focused on all healthcare workers and ancillary staff. According to the interviews conducted, approximately 80% of all workers at PMH have been trained and received certificates of proficiency. Untrained officers usually are those who default scheduled training programs. The Infection control Officer reported that there is always a follow up for those persons who default the training programs. The content of these programs are specially designed for different personnel. At PMH the Infection Control Unit/Occupational Health Committee is responsible for offering training. Interview results also indicated that all clinical waste collection operatives from contracted company, GCC and incinerator operatives from Gamodubu landfill in Kweneng District have received training in clinical waste management and have certificates of proficiency. Similar results were reported in Istanbul healthcare facilities in Turkey where 98% of healthcare facilities organize training courses for collection personnel and training is carried out twice a year (Birpınar *et al.*, 2009). Regular and updated training and awareness programs were conducted in every department as per requirement in a studied medical hospital in China and

certificates of proficient are offered (Kumari *et al.*, 2012). In Malaysia 87.5% of healthcare workers in the studied District hospitals were reported to have received training and were aware of risks of clinical waste to both human health and the environment (Dasimah *et al.*, 2012).

Several other studies reported that healthcare workers were not educated enough in management of clinical waste and most of them have not had any special training on management of clinical waste (Diaz *et al.*, 2008; Coker *et al.*, 2009; Ananth *et al.*, 2010; Mochungong, 2010). Abor (2007) reported that medical staff in the studied healthcare facility have not yet received any formal training with regard to medical waste management and are consequently unaware of environmental health impacts of medical waste. Waste handlers in some healthcare facilities often opt to carry clinical waste containers on shoulders or with bare hands, which indicates a possible lack of awareness or training about potential risks involved (Coker *et al.*, 2009). Abdulla *et al.* (2008) reported that training programs on medical waste management for nurses, doctors and technicians were limited. About 29% of the hospitals in Northern Jordan had not provided training to doctors and other personnel on medical waste management (Abdulla *et al.*, 2008).

4.4 Access and familiarity to clinical waste management documents

The government of Botswana developed a Clinical Waste Management Code of Practice, 1996. The Code of Practice was developed to guide healthcare workers on managing hazardous waste generated in healthcare facilities. Questionnaire results indicated that 70% of healthcare workers are familiar with the code of practice and 30% were not familiar with the code of practice (Figure 4.4). Results also indicated that clinics and health posts had most respondents who were not familiar with the code of practice.

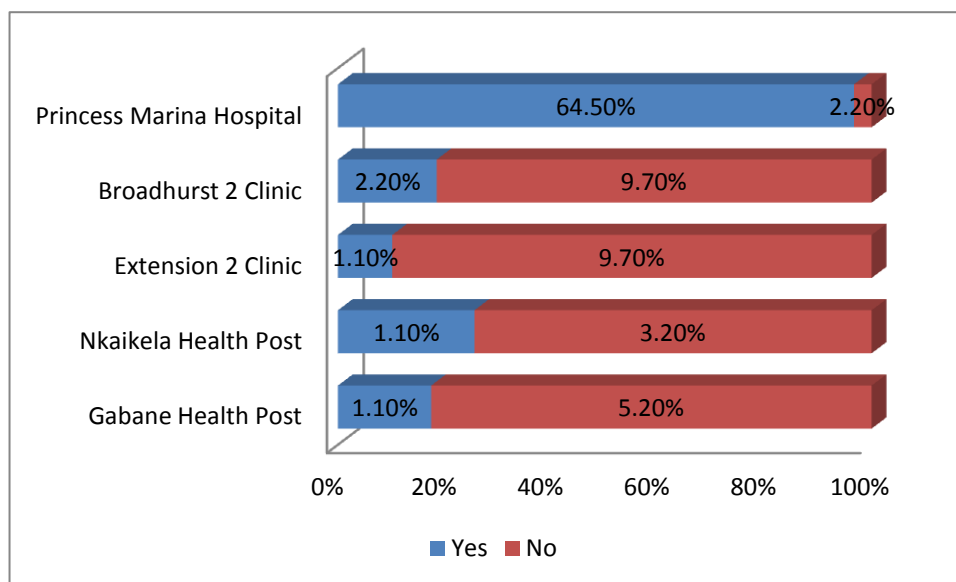


Figure 4.4: Knowledge of the Botswana Clinical Waste Management Code of Practice, 1996

All facility managers of surveyed healthcare facilities were aware of the existence of the following documents that are used in the management of clinical waste: Clinical Waste Management Code of Practice, 1996, Waste Management Act, 1998 and Clinical Waste Management Plan, 1998. It was reported that all surveyed clinics and health posts did not have the Botswana Clinical Waste Management Code of Practice and other documents related to clinical waste management. At PMH every unit and department has a Botswana Clinical Waste Management Code of Practice, 1996, Waste Management Act, 1998 and Clinical Waste Management Plan, 1998. It was reported by the Environmental Officer for GCC that lack of knowledge and understanding of the Botswana Clinical Waste Management Code of Practice, 1996 and other documents used to manage clinical waste results in different healthcare facilities applying different standards of practice to manage medical waste. In a similar research at two Botswana District Hospitals Mbongwe *et al.* (2008) reported that many healthcare workers have never seen or used the Botswana Clinical Waste Management Code of Practice, 1996.

Interview results with the Environmental Officer at GCC revealed that little progress has been made in the management of healthcare waste at healthcare facility level through the implementation of and compliance with the following documents: Botswana Clinical Waste Management Code of Practice adopted, 1996, Waste Management Act, 1998 and Clinical Waste

Management Plan, 1998. The implementation of these documents have been constrained by the fact that technical guidance provisions are weak at national, district and facility level leading to failure to achieve government goals to effectively manage clinical waste. The Environmental Officer from GCC also highlighted that clinics and health posts lack adequate and experienced human and financial resources to effectively manage clinical waste. The Environmental Officer further expressed that not enough follow up and implementation guidelines were put in place by government to persuade healthcare workers to implement these guidelines. However, lack of publication or marketing of these documents as important tools for healthcare workers has contributed to the documents not achieving their intentions to the fullest. The Environmental Officer further expressed that, due to lack of implementation of the above documents, the management of clinical waste from point of generation to final disposal was reported to be still weak and inconsistent in most healthcare facilities.

The Environmental Officer for GCC further reported that the Botswana Clinical Waste Management Code of Practice, 1996, Waste Management Act, 1998 and Clinical Waste Management Plan, 1998 address most issues concerning clinical waste management but have never been reviewed since their original publication. A review would have assisted MoH to improve the documents. The three documents were reported to be commensurable with international standards on environmental issues. The main problem was that of healthcare facilities not implementing the documents accordingly.

Contrary to the results of this study, Abor (2007) reported that in surveyed health facility in South Africa there is no clear policy or plan in place for managing medical waste. The Kotuba Hospital in South Africa has a medical waste management guideline prepared by the head of infection control but it is not strictly followed. A study by Abdulla *et al.* (2008) indicated that 29% of the healthcare facilities studied in Northern Jordan have policies that deal with medical waste, 10% of the hospitals have formal guidelines for medical waste management and 38% indicated that they were verbally informed about the national regulations. Abdulla *et al.* (2008) highlighted reasons for non compliance of these polices which include: lack of awareness, shortage of technical assistant to implement them and they are too costly to implement at their facilities. A similar study by Moreira and Gunther (2013) at a Primary Healthcare Center in Sao

Paulos, Brazil found out that most of the legal requirements for managing clinical waste were unknown to managers and healthcare workers and this resulted in many noncompliance episodes detected.

4.5 Effectiveness of clinical waste management practices in the healthcare facilities

Table 4.11: Percentage respondents rating of the effectiveness of clinical waste management practices per healthcare facility

Health Facility	Excellent %	Very Good%	Good %	Poor %	Total %
Gabane Health Post	0.0	0.0	16.7	83.3	100
Nkaikela Health Post	0.0	0.0	25	75	100
Extension 2 Clinic	0.0	0.0	40	60	100
Broadhurst 2 Clinic	0.0	0.0	27.3	72.7	100
Princess Marina Hospital	37.1	35.5	17.7.	9.7	100

The present clinical waste management practices dealing with clinical waste in surveyed clinics and health posts were rated poor by the majority of respondents. Table 4.11 shows that only respondents from PMH rated the effectiveness of clinical waste management practices excellent (37.1%) and very good (35.5%). These results suggest that the management of clinical waste at PMH is effective. The ICO at PMH concluded that the management of clinical waste at the hospital is effective; it meets most of the Botswana Clinical Waste Management Code of Practice, 1996 and WHO specifications. Dasimah *et al.* (2012) reported that the management of medical waste in studied District Hospitals in Malaysia was effective; it follows required standards and regulations.

Clinics and health posts do not have an effective management framework for collecting data on medical waste generated. Interview results reveal that all surveyed clinics and health posts do not keep or record any clinical waste management information. Since clinics moved from the management of GCC to be under the MoH, the management structure is not clear. The only record that is kept is for needle sticks and injuries that occur during treatment of patients. It was

reported that there are no committees and trained personnel responsible for monitoring the management of medical waste in clinics and health posts.

Facility manager for all studied clinics and health posts reported that ever since they were under the administration of MoH, the Ministry had not conducted any checks to ascertain compliance of clinical waste management with local and international laws. Absence of internal policies was also cited as one of the reason for poor clinical waste management. Internal policies are those that are established by individual healthcare facility to better the management of clinical waste (WHO, 2010). The Environmental Officer from GCC revealed that there are no programs in place for monitoring the management of clinical waste in clinics and healthcare facilities. Cooker *et al.* (2009) reported that the present management practices for dealing with medical waste in Ibadan, Nigeria are ineffective. This cut across waste storage, handling, collection, transportation and disposal practices. A study in China recognized that primary healthcare centers showed a number of waste management inadequacies than secondary or tertiary establishments (Ruoyan *et al.*, 2010). The identified areas of non compliance were: poor segregation, lack of equipments, inadequate location of storage containers, poor sanitary protective measures and unsafe onsite disposal (Ruoyan *et al.*, 2010).

4.6 Initiatives taken for effective management of clinical waste

In this study, no initiatives were reported at all surveyed clinics and health posts for the effective management of clinical waste at all surveyed clinics and health posts. It was reported that the Botswana Clinical Waste Management Code of Practice, 1996 and other related documents for clinical waste management are available at the Department of Clinical Services but no healthcare worker has taken any initiative to collect them. At Extension 2 Clinic it was reported that the health officers were once advised by PMH infection committee to be initiative and to come up with an Infection Control Unit. Since there has been no training in clinical waste management practices for health officers, no one was willing to take up the initiative. The facility manager at Extension 2 Clinic also reported that the management of clinical waste is not considered a core business of the healthcare facility.

A number of initiatives were reported at PMH. Clinical waste management audits are held quarterly. All the healthcare workers including those in management are sensitized and trained in clinical waste management. Training is done regularly and is a continual process. Waste handlers especially cleaners are checked by their supervisor every if they are wearing the correct protective clothing every time they go to the storage room.

The hospital has engaged private companies in cleaning and collection of clinical waste since 2010. Privatization of cleaning and collection of clinical waste has improved the management of clinical waste at the hospital. All departments and units have the Botswana Clinical Waste Management Code of Practice. There is an Infection Control Committee which is very active. The committee informs and ensures proper management of clinical waste.

4.7 The problems encountered in management of clinical waste

Questionnaire and interview respondents identified the following as problems in management of clinical waste in surveyed healthcare facilities:

- Although the system of colour coding and segregation was practiced by all surveyed healthcare facilities, labeling of containers/bags has not been adopted in clinics and health posts. As a result of the absence of appropriate labeling of clinical waste at clinics and health posts, it is difficult to identify the source and type of medical waste during treatment.
- Shortage of complete protective clothing is a major challenge in the handling of clinical waste in clinics and health posts.
- Incinerator operators and waste handlers complain of improper segregation. Empty tins and bottles of soft drinks are sometimes found in red plastics which are meant for clinical.
- Inadequate provision of storage receptacles was reported. Interview respondents reported instances of black and red bags used interchangeably especially when red bags are out of stock. Facility managers for health posts reported shortage of yellow sharps receptacles in health posts.

- The common storage containers are were badly managed and are insecure due to lake of fencing and surveillance

The following problems in management of clinical waste were also identified by Abor and Bouwer (2008) at a studied healthcare facility in South Africa:

- Lack of necessary rules, regulations on different aspects of collection and disposal of clinical waste.
- Failure to quantify clinical waste generated.
- Intermingling of clinical waste with domestic waste.
- Absence of waste managers responsible for monitoring medical waste management practices at Kotuba hospital.

Jang (2011) identified common problems in establishing sustainable management of medical waste in developing countries which include: insufficient financial and human resources for proper management of medical waste, ineffective legislation regulation for medical waste, shortage of healthcare workers and lack of public awareness about potential health effect arising from medical waste.

4.8 Risk management aspects

Exposure to risks associated with clinical waste poses potential risks to healthcare workers and operatives, the public and the environment. Therefore healthcare facilities need to manage their risks so as to protect human health and the environment from the risks associated with inappropriate management of clinical waste. The Botswana Clinical Waste Management Code of Practice requires that any healthcare worker who comes into contact with clinical waste must receive hepatitis B vaccination. Questionnaire results show that 92% of respondents have received hepatitis B vaccination and 8% did not receive the vaccination. Interview results with facility managers revealed the following: all ancillary workers and healthcare workers for Gabane Health Post and Broadhurst 2 Clinic have received the vaccination. At Extension 2 Clinic, record of vaccinated healthcare officer shows that 75% have been vaccinated and 25% defaulted. At Nkaikela Health Post it was reported that all workers in the institution received the vaccination except one who defaulted. At PMH it was reported that 80% of all healthcare

workers and ancillary staff were vaccinated, the 20% not vaccinated include new employees and defaulters. Interview results reveal that all clinical waste collection operators and incinerator operators have been vaccinated against hepatitis B.

It has been reported in literature (Ruoyan *et al.*, 2010) that 70.8% of healthcare workers in studied District hospitals in China received hepatitis B vaccination before starting work. Contrary to the findings of this study, Mochungong (2010) reported that in the studied healthcare facilities in Cameroon, waste handlers had not been immunized against tetanus and hepatitis B and the healthcare facilities invested less on safety and wellbeing of waste handlers because they are often unskilled and are of a low social status.

Interview results of this study revealed that training programs lacked in clinics and health posts. Continual training is done by PMH and authorities responsible for clinical waste collection. To minimize potential risks associated with clinical waste, use of protective clothing has been adopted by the surveyed healthcare facilities. To manage risks associated with residuals and ash dumped at landfill, the incinerator manager reported that residuals are compacted and covered with material specifically for that purpose.

4.9 Potential risks associated with clinical waste

When asked about the knowledge of potential risks associated with clinical waste about 96.8% of questionnaire respondents were familiar with the risks associated with clinical waste and 3.2% were not familiar with the risks. The most common risks cited were classified as human risks and environmental risks.

4.9.1 Risks of clinical waste on human health

The study revealed that no clinical waste related diseases were reported by questionnaire respondents. In addition, all surveyed healthcare facilities' records confirm no incidents of outbreaks of diseases related to medical waste in the past 12 months. A few cases of injuries to personnel were reported during handling and collection of clinical waste. Reported cases of injuries were at 5.4% while 94.6% did not encounter any injury. Needle pricks and blood

splashes were the main risks reported during the handling of clinical waste. An average of three needle pricks per year was reported at PMH. One case of needle prick was reported at Nkaikela Health Post in December 2012. The individual involved was tested for HIV and hepatitis B and C and the necessary treatment was given. No injuries were reported by clinical waste collection companies and incinerator operators.

According to Cooker *et al.* (2009), results revealed that incidences of contracting diseases are prevalent among waste handlers, compared to incidence of other hospital staff in Ibadan healthcare facilities in Nigeria. Waste handlers are exposed to occupational hazards or infection and are known to suffer directly from handling clinical waste in Ibadan healthcare facilities. Hospital records confirm that incidences of viral blood infection such as HIV and hepatitis B and C, skin infection, cholera, tuberculosis, bronchitis, food poisoning and typhoid fever were the contracted diseases, ailments and health risks indicated by waste handlers, which stem from medical waste handling in healthcare facilities in Ibadan, Nigeria (Coker *et al.*, 2009). It has been reported by Turnberg (1996), that in the USA, waste handlers involved in handling medical waste have a 2.7 - 4 times more chance of getting infected by HIV compared to other staff working inside a healthcare facility. Abd El-Salam (2010) reported that in more than half of surveyed healthcare facilities, clinical waste was handled manually without protective clothing, increasing potential risk of accidents and personal injury from protruding sharps. Mochungong (2010) reported that in surveyed healthcare facilities in Cameroon, waste handlers suffer from eye burns, skin related diseases, asthma and pneumonia due to shortage of protective clothing. Jang (2011) reported that in developing countries there was growing concern about the emergence of infectious diseases such as tuberculosis, hepatitis B and C virus, diphtheria and cholera caused by contact with waste materials.

Handling of clinical waste using bare hands has exposed handlers to all forms of infections (Plate 4.12). Interview results and observations also revealed that the odor from an open clinical waste storage container at Nkaikela Health Post has also affected waste collectors and people staying nearby. This study revealed that there is a shortage of heavy duty respirators for waste collectors from GCC. Waste collectors use light duty respirators and it was reported that lack/inadequate provision of protective clothing pose risks to the workers. It was evident that waste handlers

from clinics and health posts were susceptible to hazards either due to lack of protective gear or gear not fully protective, which includes, aprons, gloves, boots and masks. The facility manager for Nkaikela Health Post reported that shortage of complete protective clothing also poses risk of conveying infection from healthcare facilities to homes.

Inadequate supply of receptacles also leads to the inappropriate segregation of clinical waste, which in turn does not only pose a serious threat to the general public, operatives and the environment but mostly to refuse collectors and cleaners who are usually not equipped with adequate protective clothing to handle such waste. Improper segregation of clinical waste by staff was reported to result in needle pricks and cuts. Red plastic bags containing clinical waste from clinics and health posts were not labeled to indicate contents and place of origin. This might affect waste handlers and incinerator operators when handling them as they will not know the type of clinical waste contained and could not trace the source. It was reported that due to shortage of receptacles, the yellow containers for sharps were dangerous to close when too full.

Due to delays in clinical waste collection from clinics and health posts, flies, and worms were observed where clinical waste is stored. This can result in high chances of infectious disease outbreaks for example due to multiplication of flies which can contaminate food. Moulds were observed inside the open storage pedal bin (Plate 4.21) which can cause fungal diseases. Clinical wastes in all storage receptacles for all surveyed clinics and health posts were smelling and rotten. Taru and Kuvarega (2005) reported that absence of proper storage at the incinerator in Harare attracted rats and flies. The study further revealed that rats and flies constitute a prolific epidemic; rats have potential of spreading plague and fever, while flies may transmit bacillary dysentery and diarrhea disease when they come into contact with food.

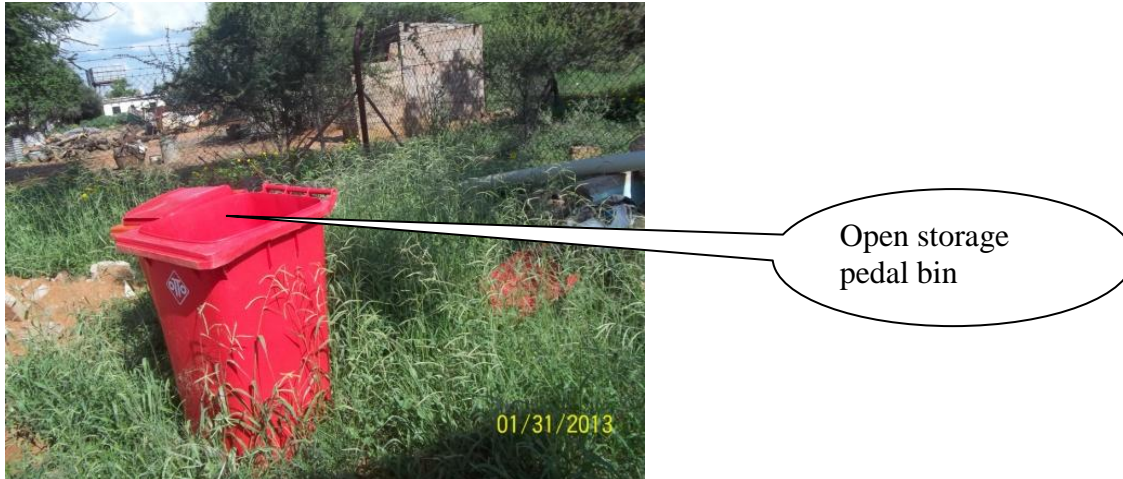


Plate 4.21: Open storage pedal bin at Nkaikela Health Post

Storage containers used at clinics were reported as not being user friendly, as they are deep. Therefore it was difficult to retrieve waste once thrown in (Plate 4.12). Facility managers confirmed that bins are not steam cleaned or disinfected after collection. This exposes clinical waste handlers to high risk of infection. Unprotected and insecure storage containers may pose health hazards to the patients, scavengers, animals and inhabitants at vicinity. The temporary storage containers at the surveyed clinics and health posts are not secured; patients, visitors and the entire environment are exposed to the dangers of clinical waste (Plates 4.12, Plate 4.13, Plate4.14 and plate 4.15).

It was evident from observational and interview analysis that residues and ash from PMH incinerator had not been disposed since 2010 when the incinerator was closed and incineration activities are now carried out at Gamodubu landfill. Tins, bottles and sharps that are harmful to workers who are directly involved in handling of such waste were observed as shown on Plate 4.22. Risks of dioxins from ash residuals which are extremely toxic substances were reported by the facility manager at PMH.



Ash residues mixed with tins in closed incinerator

Plate 4.22: Ash residues mixed with tins and bottles at Princess Marina Hospital closed incinerator

It was observed that clinical waste which was brought for incineration at Gamodubu incinerators was put on the floor before it is incinerated. There is no designated place at Gamodubu incinerators to keep clinical waste. Leakages on the floor from plastic bags containing medical waste were reported. This could be a source of health and environmental hazards (plate 4.23).



Clinical waste placed on the floor before incineration

Plate 4.23: Clinical waste placed on the floor at Gamodubu incinerators

4.9.2 Risks of clinical waste to the environment

The study revealed that due to poor segregations of waste, domestic waste, tins and bottles are disposed together with clinical waste. This has been reported by the incinerator operator to cause

incomplete combustion in the incinerators and result in release of noxious gases which pollute the air.

Clinical waste pollutes the soil and makes the environment dirty. Leachate from the open storage pedal bin at Nkaikela Health Post was reported to pollute the soil (Plate 4.21). It was also reported to contaminate water resources and underground water. The clinical waste in the open pedal bin attracted rats, dogs and birds. The waste was also exposed to direct sun, scavengers and rain that might seep through it and dissolve the hazardous components and carry them into surface and underground water.

Clinical waste residuals deposited at the landfill have potential to result in the contamination of underground water if not properly contained. It was reported by the incinerator manager at Gamodubu landfill that ashes/residual collected from the incinerators are not regularly tested to ascertain whether they were no harmful substances that could affect human health and the environment.

4.10 Solutions for effective management of clinical waste

When asked for solutions for effective management of clinical waste 26.9% of respondents were of the idea that the MoH should organize workshops for all healthcare workers, which emphasize proper segregation of clinical waste. About 8.6% mentioned that an effective and efficient waste segregation system should be developed and implemented in all clinics. Training of healthcare workers on clinical waste management issues was suggested by 68.8%. It was also suggested by 16.1% that the training programs should be conducted regularly. Interview results with facility officers at Gabane Health Post and Broadhurst 2 Clinic added that proper training in clinical waste management is necessary to develop awareness on health, safety and environmental issues. Demonstrative programs were also proposed by facility manager at Broadhurst 2 Clinic for employees who are in direct contact with healthcare waste. This was suggested to provide an improved understanding of risks and importance of health and safety measures during handling and segregation of clinical waste. The ICO at PMH suggested that all healthcare workers should attend the scheduled clinical waste management workshops.

For effective management of clinical waste 33% of questionnaire respondents suggested that secure temporary storage rooms should be built for clinics and health posts and they should be located away from public access. About 5.4% suggested that storage containers at clinics and health posts should be clearly labeled and disinfected regularly after clinical waste is collected. It was suggested by 29% of the questionnaire respondents that the MoH should employ waste management officers at each healthcare facility or Infection Control Officers who will be responsible for monitoring clinical waste management activities in clinics and health post and set up necessary strategies to manage waste. It was also suggested by 13.9% that clinics and health posts should set up committees comprising of Infection Control Officers, representatives of healthcare workers and ancillary staff to be responsible for monitoring medical waste management activities. These committees must be in charge of periodical reviewing and resolving medical waste management issue. Interview results with facility managers from Nkaikela Health Post and Broadhurst 2 Clinic also suggested that big hospitals like PMH should help monitor closely waste management activities at clinics and health posts.

For effective management of clinical waste 75.2% suggested that healthcare workers should be provided with adequate protective clothing and equipments. About 16.1% suggested that healthcare workers should know and understand the potential risks associated with medical waste and importance of consistent use of personal protective equipment.

Interviews with facility managers for surveyed clinics and health posts suggested that documents pertaining to quantity of waste generated at healthcare centers should be developed and maintained in clinics and health posts. Botswana Clinical Waste Management Code of Practice and other related documents for management of clinical waste should be provided to clinics and health posts. About 19.4% suggested that the MoH should disseminate information with respect to clinical waste management practices to clinics, health posts and the public at large.

To improve the effectiveness of clinical waste management, the manager of the contracted private company responsible for clinical waste collection suggested that the government should give license to private companies to own incinerators as this will reduce over use of the incinerators at Gamodubu landfill.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This research was carried out to evaluate the clinical waste management in GCC healthcare facilities. In this chapter, the conclusions and recommendations are given in relation to the results and the objectives of the study. Appropriate recommendations are made within the context of the findings of the study with a focus on the improvement of clinical waste management in GCC healthcare facilities. Finally, suggestions for further research are presented.

5.1 Conclusion

The MoH has developed the Botswana Clinical Waste Management Code of Practice, 1996, Waste Management Act, 1998 and Clinical Waste Management Plan, 1998 aimed at ensuring appropriate management of clinical waste in healthcare facilities. In conclusion, the main findings of the study are identified as follows:

- The medical waste generation ranged from 0.11kg/patient/day to 0.75kg/patient/day in the surveyed healthcare facilities with an average of 0.24kg/patient/day. PMH has an average generation rate of 1.1kg/bed/day. The most significant factors affecting generation of medical waste were type and size of the healthcare facility, number of patients who visit the healthcare facility and the type of services provided. Results indicated that clinical waste was always measured and results well documented only at PMH. In the surveyed clinics and health posts clinical waste was not quantified and there were no documents for clinical waste generated. “You cannot manage what you do not measure”, is a classical management axiom and has been repeatedly proven (Ananth *et al.*, 2010). Managing clinical waste for improvement is impossible if it is not quantified. Quantifying clinical waste will help ascertain the nature of the waste and also the healthcare facilities that generates the highest and lowest medical waste and this could have an implication for resource allocation in managing medical waste

- Segregation procedures of different types of wastes were not constantly followed. Poor segregation was reported in all surveyed healthcare facilities where instances of clinical waste mixed with general waste, was observed at the incinerator. Poor segregation was observed at Gabane and Nkaikela Health Posts where only red plastics and yellow sharps receptacles were used. It was only at PMH where waste receptacles were well labeled after segregation. Clinical waste receptacles in surveyed clinics and health posts are not labeled after segregation. This is a sign of poor clinical waste management practice, because clinical waste from these facilities cannot be traced back to the healthcare facilities of origin when it gets to the incinerator.
- Typically handling of clinical waste in the surveyed clinics and health posts was assigned to healthcare workers who performed all activities without proper training and with insufficient protection. Waste handlers at PMH and contracted collection companies handled clinical waste with appropriate health and safety measures, using appropriate protective clothing.
- Clinical waste is temporarily stored in a secure, well sanitized and well ventilated central storage facility at PMH. Storage facilities at the surveyed clinics and health posts lacked security and surveillance and were not cleaned after collection. Storage facilities at clinics and health posts failed to meet the requirements of the regulations.
- Collection of clinical waste is outsourced to a private company at PMH and it is done by the local authority at surveyed clinics and health posts. Collection services are efficient and reliable at PMH whereas the local authority provides unreliable collection services for the clinics and health posts.
- The common mode of transporting clinical waste to storage containers at clinics and health posts was by the use of hands. Waste handlers carried clinical waste with bare hands, this indicated a lack of training and awareness of potential risks associated with medical wastes. Pedal bins were used to transport clinical waste to storage facilities at PMH. Offsite transportation of clinical waste to Gamodubu landfill was done by local the authority and the private company. Clinical waste was transported safely using

designated vehicles which met the required safety standards. Transportation by GCC was reported to be less efficient as clinical waste would stay in storage containers for 2-3 days before transportation for incineration.

- The most common treatment method used for clinical waste was incineration. Centralized incineration was used for all healthcare facilities in Gaborone and surrounding districts. Well regulated and systematic treatment of clinical waste that follows the Guidelines for Disposal of Waste by Landfill, 1997 was reported. The two incinerators at Gamodubu Landfill in Kweneng District meet the MoH regulation/requirements. There were no regular maintenances for incinerators. Requirement for residual/ash disposal were adhered to.
- About 86% of healthcare workers received training in clinical waste management. PMH offers continual training for all healthcare workers including those in management. There was absence of training programs at the surveyed clinics and health posts. The last training reported was in 2008 when clinics and health post were under the administration of the local authority. The management of clinical waste at clinics and health posts is governed by untrained waste handlers.
- About 70% of respondents were familiar with the Botswana Clinical Waste Management Code of Practice and other related documents. Every department/unit at Princess Marina hospital has the Botswana Clinical Waste Management Code of Practice and related documents for management of clinical waste. Surveyed clinics and health posts did not have any document used for management of clinical waste. Due to lack of application of clinical waste related documents at the surveyed clinics and health posts, management of clinical waste is weak and inconsistent. Healthcare workers at clinics and health posts were not aware of the waste regulations and standards available in management of clinical waste.
- From the study results it is obvious that clinical waste management at clinics and health post is not properly managed. Clinical management practices have been rated poor at clinics and health posts. It has become evident that as clinics and health posts fulfill their

commitment to provide safe healthcare services and to heal the sick, aspect of managing clinical waste are left behind. A number of initiatives were carried out at PMH which resulted in effective management of medical waste.

- Survey respondents showed various levels of understanding risks associated with medical waste and how they are managed.

5.2 Recommendations

The current practices of medical waste management in surveyed GCC healthcare facilities were assessed and areas of non compliance were identified. Based on the findings of this study, there is need to improve the clinical waste management practices in the local context. To achieve this some recommendations are presented here, for different aspects of medical waste management.

5.2.1 Generation

- Clinics and health posts should have weighing facilities so as to have quantified statistics of clinical waste generated. This will assist them in making informed decisions regarding clinical waste generated and disposed of.
- Healthcare facilities should be benchmarked using a standard by which clinical waste may be measured in comparison to clinical waste management best practices at similar facilities. When benchmarks are established healthcare facilities will be able to monitor themselves and compare their performance with peer groups within the country, region or the whole world.
- Documents pertaining to quantity of clinical waste generated and health care waste management practices in clinics/health post should be maintained and updated.

5.2.2 Segregation and handling

- Proper training should be provided to healthcare workers, ancillary staff, patients and everyone involved in the clinical waste management process regarding appropriate

segregation practices and potential hazards associated with improper procedures such as handling without personal protective equipment.

- A system of labeling of waste receptacles according to requirements of Botswana Clinical Waste Management Code of Practice should be used consistently in clinics and health posts.
- Healthcare facilities should ensure that different types of receptacles are in adequate quantities and are continuously available in order for clinical waste to be segregated.
- Management at clinics and health posts should ensure that, not under any circumstances should bare hands be used to transport bags containing clinical waste to storage containers.
- Healthcare facilities managers should ensure that adequate protective clothing is available and waste handlers wear full protective clothing at all times when handling clinical waste.

5.2.3 Storage and collection

- GCC should build secure storage facilities for clinics and health posts with “No entry” sign strategically placed to inform unauthorized persons of dangers of entering controlled area.
- Storage facilities at clinics and health posts should be cleaned and disinfected in conformity with Botswana Clinical Waste Management Code of Practice to reduce possibility of risks that may occur as a result.
- Proper location of temporary storage areas should be enforced that is away from functional areas such as toilets.
- Considering that Botswana is characterized by hot temperatures clinical waste should be collected daily at clinics and health facilities

5.2.4 Transportation

- Medical waste should be transported on-site and in suitable dedicated wheeled and leak-proof containers which are clearly marked BIO HAZARD in all clinics and health posts.

- MoH should encourage clinics and health posts to ensure that clinical waste which is subject to transportation for incineration off-site is packed and labeled in conformity with the requirements of Botswana Clinical Waste Management Code of Practice and generally accepted and recognized international standards for easy identification and urgent incineration.
- Fixed schedule for off-site transportation of clinical waste should be defined, thus reducing the complexity of medical waste management.

5.2.5 Treatment and disposal

- Storage shelves to keep clinical waste before incineration should be erected in the storage room at the incineration plant, to avoid putting the clinical waste on the floor.
- Healthcare facilities should follow up waste collected within their portfolios and check if it has been appropriately treated and disposed of in order to minimize risks to human health and environment.
- Private companies might have plans to own incinerators so that they can treat clinical waste they collect. It is recommended that the government give licenses to private companies to own incinerators.
- Residuals/ash should be regularly tested for harmful substances that could affect human health and the environment and disposed appropriately.
- Waste like tins, bottles and plastics should be recycled and not incinerated.

5.2.6 Training and education

- Staff at all levels should be continually trained on clinical waste management issues to ensure complete awareness and compliance to Botswana Clinical Waste Management Code of Practice.
- The MoH should periodically evaluate the effectiveness of training and education programs.

- Clinics and health posts should have Infection Control Team/committees which include environmental health experts and waste management experts. This will improve the ability and effectiveness of the Infection Control Team to carry out its operations.
- Information with respect to risks involved in healthcare waste management practices have to be disseminated to the public or general community.
- MoH should develop training modules in both English and Setswana on clinical waste management procedures for all health personnel at different levels.
- MoH should establish and implement medical waste management programs to control and improve the existing situation in GCC healthcare facilities.
- The MoH should expand capacity building and training of healthcare workers in healthcare waste management at national level.

5.2.7 Clinical waste management aspects

- Clinics and health posts should develop strategic plans for dealing with management of clinical waste issues, which include performance indicators in order to address health and environmental risks.
- Healthcare facilities should evaluate operations within their jurisdictions in order to assess whether they efficiently and effectively comply with Botswana Clinical Waste Management Code of Practice requirements and take corrective action.
- The MoH should upgrade the Botswana Clinical Waste Management Code of Practice, Clinical Waste Management Plan and Waste Management Act in order to meet the current international standards on clinical waste management.
- MoH should conduct spot checks to ascertain compliance of clinical waste management to local and international laws and to ensure environmentally sound principles are adhered to.
- The MoH should use mass media in sensitizing the general public and raising their awareness level on environmental risks associated with improper management of medical waste.
- Healthcare facilities should manage risks so as to protect human health and environmental risks associated with inappropriate management of clinical waste.

5.3 Recommendations for further study

This study was not exhaustive, additional research is required on the management of clinical waste.

- There is need to find the actual cost of medical waste management in healthcare facilities since this was not evaluated in this study.
- There is also need to evaluate clinical waste management practices in more healthcare facilities in Botswana, including the private owned healthcare facilities.

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APPENDIX I: QUESTIONNAIRE

AN EVALUATION OF CLINICAL WASTE MANAGEMENT IN GABORONE CITY COUNCIL HEALTHCARE FACILITIES.

My name is Bongayi Kudoma. I am carrying out a study on the evaluation of clinical waste management in Gaborone City Council healthcare facilities. This study is a requirement in partial fulfillment for the completion of Masters Degree in Environmental Management with the University of South Africa (UNISA).

Information collected will be treated confidentially, only the researcher and the college will have access to information provided and the results will be used for academic and research purposes only. Participation in this survey is voluntary and you can withdraw from the study without any obligations, but you are encouraged to take part and answer all questions to the best of your ability.

SECTION A (Demographic data)

TICK IN THE MOST APPROPRIATE BOX WHERE APPLICABLE.

- 1. Name of your healthcare facility -----
- 2. Status of your healthcare facility: Referral hospital Hospital Clinic
Health Post Other specify -----
- 3. Gender : Male Female
- 4. Age: 21-30 31-40 41-50 51-60 60+
- 5. Occupation: Doctor Nurse Pharmacist Laboratory Staff
Ancillary Staff Pharmacist Radiographer Other Specify-----
- 6. State your period of work experience in health facility -----

SECTION B. (Clinical waste generation and management strategies).

- 7. What are the types of wastes generated at your healthcare facility?-----

- 8. Is infectious waste generated at your healthcare facility? Yes No
- 9. What are the sources of clinical waste generated in your health care facility -----

- 10. On average how much waste is generated per day in your healthcare facility? -----

11. Is waste generated in your healthcare facility segregated? Yes No
12. How do you rate segregation of clinical waste?
 Poor Good Very Good Excellent
13. Describe how waste is segregated -----

14. Where is hazardous clinical waste stored? Black refuse plastic bag
 Red clinical waste plastic bag Standard metal dust bin
 Pedal bin Yellow Sharp container others specify -----
15. How is the storage of clinical waste awaiting transportation to the incinerator?
 Secure Insecure
16. How do you rate the handling of clinical waste?
 Excellent Very Good Good Poor
17. Do you use protective clothing when handling clinical waste? Yes No
18. Are you provided with protective clothing when handing clinical waste?
 Yes No
19. If yes state the protective clothing you use:-----

20. Have you received any training in clinical waste management?
 Yes No
21. Who collect clinical waste in your healthcare facility-----
22. How often is clinical waste collected by the authority mentioned in (21)?
 Daily Once a week Once per fortnight
 Once per month Others specify-----
23. What is the mode of transportation of clinical waste within the healthcare facility (onsite)?

24. Is there an incinerator at your healthcare facility? Yes No
25. If no, where is clinical waste incinerated? -----
26. How do you rate the effectiveness of clinical waste management processes in your healthcare facility?
 Poor Good Very Good Excellent
27. What are the initiatives taken for effective management of clinical waste? -----

28. What are the problems you encounter in managing clinical waste in your healthcare facility?

29. Are there any outbreaks of clinical waste related diseases reported in your healthcare facility in the past 12 months? Yes No

30. If yes, State the diseases-----

31. Have you ever read or taught about the Clinical Waste Management Code of Practice?

Yes No

32. The Clinical Waste Management Code of Practice requires any healthcare worker who comes into contact with clinical waste to receive hepatitis B vaccination. Did you receive the vaccination? Yes No

33. Have you ever sustained any injury during the handling of clinical waste in the past 12 months? Yes No

34. What are the risks of clinical waste to:

a) The human health-----

35. The environment-----

36. What solutions should employed for effective management of Clinical waste?-----

APPENDIX II: INTERVIEW GUIDES

INTERVIEW GUIDE: For contractor /Gaborone City Council authority responsible for collection and disposal of clinical waste.

1. How often do you collect clinical waste in healthcare facilities?
2. How much waste do you collect in (a) Clinics (b) Hospitals (c) Health posts?
3. Is the clinical waste that you collect segregated at source?
4. Where is clinical waste stored waiting for collection and disposal?
5. How secure are the clinical waste storage facilities in healthcare facilities where you collect clinical waste?
6. What types of vehicles are used to transport clinical waste?
7. Is the transportation of clinical waste to designated places safe?
8. Where is clinical waste treated?
9. Did clinical waste handlers receive any training in management of clinical waste?
10. Are waste handlers provided with protective clothing when handling clinical waste?
11. Did waste handlers receive any vaccination against hepatitis B?
12. What are the risks associated with clinical waste that have been encountered by in the past 12 months?
13. What are the problems that you encounter in collection and disposal of clinical waste?
14. What recommendations would you give for the improvement of medical waste management?

INTERVIEW GUIDE: Facility waste manager/Health safety officer.

1. How many people visit your healthcare facility per day?
2. How much clinical waste is generated per day?
3. How many injuries related to clinical waste have been reported by healthcare workers and waste handlers in the past 12 months?
4. The Clinical Waste Management Code of Practice requires that all healthcare workers and operatives should be offered hepatitis B vaccination. How many health workers in your institution received the vaccination?
5. How often is clinical waste collected?
6. If clinical waste is not collected as per schedule what do you do with it?
7. Is clinical waste storage accessible to any person or scavengers?
8. Do you record any clinical waste management information?
9. How often is in-service training on clinical waste management for healthcare workers done?
10. Who is responsible for providing a continuous clinical waste training for healthcare workers?
11. How do you manage risks associated with clinical waste?
12. Do you make a follow up of clinical waste collected from your healthcare facility to the landfill to check if it is incinerated properly?
13. What are the problems that you encounter in managing clinical waste?
14. What are the initiatives taken for effective management of clinical waste?
15. What are the risks that inappropriate management of clinical waste poses to?
 - (a) The environment.
 - (b) Human health.
16. What solutions can be employed to improve the efficiency of clinical waste management used?

INTERVIEW GUIDE: For Environmental officer from Gaborone City Council

1. To what extent do healthcare facilities implement and comply with the following documents:
 - a. Botswana Clinical Waste Management Code of Practice adopted in 1996.
 - b. Waste Management Act, 1998.
 - c. Clinical Waste Management Plan, 1998.
2. Has the above documents being evaluated to assess if it is addressing all clinical waste issues?
3. Is the Botswana Clinical Waste Management Code of Practice commensurable with international standards with on environmental issues?
4. What are the risks that inappropriate clinical waste management poses to the environment and human health?
5. How often does the city council monitor the management of clinical waste in healthcare facilities?
6. Is clinical waste disposed same as domestic waste at landfill?

APPENDIX III: OBSERVATION/ MEASUREMENT SHEET

PLACE OF OBSERVATION

DAY	1	2	3	4	5	6	7
DATE							
Quantity of clinical waste per day							
Number of patients who visited the healthcare facility per day							
Sources of clinical waste							
Segregation of waste at source: Yes No							
Bag containing waste -Secured fastened -Not fastened securely -Placed at right place -Left for too long							
Supply of Receptacles Adequate/inadequate -Red plastic -Sharp container -Pedal bins -Others (Specify)							
Use of colour coded and labeled receptacles							
Mode of transport to storage place							

-Use of hands -Pedal bin -Other specify							
Use of protective clothes when handling waste							
Types of protective clothing used							
Clinical waste storage room -Secure/ insecure -Ventilated/not ventilated area -Presents of scavengers -Presents of worms, flies, animals -Presents of leachates. -Waste spilling.							
State of waste. -Rotten -Smelling -Dry							
Collection -Collected/ not collected							
Storage room, bins, trolleys cleaned after collection							

<p>Waste transportation off-site</p> <ul style="list-style-type: none"> -Use of designated vehicle -Use of any vehicle 							
<p>Presence of incinerator.</p> <ul style="list-style-type: none"> -Incineration procedure followed/ not followed -Residues collected to landfill /not collected 							
<p>Others things observed</p>							

APPENDIX IV: CLINICAL WASTE MONITORING TOOLS FOR PRINCESS MARINA HOSPITAL

INFECTION CONTROL/ OH & S OFFICE

CLINICAL WASTE MONITORING TOOL

DATE	TIME	WARD/UNIT	NO OF WASTE BAGS	NO OF SHRPS CONT.	WEIGHT	BROUGHT BY (FULL NAME)	RECEIVED BY (FULL NAME)
25/02/13	08:09	BCT	13		75.1kg	Cecilia	MALCOTE
25/02/13	08:20	ICU	11		11.65kg	Kgwato	MALCOTE
25/02/13	08:25	BHP	9		24.7kg	Boniface	Mpoloka
25/02/13	08:30	Fow	9		14.9kg	Tholego	Mpoloka
25/02/13	08:37	Surigical	13		15.5kg	Emetsh	Mpoloka
25/02/13	08:37	Lab ward	20		25.25kg	Shefiso	Mpoloka
25/02/13	08:40	Lab ward	11		9.65kg	Pinkie	Mpoloka
25/02/13	08:40	MOW	4		5.65kg	Maggie	Mpoloka
25/02/13	08:44	msw	12		10.15kg	Tshekhatso	Mpoloka
25/02/13	08:45	Oronology	4		6.25kg	Gosalamana	Mpoloka
25/02/13	08:59	Dental	17		10.70kg	N. Rakgano	MALCOTE
25/02/13	09:18	Gunaward	21		27.4kg	Tshogo	Mpoloka
25/02/13	09:39	MMW	23		42.30kg	SERWALO	MALCOTE
25/02/13	09:41	✓ A&E	10	13 SHRPS	23.00kg	Mpoloyeng	MALCOTE
25/02/13	09:45	MNU	11		10.40	kgomoko	MALCOTE
25/02/13	10:05	FMIW	11		15.00	Boipelo	Boikamo
25/02/13	10:19	I.C.U	13		13.05kg	TEBOGO	Boikamo
25/02/13	10:19	FSW	12		9.80kg	GRALALETENG	Boikamo
25/02/13	11:20	PSW	7		11.25kg	TATHEGO	MALCOTE
25/02/13	11:55	PMH LAB	14		24.9kg	Victoria	Mpoloka
25/02/13	12:45	pmw	14		30.35kg	BAMJANA	Boikamo
25/02/13	13:20	940AE ET	6		10.70kg	Beauty	Boikamo
25/02/13	13:50	LABOUR	12		42.1kg	Betty	Boikamo
25/02/13	14:20	IG	20		29.40	segomoto	Boikamo
25/02/13	14:30	BH LAB	17		12.90kg	LMOREMI	Boikamo
25/02/13	14:30	Spinalis	11		4.90kg	kgomotoo	Boikamo
25/02/13	14:51	F.m.w	4		7.5kg	Boitumeto	

PREPARED BY.....SIGN.....DATE.....

AUTHORIZED BY.....SIGN.....DATE.....



INFECTION CONTROL OFFICE
CLINICAL WASTE COLLECTION

DATE	WEIGHTS

Compiled By : _____

Signature : _____

Collected By : _____

Signature : _____

DATE	WEIGHTS

Compiled By : _____

Signature : _____

Collected By : _____

Signature : _____

APPENDIX V: CONSENT OF PARTICIPANTS

CONSENT FORM

TITLE OF RESEARCH PROJECT

An evaluation of the effectiveness of clinical waste management systems in Gaborone City Council health facilities.

Dear Mr/Mrs/Miss/Ms

G. Dikho

Date 13.12.2013

NATURE AND PURPOSE OF THE STUDY.

The purpose of the study is to assess the clinical waste management systems used in Gaborone City Council health facilities.

The study involves individual interviews to get their views on clinical waste generation, its management practices, impacts and knowledge on clinical waste management. More information will be gathered from questionnaires which will be administered to selected health facility workers. Questionnaire will be used to solicit on types of clinical waste generated, collection patterns, treatment/disposal method and risks related to clinical waste.

RESEARCH PROCESS

1. The research requires your individual participation in answering interview questions based on clinical waste management practices.
2. The interview discussion will be lead by the resaecher.
3. The interview will offer you an opportunity to express your opinion on clinical waste management practices used in health facilities.
4. There is no right or wrong answers and all your opinions will be valued.
5. You do not need to prepare anything inadvice for the interview; the researcher will visit you in your office at your work place.
6. The reseacher will bring along an interpreter to translate the discussion into Setswana if you want to communicate in Setswana.

NOTIFICATION THAT PHOTOGRAPHIC MATERIAL, TAPE RECORDINGS, ETC WILL BE REQUIRED

- No tape recording will be done during the interview and questionnaire answering but the reseacher will take photographs of clinical waste as the study will be going on.

CONFIDENTIALITY

- The opinions of every participant will be treated as confidential and only the researcher and college will have access to the information provided. No names will be published in the dissertation. Your anonymity is therefore assured.

WITHDRAWAL CLAUSE

- I understand that I may withdraw from being part of the interviewee at any time. I therefore participate voluntarily until such time as I request otherwise.

POTENTIAL BENEFITS OF THE STUDY

workers, the community at large and the environment. This research is meant to improve the situation on clinical waste management systems. Findings will help to supplement the existing knowledge on clinical waste management systems and to improve the existing policies and planning measures in order to mitigate impacts of ineffective management of clinical methods used.

INFORMATION (contact information of your supervisor)

- If you have any question concerning the study you may contact the supervisor, Prof Memory Tekere, at the Department of Environmental Sciences, Florida Campus, UNISA.
- Tel +27 11 471 2270. Fax +27 11 471 2866 email tekerm@unisa.ac.za

CONSENT

I, the undersigned, GOKATHONG DICKO (full name) have read the above information relating the research and have also heard the verbal version, and declare that I understand it. I have been afforded the opportunity to discuss relevant aspects of the research with the researcher, and hereby declare that I agree voluntarily to participate in the project.

I indemnify the university and any employee or student of the university against any liability that I may incur during the course of the project.


I further undertake to make no claim against the university in respect of damages to my person or reputation that may be incurred as a result of the research or through the fault of other participants, unless resulting from negligence on the part of the university, its employees or students.


I have received a signed copy of this consent form.

Signature of participant: Dicko

Signed at P.M.H on 13/02/2013

WITNESSES

1 SIMBATHE T. GATHIRAI 

2 TAKESURE KANGOMA 

APPENDIX VI: UNISA ETHICS CLEARANCE LETTER



2013-01-23

Ref. Nr.: 2012/CAES/044

To:
Student: Mrs B Kudoma
Supervisor: Prof M Tekere
Department of Environmental Science
College of Agriculture and Environmental Sciences

Student nr: 50519204

Dear Prof Tekere and Mrs Kudoma

Request for Ethical approval for the following research project:

An evaluation of the effectiveness of clinical waste management systems in Gaborone city council health facilities

The application for ethical clearance in respect of the above mentioned research has been reviewed by the Research Ethics Review Committee of the College of Agriculture and Environmental Sciences, Unisa. Ethics clearance for the above mentioned project (Ref. Nr.: 2012/CAES/044) **is granted** after careful consideration of all documentation and submitted to the CAES Ethics committee. The researcher is requested to adhere to all stipulations indicated in the letter dated 20 November 2012 with reference number PPME 13/18/1 PS V(237) made by the Botswana Ministry of Health.

Please be advised that the committee needs to be informed should any part of the research methodology as outlined in the Ethics application (Ref. Nr.: 2012/CAES/044), change in any way. In this instance a memo should be submitted to the Ethics Committee in which the changes are identified and fully explained.

We trust that sampling, data gathering and processing of the relevant data will be undertaken in a manner that is respectful of the rights and integrity of all participants, as stipulated in the UNISA Research Ethics Policy.

The Ethics Committee wishes you all the best with this research undertaking.

Kind regards,

Prof E Kempen,
CAES Ethics Review Committee Chair



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

APPENDIX VII: MINISTRY OF HEALTH CLEARANCE LETTER

TELEPHONE: 363 2766
FAX: 391 0647
TELEGRAMS: RABONGAKA
TELEX: 2818 CARE BD



Republic of Botswana

MINISTRY OF HEALTH
PRIVATE BAG 0038
GABORONE

REFERENCE NO: PPME 13/18/1 PS V (237)

20 November 2012

Health Research and Development Division

Notification of IRB Review: New application

Bongayi Kudoma
Tshwaragano Brigades
P.O. Box 181
Gabane

Protocol Title: AN EVALUATION OF THE EFFECTIVENESS
OF CLINICAL WASTE MANAGEMENT
SYSTEMS IN GABORONE CITY COUNCIL
HEALTH FACILITIES

HRU Protocol Number:	HRU 00777
HRU Approval Date:	20 November 2012
HRU Expiration Date:	19 November 2013
HRU Review Type:	HRU reviewed
HRU Review Determination:	Approved
Risk Determination:	Minimal risk

Dear Ms Kudoma

Thank you for submitting new application for the above referenced protocol.

This approval includes the following:-

1. Application form
2. Protocol
3. Data collection tools

This permit does not however give you authority to collect data from the selected sites without prior approval from the management. Consent from the identified individuals should be obtained at all times.

The research should be conducted as outlined in the approved proposal. Any changes to the approved proposal must be submitted to the Health Research and Development Division in the Ministry of Health for consideration and approval.

APPENDIX VIII: PRINCESS MARINA HOSPITAL CLEARANCE LETTER AND MEMO FOR PERMISSION TO CONDUCT STUDY



Telephone: +267 362 1400

P O Box 258, Gaborone, Botswana

REFERENCE:	PMH 5/79 (1)	DATE: 7 January 2013
Title	The Evaluation of Clinical Waste Management Systems in Gaborone City Council Health Facility	
Principal Researchers	Mrs Bongayi Kudoma, Tshwaragano Brigade, P O Box 181, Gabane. Telephone: (+267) 7144-2531/ (+267) 7323-5979. E-mail: bmakova06@yahoo.com .	
PMH Decision	Full approval	
Expiry Date	6 January 2014	

Dear Mrs Kudoma,

Reference is made to your letter of response dated 4 January 2012. We thank you for making the corrections that we requested you make. You have full approval to conduct the research at Princess Marina Hospital. The following conditions will apply:

1. You must submit one (1) hard copy and one (1) soft copy of the final report;
2. You must submit the report of the research project within three (3) months of completion of the study.
3. Any amendments to the research proposal that has been approved must be submitted for consideration to the Princess Marina Hospital Research and Ethics Committee (REC) for consideration.
4. You must allow the REC access to the study at any time for purposes of auditing;
5. You must get permission from the relevant head of department to conduct research in their departments.

If you have any questions, please, contact Mr B. Butale at +267 362 1677 or babutale@gov.bw or Mrs G Tlhomelang at 362 1409 or gtlhomelang@gov.bw .

Yours sincerely




Bakani Butale
Secretary

M E M O

TO: All HODs/Units
Princess Marina Hospital

FROM:



Dr K. Motumise
Clinical Director

REF: PMH 3/12/5

23rd January 2013

RE: PERMISSION TO CONDUCT RESEARCH AT PRINCESS MARINA FACILITY
- MRS BONGAYI KUDOMA

Mrs Kudoma has been granted permission to conduct Research on Clinical Waste Management System in Princess Marina Hospital by PMH and Ministry of Health, Research and Ethics Committee.

Please kindly assist her accordingly. She will produce approval letters from Research Committees.

Thank you for your usual cooperation,

With thanks

APPENDIX IX: PERMISSION LETTERS TO CONDUCT RESEARCH AT CLINICS AND HEALTH POSTS

TELEPHONE: (267) 3657519
FAX
REFERENCE: DHMT



REPUBLIC OF BOTSWANA

Ministry of Health
Department of Clinical Services
Gaborone District Health Management
P.O.Box 258
GABORONE
BOTSWANA

DATE: 06/10/12

To:
Nurse in charge

BH2 clinic

RE: PERMISSION FOR PLACEMTNT OF STUDENT

This serves to inform you that permission has been granted for Bangai Kudoma
to be attached to BH2 clinic from January 2013 to December 2013

K. Thebenyane
K. Thebenyane/For DHMT Cordinator



TELEPHONE: (267) 3657519
FAX
REFERENCE: DHMT



REPUBLIC OF BOTSWANA

Ministry of Health
Department of Clinical Services
Gaborone District Health Management
P.O.Box 258
GABORONE
BOTSWANA

DATE: 06/10/17

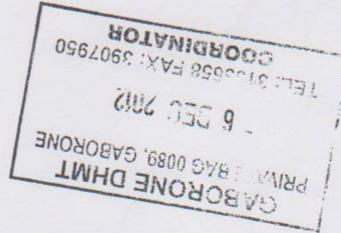
To:
Nurse in charge

Ext-2 clinic

RE: PERMISSION FOR PLACEMTNT OF STUDENT

This serves to inform you that permission has been granted for Bongai Kudom9
to be attached to Ext 2 clinic from January 2013 to December 2013

K. Thebenyane
K. Thebenyane/For DHMT Cordinator



TELEPHONE: (267) 3657519
FAX
REFERENCE: DHMT



REPUBLIC OF BOTSWANA

Ministry of Health
Department of Clinical Services
Gaborone District Health Management
P.O.Box 258
GABORONE
BOTSWANA

DATE: 06/12/12

To:
Nurse in charge

Nkankela Health Park

RE: PERMISSION FOR PLACEMENT OF STUDENT

This serves to inform you that permission has been granted for

to be attached to Nkankela H. Park from Bongai Kuduana
January 2013 to December 2013


K. Thebenyane/For DHMT Coordinator



TELEPHONE: (267) 3657519
FAX
REFERENCE: DHMT



REPUBLIC OF BOTSWANA

Ministry of Health
Department of Clinical Services
Gaborone District Health Management
P.O.Box 258
GABORONE
BOTSWANA

DATE: 06/12/12

To:
Nurse in charge
Gabane Health Post

RE: PERMISSION FOR PLACEMTNT OF STUDENT

This serves to inform you that permission has been granted for Bongayi Kudoma
to be attached to Gabane Health Post from January 2013 to December 2013

K. Thebenyane
K. Thebenyane/For DHMT Cordinator

GABORONE DHMT
PRIVATE BAG 0089, GABORONE
- 6 DEC 2012
TEL: 3133658 FAX: 3907900
COORDINATOR

APPENDIX X: PERMISSION TO CONDUCT REASERCH IN GABORONE CITY COUNCIL



All correspondence should be addressed to the

The Town Clerk
Private Bag 0089
Telephones: 3657400
Tel. Add.: 'CIVIC'
GABORONE
BOTSWANA
Fax: 3900141

REF: GCC/94/6

DATE: 07/02/13

GABORONE CITY COUNCIL

**Mrs Bongayi Kudoma
Tshwaragano Brigades
Box 181
Gaborone**

RE: PERMISSION TO UNDER TAKE STUDY

This is to notify you that you have been given permission to undertake a Clinical waste research in Gaborone City Council. You are to give the Council a copy of your findings. As indicated before we believe this research will only be used for academic perposes and therefore under no circumstances should the information found be revealed to the media or public.

Thank you.

Yours Faithfully

**B. Mooketsi
For /City Clerk**

APPENDIX XI: PERMISSION TO CONDUCT STUDY AT GAMODUBU LANDFILL

KWENENG DISTRICT COUNCIL

Telephone:

Private Bag 005
Molepolole
BOTSWANA

Department: **Public Health**

Your Reference:

Our Reference: KDC/HQ/2/11/5

Switch Board 5920200/2
Council Secretary 5920115
Treasurer 5920095
Prn. Eco. Planner 5920206
Fax 5920209

Telex Address Kwena



Bongani Kudoma
Tshwaragano Brigade
P O Box 181
GABANE

Dear Sir

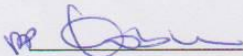
RE: REQUEST FOR PERMISSION TO CONDUCT A RESEARCH STUDY

Reference is made to your letter dated 14 March 2013 on the above subject matter.

Permission is hereby granted to you to conduct a research study as requested. Please contact Mr P.C. Segokotlo at 74553246 for further arrangements.

Thank you.

Yours faithfully



J. M. Banyatsang
For/COUNCIL SECRETARY