

**THE QUANTIFICATION OF MEDICAL WASTE FROM THE POINT OF
GENERATION TO THE POINT OF DISPOSAL: CASE STUDIES AT THREE
PRIVATE HOSPITALS IN PRETORIA**

by

Louis Barend Heunis

Submitted in accordance with the requirements for

the degree of

MASTER IN SCIENCE

in the subject

Environmental management

at the

University of South Africa

Supervisor: Prof. K Mearns

November 2016

DECLARATION

I Louis Barend Heunis declare that THE QUANTIFICATION OF MEDICAL WASTE FROM THE POINT OF GENERATION TO THE POINT OF DISPOSAL: CASE STUDIES AT THREE PRIVATE HOSPITALS IN PRETORIA is my own work and that all my resources that I have used or quoted have been indicated and acknowledged by means of complete references. The thesis has not been submitted to any other university or institution for the award of a degree.

This degree was examined and awarded posthumously.

Signed (Author) : Date:

(Mr LB Heunis)

Signed (Supervisor)..... Date:.....

(Prof KF Mearns)

ABSTRACT

The South African Waste Information System (SAWIS) was developed by the Department of Environmental Affairs and Tourism (DEAT) in 2005. This is a system used by government and industry to capture routine data on the tonnages of waste generated, recycled and disposed of in South Africa on a monthly and annual basis. All waste producers and waste management organisations should contribute to this national waste database and should accurately monitor the types and quantities of waste produced and handled. According to DEAT (2006) the need for Data verification is important. DEAT (2006:59) defined the term Data Verification as: "assessing data accuracy, completeness, consistency, availability and internal control practices that serve to determine the overall reliability of the data collected."

The aim of the study is to determine a procedure, as well as the nature and extent of internal and external source documents, which could be used in the reconciliation of medical waste quantities from generation to disposal. The key objectives are to determine whether the selected hospitals keep internal records of the quantities of medical waste generated; to reconcile the waste quantities on the internal records with the external records, such as the collection certificates, invoices and waste incineration certificates; to ascertain whether the quantity of medical waste generated is equal to the quantity of waste incinerated and disposed of to determine the ratio factor between the quantity of medical waste before incineration and the quantity of the residue (ashes) after incineration, and to make recommendations on the reconciliation of waste quantities from the point of generation to the point of disposal.

The results of the study indicate that the destruction certificate is the proof that the waste that was on-site collected by the service provider has been disposed /treated. Especially as an internal control measure. The health care risk waste (HCRW) management record keeping of quantities of weight as per Hospital A, Hospital B and Hospital C allows the opportunity to analyse the weight per month and per Hospital and per category and to make comparisons. The weakness or the gap however still exist that the waste is not weighed at the point of origin, but at the point where the waste service provider collects the waste onsite. It is from this point onwards that the service level agreement between the hospital and the waste service provider and the document management system and the tracking receipt and the waste collection documents (WCD) becomes relevant and where the quantities of waste

per category are for the first time recorded. The hypothesis as stated in Chapter 1 was proven valid.

The study concludes that reconciliation and comparison between the collection certificate and the destruction certificate and the monthly invoice is therefore possible, but the risk of mixing of waste and the understating or overstating of waste quantities is still not overcome.

Key words: Health care risk waste, categories of health care waste, private sector hospitals, health care waste stream, collection certificate, destruction certificate, polluter-pays-principle, cradle-to-grave, reconciliation of waste quantities

ACKNOWLEDGEMENTS

Thanks to the go to the Funders under the ERB-SADC project, it would never have materialised without financial support. Further appreciation goes to the Anonymous Hospital Group. Final appreciation goes to my departmental supervisor at UNISA, Prof K.F. Mearns.

I would like to express my sincere thanks to my Mrs Kitty Heunis for her unfailing support and encouragement during the course of the study.

Contents

CHAPTER ONE: INTRODUCTION	1
1.1 GENERAL BACKGROUND	1
1.2 RATIONALE/MOTIVATION FOR THIS STUDY	4
1.3 WORKING HYPOTHESIS	7
1.4 AIMS AND OBJECTIVES	8
1.4.1 AIM OF THE STUDY	8
1.4.2 OBJECTIVES OF THE STUDY	8
1.5 THE STUDY AREA	9
1.6 STRUCTURE OF CHAPTERS	10
CHAPTER TWO: LITERATURE REVIEW	11
2.1 THEORETICAL BACKGROUND	11
2.2 APPLICATION OF HCW MANAGEMENT IN SOUTH AFRICA.....	12
2.3 APPLICATION OF HCW MANAGEMENT IN THE STUDY AREA.....	16
2.3 OTHER STUDIES UNDERTAKEN	26
2.4 CONCLUSION.	32
CHAPTER THREE RESEARCH DESIGN AND METHODOLOGY	34
3.1 INTRODUCTION	34
3.2 SAMPLE DESIGN.....	36
3.3 SAMPLE SELECTION.....	38
3.4 DATA COLLECTION	40
3.5 DATA ANALYSIS	43
3.6 DATA INTERPRETATION	43
3.7 THE PILOT STUDY.....	44
3.8 CONCLUSION	44
CHAPTER FOUR: RESULTS AND DISCUSSIONS	45
4.1 INTRODUCTION	45
4.2 RECONCILIATION OF WASTE QUANTITIES ON THE INTERNAL RECORDS WITH THE EXTERNAL RECORDS	46
4.3 QUANTITIES OF MEDICAL WASTE GENERATED IS EQUAL TO THE QUANTITY OF MEDICAL WASTE DISPOSED/TREATED	52
4.4 CONCLUSION	74
CHAPTER FIVE: CONCLUSIONSSIONS	75
5.1 INTRODUCTION	75

5.2	RECONCILIATION OF WASTE QUANTITIES BETWEEN THE INTERNAL RECORDS WITH THE EXTERNAL RECORDS	75
5.3	QUANTITIES OF MEDICAL WASTE GENERATED IS EQUAL TO THE QUANTITY OF MEDICAL WASTE DISPOSED/TREATED.	77
5.4	RATIO FACTOR BETWEEN THE QUANTITY OF MEDICAL WASTE BEFORE INCINERATION AND THE QUANTITY OF THE RESIDUE AFTER INCINERATION	79
5.5	LIMITATIONS	79
5.6	SUMMARY	80
5.7	RECOMMENDATION.....	80
5.8	FURTHER RESEARCH.....	82
	Reference List	83

LIST OF TABLES

Table 1: Classification of hazardous water in South Africa.	15.
Table 2: Colour coding scheme for containers.	21.
Table 3: Hospital A: Categories and actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.	58.
Table 4: Hospital B: Categories and actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.	60.
Table 5: Hospital C: Categories and actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.	62.
Table 6: Actual disposed sharp waste as a specific category per hospital.	64.
Table 7: Actual disposed infectious waste as a specific waste category per hospital.	65.
Table 8: Actual disposed pharmaceutical waste as a specific waste category per hospital.	66.
Table 9: Actual disposed plasma/anatomical waste as a specific waste category per hospital.	68.
Table 10: Total quantity of waste per hospital over a period of 12 months.	69.
Table 11: Average weight of HCRW collected per day over period of 12 months.	71.
Table 12: Actual monetary value paid to the waste service provider per month as per hospital to collect and to dispose the waste.	71.
Table 13: Average cost per kg over 12 month period	72.
Table 14: Summary of the total number of patients per hospital for the calendar year.	73.

LIST OF FIGURES

Figure 1: Illustrating the HCW stream.	17.
Figure 2: The waste stream linked to the findings.	47.
Figure 3: Hospital A: Categories and actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.	59.
Figure 4: Hospital B: Categories and actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.	61.
Figure 5: Hospital C: Categories and actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.	63.
Figure 6: Actual disposed sharp waste as a specific category over a period of 12 months.	64.
Figure 7: Actual disposed infectious waste as a category per hospital over 12 months.	66.
Figure 8: Actual pharmaceutical waste as a category per hospital over a period of 12 months.	67.
Figure 9: Actual disposed plasma/anatomical waste as a category over a period of 12 months.	69.
Figure 10: Total quantity of waste generated for the Group in comparison to the total weight for Hospital A, Hospital B and Hospital C.	70.
Figure 11: Actual monetary value (ZAR) as invoiced and paid to the waste service provider per month.	72.
Figure 12: Average weight per patient per Hospital A, B and C	73.

ACRONYMS AND ABBREVIATIONS

DACEL	:	Department of Agriculture, Conservation and Environmental Affairs
DEAT	:	Department of Environmental Affairs and Tourism
DMS	:	Document Management System
DoH	:	Department of Health
DWAF	:	Department of Water Affairs and Forestry
EPR	:	Extended producer responsibility
GDACE	:	Gauteng Department of Agriculture, Conservation and Environment
GDACEL	:	Gauteng Department of Agriculture, Conservation, Environment, and Land
HCF	:	Health care facility
HCF's	:	Health care facilities
HCGW	:	Health care general waste
HCRW	:	Health care risk waste
HCRWMP	:	Health care risk waste management plan
HCW	:	Health care waste
HCWH	:	Health Care Without Harm
HCWM	:	Health Care Waste Management
MSW	:	Municipal Solid Waste
NDoH	:	National Department of Health
NHS	:	National Health System
NWMS	:	National Waste Management System
OHS	:	Occupational Health and Safety
PPE	:	Personal Protective equipment
SABS	:	South African Bureau of Standards

WCD	:	Waste Collection Document
WIS	:	Waste Information System
WHO	:	World Health Organisation
WMP	:	Waste Management Practices

CHAPTER ONE: INTRODUCTION

1.1 GENERAL BACKGROUND

The modern health sector generates growing amounts of health care waste (HCW). This waste includes both health care risk waste (HCRW), which presents special health and environmental risks, as well as health care general waste, which can be considered to be similar to general waste.

Increased generation of HCW

During the past two decades, the world has experienced a dramatic increase in the amount of hazardous waste generated. As a result, this period also witnessed a vigorous drive for sustainable development and increased awareness, as well as concern for the environment (Ketlogetswe, Oladirang & Foster, 2004:67). The United Nations Environment Programme (UNEP) (UNEP, 2006:2) argued in their International Sourcebook on Environmentally Sound Technologies for Municipal Solid Waste Management that among all the wastes, HCW was one of the most problematic types.

Consequently, there has also been a sharp increase in the amount of waste generated from health facilities. According to World Health Organisation (WHO), between 10 and 25 percent of waste generated in health facilities is regarded as hazardous due to its composition. The remaining 75 to 90 percent poses no risk of infection, as it is comparable to domestic waste (UNAIDS, 2002:44).

In South Africa at the national level, there have been a number of initiatives that the Government embarked upon to address the HCW problem. An example is the legislation which includes the Environment Conservation Act (DEAT, 2006b:42). It was under this Act that the Gauteng Department of Environment developed the Gauteng HCW Management Regulations (DEAT, 2006b:42). However, what is important is not just the presence of Acts or Regulations. Waste management regulations require HCW generators to take all reasonable measures to ensure that HCRW generated at its facility is stored, transported, treated, and disposed of in strict compliance with such regulations. This responsibility is called extended producer responsibility (EPR Working Group, 2008:2). The regulations further oblige HCW generators to ensure regular training of all employees on environmental awareness (Ramokate, 2007:17).

Since the last decade, there has been an increased environmental awareness in South Africa about dangers that HCW poses to humans and environment. This awareness forced authorities to take a responsible action to mitigate inherent dangers of waste management (DACEL, 2005:8; DEAT, 2006a:2). However, a lack of capacity manifested by the absence of administrative and operational procedures resulted in HCRW not being segregated from the general waste stream.

Misclassification and mixing of wastes

In a study conducted by Weir (2002:34) in Toronto children's hospital in Canada, it was found that HCRW comprised of other items that are not classified as HCRW. This misclassification was very costly since it was estimated that disposing HCRW was sixteen times more expensive than it was for health care general waste. The investigator concluded

that the issue of the cost of HCW management is often overlooked by Government facilities in particular.

The DEAT (2000b:15) found that hospitals in eight of the nine South African Provinces did not classify waste into categories. If hospitals do not quantify waste into its categories, namely, HCRW versus General waste, this waste get mixed and becomes expensive in terms of disposal and treatment. Characterizing HCW enables identification of the most problematic wastes. This helps in quantifying daily needs for waste collection and handling equipment, as well as materials needed, for instance, yellow plastic bags, sharps, and the size of the treatment facility needed. Financial and human resource needs can only be determined after waste classification has been made. Gabela (2007:7) notes that, in South Africa, there was no legislation promulgated to enforce reporting of HCW generated, and that there were no guidelines in respect of the type of information to be collected. Gabela (2007:13) argues that limited information about waste characteristics was as a result of poor segregation of HCW”.

Misplacement of needles in general waste is a problem in many countries (Path, 2006:6). This was confirmed by Kristiansen (2007:8) in a study that was conducted in Leratong Hospital, Gauteng. One of the objectives of the study was to assess the pre- and post-intervention efficiency of the HCW segregation of sharps. It was found that, as in other public healthcare facilities, there was a significant mis-segregation of healthcare waste occurring with adverse financial impacts. The post-intervention results demonstrated that although there were improvements in the segregation of sharps, there were still misplacements.

In South Africa, for instance, a study was undertaken by Abor and Bouwer (2008) on Medical waste management practices in a hospital in Cape Town, South Africa. This study mentions that in many countries, hazardous and medical wastes are still handled and disposed together with domestic wastes, thus creating a great health risk to municipal workers, the public and the environment. The results of this study revealed that the hospital does not quantify medical waste.

Recent studies have shown that there are problems regarding HCW practices, particularly segregation and storage of HCW. In a study conducted by Taru and Kyarega (2005:153), to evaluate HCW practices at Parirenyatwa Hospital in Harare, Zimbabwe, an overwhelming percent of the employees interviewed reported that HCW was neither segregated nor stored according to its composition. It was also observed that HCRW and General waste were largely collected and stored together before final disposal.

1.2 RATIONALE/MOTIVATION FOR THIS STUDY

There is a worldwide concern about waste which prompted the researcher to carry out a study on waste. The United Nations see waste as such an important topic that the 1992 Rio Earth Summit, which was followed by the 2002 Johannesburg World Summit, provided a platform to learn and begin to implement sustainability practices about waste (DEAT, 2011a:5). At national level, the South African government, and in specific Department of Environmental Affairs, echoes the worldwide concern about waste and issued several strategies over the past ten years. The latest strategic inputs from the South African Government is the National Waste Management Strategy (NWMS) and the inclusion of “Waste Management” and eight related indicators in the Action Plan of the National

Framework for Sustainable Development (NSSD1) for the period 2011-2014 (DEAT, 2011a:22). The NSSD1, which was approved by the South African Government on 23 November 2011, is a proactive strategy that regards sustainable development as a long-term commitment, which combines environmental protection, social equity and economic efficiency with the vision and values of the country. The twenty headline indicators listed in the Action plan have been identified to monitor progress in the implementation of NSSD1 (2011–2014). These headline indicators were selected from existing indicators including the Development Indicators, the Millennium Development Goals and the 12 government outcomes (DEAT, 2011a:5).

“These issues led to this research. This research, as envisaged, is of prime importance as hospitals feel more pressure to take up their producer responsibility. There is generally a lack of a speedy progress with HCW issues. Discovering an appropriate and convenient model may assist in expediting the progress”.

The South African Waste Information System (SAWIS) was developed by the Department of Environmental Affairs (DEA) in 2005. This is a system used by government and industry to capture routine data on the tonnages of waste generated, recycled and disposed of in South Africa on a monthly and annual basis. All waste producers and waste management organisations should contribute to this national waste database and should accurately monitor the types and quantities of waste produced and handled. According to DEAT (2006: 59) the need for Data verification is important. DEAT defined the term Data Verification as: "Assessing data accuracy, completeness, consistency, availability and internal control practices that serve to determine the overall reliability of the data collected."

The tabling of the White Paper on Integrated Pollution and Waste Management in 2006 showed further commitment by the South African government to implement the objectives of SAWIS. The White paper indicates the need to develop and maintain databases and information management systems to provide accessible information to interested and affected parties that will support effective integrated pollution and waste management.

The Private Sector hospitals have a contribution to make in pursuit of sustainable development objectives and targets and also in terms of providing information to the South African Waste Management Information System (DEAT, 2011a:54).

The study will concentrate on selected Private Sector Hospitals in Pretoria, Gauteng and on the quantities of medical waste. The reliability, accuracy and completeness of the quantities will have several advantages. It will firstly help the hospitals in the study area to compile information to address two of the eight NSSD1 indicators; it will secondly enable the hospitals in the study area to provide reliable quantities of medical waste to the South African Waste Management Information system. Reliable quantities of waste will also enhance the internal accounting process, which could include accurate billing and more precise budget estimates.

Recommendations will be made on the procedure and the source documents to be used to reconcile the quantity of medical waste from point of generation to point of disposal. This process and source documents should enhance data accuracy, completeness, consistency, availability and internal control practices that serve to determine the overall reliability of the medical waste quantities. The three case studies in this study are part of a Hospital Group network of a large number of hospitals. The recommendations emanating from this study could therefore influence the whole network of hospitals.

1.3 WORKING HYPOTHESIS

Hypotheses 1: The hospital does not weigh the HCRW after it has been generated and before it is taken to the intermediate and/or central storage area.

Hypotheses 2: HCRW is weighed by the service provider that collects, transport and disposed the HCRW and the service provider will issue a collection certificate, indicating the date of collection and the quantity of the HCRW at the hospital. A representative of the hospital will certify that the quantity of the waste, as indicated on the certificate is correct. Differences if any, will be followed up and rectified.

Hypotheses 3: The service provider will issue a destruction certificate that HCRW was treated/incinerated/disposed. This certificate will also indicate the quantities of the medical waste. Information and certifications on financial related invoices and waste certificates by responsible/ designated employees at the hospitals and the service providers will provide reliable trace of the quantities of medical waste generated, collected and disposed. The service provider will invoice the hospital for services rendered. This invoice will indicate the date when services were rendered, as well as the unit prize and the unit (quantity) of the waste that was collected, transported and disposed. The hospital will certify, as part of the internal accounting billing process, that the services were rendered as invoiced.

1.4 AIMS AND OBJECTIVES

1.4.1 AIM OF THE STUDY

The aim is to determine a procedure, as well as the nature and extent of internal and external source documents, which could be used in the reconciliation of medical waste quantities from generation to disposal.

1.4.2 OBJECTIVES OF THE STUDY

- I. To determine whether the selected hospitals keep internal records of the quantities of medical waste generated.
- II. To reconcile the medical waste quantities on the internal records with the external records, such as the collection certificates, invoices and waste incineration certificates.
- III. To ascertain whether the quantity of medical waste generated is equal to the quantity of medical waste incinerated and disposed of.
- IV. To determine the ratio factor between the quantity of medical waste before incineration and the quantity of the residue (ashes) after incineration.
- V. To make recommendations on the reconciliation of medical waste quantities from the point of generation to the point of disposal.

1.5 THE STUDY AREA

GENERAL DESCRIPTION OF THE STUDY AREA

The study area is in Pretoria, Gauteng, South Africa. Pretoria is a city in the northern part of Gauteng Province, South Africa. It is one of the country's three capital cities, serving as the executive (administrative) and de facto national capital; the others are Cape Town, the legislative capital, and Bloemfontein, the judicial capital.

The aim is to select three private sector hospitals, situated in the Pretoria area, which will form part of the study. It is envisaged at this stage that the three hospitals would represent a large Hospital Group the three selected are however anonymised to Hospital A., B and C. The Hospital Group network includes a large number of hospitals (of which the majority are owned by the Group and another seven in which the Hospital Group holds substantial minority ownership), providing a range of healthcare services throughout South Africa. The group has hospitals in seven of the country's nine provinces, and in the country's most populous metropolitan areas, including Johannesburg, Pretoria, Cape Town, Durban, Port Elizabeth, East London and Bloemfontein. The hospital division provides services primarily to the private medically insured market and includes core acute care hospital business, comprising general hospital facilities of various sizes that include intensive care units (ICUs), high care units (HCUs), operating theatres, emergency units, maternity units and cardiac units, as well as other specialised facilities that provide either inpatient or outpatient services in the areas of acute rehabilitation, chronic renal dialysis, mental healthcare services and radiation and chemotherapy oncology.

1.6 STRUCTURE OF CHAPTERS

The first chapter, an introduction, gives an overview of Health Care Waste Management (HCWM) practices in South African Private sector hospitals. The background provides the rationale, and, also indicates the motivation to pursue this study. The chapter goes on to discern the problem statement, research objectives and specific underlying objectives which were used to develop the research instrument.

Chapter two provides the review of literature surrounding HCWM processes and consists of the two parts, that is, the best practice methods and the optimal model for HCWM. In addition, the South African standards and norms affecting HCWM are also discussed.

Chapter three outlines the research design and methodology that directs this investigation. This chapter further explains the rationale behind the choice of a quantitative methodology. The research questionnaires are analysed in detail.

Chapter four presents the results in accordance with the study sub-objectives.

The data collected is analysed using descriptive and analytical measures and is summarised in various tables and graphs. Chapter 4 also contains the interpretation of the results.

Chapter five the final chapter, gives detailed recommendations, suggested measures for the implementation of HCWM and a proposal for further research.

CHAPTER TWO: LITERATURE REVIEW

2.1 THEORETICAL BACKGROUND

The theoretical background of this study is based on the medical waste stream and the substantive documents that shows that the HCRW was handled in line with the cradle-to-grave concept, as well as the concepts, definitions and descriptions of Health Care Waste (HCW) and the process, steps, practises, handling and operating procedures.

The WHO (2005b:2) defined HCW as the total waste stream from a Health Care Facility (HCF) that includes both potentially infectious and non-infectious waste materials. In South Africa, the definition of HCW was taken from the current version of the South African Bureau of Standards (SABS) standard, which includes all the wastes generated in HCFs, health care research facilities, as well as that originating from healthcare undertaken in the homes, for instance, dialysis and insulin injections (DEAT, 2005:9). While the DEAT's definition is focussed in healthcare facilities, some provinces have extended the definition to include all facilities that are potentially infectious to humans, for instance, tattoo artists and body piercers.

Further, the Health Professional Council of South Africa (HPCSA) (2008:4) defined HCW as any undesirable or superfluous by-product, emission, residue or remainder generated in the course of work by a health professional, healthcare facilities and other non-healthcare professionals. This waste is discarded, accumulated or stored with the purpose of eventually discarding it, or is stored for the purpose of recycling it, reusing or extracting a usable product from such a matter. HCW may if handled improperly, have the capacity to harm people, property or the environment. In this regard, all human anatomical waste blood and

body fluids are considered to be potentially hazardous. The unsafe disposal of such waste could have detrimental effects for people who might come into contact with HCW.

The term **Health Care General waste (general waste)** describes waste which is both non-infectious and non-hazardous, and therefore, does not require specialist treatment or disposal. This waste, though, may cause offence to those coming into contact with it (London Department of Health, 2006:4).

2.2 APPLICATION OF HCW MANAGEMENT IN SOUTH AFRICA

The Government of South Africa is on an on-going basis tabling and implementing legislation, strategies and policies in its effort to mitigate the danger to the environment and the health of humans and animals. The Constitution of the Republic of South Africa (Act 108 of 1996) provides the foundation for environmental regulation and policy in South Africa. The right to environmental protection and to live in an environment that is not harmful to health or well-being is set out in the Bill of Rights (section 24 of Chapter 2). This fundamental right underpins environmental policy and law, in particular the framework environmental legislation established by the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998). NEMA introduced a number of additional guiding principles into South African environmental legislation, including the life-cycle approach to waste management, producer responsibility, the precautionary principle and the polluter pays principle. NEMA also places a duty of care on any persons who may cause significant pollution or degradation of the environment, requiring them to institute measures to either prevent pollution from occurring, or to minimise and rectify the pollution or degradation where it cannot reasonably be avoided. The Waste Act (2008) echoes the duty of care

provision by obliging holders of waste to take reasonable measures to implement the waste management hierarchy (DEAT, 2011b:12).

According to Department of Environment Affairs (2011a:5) the National Strategy for Sustainable Development and Action Plan – also referred to as NSSD1 (2011–2014) – was approved by Cabinet on 23 November 2011. The NSSD1 and several initiatives were launched by the business sector, government, NGOs, civil society, academia and other key role players to address issues of sustainability in South Africa. The NSSD1 was implemented during the period 2011– 2014. The lessons and evaluation of progress regarding the implementation of NSSD1 will inform NSSD2 (2015–2020). This is a proactive strategy that regards sustainable development as a long-term commitment, which combines environmental protection, social equity and economic efficiency with the vision and values of the country. The NSSD1 marks the continuation of a national partnership for sustainable development. It is a milestone in an ongoing process of developing support, and initiating and up scaling actions to achieve sustainable development in South Africa. The 1992 Rio Earth Summit, which was followed by the 2002 Johannesburg World Summit on Sustainable Development, provided a platform to learn and begin to implement sustainability practices.

Five strategic objectives are identified in the NSSD 1. These objectives address the enhancing of systems for integrated planning and implementation, sustaining our ecosystems and using natural resources efficiently, working towards a green economy, building sustainable communities and responding effectively to climate change. Various interrelated and enabling interventions that promote sustainable development are being implemented throughout the country. The NSSD1 identifies 113 interventions that can be monitored for implementation. The twenty headline indicators have been identified to

monitor progress in the implementation of NSSD1 (2011–2014). These headline indicators are selected from existing indicators including the Development Indicators, the Millennium Development Goals and the 12 government outcomes DEAT (2011a:5). The NSSD1 include waste management as one of the interventions of the action plan. Two of the eight indicators that are linked to waste management, focuses on the tonnage of waste going to landfill sites and the generation of hazardous waste (DEAT, 2011a: 22).

The National Waste Management Strategy (NWMS) is a legislative requirement of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008), the “Waste Act”. The purpose of the NWMS is to achieve the objects of the Waste Act. Organs of state and affected persons are obliged to give effect to the NWMS (DEAT, 2011b:5). According to Department of Environmental Affairs (2006:8) the White Paper on Integrated Pollution and Waste Management (IP&WM) (Republic of South Africa, 2000) recognised the need to develop and maintain databases and information management systems, so as to monitor and collect information on pollution and waste generation. According to the White Paper, information is "crucial for the implementation of pollution and waste reduction measures. Moreover, the sharing of such information and creating awareness about the issues will enable all stakeholders, including communities, to gain a better understanding of the relation between pollution, waste management and the quality of life." The South African Waste Information System (SAWIS) was developed by the Department of Environmental Affairs (DEA) in 2005. This is a system used by government and industry to capture routine data on the tonnages of waste generated, recycled and disposed of in South Africa on a monthly and annual basis. All waste producers and waste management organizations should contribute to this national waste database and should accurately monitor the types and quantities of waste produced and handled. According to DEAT (2006:59) the need for Data

verification is important. DEAT defined the term Data Verification as: "Assessing data accuracy, completeness, consistency, availability and internal control practices that serve to determine the overall reliability of the data collected." According to GDACE (2005:13), South Africa uses **SANS 10228 Classes** which divides hazardous waste into nine categories, based on their hazardous nomenclature (Table 1).

Table 1: Classification of hazardous waste in South Africa.

Class	Explanation
Class 1	Explosives
Class 2	Gases: compressed, liquefied or dissolved under pressure Flammable gasses Non-flammable, non-toxic gasses Toxic gases
Class 3	Flammable liquids: Low flashpoint group of liquids; flashpoint below – 18°C*. Intermediate flashpoint group of liquids; flashpoint of –18°C up to, but not including 23°C c.c. High flashpoint group of liquids flashpoint of 23°C up to, and including, 61°C
Class 4	Flammable solids or substances Flammable solids Flammable solids liable to spontaneous combustion Flammable solids which emit flammable gases when in contact with water
Class 5	Oxidising substances and organic peroxides Oxidising substances Organic peroxides
Class 6*	Toxic and infectious substances Toxic substances Infectious material
Class 7	Radioactive substances
Class 8	Corrosive substances
Class 9	Other miscellaneous dangerous substances , that is any other substance which experience has shown, or may show, to be of such dangerous character that the provisions of this Section should apply to it.

**It is noted that, in South Africa, an infectious waste is a sub-category of Class 6.*

Other wastes produced by health care facilities include flammable liquids, and toxic materials such as drugs and radioactive waste (Class 7) as well as compound gas (Class 2).

Radioactive and infectious wastes are generally managed separately from other categories, which are all classified as chemically hazardous wastes, whether they arise from a hospital or the chemical and petroleum industry.

2.3 APPLICATION OF HCW MANAGEMENT IN THE STUDY AREA

HCW produced in hospitals should follow an appropriate, well-identified stream from their point of generation until their final disposal (Kristiansen, 2007:7). The stream comprises several steps that include generation, segregation, on-site transportation, on-site storage, off-site transportation and final disposal or offsite treatment. However, the most important key point is always the minimisation of HCW generated. Therefore, ensuring efficient and reliable segregation remains the most important step. Like WHO (2005a), the State of Eritrea (2005:6) produced a HCW stream synopsis for translating HCWM plans at a healthcare facility level (Figure 1).

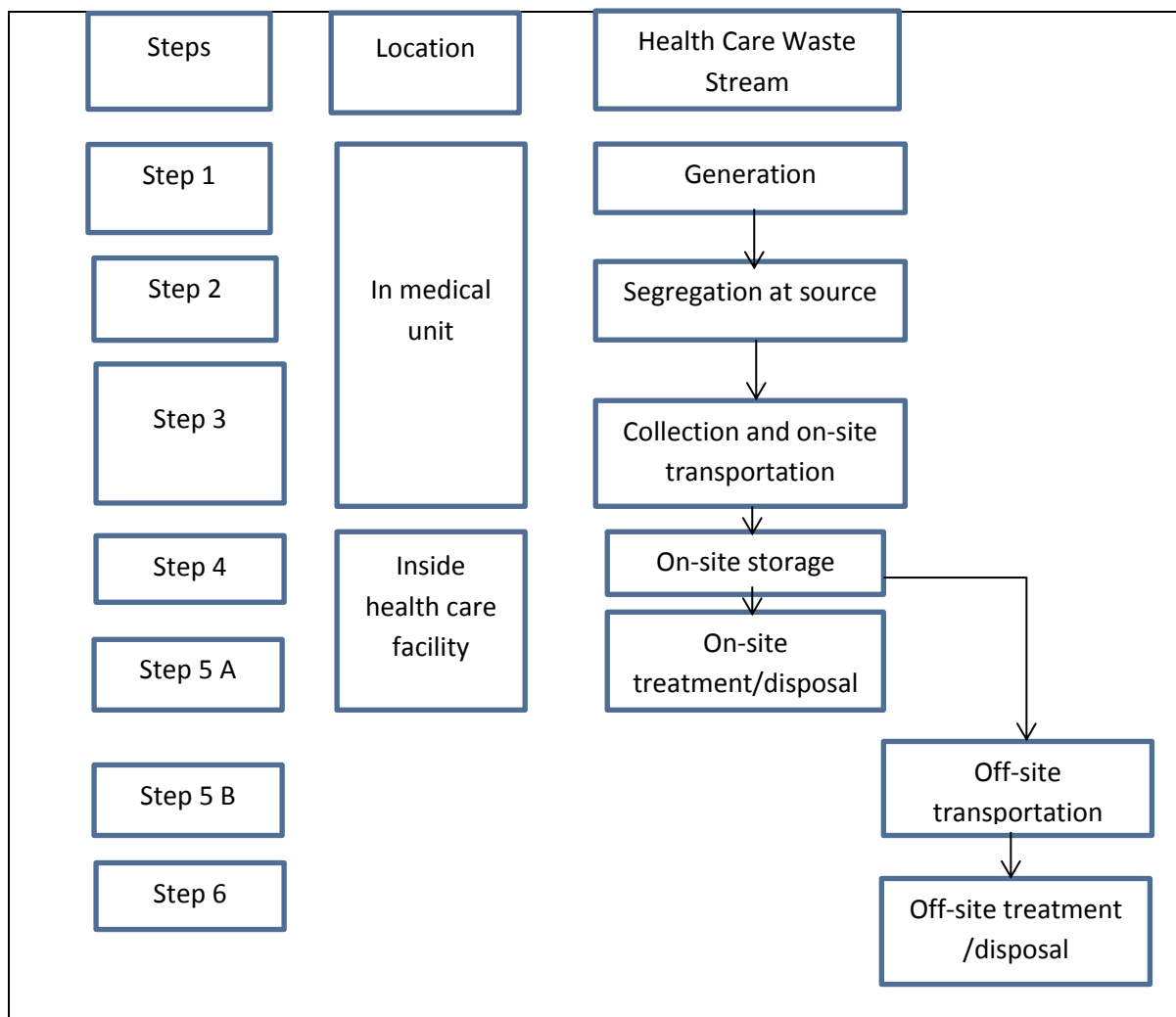


Figure 1: Illustrating the HCW stream (Adopted from the State of Eritrea, Ministry of Health (2000:24).

A systematic approach is indispensable from step 1 to step 4. The same personnel are involved from generation (step 1) to segregation (step 2). Then, waste collectors transport waste from a ward, normally from a temporary storage area to an on-site storage, also called the central storage area (State of Eritrea, 2004:25). From the on-site storage area, waste will either be transported to an on-site treatment/disposal area if waste is treated or disposed of locally or handed over to the service provider if the waste is treated or disposed of outside

the hospital. The State of Eritrea (2004:25) advises that written procedure manuals be available in order to minimise risks associated with HCW injury.

Adapted from the State of Eritrea, Ministry of Health (2004:24).

A. Segregation of Waste

Segregation is the process of separating different types of waste at the point of generation and keeping them isolated from each other (Department of Health, Manila, 2005:23).

According to the Vermont Department of Environment Conservation (2001:10), the key to effective management of HCW is segregation. This is the responsibility of the producer and should take place as close as possible to where the waste is being generated. The Vermont Department of Environmental Conservation (2001:10) found that waste practice in many hospitals was that all waste is potentially infectious. Wastes emanating from offices, kitchen, operation theatres, pharmacies, as well as wards were mixed together as they were generated, and were all collected, transported and finally disposed of together.

As a result of this failure to establish and follow segregation protocols and infrastructural requirements (storage areas), wastes leaving hospitals, as a whole, is potentially infectious and hazardous.

Contaminated sharps can contain diseases (WHO, 2005c:31). According to Path (2006:11), most people are aware of the risk of contracting HIV, the virus that causes AIDS, from dirty needles. However, many HCW workers and patients are not aware of the high risks of contracting Hepatitis B or C from the same needles and syringes.

The WHO (2005c:6) estimates that, every year, unsafe injections and needles-stick injuries cause 8 to 16 million Hepatitis B infections, 2.3 to 4.7 million Hepatitis C infections and 160 000 HIV infections. It is, therefore, important that needles and syringes, in particular, be handled with caution.

Misplacement of needles in general waste is a problem in many countries (Path, 2006:6). This was confirmed by Kristiansen (2007:8) in a study that was conducted in Leratong Hospital, Gauteng. One of the objectives of the study was to assess the pre- and post-intervention efficiency of the HCW segregation of sharps. It was found that, as in other public healthcare facilities, there was a significant mis-segregation of healthcare waste occurring with adverse financial impacts. The post-intervention results demonstrated that although, there were improvements in the segregation of sharps, there were still misplacements.

The WHO (2005c:7) recommends that intensive training be conducted for HCW workers regarding segregation of sharps. This follows a World Health Organisation (WHO) assessment of misplacement of sharps in twenty-two development countries where it was found that 18 to 64 percent of HCFs do not use proper waste disposal methods.

According to HCWHA (2004:28), colour-coded and properly-labelled trash bins are readily available and strategically placed in most of the areas of the hospital, encouraging proper segregation at source. The success of the hospital's segregation programmes as waste minimisation activities were found to rely heavily on the following:

- Cooperation of the waste producers and handlers;
- The dedication and leadership of the hospital management;

- Information materials of the hospital on proper waste segregation; and
- Incentive system for best practices in the segregation of waste.

The two important reasons for practising segregation are financial and environmental. The segregation of HCRW from general waste following a robust risk assessment allows the two waste streams to be treated and disposed of separately. Sniffer (2007:2) observed that the majority of the HCRW is subjected to onerous consignment and disposal requirements, as the cost of disposing HCRW is approximately four times higher than the cost of disposing General waste. Sniffer (2007:4) cautions that if waste is not segregated in terms of HCRW and general waste streams, the whole waste should be considered HCRW. This procedure will usually command more expensive treatment.

Codification

As part of segregation, codification is a colour coding system that defines the containers in which the waste must be stored once segregated (WHO, 2005c:5).

Large quantities of obsolete or expired pharmaceuticals stored in hospital wards should be returned to the pharmacy for disposal (Department of Health, Manila, 2005:29). Other pharmaceutical waste generated at this level such as expired drugs, should be returned because of the risk of contaminating the pharmacy. Large quantities of chemical waste should be packed in chemical resistant containers and sent to specialized treatment facilities. The identity of the chemicals should be clearly marked on the containers. Hazardous chemical waste of different types should be separated.

To prevent injuries, the staff should never try to correct the errors of segregation by retrieving items from a bag or container after disposal or by placing one bag inside another

bag (packing) of a different colour. If general, or if hazardous waste is accidentally mixed, the mixture should be classified as HCRW (Department of Health, Manila, 2005:28).

Table 2: Colour coding scheme for containers.

Type of waste	Colour container and markings	Type of container
Highly infectious waste	Yellow, marked “Highly infectious”	Strong leak-proof plastic bag or container capable of being autoclaved
Other infections waste. Pathological and Anatomical waste	Yellow	Leak-proof plastic bag or container
Sharps	Yellow” marked sharps”	Puncture proof container
Chemical and Pharmaceutical waste	Brown	Plastic bag container
Radioactive waste	-	Lead box, labelled with radioactive symbol.
General waste	Black	Plastic bag

Adapted from: WHO (2005a:63)

As part of good segregation practices, WHO (2005b: 6) recommends that the colour coding of waste containers be practised as follows:

- General HCW should join the stream of domestic refuse for disposal;
- Sharps should all be collected together, regardless of whether or not they are contaminated. Containers should be puncture proof and always be fitted with covers;
- Bags and containers for infectious waste should be marked with the international infectious waste symbol;
- Highly infectious waste should where possible, be sterilised immediately by autoclaving; and
- Cytotoxic waste (pharmaceuticals) should be collected in strong, leak-proof containers, clearly labelled “cytotoxic waste”.

In addition, the WHO (2005b:6) recommends that the same colour coding be used for the storage of waste. The use of international colour codes is useful as some waste is moved across national borders for disposal and research purposes (WHO, 2005b:6).

Regarding the storage of waste, African countries face a number of infrastructural problems. Abor (2007:IV), in his research in Tygerberg Hospital, found that the hospital faced huge problems including the lack of use of coloured bags, thus limiting the storage of all kinds of waste to one colour bag. This problem was also found by DEAT (2005:16), in the Zeerust pilot project, where it was found that there were no storage containers in the facility. Waste was disposed of in the pit as it was generated, irrespective of whether it was HCRW or general waste.

To prevent prolonged storage of HCW at the point of generation, the internal collection and transportation of waste is required (GDACE, 2005:6). The internal transportation involves the removal of waste from the intermediate storage to the central storage area (GDACE, 2005:5).

B. Internal storage and transportation

The on-site collection and transportation of waste is done in order to avoid an accumulation of waste. As such, the frequency of the collection of HCW depends on the type of hospital and human resources available. One to two collections per day are normally scheduled. The State of Eritrea (2004:26) revealed a few problems encountered in Eritrea. The collection of waste was not done on a regular basis, or along well-defined routes within the HCFs. In a few places, the nursing assistants transported and dropped off the waste directly to storage

and disposal points. This practice needs to be avoided in order to minimise the risk of spreading infections, once nurses are back in the wards.

The medical waste included syringes and needles often dropped from the overfilled bins (sharps' boxes) and could be found scattered on the ground inside the hospital compounds.

CGH Environmental Strategists (2002:1) offered advice to mitigate these problems where they felt that if the benefits of segregation are to be realised, there has to be secure internal and external collection and transportation systems for waste. If waste is segregated at the point of generation, only to be mixed together by labourers as they collect it or if a hospital has segregated its waste and secured it in separate containers for ultimate disposal, only to have municipal workers mix it together after a single collection, then the ultimate value is lost. Further, while worker safety may have been enhanced, the ultimate cost of damage to the environment and the general public is negative. In addition; the very real concern of hospital administrators to prevent the reuse of medical devices, containers and equipment after disposal should be taken into account in any management meetings. According to McRae (1998:7), street vendors sell used latex gloves or using cidex (a disinfectant regulated as a pesticide in the USA) containers to hold water for making tea. In addition, the practice of cleaning and reselling syringes, needles, medicine vials and bottles, is not well documented, but there appears to be enough informal evidence to indicate that it is a serious concern. It is, therefore, suggested (McRae, 1998:8) that items that could potentially be reused illegitimately either be rendered unusable after their use, for instance, cutting needles, puncturing intravenous bags or be secured for legitimate recycling by a vendor.

The transportation of HCRW from health care facilities to the treatment facilities contributes a significant proportion of the overall cost of HCRW management.

Vehicles used for the transportation of HCRW require custom-built van bodies, which allow for securing of the load internally to prevent HCRW containers from falling over or shifting in transit. The design must also prevent the spillage of any liquids out of the vehicles and the vehicles must carry a “spills kit” that can be used in emergencies. (Otto, 2008:91).

Where a reusable container is used, (such as boxes and wheelie-bins) and where the same vehicles are used for the collection of full containers as well as the return of the empty (clean) containers to the health care facilities, separate load compartments must be provided in the vehicle (Otto, 2008:91). In view of all these requirements, the KZN Department of Health (2008:12) preferred to outsource the HCRW management and disposal services for their hospitals, whereby the contract packages of tendering are administered by the department at a provincial level.

The major advantage of outsourcing the collection and transportation of the HCW is that a service provider will generally utilise a range of different size of vehicles, in order to cater for the expected quantity of HCRW to be collected, the distance to be travelled, and the type of containers to be transported, and this becomes less of a problem for the hospital management (Otto, 2008:98).

The transportation of waste should be done on dedicated containers, preferably usable containers (WHO, 2005a:1). Types and sizes of containers depend on the size of the treatment system that the hospital uses, for instance, reusable containers should be able to fit into the hospital’s autoclave or that of the service providers (Health Care Coalition for Emergency Preparedness, 2009:6).

Outsourcing the transportation of waste may be required when hazardous waste is treated outside the hospital. According to the WHO (2007:65), the HCW producer is responsible for HCW until the return of the filled and signed consignment note from the contractor, indicating that the waste has been finally disposed of. The out-sourcing of the HCW disposal is suitable for small hospitals, whereby the increasing costs associated with treatment processes is above their waste budgets (Health care coalition for emergency preparedness, 2009:6).

This is true for hospitals that previously relied on their on-site incinerator and have no staff or vehicles to transport waste (Abor & Bouwer, 2008).

C. HCW treatment and disposal capacity for South Africa

The National Waste Management Strategy Action Plan for waste treatment and disposal focuses on the improvement in the segregation of all waste treatment facilities, including the revision and enforcement of air emissions standards (Molefe, *et al.*, 2007:3). That being the case, a most comprehensive assessment study of the HCRW quantities, including treatment and disposal capacity, was conducted (Molefe, *et al.*, 2007:3). The study concluded that the HCRW generation and treatment capacity on a national scale matches well. There was nevertheless inequity in terms of the treatment capacity, where some regions had limited HCRW treatment capacity compared to others. This inequity resulted in some regions paying more for HCRW treatment than others.

After the waste minimisation strategies have been carried out to reduce the volume of waste produced, the final step waste in waste management is the proper end-disposal of the

remaining waste. While general waste in the Philippines is collected by the hospitals' respective transport system, each of the four hospitals has contracts with a private waste treater that uses a non-burn technology in the treatment of infectious waste (Department of Health, Manila, 2004:20).

Kayser (2006:1) maintained that the health sector is a major source of dioxin (persistent organic pollutants) and mercury (a persistent toxic substance) in the global environment. They argue that this is mostly because of medical waste incineration of substances containing mercury such as thermometers and sphygmomanometers. Kayser (2006:1) recommends the use of an affordable infectious waste treatment technology that avoids formation and release of persistent organic pollutants. This technology, they argue, will help demonstrate best practices in HCW management in model facilities with a focus on the replicability of these models to permit country operationalisation of the Stockholm Convention.

2.3 OTHER STUDIES UNDERTAKEN

According to Al-Emad (2011) his study was the first study about the management of medical waste that has been published in the Republic of Yemen. The study investigates the occupational risk exposure of health workers and waste-handlers and environmental exposure of the public. That is caused directly by illegal or careless management and disposal practices or indirectly through emissions and ash handling from medical waste incinerators. This research in 5 government and 12 private hospitals in the main city, Sana'a, aimed to evaluate waste-workers' and hospital administrators' knowledge and practices regarding medical waste handling. Interviews and observations showed that the waste-

workers were collecting medical and non-medical wastes together manually in all hospitals without receiving adequate training and without using proper protection equipment. There was poor awareness about medical waste risks and safe handling procedures among hospital administrators, and most hospitals did not differentiate between domestic and medical waste disposal. Budgets were not allocated for waste management purposes, which led to shortages in waste handling equipment and an absence of training programmes for staff. Poor knowledge and practices and a high rate of injuries among waste-workers were noted, together with a risk of exposure of staff and visitors to hazardous waste.

Mathur, Dwivedi, Hassan and Misra (2011) conducted research in the city of Allahabad, India highlighting the waste produced in the course of healthcare activities carries a higher potential for infection and injury than any other type of waste. Inadequate and inappropriate knowledge of handling of healthcare waste may have serious health consequences and a significant impact on the environment as well. The objective was to assess knowledge, attitude, and practices of doctors, nurses, laboratory technicians, and sanitary staff regarding biomedical waste management of a larger study of assessing biomedical waste management among hospitals with bed capacity >100 within Allahabad. The study was conducted in one year. Study participants included healthcare personnel working in different departments of the hospitals. A total of 283 healthcare personnel consented for interview (93% response rate) which included 75 doctors, 60 nurses, 78 laboratory technicians, and 70 sanitary staff, who were interviewed and observed for biomedical waste management practices. These interviews and observations were conducted on a predesigned and a pretested questionnaire and checklist. The study furthermore shows that Doctors, nurses, and laboratory technicians have better knowledge than sanitary staff regarding biomedical waste management. Knowledge regarding the colour coding and waste segregation at source was found to be

better among nurses and laboratory staff as compared to doctors. Regarding practices related to biomedical waste management, sanitary staff was ignorant on all the counts. However, injury reporting was low across all the groups of health professionals.

Patil and Pokhrel (2005) conducted a case study on biomedical solid waste management in an Indian hospital. They argued that the onus lies on hospitals and other health care institutions to ensure that there are no adverse health and environmental consequences as a result of their waste handling, treatment and disposal activities. Waste management has become a critical issue as it poses potential health risks and damage to the environment, which has taken a central place in the national health policy of India and is attracting a considerable international interest. The objectives of this study were to assess the waste handling and treatment system of hospital bio-medical solid waste and its mandatory compliance with, at the chosen Hospital and Medical Research Centre, Belgaum, India and to quantitatively estimate the amount of non-infectious and infectious waste generated in different wards/sections. A general survey of the operating procedures practiced in handling and treatment of solid waste was performed to assess its compliance with standard legal norms and procedures, as well as the quantitative determination of waste. Questions were raised about the determination of medical waste generated from different places in the study area and over the nature of assistance and support that was needed in determining the quantity of wastes during the study period. Coded stickers were placed on all of the colour-coded, high-density, polyethylene bags used for collection of the waste to facilitate in tracing the source of waste generation for the data collection. The quantities of infectious and non-infectious solid waste were recorded in two places, namely inside the incinerator room and outside the incinerator room for infectious and non-infectious wastes, respectively. Solid waste of both types (infectious and non-infectious) was weighed individually on a

suspension spring scale (± 100 g) with the assistance of the staff and the weight was recorded by department. The amount of non-infectious and infectious waste generated in kg/day in each ward and various blocks was determined and recorded for each day over a 3- month period. During the study, it was observed that the personnel working were trained to take adequate precautionary measures in handling these bio-hazardous waste materials. The process of segregation, collection, transport, storage and final disposal of infectious waste was done in compliance with the Standard Procedures and rules. The non-infectious waste was collected separately in different containers and treated as general waste, on average about 520 kg of non-infectious and 101 kg of infectious waste is generated per day (about 2.31 kg per day per bed, gross weight comprising both infectious and non-infectious waste).

A study by Hassan, Ahmed, Rahman and Biswas (2008) on the practice of handling medical waste management in Dhaka City, Bangladesh, indicates that Medical waste is infectious and hazardous. It poses serious threats to environmental health and requires specific treatment and management prior to its final disposal. The problem is growing with an ever-increasing number of hospitals, clinics, and diagnostic laboratories in Dhaka City, Bangladesh. However, research on this critical issue has been very limited, and there is a serious lack of information for planning. This paper seeks to document the handling practice of waste (e.g. collection, storage, transportation and disposal) along with the types and amount of wastes generated by Health Care Establishments (HCE). A total of 60 out of the existing 68 HCE in the study areas provided relevant information. The study of Hassan, *et al.* (2008) study used empirical field observations and field-level data collection through inventories, questionnaire surveys and formal and informal interviews. A structured questionnaire was designed to collect information addressing the generation of different medical wastes according to amount and sources from different HCE. A number of in-depth

interviews were arranged to enhance the understanding of previous and existing management practice of medical wastes. A number of specific questions were asked of nurses, hospital managers, doctors, and cleaners to elicit their knowledge. The collected data with the questionnaire survey were analysed, mainly with simple descriptive statistics; while the qualitative mode of analysis is mainly in narrative form. The paper shows that the surveyed HCE generate a total of 5,562 kg/day of wastes, of which about 77.4 per cent are non-hazardous and about 22.6 per cent are hazardous. The average waste generation rate for the surveyed HCE is 1.9 kg/bed/day or 0.5 kg/patient/day. The study reveals that there is no proper, systematic management of medical waste except in a few private HCE that segregate their infectious wastes. Some cleaners were found to salvage used sharps, saline bags, blood bags and test tubes for resale or reuse. The paper reveals that the lack of awareness, appropriate policy and laws, and willingness are responsible for the improper management of medical waste in Dhaka City. The paper also shows that a newly designed medical waste management system currently serves a limited number of HCE. New facilities should be established for the complete management of medical waste in Dhaka City.

Yemen, India and Bangladesh are not the only countries where medical waste is a problem. The United Nations of America experience similar problems as indicated in the study by Bernstein, Haug and Ottenfeld (2009). This study shows that proper and safe disposal of hospital waste constitutes an extremely important aspect of hospital operations from both a managerial and marketing standpoint. This research is based on a survey of 410 United States hospitals which seeks to identify the key problems these institutions face regarding waste disposal, and the current practices that they employ. Among the findings, are that the top five important dimensions in selecting an outside service to dispose of medical waste included the reliability of service, environmental responsibility, accurate billing, price

considerations, and attitude of employees. The impact of institutional size (based on hospital census) is also investigated in terms of its influence on waste management practices.

Southern African countries also face similar concerns with medical waste and in this regard a case study by Taru and Kuvarega (2005) on solid medical waste management at the Parirenyatwa Hospital, Harare Zimbabwe confirms the aforementioned concerns that medical waste is potentially hazardous, infectious and toxic. It therefore requires special handling and disposal practices. This research investigated the flow of solid medical waste. Qualitative and quantitative data collection techniques were used. The researchers made frequent visits to the hospital to find out how solid medical waste is generated, stored, collected, and disposed of. Interviews were carried out with key personnel such as the incinerator operator, infection control sister, and matron. Waste collection workers were also interviewed to establish how they collect and store solid material waste. The study established that solid waste is largely collected and stored together with other refuse such as plastics, organics, and food leftovers. Of the interviewed workers, 98% reported that solid medical waste is not separated from other refuse. This implies that medical waste ultimately finds its way to the municipal dumpsite. It is recommended that medical waste be stored and collected separately from other refuse. Taking an integrated approach to solid medical management may reduce the volume of waste that has to be stored, collected, and incinerated, thus, reducing cost. Besides, environmental health and waste management experts must be included in the infection control team. This may increase the effectiveness and ability of the infection control team to manage solid medical waste so that it does not find its way to the municipal dumpsite.

In South Africa, for instance, a study was undertaken by Abor and Bouwer (2008) on Medical waste management practices in a hospital in Cape Town, South Africa. Medical waste management has become a critical issue as it poses potential health risks and damage to the environment, which has taken a central place in the national health policies of many countries. In developing countries, medical wastes have not received sufficient attention. This is because, very often, health issues compete for the very limited resources. In many countries, hazardous and medical wastes are still handled and disposed together with domestic wastes, thus creating a great health risk to municipal workers, the public and the environment. The methodology to be adopted for this study followed a two stage strategy, namely the examination of the rules, procedures, and regulations regarding the management of medical waste and the spending of time in the different departments of the hospital in recording observations and writing notes about the practices of the medical waste management. The results of this study revealed that the hospital does not quantify medical waste. Segregation of medical waste into infectious waste and non-infectious waste is not conducted according to definite rules and standards. Separation of medical waste and municipal waste is however practiced to a satisfactory extent. Wheeled trolleys are used for on-site transportation of waste. Off-site transportation of waste is outsourced to a private firm. Incineration is used in the final disposal of infectious waste. Non-infectious waste is disposed using land disposal method. There is no policy and plan in place for managing medical waste.

2.4 CONCLUSION.

This chapter has provided the theoretical basis for the study and has revealed that HCW Management has been developing throughout the world since poor management of health

care waste potentially exposes health care workers, waste handlers, patients and the community at large to infection, toxic effects and injuries, and risks polluting the environment. It is essential that all medical waste materials are segregated at the point of generation, appropriately treated and disposed of safely (WHO, 2007). They may also pose an immediate threat when improperly treated, stored, transported, disposed of or otherwise managed and exhibit the characteristics of corrosivity, toxicity, inflammability, volatility, explosivity or radioactivity (Fuggle & Rabie, 1992: 495).

Previous research studies on the area of medical waste echoes the United Nations global concerns about the problems of medical waste. The literature review highlighted previous research studies on this area, carried out in countries such as Yemen, India, Bangladesh, United Nations of America and in Southern African countries such as Zimbabwe and South Africa.

Segregation was expounded on and described as a key strategy with two-fold advantages, namely, financial and environmental. It was mentioned that segregation allows risk wastes and general wastes to be treated and disposed of separately. The nature of waste was discussed in terms of infectious sharps, infectious non sharps and non-infectious wastes, each needing a special treatment technology.

The research methodology is discussed in the next chapter. It describes the approach and methods used in the selection of the study area, as well as the sample selection, data collection and data analysis in order to meet the objectives stated in Chapter 1.

CHAPTER THREE RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

This chapter discusses sample design, sample selection, data collection, data analysis and the pilot study. An individual interview based on an open-ended questionnaire was used to collect data from three private sector hospitals, which are based in the Gauteng province, South Africa. Data collected, included total number of patients visiting each hospital for the year, as well as HCW stream and processes, actual quantities of the HCRW from the point when it was on-site collected by the waste service provider and is taken for autoclave treatment. The questionnaire was tested in a pilot survey.

A Secondary Data Analysis (SDA) design, combined with multiple case studies, was applied. This empirical study used existing data. The SDA aims at reanalysing such data in order to test hypotheses or to validate models (Mouton, 2001:164). The design classification is based on numeric data with medium (statistical) control and key research questions are casual in nature. Although the researcher in SDA cannot undertake primary analysis, one of the advantages of SDA is that it forces the researcher to be explicit about the assumptions and theory that underlie the data. Data analysis in SDA is based on standard statistical techniques. The strengths of SDA are saving in time and costs, because of the use of existing data or the possibility of re-analysing using previous findings. The limitations of SDA are that it is not able to control data collection errors and that it is constrained in analysis by original objectives of the research (Mouton, 2001:164).

A multiple case study research design is preferred for the examining of contemporary real-life situations that cannot be manipulated by the researcher.

The SDA design combined with multiple case studies will make use of secondary data collected and primary data collected during key informant interviews. Key variables that will be collected include (these were selected from what was available from secondary data and after the literature study as completed)

- Total number of patients
- Actual quantities
- Type of infrastructure and services
- Areas where HCW is generated, due to different services
- Waste management team
- Number of beds.
- Number of patients.
- Diverse facilities (acute care hospital business, general hospital facilities of various sizes that include intensive care units (ICUs), high care units (HCUs), operating theatres, emergency units, maternity units and cardiac units, as well as other specialised facilities that provide either inpatient or outpatient services in the areas of acute rehabilitation, chronic renal dialysis, mental healthcare services and radiation and chemotherapy oncology).
- Different categories of waste.
- Use of protective equipment
- Storage and collection of sharps, Infectious waste, plasma/anatomical waste and pharmaceutical waste
- Share same fixed contract with the same waste service provider

- Disposal costs of HCW per unit prize per month
- Manual, policy, or guidelines for HCW risk management
- Defined procedure for HCW handling- not be found.
- Training of staff on HCW handling
- Handlers of HCW
- Transportation of HCW to central storage points

Chapter 2 established the model for the optimization of HCRW management, including the HCRW stream. This serves as basis for the development of the interview questions used in conjunction with the objectives to collect information from the selected respondents in respect of HCW management practices, including the HCRW Stream. The focus of this study was ensured through the twofold course of actions, namely, the overview of the available literature on HCW management, as well as the empirical research at the private sector Hospitals.

- Data on Tracking receipts and WCD of 365 days per hospital X 3 hospitals and invoices and summary x 12 months x 3 hospitals were collected using this method.
- Field data collection entailed the use of WCD and invoices interviews, open discussions with key informants.

The next sections describe the methodology under the sub-headings sample design, sample selection, data collection, data analysis and the pilot study.

3.2 SAMPLE DESIGN

Three private Hospitals in the Gauteng province were targeted. In each hospital, three employees involved in HCW management were personally interviewed who were the

persons handling the day-to-day operation at the three private Hospitals' HCRW waste stream/ management activities, regarding HCW collection, transport, treatment and keeping the file with all the substantive WCD documents, such as the tracking receipt, white copy 1 and the pink copy, the destruction certificate and the copy of the invoice with the attached summary of sequence number of the WCD and the quantities. It includes Employees/Persons administrating the DMS and WCD and invoices, such as the Quality Safety Support Specialist and Services Managers/co-ordinators. These employees were crucial in providing information about actual practices regarding HCW collection, transport, treatment and final disposal.

The research process in this study involves the evaluation of the available literature in search of a model for an effective HCW management, waste stream (quantification of waste from point of origin to point of disposal). The open ended research questionnaire was used to obtain background information about the administrative processes that is used to record the quantities. These questionnaires were discussed with the Quality Safety Support Specialist and Service managers/coordinator.

The sample size of this study comprises 3 hospitals. Three hospitals were chosen in the Gauteng province. Sampling method: Saunders *et al.*, (2005:175) maintain that purposive sampling enables the researcher to use own judgment in selecting cases that best enable the researcher to answer the set questions and to meet the study's objectives. For this reason, this method was chosen for this study.

Reliability can be explained as the extent to which a tool can be relied upon to give results that are consistent (Neuman, 2006:222). Neuman (2006:223) adds that similar results must

be obtained if the same test is carried out on more than one occasion under the same conditions. In this study, copies of documents were used to extract the data needed.

These types of questions are normally consistently interpreted each time they are used (Neuman, 2006:223).

3.3 SAMPLE SELECTION

Judgemental or purposive sampling was used to select the case studies. No further sampling was possible, given that existing data over a period of 12 months were analysed. The three private hospitals were considered to make up the accessible population for this study.

The Hospital Group includes more than 30 hospitals and offers a range of healthcare services throughout South Africa. The Group has hospitals in seven of the country's nine provinces, and in the country's most populous metropolitan areas, including Johannesburg, Pretoria, Cape Town, Durban, Port Elizabeth, East London and Bloemfontein. World-class facilities and expertise are complemented by mental health, acute rehabilitation, renal dialysis, acute hospitalisation and long-term services. The Group has over 8000 registered beds respectively made up of 7000 acute hospital beds, over 700 ICU beds and over 300 high-care beds. There are in addition acute rehabilitation facilities, acute rehabilitation beds, mental health care facilities, mental health care beds, renal dialysis units and renal stations.

The rationale for choosing this was because private sector hospitals have a large contribution towards the generation of HCW in South Africa. Locations of the selected hospitals were

convenient. The objective is not to find weaknesses in the waste stream, but to target an audience that could provide answers to the research problem/procedure. Whether quantification from point of generation to point of disposal still exist and the possibility to get answers at a private sector hospital within a bigger metropolitan area, is more likely than at a public sector hospital in a remote area. Have better trained staff, funding to cater for waste service provider and better technology to afford more environmentally friendly treatment of HCW.

The criteria used for selection were the relevant province, Gauteng- representing the wealthiest province in South Africa and the economic hub. The population sample size of this study comprises of more than 30 hospitals of which three hospitals in the Gauteng province are targeted/ were selected. In each hospital 3 employees involved in HCW were personally interviewed.

The case studies in this study are represented by three hospitals in the Group from the total of more than 30 hospitals. Hospital A facilities includes 364 beds and 14 theatres. The services include a cardiac unit, cardiothoracic intensive care, orthopaedic surgery, neuro-spinal rehabilitation, radiology and a maternity unit. Hospital B facilities includes 214 beds and 9 theatres. The services entails orthopaedic care, surgery in connection with physiotherapy, oncology clinic, accident and emergency unit, general intensive care unit, a stroke unit, high care unit, a skin and laser clinic and a radiology unit. Hospital C facilities include a 28 bed maternity unit, a 10 bed neonatal intensive care, a 4 bed paediatric intensive care unit and a 12 bed general intensive care unit. The services covers a 24 hour accident and emergency unit, dedicated helicopter landing pad, radiology facility, an infertility clinic,

urodynamic unit, wound care clinic and a oncology unit. These three hospitals were selected based on easy access to the researcher.

It was meant to provide insight into issues relating to the administration and recording of HCW.

3.4 DATA COLLECTION

A questionnaire with a set of open-ended questions, which required more context, explanation and insight from the responder, was directly administered to the selected hospitals in the Pretoria area. Data collection was started in mid-January 2014 and ended on June 2014. This was done after receiving letters of approval from the Group and all three the private hospitals' and all the selected hospitals were visited with notification and by appointment.

Data collection: to facilitate reliability and validity the questionnaire were administered personally. Interviews were conducted in one day per hospital. Permission was obtained from the Group, as well as the relevant hospitals on condition that the name of the Group and the name of hospital and the outsourced waste service provider were not used in the dissertation. The information obtained has been used to answer the research questions, and to compare this study with studies conducted by other researchers in this field.

The questionnaire had sections that were arranged to suit the set objectives of the study and to determine and at the same time gathered data on actual quantities of waste with regard to

the generations of waste; segregation of waste, collection of waste, disposal/treatment, as well as data involved in the payment for services rendered by a waste service provider.

To facilitate reliability and validity, the questionnaire was administered personally, for the purpose of data collection. 1 day per hospital was spent during the period January to June 2014 collecting the data.

The three hospitals's requested that the interview be held on Fridays because it was less busy. Therefore, the Private Sector hospitals visit schedule was adjusted to accommodate hospitals that preferred Fridays.

Ethics Institutional ethical review

Ethical approval was granted by the University of South Africa, on the condition that landfill sites are not visited and that HCW not handled. Prior to the Ethics Committee's approval, a letter was then dispatched to the Groups' Head Quarters, asking for permission to conduct the research study in the three selected hospitals. This request was positively met and a letter of consent was received. Furthermore, permission was sought from each of the selected hospitals before an appointment was made to visit each hospital before data collection process started. Permission was granted in all the cases. Permission was also obtained from the relevant hospitals on condition imposed that the name of the hospital and the waste service provider was not be used in the dissertation.

Confidentiality and anonymity was guaranteed by stipulating that no names would be written on the questionnaires and that participation was voluntary.

- **Question 1, 2 and 3, and question 5 and 6:** These five questions seek to gain an understanding of the admin processes followed to record the actual quantities of HCW generated in each hospital. The findings revealed that the actual quantities of HCRW are not recorded at the point of generation, but when it is collected by the waste service provider. This was followed by a request to provide the relevant documentation that substantiates the tracking, recording and capturing and reconciliation process over the period 1/1/2013- 31/12/2013 as per hospital. The outcome of these five questions revealed the following WCD documents:
 - Tracking receipt
 - Collection certificate (white copy)
 - Destruction certificate (pink copy)
 - Invoice and summary
 - Risk management plan per hospital
 - Invoice and the attached summary
- **Question 4, 5, 6, 7, 8 and 9:** These six questions involve the monitoring and obtaining assurance/confirmation about the reliability and accuracy of the quantities.
- **Question 10:** This question specifically covered the awareness about the Waste information system.
- **Question 11 and 12:** These two questions raised whether there are plans and policies in place to comply with Occupational Health and Safety legislation, training and induction of staff and risk management plan, which include risks to humans and the environment.
- **Question 13:** number of patients per hospital for the period under review.

It was at this stage revealed that the autoclave treatment system is used and not the incineration disposal method.

3.5 DATA ANALYSIS

Secondary data was used with regard to the following DMS documents for the period 1/1/2013-31/12/2013.

- Hard copy of WCD: Tracking receipts for 365 days x 3 hospitals=1095 copies
- Hard copy of WCD Pink copy: Destruction certificate for 365 days x 3 hospitals=1095 copies-
- Hard copy of Invoices: 1 copy per month x 12 months x 3 hospitals=36 copies
- Hard copy of summaries attached to invoices: 1 copy per month x 12 months x 3 hospitals =36 copies.
- Obtain the risk management plan per hospitals
- Verified that all signatures certifying the completeness and accuracy are on WCD pink destruction certificate. This was found to be complete on all the destruction certificates of all three hospitals.

3.6 DATA INTERPRETATION

A monthly recalculation was done, per hospital and over the 12 month period, to reconcile the quantities of the different waste categories, as reflected on the sequence numbered destruction certificate, with the corresponding information on the summaries that accompanies the monthly invoice. This was done as a measure to mitigate numerical errors and to test whether the information on the WCD could be traced to the invoice and *vice versa*.

Desk top study conducted to capture the secondary data on MS Excel spread sheets to and to recalculate the quantities of HCW per category, per month and per hospital. The cost involved in payment for services rendered by the waste service provider, as well as the number of patients per year, per hospital, was also captured on Excel spread sheets. Tabulations and graphs were thereafter compiled to provide visual interpretation of the quantities and categories of HCW per hospital, as well as number of patients per year and the monetary value paid to the service provider for services rendered.

3.7 THE PILOT STUDY

The questionnaire was pre-tested in one hospital. This was done to refine the questionnaire and to enable ease in the understanding of the questions by the respondents and to prevent problems in recording data (Saunders, *et al.*, 2005:308).

3.8 CONCLUSION

This chapter described the methods used in the design and selection of the sample, and the collection and analysis of data. The next chapter presents the results of the study with a view to meeting the stated objectives and testing the working hypotheses.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

The data collection was carried out from January to June 2014. The methods of sample selection and data collection are mentioned in Chapter 3, with a total of three case studies from the 63 private hospitals within The Group. The three case studies are part of a Hospital Group. The Hospital Group includes 63 hospitals and offers a range of healthcare services throughout South Africa and complemented by mental health, acute rehabilitation, renal dialysis, acute hospitalisation and long-term services.

The description of health care risk waste impacts on air, water, soil, natural habitats and workers health and safety are mentioned in the Groups Health Care Risk Waste Management Plan of January 2012. These impacts indicate that water quality could be affected when contaminated water/chemicals are spilled into the general drainage systems, soil could be polluted if the HCRW was not properly treated, exposure to HCRW can lead to contamination and spreading of diseases. Some viruses e.g. Hepatitis B is easy transmittable. Needle stick exposures could cause serious diseases, when HCRW is not treated correctly and spillages occur close to communities, it could affect their water and soil quality, children playing in such areas or people passing could get infected. This could lead to out-breaks of diseases and to multiple facilities. The Chapter presents the results and the discussions of the main study under the sub-headings “reconciliation of waste quantities on the internal records with external, records”, “quantities of medical waste is equal to the quantity of medical waste disposed/treated”. Actual secondary data captured, over a period of 12 months on the quantities of HCRW, can help explain whether the quantification of HCRW from the point of generation to final disposal is possible, as stated in working Hypotheses 1, 2 and 3.

“Reconciliation of waste quantities on the internal records with external, records” addresses objective 2 and could also assist to help test hypotheses 1. “Quantities of medical waste generated are equal to the quantity of medical waste disposed/treated” addresses objective 2 and this objective is linked to the testing of Hypotheses 2 and Hypotheses 3. “Ratio factor between the quantity of medical waste before incineration and the quantity of the residue after incineration”, address objective 3 and it could also serve to test Hypotheses 1.

4.2 RECONCILIATION OF WASTE QUANTITIES ON THE INTERNAL RECORDS WITH THE EXTERNAL RECORDS

The HCW produced in the three hospitals follows an identified stream, as indicated earlier (Figure 1 refers). (Kristiansen, 2007:7). The stream comprises several steps that include generation, segregation, on-site transportation, on-site storage, off-site transportation and final off-site Autoclave treatment. The findings are shown in Figure 2, against the background of each step in the waste stream.

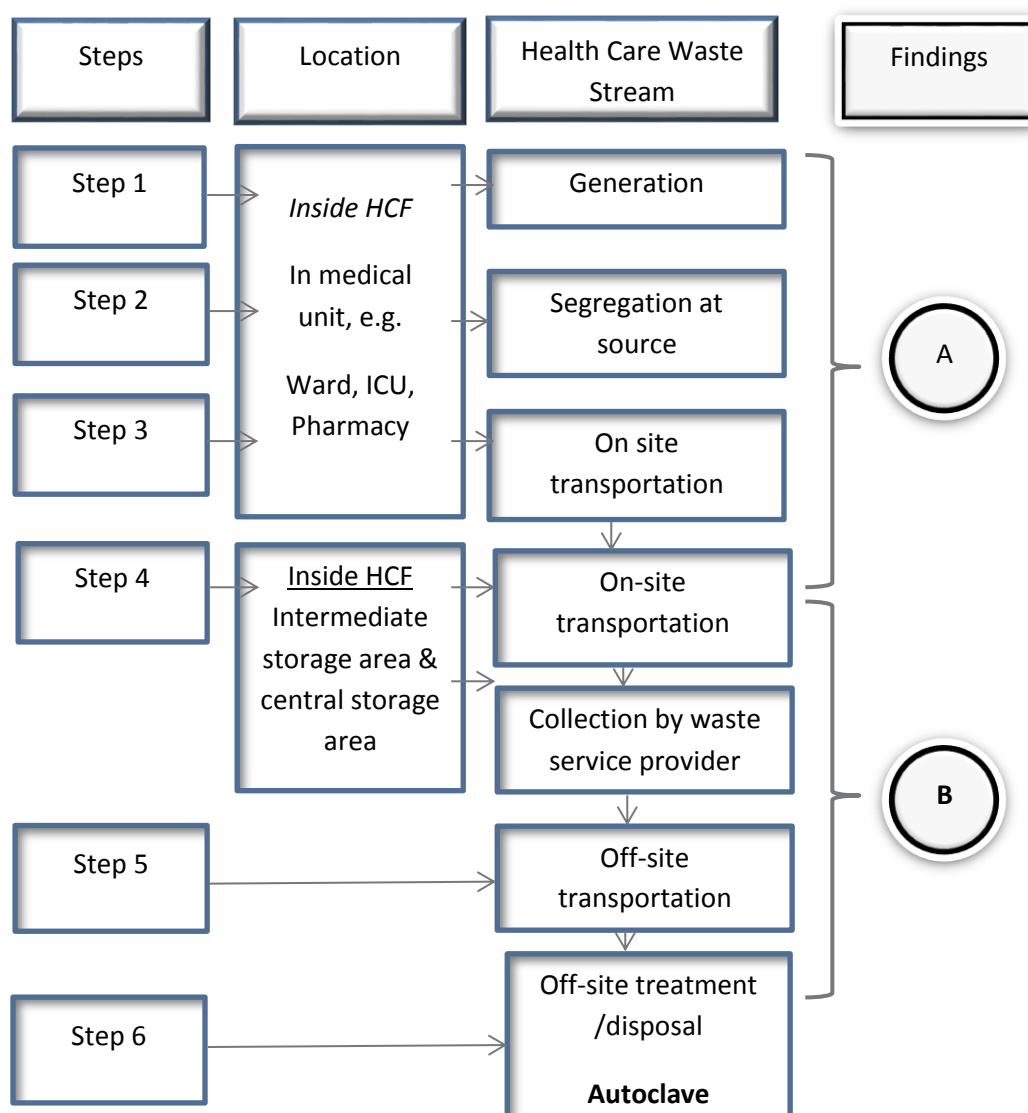


Figure 2: The Waste stream linked to the findings (Adopted from the State of Eritrea, Ministry of Health (2000:24).

Finding A, Figure 2 is linked to the steps in the waste related to generation, segregation, on-site transportation and on-site storage (Hypotheses 1). The collection of HCW takes place from generation point areas, such as a ward, theatre, intensive care unit, oncology unit and casualty unit and is thereafter taken to the intermediate storage area, which could include a sluice room, theatre fridge, mortuary, the pharmacy, maintenance department and procedure room. Internal transport from the intermediate storage area to the central storage area is done

via a 240 litre wheelie bin, sac trolley/double panel trolley and is taken to the central storage area, which is the hospital's waste room. The containers used include differences and variations in volume and sizes of reusable containers, sharps containers, specifics and cylinder containers. According to the Groups Plan, the container colour for Sharps waste is yellow, the container colour for infectious and plasma/anatomical waste is red and the container colour for pharmaceutical waste is green.

The three hospitals generate health care general waste (Domestic waste), as well as health care risk waste. The source of the health care waste is from offices, kitchens, treatment rooms, stores and the garden. This type of waste includes for example paper, food, fruit peels, dry flowers, packing material, grass, leaves, etc. The containerisation of health care general waste entails transparent liners in domestic bins, the frequency of disposal of health care general waste is on a daily basis, except for garden refuse that is collected and disposed of on a weekly basis. The method of the disposal of the health care general waste is at a municipal landfill sites. The generation and disposal of health care general waste does not form part of the waste stream for this investigation, as illustrated in Figure 2.

The health care risk waste generated at the three hospitals, include sharps waste, infectious waste, plasma/anatomical waste and pharmaceutical waste. The method of disposal of this health care waste is not through incineration, but through autoclave by an external service provider. Health care waste is collected and autoclave on a daily basis. If hospitals do not quantify waste into its categories, namely, HCRW versus General waste, these waste streams get mixed and becomes expensive in terms of disposal and treatment (DEAT, 2000b:15).

HCRW needs to be segregated on a daily basis as HCRW is collected on a daily basis by the waste service provider. Segregation is the process of separating different types of waste at the point of keeping them isolated from each other (Department of Health, Manila, 2005:23). If waste is segregated at the point of generation, only to be mixed together by labourers, as they collect it, or if a hospital has segregated its waste and secured it in separate containers for ultimate disposal, only to have municipal workers mix it together after a single collection, then the ultimate classification is lost (CGH Environmental Strategists (2002:1). Therefore, ensuring efficient and reliable segregation remains the most important step. If medical waste is not separated from other refuse, then this implies that medical waste ultimately finds its way to the municipal landfill site. It is recommended that medical waste be stored and collected separately from other refuse (Tura and Kuvarega, 2005).

The impact of HCW waste, even if only one or two used sharp needles have been mixed with domestic waste and it is been found on a municipal landfill site could result into legal implications for the hospitals. The impact on the other hand could be of a financial nature having implication if general waste, such as paper or kitchen waste is regularly mixed with HCW. The average unit prize of about R9.50 per kg, shows that just 500 grams of used paper or packing material, mixed with HCRW per day, over 365 days, could overstate the annual costs for one hospital with about R 100 000.00.

The hospital does not weigh the health care waste at the source or point of origin or inside the medical/unit (e.g. wards, theatre intensive care unit), and/or after it has been generated, segregated and onsite transported to the on-site intermediate and/or central storage area. The on-site collection and transportation of waste is done in order to avoid an accumulation of waste in the wards (The State of Eritrea, 2004:26).

There are therefore no internal records to show quantities of HCW or general waste (domestic waste) generated. The risk that the quantities in the next step, namely when it is collected and weighed by the waste service provider is overstated by miss-segregation, for example mixing of health care general waste (general or domestic waste) with the HRW, still exist. In South Africa, a study mentions that in many countries, hazardous and medical wastes are still handled and disposed together with domestic wastes, thus creating a great health risk to municipal workers, the public and the environment (Abor & Bouwer ,2008).

The Groups action to mitigate the risk of miss-segregation is embedded in their Health Care Risk Waste Management Plan (HCRWMP). The primary function of this plan is to demonstrate that there is a 2 years plan in place to ensure the safe handling of health care waste from the source of generation, through correct segregation, containerization, storage, transportation, treatment and final disposal thereof.

This plan furthermore covers the description of the impact of health care risk waste on air, water, soil, natural habitats e.g. wetlands, workers health and safety and public health and elaborate on the internal HCRW management procedures and policies. These management procedures and policies addresses the definition and nature of health care risk waste, the waste management audit, induction of new employees, personal protective equipment management and incident Management. There is, as part of the HCRW management procedures and policies, also a monitoring plan. This plan includes the aspects to be monitored, tool to be used (checklist or physical inspection), frequency of the monitoring (monthly, or quarterly), reference to the person that conducted the monitoring and reference to the report.

The plan also provides the structure on the nature and extent of statistics to be compiled on a monthly basis. This statistics entails the number of patients treated, average tonnage of HCRW generated per month, quantity and type of containers used, reported incidents (service delivery failures, needle stick injuries, internal spillage from poorly sealed containers), poor segregation, in-service training on waste segregation conducted.

HCRWMP Training programme. This programme includes reference to the targeted staff, the frequency of the training (monthly or quarterly) the content of the training, the methodology of the training and the possible venue. The content of the training covers the categories of HCRW, segregation, HCRWM Monitoring principles, HCRWM protocols, Pharmaceutical protocol, HCRWM costs, HCRWM regulations, the colour coding scheme, personal protective clothing, health hazards, assembly and placement and replacement of containers and the finance systems training.

The hospital uses the colour coding container scheme as indicated in their waste management plan. This plan recognises the existence of different types of hospital waste such as the sharps waste, infectious waste, plasma/anatomical waste and pharmaceutical waste.

The mitigating measures, that are put in place to overcome the risk which miss-segregation, as a result that there is no quantification of waste from point of generation, covers plans, policies, waste audits, induction of new employees, general training, personal protective equipment, colour coded containers and monitoring demonstrates that the Group has mitigating measures in place to counter the risk that miss-segregation of HCRW entails.

Hypotheses 1, that the HCRW is not weighed at the source or point of generation is however confirmed, in spite of all the mitigating measures. The lack of quantities also does not allow for the calculation to be made of the percentage of HCRW versus the percentage of domestic waste/ Health care general waste. A study by Hassan, *et al.* (2008) on the pattern of medical waste management in Dhaka City, Bangladesh, indicates that shows that the surveyed HCE generate a total of 5,562 kg/day of wastes, of which about 77.4 per cent are non-hazardous and about 22.6 per cent are hazardous. The average waste generation rate for the surveyed HCE is 1.9 kg/bed/day or 0.5 kg/patient/day.

4.3 QUANTITIES OF MEDICAL WASTE GENERATED IS EQUAL TO THE QUANTITY OF MEDICAL WASTE DISPOSED/TREATED

Finding B, Figure 2 is lined to the steps related to the collection of HCRW on-site, the off-site transportation of the waste, the final treatment of the waste, as well as the payment process for the services rendered by the waste service provider.

The success of the three hospitals processes to obtain the actual quantities of the HCW that is collected and autoclave treated were found to rely on a fixed contractual arrangement between the hospitals and an outsourced waste service provider. This fixed contract covers the collection, off-site transportation of the waste and the treatment of the waste. The fixed contract furthermore provides for the implementation of a Document Management System (DMS).

The DMS provides access to documentation, such as the waste tracking receipt, Waste Collection Document (WCD) and the destruction certificate and this documentation allows for an auditable tracking system from collection of the waste to its autoclave treatment

(cradle to grave). This documentation also allows the detailed breakdown of the actual quantities waste collected and treated. This breakdown allows accurate billing, because reconciliation and tracking between the recording information on the WCD and the invoice is possible and allows reliable analysing of tonnages of waste collected and transported and treated on a daily, weekly and monthly basis.

The major advantage of outsourcing the collection and transportation of the HCW is that a service provider will generally provide the technology to record the type and quantity of HCW collected, the type of container to be used and the service waste provider will also utilise a range of different size of vehicles, in order to cater for the expected quantity of HCRW to be collected and the distance to be travelled. There is then a dual responsibility as envisaged in the fixed contract between the two parties that signed the contract to ensure that the HCW is handled in terms of the requirements of legislation.

The application of this objective for this study led to the collection of the empirical data being presented in subsequent paragraphs in this chapter and a desk top study was conducted to capture the secondary data on MS Excel spread sheet and to recalculate the actual quantities of HCW per category, per month and per hospital that were collected by the waste service provider to test whether reconciliation are actually possible. The cost involved in the payment for services rendered by the waste service provider, as well as the number of patients per year, per hospital, was also captured on MS Excel spread sheets.

The collection certificates per hospital shows that the three hospitals generated the same type/categories of waste over the 12 month period, namely sharps, infections waste, pharmaceutical waste and plasma/Anatomical waste. The quantities of the HRCW generated

per hospital over the 12 month period will however, be different due to the differences in the facilities and services rendered as per hospital.

The empirical data was collected from 1 January to 31 December 2013, and the tabulations and graphs start off by giving the total of weight collection, per hospital, per month for the year.

The DMS consists of four copies. Copy 1 and 4 is white and is kept by the client, which is the three hospitals in this case; Copy 2 is also white and is kept by the outsourced waste service provider. This copy will be used at a later stage by the waste service provider to create the invoice that will be sending to the hospital, Copy 3 is pink in colour and represents the destruction certificate. This copy is kept by the client or the hospital in this case and is the proof that the waste that was collected and off-site transported by the outsourced waste service provider has reached the final step of treatment/disposal. All the copies have sequence numbers and reflect the same information, but the description certificate shows, in addition to the other copies, the dates of autoclave treatment and the signature of the representatives of the outsourced waste service confirming that the waste as collected was treated. The DMS furthermore make provision for the representatives of both the hospitals and the outsourced waste service provider to declare the nature, as well the correctness of the weight of the waste collected and treated. The very first document to be completed in the process is the tracking receipt (scanning slip), which is generated via the Reutech system. This system provides bar coding technology to help successfully track and weigh healthcare risk waste.

This tracking receipt shows the customer ID, date, drivers ID number, time, reference to the WCD sequence number, type/category of waste, type of container, actual quantity of waste (kg) per container, actual total weight of all the containers, signature of the representative of the hospital and signature of the representative of the waste service provider and the date.

The Generators certification, which is done by the representative of the hospitals, declare, at the point when the waste is collected by the outsourced waste service provider, that the contents are properly described, packaged, marked, labelled prior to transportation according to all relevant legislation. The name and signature of the hospitals representative, as well as the date appears on the white copies.

The waste service providers shows the acknowledgment of receipt of material on the white copy and declare that the contents as described, are packaged, marked and labelled according to all relevant legislation. The name and signature of the representative of the waste service provider and the date appears on the white copies, as well as the official stamp of the waste service provider. The waste service provider complete the pink copy, which is the destruction certificate and the name and signature of the representative of the waste service provider and the date of final treatment will appear on the destruction certificate. This is the confirmation that the waste has been collected by the waste service provider has reached the final step in the waste stream, namely treatment through the autoclave method.

Finding 2 also reveal that the waste service provider has a dual responsibility together with the client (Hospital) in ensuring cradle-to-grave compliance. This dual responsibility is embedded in the overall healthcare risk waste management service that forms part of the fixed contract, and entails a trained team that are committed to treat and dispose of waste and to assist the hospitals with the supply of disposable and reusable healthcare risk waste (HCRW) products, such as containers, bags and boxes, the distribution and transport of

containers and the collection of HCRW for treatment and disposal. The trucks of the waste service provider are also linked to iTruck real time tracking, enabling 24 hour surveillance of all vehicles and providing comprehensive logistical reports on vehicle movements, as well as the Reutech system, which provides bar coding technology to help successfully track and weigh healthcare risk waste, including the training of healthcare workers by SETA accredited trainers. This training covers topics such as the "Cradle-to-Grave" management of HCRW, the regulations and legislation governing the HCRW industry, the correct segregation of waste, as well as other training modules relating to the industry. Drivers, treatment and load assistants are also trained on the correct handling of healthcare risk waste and emergency procedures.

The service provider invoice the hospital on a monthly basis for services rendered. The invoice reflects the name of the customer (Hospital), delivery address, description of the category of the waste, quantity of the waste per category, price per category of waste, total rand value and reference to the sequence numbers of the WCD.

This invoice is supported by the summary of all the WCD issued during the month.

This summary refers to the hospital's name, date the service was rendered (date on the WCD certificates), WCD sequence numbers, category and quantity of waste collected and treated and the unit price per kg.

The hospital certify, as part of the internal accounting billing process, that the services, including destruction, as substantiated by the pink destruction certificate copy, were rendered as invoiced. This is very auditable due to the nature and extent of the supportive and sequence numbered documentation and certifications and declarations that provide sufficient information to conduct reconciliation.

Hypotheses 2 and 3 is partly true: Reconciliation and comparison between the invoice and the WCD destruction certificate is possible, because actual quantities on the summary and invoice and quantities on the WCD reconcile, as proven during the recalculation of the actual secondary data during this study and reflected in Tables. Information and certifications on financial related invoices and waste certificates by responsible/ designated employees at the hospitals and the service providers provide reliable trace of the quantities of medical waste generated, collected and disposed. The pink destruction certificate is the proof that the waste that was on-site collected by the service provider has been disposed /treated. The waste is however not quantified from point of origin to final autoclave treatment.

The DMS allows for the nature and extent of statistics to be compiled on a monthly basis. This statistics entails the tonnage of HCRW generated per month and quantity and type of containers used.

The following tables and figures should be seen in the light that it does not represent the quantities of HRWC generated, but only the quantities collected and autoclave treated over the period under review. It demonstrates however the nature and extent of the statistics and scenarios that could be created with tables, graphs and/or figures. Both the Tables and the graphs are included to show the actual quantities of HCW per month and per case study.

Hospital A:

Table 3 shows that Hospital A generated a total of 156 229 kg infectious waste over a period of 12 months. Figure 3 illustrates that the other three categories of waste generated by Hospital A, namely sharps, plasma/anatomical waste and pharmaceutical waste are significantly less in quantity, in comparison to the quantities of infectious waste. In comparison sharps is the second highest with a total of 9300 kg over a period of 12 months,

plasma/anatomical is next with a total of 1485.96kg over 12 months and pharmaceutical waste is the lowest, with a total of 195 kg over a period of 12 months.

Table 3: Hospital A: Categories and actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.

Month	Hospital A:			
	Disposed sharps (Kg)	Disposed plasma/Anatomical (Kg)	Disposed infectious waste (Kg)	Disposed Pharmaceutical (Kg)
January 2013	451.85	45.45	8 189.34	
February 2013	850.15	77.10	14 108.23	7.80
March 2013	1 053.30	76.85	17 596.07	17.40
April 2013	668.72	56.00	13 136.17	
May 2013	767.95	69.83	12 779.21	22.12
June 2013	752.69	62.59	12 945.37	
July 2013	812.50	96.90	13 521.38	
August 2013	817.53	62.70	11 844.03	105.00
September 2013	635.35	258.50	10 065.31	4.10
October 2013	995.74	287.84	17 419.87	29.75
November 2013	852.45	273.30	14 179.22	9.60
December 2013	642.13	118.90	10 445.76	
	9300.36	1485.96	156 229.96	195.77

*As a result of the low quantities of pharmaceutical waste these are not disposed of and quantified every month

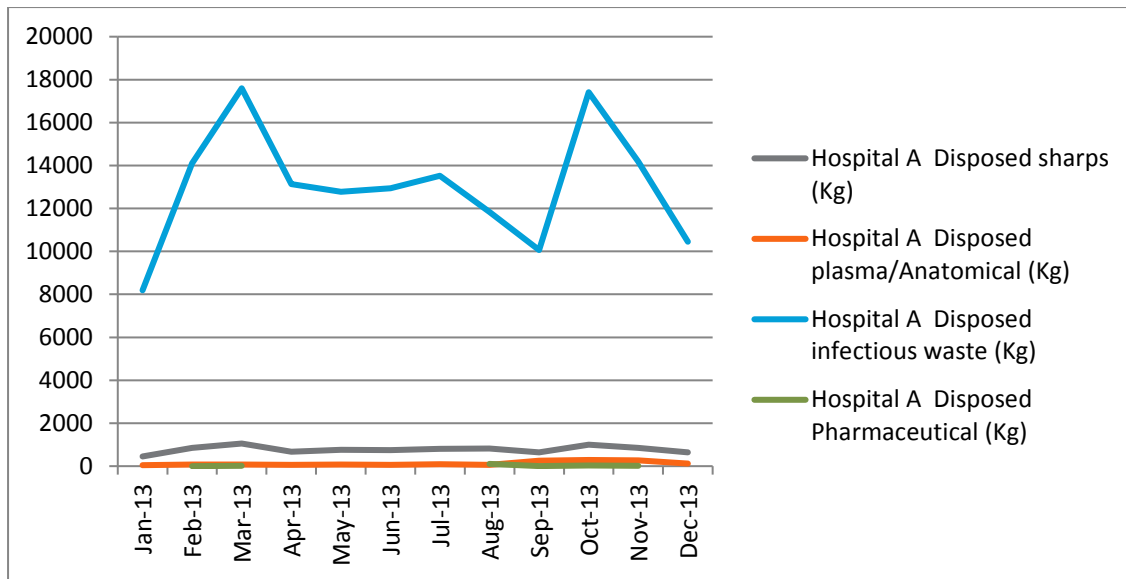


Figure 3: Hospital A: Categories and actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.

Hospital B:

Figure 4 shows that Hospital B generated a total of 86 720.49 kg infectious waste, which is significantly more than sharps as the second highest category with a total of 8032 kg over a period of 12 months, then pharmaceutical waste, with a total of 322 kg over a period of 12 months and plasma/anatomical waste (33.33 kg) is the lowest.

Table 4: Hospital B: Categories and actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.

Month	Hospital B:			
	Disposed sharps (Kg)	Disposed plasma/Anatomical (Kg)	Disposed infectious waste (Kg)	Disposed Pharmaceutical (Kg)
January 2013	456.15	18.00	3728.59	27.46
February 2013	619.00	9.38	7203.26	15.8
March 2013	1002.45	0.85	10361.11	
April 2013	738.6	0.45	7567.69	65.4
May 2013	596.03	0.15	6925.74	26.55
June 2013	613.77		7021.68	49.7
July 2013	677.35	0.3	7142.49	12.55
August 2013	649.62	2.8	7557.63	16.6
September 2013	528	0.85	6892.3	10.45
October 2013	800.4	0.4	8590.22	26.3
November 2013	675.07	0.15	8242.99	64.2
December 2013	676.39		5486.79	7.7
	8032.83	33.33	86 720.49	322.71

*As a result of the low quantities of pharmaceutical waste these are not disposed of and quantified every month

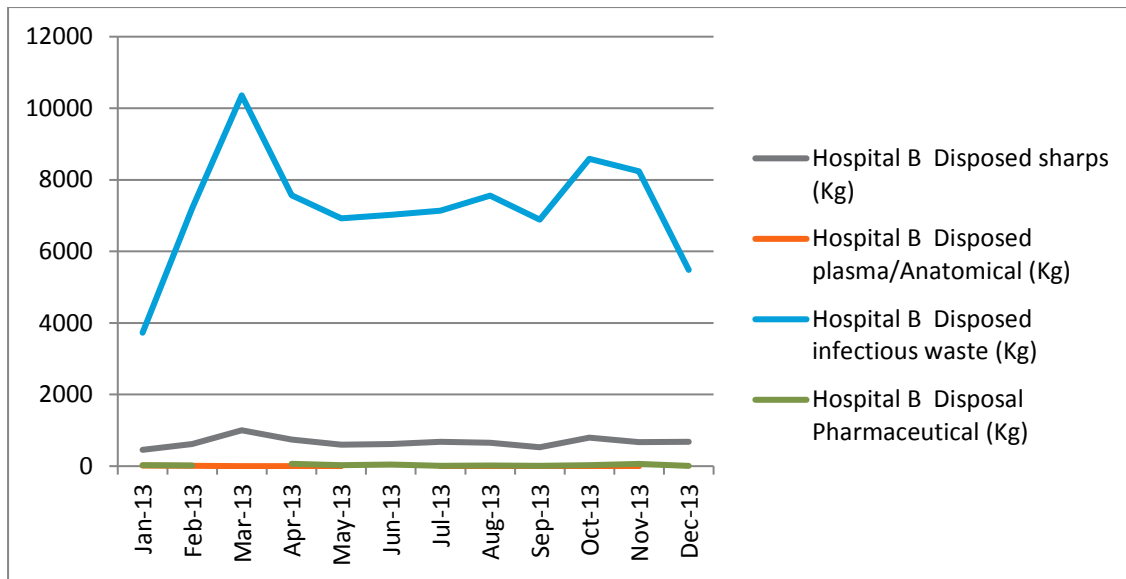


Figure 4: Hospital B: Categories and actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.

Hospital C:

Table 5 shows that Hospital C generated infectious waste with a total of 11 478 kg over a period of 12 months, sharps is the second highest with a total of 991 kg over a period of 12 months, then plasma/ anatomical waste (4389.25 kg) and pharmaceutical waste is the lowest quantity generated, with a total of 41 kg over a period of 12 months. As in Figure 4, the quantities differ to such an extent per case study that Figure 5 could not reflect the fluctuations to the full capacity.

Table 5: Hospital C: Categories and Actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.

Month	Hospital C			
	Disposed sharps	Disposed plasma/Anatomic al (Kg)	Disposed infectious waste (Kg)	Disposed Pharmaceutical (Kg)
January 2013	934.45	170.75	9 290.48	32.60
February 2013	1 590.00	240.58	13 395.29	54.10
March 2013	1 537.99	237.90	14 222.02	29.13
April 2013	1 480.87	268.25	15 664.62	59.30
May 2013	1 484.72	285.66	14 797.45	37.00
June 2013	1 335.81	263.77	13 597.89	49.13
July 2013	1 551.20	501.54	14 741.39	27.05
August 2013	1 482.05	465.54	15 508.77	51.55
September 2013	1 097.05	520.55	11 739.66	
October 2013	1 429.90	499.39	14 343.24	
November 2013	1 205.39	472.05	13 454.22	76.15
December 2013	991.18	463.27	11 478.51	41.03
	16120.61	4389.25	162233.54	457.04

*As a result of the low quantities of pharmaceutical waste these are not disposed of and quantified every month

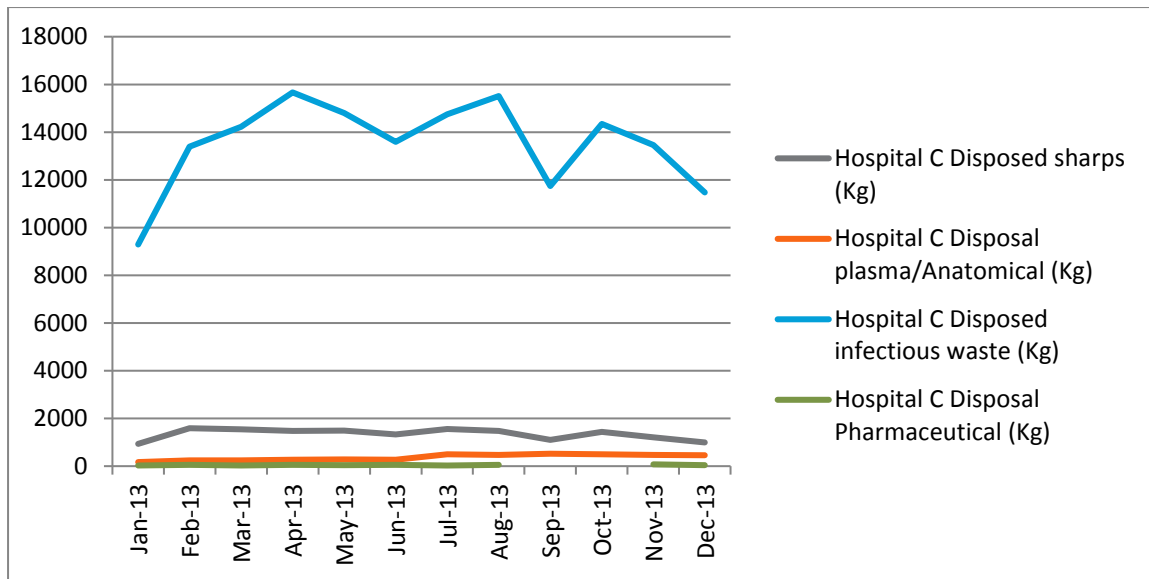


Figure 5: Hospital C: Categories and Actual quantities of health care waste collected, disposed and treated over a period of 12 months by the service provider.

Sharps – needles and syringes (not separated), scalpel blades, blades, razors, lancets, broken vials/ ampoules placed in yellow sharp containers, lids completely sealed and send to hospital waste storage room. It is weighed, manifest completed, signed, transported and autoclaved. Signed manifest then kept on file.

Table 6 shows per case study (Hospital A, B and C) the quantities of sharps that has been generated over the period of 12 months. Figure 6 shows the curves in respect of each hospital.

Table 6: Actual disposed sharp waste as a specific category per hospital.

Month	Hospital A (Kg)	Hospital B (Kg)	Hospital C (Kg)
January 2013	451.85	456.15	934.45
February 2013	850.15	619.00	1 590.00
March 2013	1 053.30	1002.45	1 537.99
April 2013	668.72	738.6	1 480.87
May 2013	767.95	596.03	1 484.72
June 2013	752.69	613.77	1 335.81
July 2013	812.50	677.35	1 551.20
August 2013	817.53	649.62	1 482.05
September 2013	635.35	528	1 097.05
October 2013	995.74	800.4	1 429.90
November 2013	852.45	675.07	1 205.39
December 2013	642.13	676.39	991.18

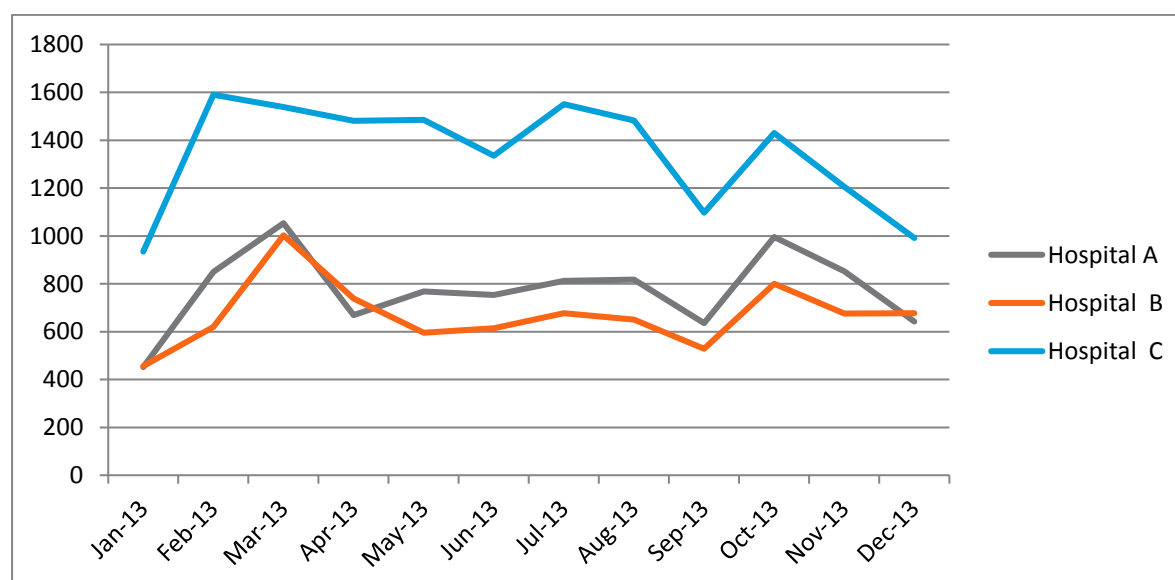


Figure 6: Actual disposed sharps as a specific category over a period of 12 months.

Infectious waste - used dressings, swabs, blood bags, vaculiter bags, soiled linen savers, IV lines, urinary drainage bags etc. placed in red hazardous waste containers with a red liner – taken to hospital waste storage room, weighed, manifest completed, signed, transported and autoclaved. The signed manifest then kept on file.

Table 7 shows per case study (Hospital A, B and C) the quantities of infectious waste that has been generated over the period of 12 months. Figure 7 shows the fluctuations/ curves in respect of each hospital.

Table 7: Actual disposed infectious waste as a specific category per hospital.

Month	Hospital A (Kg)	Hospital B (Kg)	Hospital C (Kg)
January 2013	8 189.34	3728.59	9 290.48
February 2013	14 108.23	7203.26	13 395.29
March 2013	17 596.07	10361.11	14 222.02
April 2013	13 136.17	7567.69	15 664.62
May 2013	12 779.21	6925.74	14 797.45
June 2013	12 945.37	7021.68	13 597.89
July 2013	13 521.38	7142.49	14 741.39
August 2013	11 844.03	7557.63	15 508.77
September 2013	10 065.31	6892.3	11 739.66
October 2013	17 419.87	8590.22	14 343.24
November 2013	14 179.22	8242.99	13 454.22
December 2013	10 445.76	5486.79	11 478.51

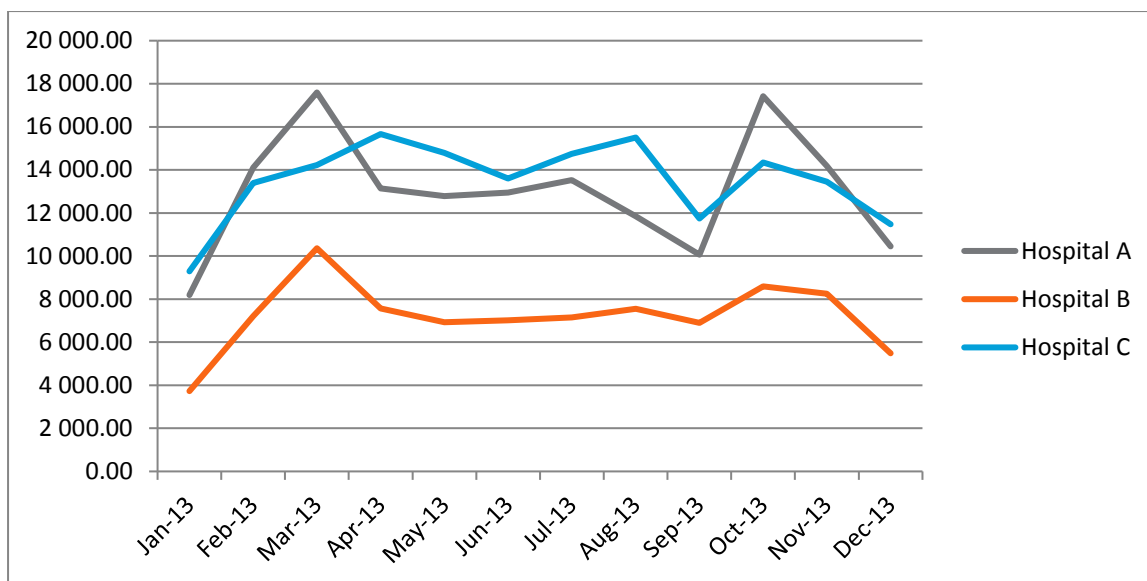


Figure 7: Actual disposed infectious waste as a category per hospital over 12 months

Pharmaceutical waste – drugs, vaccines (unused, expired or spilled) are taken to pharmacy.

Pharmacy keeps a register and uses the green pharmaceutical waste containers. This is collected at the pharmacy is weighed and the manifest is completed.

Table 8 shows per case study (Hospital A, B and C) the quantities of Pharmaceutical waste that has been generated over the period of 12 months. Figure 8 shows the fluctuations/ curves in respect of each hospital.

Table 8: Actual disposed pharmaceutical waste as a specific waste category per hospital.

	Hospital A	Hospital B	Hospital C
January 2013		27.46	32.60
February 2013	7.80	15.8	54.10
March 2013	17.40		29.13
April 2013		65.4	59.30

May 2013	22.12	26.55	37.00
June 2013		49.7	49.13
July 2013		12.55	27.05
August 2013	105.00	16.6	51.55
September 2013	4.10	10.45	
October 2013	29.75	26.3	
November 2013	9.60	64.2	76.15
December 2013		7.7	41.03

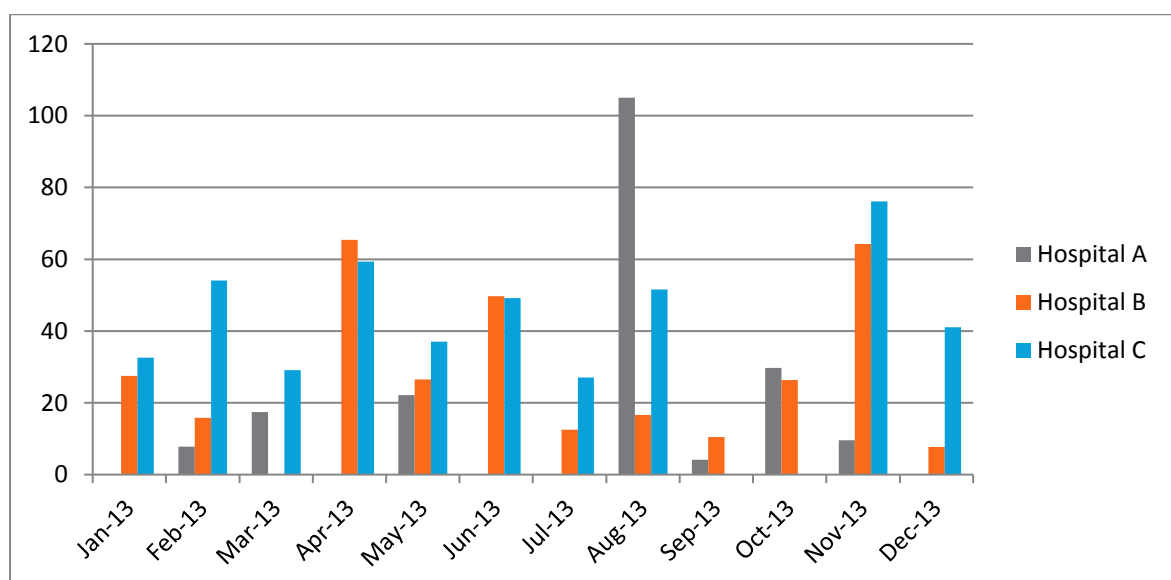


Figure 8: Actual pharmaceutical waste as a category per hospital over a period of 12 months.

Anatomical waste -This category includes for example organs, placentas, body fluids and body parts. It is taken to the hospital waste room and locked away in the anatomical waste freezer. From there it is weighed, manifest completed, signed, transported by the waste service provider and incinerated. Signed manifest is kept on file.

Table 9 shows that Hospital B and C generate in addition to the above-mentioned waste categories, also anatomical waste. Hospital C generated per month over a period of 12 months, in comparison to Hospital B, much more anatomical waste.

Table 9: Actual disposed plasma/anatomical waste as a specific category per hospital.

Month	Hospital B (Kg)	Hospital C (Kg)
January 2013	18.00	170.75
February 2013	9.38	240.58
March 2013	0.85	237.90
April 2013	0.45	268.25
May 2013	0.15	285.66
June 2013		263.77
July 2013	0.3	501.54
August 2013	2.8	465.54
September 2013	0.85	520.55
October 2013	0.4	499.39
November 2013	0.15	472.05
December 2013		463.27

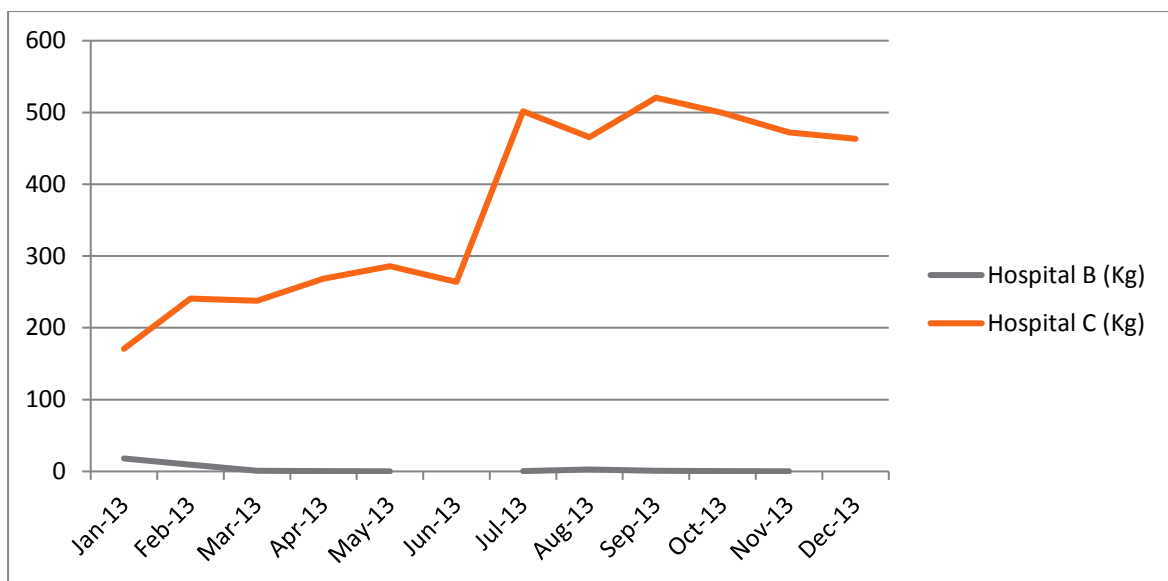


Figure 9: Actual disposed plasma/anatomical waste as a category over a period of 12 months.

Total Mass- The total quantity for Hospital A over the period of 12 months is 167 212.00 kg. Hospital B generated 95 109.36 kg, followed by Hospital C with 182 743.40 kg. The Group generated a total mass of 3513 000 kg, also over the same period of 12 months. The Group's total mass of 3513 000 kg should be seen in the light that the Hospital Group offers world-class facilities and expertise and are complemented by mental health, acute rehabilitation, renal dialysis, acute hospitalisation and long-term services. While Table 10 below indicates the total mass of HCRW produced for each hospital over the 12 month period under investigation.

Table 10: Total quantity of waste produced per hospital over a period of 12 months.

Hospital	Mass of waste produced
Hospital A	167 212.09 Kg
Hospital B	95 109.36 Kg
Hospital C	182 743.40 Kg

To place these results in context they are illustrated in Figure 10.

Figure 10 illustrates the total weight generated by the Group in comparison to the weight generated by Hospital A, Hospital B and Hospital C. The total quantity of waste for the Group is disclosed in the Group's Annual Integrated Report for 2013 as a performance indicator.

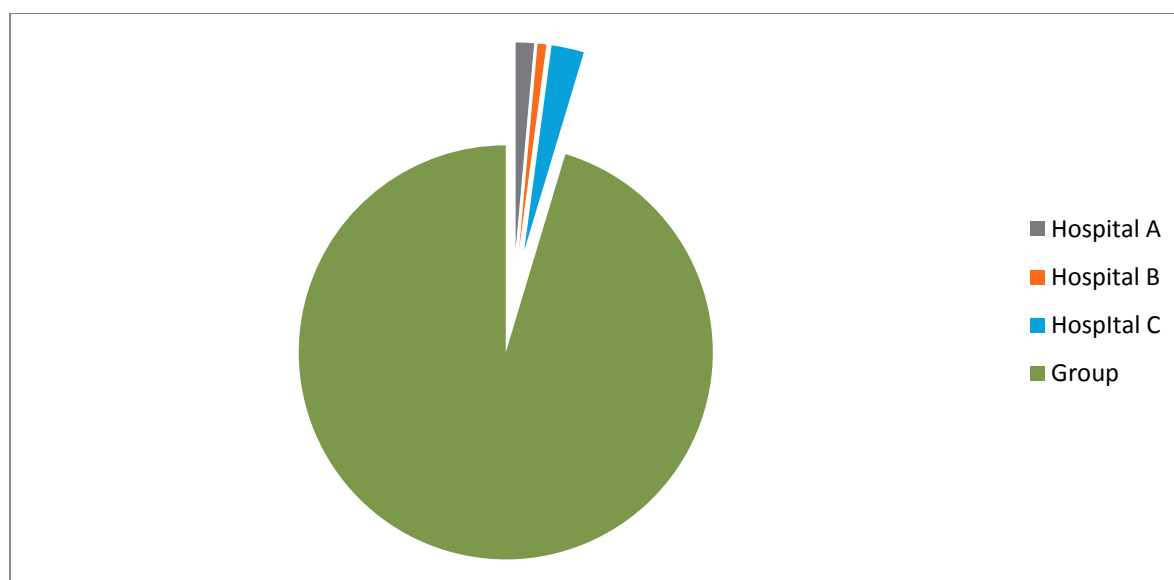


Figure 10: Total quantity of waste generated for the Group in comparison to the total weight for Hospital A, Hospital B and Hospital C.

Total costs- Table 11 shows the actual cost for services rendered such as collection, off-site transport and disposal/treatment. The invoice reflects the name of the customer (Hospital), delivery address, description of the category of the waste, quantity of the waste per category, price per category of waste, total rand value and reference to the sequence numbers of the WCD. The invoice is supported by a summary of all the WCD issued during the month. Reconciliation and comparison between the invoice and the WCD destruction certificate is

therefore possible. Especially as an internal control measure. The pink destruction certificate is the proof that the waste that was on-site collected by the service provider has been disposed /treated.

Table 11: Average weight of HCRW collected per day over period of 12 months (in kg).

Hospital A	460
Hospital B	262
Hospital C	500

Table 12: Actual monetary value paid to the waste service provider per month as per hospital to collect and to dispose the waste (ZAR)

Month	Hospital A	Hospital B	Hospital C
January 2013	80 672.79	39 580.53	97 350.41
February 2013	139 789.97	72 906.98	142 265.61
March 2013	174 232.36	105 871.00	231 651.76
April 2013	128 702.67	78 406.48	163 171.00
May 2013	126 906.28	70 337.56	154 894.91
June 2013	127 781.80	79 297.32	142 392.89
July 2013	134 048.84	72 822.00	157 099.58
August 2013	118 377.02	76 525.65	163 696.05
September 2013	102 144.95	69 077.83	124 683.10
October 2013	174 569.08	87 677.36	151 708.51
November 2013	152 064.06	100 636.82	152 083.62
December 2013	111 072.35	61 151.98	129 556.33
	1 570 362.17	914 291.51	1 810 553.77

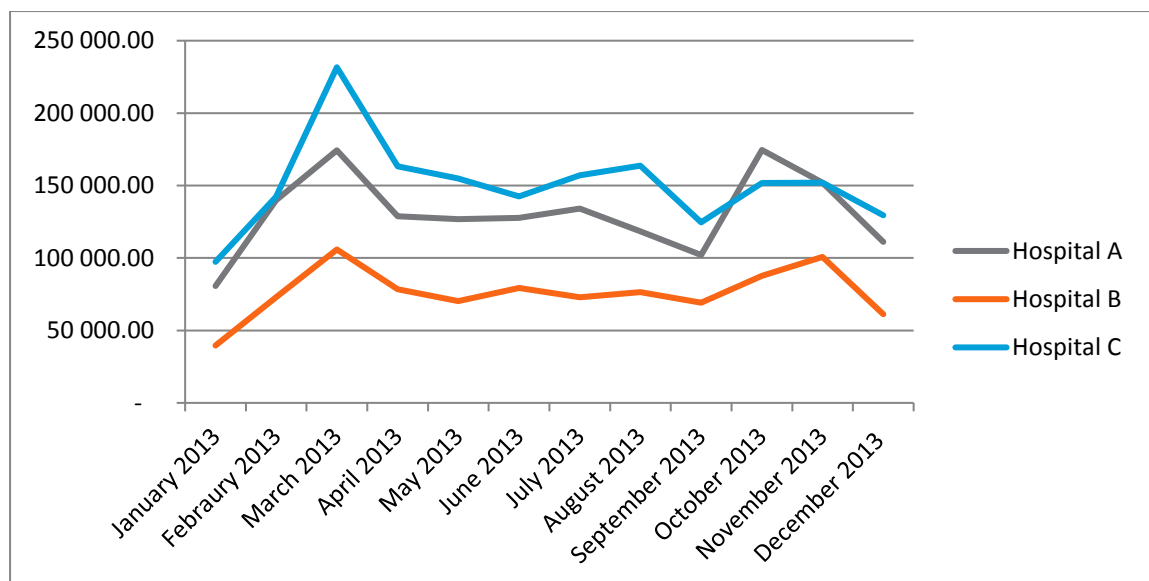


Figure 11: Actual monetary value (ZAR) as invoiced and paid to the waste service provider per month.

Table 13: Average cost per kg over 12 month period.

	Kg	Rand	Cost per kg
Hospital A	167 212	1 570 362	9.39
Hospital B	95 109	914 109	9.61
Hospital C	82 743	1 810 553	9.90

Table 14 shows the total number of patients per hospital at the end of 31 December 2013. The number of patients per day or per month could not be obtained from Hospital A, B or C as a result only the annual; figures could be used. Hospital A has the highest number of patients per year, namely 52 657, followed by Hospital C with 93 492. Hospital has the lowest number of patients, namely 25 200.

Table 14: Summary of the total number of patients per hospital for the calendar year.

Hospital A:	Hospital B	Hospital C
93191	52 657.00	25200

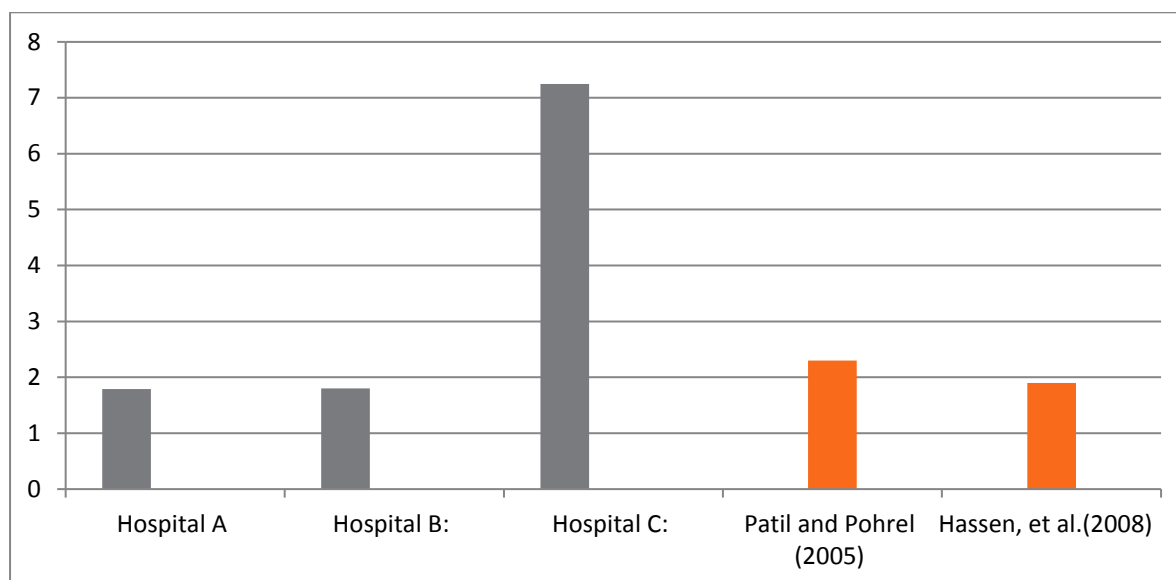


Figure 12: Average weight per patient per Hospital A, B and C.

Figure 12 shows the average mass of waste generated per patient per day. The average mass per patient as indicated in the following two research studies are also included as a comparison. Patil and Pokhrel (2005) conducted a case study on biomedical solid waste management in an Indian hospital. Solid waste of both types (infectious and non-infectious) was weighed individually on a suspension spring scale (± 100 g) with the assistance of the staff and the weight was recorded by department. The non-infectious waste was collected separately in different containers and treated as general waste, and on an average about 520 kg of non-infectious and 101 kg of infectious waste is generated per day (about 2.31 kg per day per bed, gross mass comprising both infectious and non-infectious waste).

A study by Hassan *et al.* (2008) on the pattern of medical waste management in Dhaka City, Bangladesh shows that the surveyed HCE generate a total of 5,562 kg/day of wastes, of which about 77.4 per cent are non-hazardous and about 22.6 per cent are hazardous. The average waste generation rate for the surveyed HCE is 1.9 kg/bed/day or 0.5 kg/patient/day. The comparison shows that the average weight per patient per Hospital A, B and C is more or less in line with the results of previous research studies.

4.4 CONCLUSION

This chapter discussed the results of the investigation and then analyses the findings. The next chapter discusses the finding of the study in terms of the aim and objectives of the study.

CHAPTER FIVE: CONCLUSIONSSIONS

5.1 INTRODUCTION

The aim of this study was to determine a procedure, as well as the nature and extent of internal and external source documents, which could be used in the reconciliation of medical waste from generation to disposal.

This study summarises the results of the study in relation to the stated objectives and hypotheses and makes conclusion and recommendations under the sub-headings “reconciliation of waste quantities on the internal records with external, records”, “quantities of medical waste is equal to the quantity of medical waste disposed/treated” and the “Ratio factor between the quantity of medical waste before incineration and the quantity of the residue after incineration” and concludes with a summary.

5.2 RECONCILIATION OF WASTE QUANTITIES BETWEEN THE INTERNAL RECORDS WITH THE EXTERNAL RECORDS

The three hospitals generate both health care general waste (domestic waste), as well as health care risk waste. The source of the health care general waste is from offices, kitchens, treatment rooms, stores and the garden. This type of waste includes for example used paper, food waste (e.g. fruit peels, food left overs), dry flowers, packing material, grass, leaves. The containerisation of health care general waste entails transparent liners in domestic bins. The frequency of disposal of health care general waste is on a daily basis, accept for garden refuse that is collected and disposed at a weekly basis. The method of the disposal of the health care general waste is at municipal landfill sites.

The health care risk waste generated at the three hospitals, include sharps waste, infectious waste, plasma/anatomical waste and pharmaceutical waste. The frequency of the collection of health care waste, by the waste service provider, is on a daily basis. The method of disposal of this health care waste is not through incineration, but through autoclave.

It is important to note that, if hospitals do not quantify waste into its categories, namely, HCRW versus General waste, there is the risk that these wastes can get mixed. The impacts of HCRW, that is mixed with health care general waste, and it is taken with health care general waste, to a municipal landfill sites, could include for example, pollution of water and soil and spreading of diseases.

The HCW produced in the three hospitals follows an identified stream, and this stream comprises several steps that include generation, segregation, on-site transportation, on-site storage, off-site transportation and final disposal or off-site autoclave treatment. The generation and disposal of health care general waste does not form of the waste stream.

The hospital does not weigh the health care waste at the source or point of origin or inside the medical/unit (e.g. wards, theatre intensive care unit), and/or after it has been generated, segregated and on-site transported to the on-site intermediate and/or central storage area.

The Group's action to mitigate the risk of incorrect segregation is embedded in their Health Care Risk Waste Management Plan. The primary function of this plan is to demonstrate that

there is a 2 years plan in place to ensure the safe handling of health care waste from the source of generation, through correct segregation, containerisation, storage, transportation and final treatment.

There are also no internal records to show the quantities of HCRW or general waste (domestic waste) that was generated per day at the various points of origin. The risk still exist that the quantities in the next step, namely when it is collected and weighed by the waste service provider is overstated by incorrect segregation.

The quantification of HCRW from point of origin to the point of disposal is not taking place and could not be confirmed. The objective to reconcile HCRW quantities between the internal records and external records could not be achieved. Hypotheses 1 was confirmed.

5.3 QUANTITIES OF MEDICAL WASTE GENERATED IS EQUAL TO THE QUANTITY OF MEDICAL WASTE DISPOSED/TREATED.

The major advantage of outsourcing the collection and transportation and treatment of the HCRW, is that a service provider will generally provide the technology to record the type and quantity of HCRW collected and the type of container to be used. The waste service provider will also utilise a range of different size of vehicles, in order to provide for the expected quantity of HCRW to be collected and the distance to be travelled. This fixed contract also include the Document Management System (DMS) to keep tracking of the type and quantity of waste that was on-site collected, off-site transported and off-site treated.

The DMS also provides access to documentation, such as the waste tracking receipt, Waste Collection Document (WCD) and the destruction certificate. This documentation allows, in general, for an auditable tracking system and for the detailed breakdown of the actual quantities waste collected and autoclave treated.

Accurate billing is possible, because reconciliation and tracking between the recorded information on the WCD and the invoice can be performed. This allows reliable analysis of tonnages of waste; collected and transported and treated on a daily, weekly and monthly basis.

There is then a dual responsibility, as envisaged in the fixed contract, between the two parties that signed the contract to ensure that the HCRW is handled in terms of legislation.

As a result of the auditable, sequence numbered, traceable documentation, actual secondary data could be captured, over a period of 12 months on the quantities of HCRW collected by the waste service provider in terms of the fixed contract.

The information about costs and tonnage HCRW per waste category makes it possible to conduct all sorts of analyses, but the question will always remain whether the cost and tonnage per year should not be significantly more than what the records are showing. This is because the waste is not weighed at point of origin.

Declarations and certifications on financial related invoices and waste certificates, signed by the representatives of the hospitals and the service provider, provide reliable trace of the

quantities of medical waste generated, collected and autoclave treated. The pink destruction certificate is the proof that the waste that was on-site collected by the service provider, has been disposed /treated. The waste is however not quantified from point of origin to final treatment. Hypotheses 2 and 3 could therefore not be confirmed and the objective was not achieved.

5.4 RATIO FACTOR BETWEEN THE QUANTITY OF MEDICAL WASTE BEFORE INCINERATION AND THE QUANTITY OF THE RESIDUE AFTER INCINERATION

The objective was not achieved because incineration as a disposal method was not used during the period under review. An alternative method was used, namely the environmentally friendly Bondtech autoclave treatment technology, which assists in destroying all viruses and bacteria to create a safe matter without hazardous emissions was used during the period under review.

5.5 LIMITATIONS

The hospital management teams gave permission for the research study on the condition that the specific names of the hospitals, which form part of the case studies, are not disclosed. This condition also includes the non-disclosure about the name and details of the outsourced waste service provider. As such, hospitals were referred to as Hospital A, Hospital B and Hospital C. No landfill site was visited and no research was conducted at any municipal and/or hazardous landfill waste site, before, and during the research study.

5.6 SUMMARY

The destruction certificate is the proof that the waste that was on-site collected by the service provider and that the HCRW has been treated by the waste service provider. The weakness or the gap however still exist that the waste is not weighed at the point of origin, but at the point when and where the waste service provider collects the waste on-site. It is from this point onwards that the fixed term contract/service level agreement between the hospital and the waste service provider and the document management system and the tracking receipt and the waste collection documents (WCD) becomes relevant and where the quantities of waste per category are for the first time recorded. The hypothesis as stated in Chapter 1 was proven valid.

5.7 RECOMMENDATION

It is recommended that the hospitals should put internal control measures in place, to record the ID and type of the containers that are issued at the point of origin, using a scanning method to weigh the HCRW and scan the containers, for its ID, when and as it is placed in the collection room.

Internal records of the category and quantity of HCRW could be created by keeping a computerised information inventory list of the empty bar-coded containers, issued to the point of origin, where HCRW is generated, such as the wards, intensive care unit and/or pharmacies. This type of technology should be compatible with the Reutech system technology, which is used by the waste service provider. Allowing for comparisons between the internally created information and the external information created by the waste service

provider. A computerised information system could help to create the process of quantifying HCRW from point of origin to point of disposal/treatment. This extended tracking receipt system then shows the ID of the point of origin, for example a hospital's ward, intensive care unit or pharmacy, the container's bar code, weight generated as per container in kg, category of the waste generated, the date the empty container was issued, date the filled container was collected at the point of origin and taken to the collection room. The total weight of the container when weighed internally.

The DMS record that is created when the Bar-coded containers are collected by the waste service provider, serves then as the external records. The internal and external records should then be compared, because the internal records reflect the category and quantity of HCRW generated and as and when it was placed in the collection room. DMS shows the quantity of the HCRW as per container, as and when collected by the waste service provider. This comparison will not mitigate the risk of incorrect segregation, but it will provide the quantity of HCRW from point of origin to point of disposal/treatment. It will also have the advantage that if the quantities of waste generated is shown over a longer period, and is linked to the point of origin, simple statistics will show patterns and trends. Significant fluctuations in HCRW generated will help to identify problems, such as over - or understated quantities.

This internal control measure to quantify HCRW generated will put an additional financial - and capacity burden onto the hospitals, because it will entail that the hospital should implement bar code and scan each container for internal usage and that the filled containers must be scanned and weighed as and when placed in the collection room.

5.8 FURTHER RESEARCH

Further research could focus on utilising bar code and scanning technology to record the quantity of HCRW and health care general waste as generated at the point of generation. Weighing and scanning, using technology, such as Reutech system, will help to keep track of the HCRW generated at the point of origin. Subsequent information will help to identify fluctuations, trends and patterns of HCRW generated at point of origin. Alternative is to enter into an agreement where health care general waste and HCRW is collected and weighed and treated by waste service provider to ensure that it is disposed of appropriately.

Reference List

Aaker, D. 2008: http://www.ucn.edu.ni/environment/pdfs/UCNP_COURSE-_catalogue_MBA_ENM.pdf. Accessed 23 January 2009.

Abor, P.A. 2007. *Medical waste management in Tygerberg hospital in the Western Cape, SA*. Cape Peninsula University of Technology: Cape Town.

Abor, P.A. & Bouwer, R. 2008. *Medical waste management practices in a Southern African hospital*. International Journal of Health Care Quality Assurance. 21(4): 356-364.

African Development Bank, 2005. *World Development Indicators*: CD ROM, Washington: DC.

Al-Emad, AA. 2011. *Assessment of medical waste management in the main hospitals in Yemen/Évaluation de la gestion des déchets médicaux dans les principaux hôpitaux du Yémen*. Eastern Mediterranean Health Journal, Alexandria. 17 (10): 730-737.

Aluyi, H.S. and Banka, M.M. 2007. *National Health Care Waste Management Plan for Nigeria*. Nigeria.

Appleton, J. and Ali, M. 2000. *Health care, health risk? Risk for healthcare. Waste to the poor*. Well study: UK.

Babbie, E. 2000. *The practice of social research*. Ninth Edition. Wadsworth Thomson Learning: Belmont. USA

Ball, J. 2006. *Waste management in developing countries: seven characteristics and seven principles*. Waste 2006 conference, Startford-upon-Avon, Warwickshire, UK.

Barde, J. 2000: *Environmental policy and policy instruments*, in: *Principles of environmental and resource economics*, 2nd edition, edited by H Folmer, and HL Gabriel, Cornwall: MPG books: 157-201.

Bernstein, D.; Haug, R.; Ottenfeld, M. 2009. *Hospital waste management: An informational assessment*. Academy of Health Care Management Journal, Arden. 5(1/2): 97-112.

Begyl, S.E., Wassermann, T., Scheider, B. and Salhoter, S. 2004. *Forecasting municipal solid waste generation in major European cities*: International environmental modelling. Osnabruck: Germany.

Bell, R.G. and Russel, C. 2006. Environmental Policy for developing countries. *Issues in Science and technology*, 18(3): 63-70.

Biermann, J. 2007. *South Africa's health care under threat*. University of Pretoria: Pretoria.

Broomberg, D. 2007. The hospital strategy project in South Africa. Centre for Health Policy and National Labour and development Institute: South Africa.

Bouwer, A. 2008. Medical waste management practices in Southern African hospitals. *International journal of health care quality assurance*. England. 21(4): 356-364.

Brainquote, 2004. Definition of a model [Online]. Available at: <http://www.brainquote.com/words/mo/model191086.html>. Accessed 19/09/2009.

Brent, A.C., Rogers, D.E.C., Siimane, T.S.M., and Rohwer, M.B. 2007. *Application of the analytic hierarchy process to establish health care waste management systems that minimize infection risks in developing countries*. University of Pretoria: Pretoria.

Burns, N. and Grove, S. 2003. *Understanding Nursing Research*. 3rd Edition. W.B. Saunders Company: Philadelphia.

Burns, N. and Grove, S. 2006. *The practice of nursing research: conduct, critique, and utilization*. Saunders: Philadelphia.

Cape Argus, 2005. Bill to turn up the heat on medical waste [Online]. Available at: <http://www.capegateway.co.za>. Accessed 12/08/2009.

California Integrated Waste Management Board. 2007. Health care waste management. Sacramento: California.

Cardiff and Valle NHS Trust, 2008. *Waste Management Procedure 12. ISO 14001*. Wales.
Cascio, J. 2004. *International Environmental Management Standards (ISO 9000's less tractable siblings)*. In 1994 IEEE Inter. Symp. On electronics and the Environment. San Fransisco, Calif.

Claasen, P. (ed). 2003. *Environmental Resource economics. Discussion document 1. Towards a national policy for the use of environmental resource economics in environmental impact management*. Department of Environmental Affairs and Tourism: Pretoria, South Africa.

CGH Environmental Strategist, 2002. *Eleven Recommendations for improving health care waste management*. USA, Burlington: Vermont.

Citywatch, 2008. Health care risk waste [Online]. Available at: <http://www.westford-ma.gov/pages/government/TownDepartments/boardsandcommi>. Accessed 30/08/2008

Commission Cora, 2007. Waste management strategy in Netherland. NRG. Netherland.

Cullinan, K. 2005. *Health stats in a nutshell*. Health Systems Trust: Durban
Cullinan, K. 2006. *Health services in South Africa: Basic introduction*. Health ENews Service: Gauteng. South Africa.

DACEL, 2002. Health care waste information system. User's guide for health care waste transporters and treatment facilities. CSIR: Pretoria.

DACEL, 2005. *Gauteng Health Care Waste Management Regulations*. June 2005. South Africa.

DANIDA, 2006. *National waste management strategy implementation: South Africa. Short term financial mechanisms and economic instruments for healthcare waste management*. DEAT Report Number 12/9/6.

Daschner, S. 2009. Useful and useless techniques in intensive care units. *Intensive care medicine journal*. 2(6): 283.

DEAT, 2004. *A framework for the national waste management strategy. Draft version for review*. RSA.

DEAT, 2000a. Program for the implementation of the national waste management strategy: starter document for HCWM. [Online]. Available at: http://www.environment.gov.za/NWMSI/background/planning_legreview_starTerdoc.pdf. Accessed 02/04/2008.

DEAT, 2000b. Programme for the implementation of the National Waste Management Strategy. Starter document for HCW. Final draft. RSA 198.

DEAT, 2004a. *National waste management strategy implementation in South Africa: Progress report for the period 15 June – 12 October 2004*. DEAT Report Number: 12/9/6.

DEAT, 2004b, *National Environmental Management Act*. [online] Available at: <http://www.environment.gov.za> Accessed 02/04/ 2008.

DEAT, 2005. *Zeerust Sub-District Status QUO Report*. May – October 2005. Version 05 Final.

DEAT, 2006a. *Projections for health care risk waste treatment*. HCRW project team. DEAT Report Number 12/96.

DEAT, 2006b. *National Waste Management Strategy Implementation: South Africa: PSC completion report..*

DEAT, 2007a. *Development of Hazardous Waste Management Plan for Mpumalanga Province*. Draft final: inception report. DNWE Consultancy.

DEAT, 2007b. *Development of a Hazardous Waste Management Plan for Mpumalanga Province. Draft Final Inception Report*. Report Number: DNW/MDALA/0001.

DEAT, 2008. *Business Plan 01 April 2008 – 31 March 2009*. UEMP: Pretoria.

DEAT, 2000. *Program for the implementation of National Waste Management Strategy. Starter documents for Health Care Waste*. DEAT: Pretoria.

DEAT, 1999. *National Waste Management Strategy and action plans. Strategy formulation phase*, Version D, 15 October 1999.

Delcarme, B. 2007. *Definition and institutionalisation of an integrated healthcare waste information system for effective waste management*. Department of health, Peninsula Technikon. RSA.

Department of Environmental Protection, 2005. *Mercury: a Significant Environmental Problem* [online] Available at: <http://www.maine.gov/dep/mercury>. Accessed 25/01/2009.

Department of Epidemiology Bulletin, 2005. *Saudi Epidemiology Bulletin*. Ministry of Health/ Riyadh. 12 (2):5-13.

Department of Health, Manila, 2004. *HCW Management Manual*, Manila: Philippines.

Department of Health Republic of South Africa. 2007. *Health Indicators update: Hospital Efficiency*. Cluster: Health information, evaluation and research. Government Printers: Pretoria.

Department of Health. 2008. *Hospital list according to province* [Online]. Available at: <http://www.doh.gov.za/docs/tenders/hospitallist.pdf>. Accessed 05/05/2008.

Department of Water Affairs and Forestry, 2000. *Policy and Strategy for groundwater quality management in South Africa*. DWAF: Pretoria.

Devi, B. 2009. *Factors affecting hazardous waste*. Hilya University: India.

Diamantopoulos, A. & Schlegelmilch, B.B. 2000. *Taking the fear out of Data Analysis*, Second edition. Thomson Learning: London.

Dillman, D.A. 2005. *Mail and Telephone Surveys. The Total Design Method*. John Wiley and Sons: New York.

Dodd, D.H. 2000. *Direct Disposal of spent fuel from test and research reactors in the Netherlands, a preliminary investigation*. NRG Report 21406/00. 24187/P, 31 January 2000.

Dodd, W. 2000. London Dumping Convention [Online]. Available at: www.imo.org/conventions/contents.asp?topic_id=258. Accessed 12/09/2009.

Dutch Government, 1993. *Cabinet position on underground disposal*. NEPPAction 62, 27 April 1993.

Dutch Government, 1999. Underground disposal of highly toxic waste [Online]. Available at: www.knaw.nl/publications/pdf20011075-20.pdf. Accessed 12/09/2009.

Environmental Engineers Consultants, 2007. *Green purchasing for hospitals*. EPTA LTD. Athens: Greece.

Enviroserve, 2008. *Waste recycling* [Online]. Available at: www.capetown.gov.za/iwex/. Accessed 05/10/2009.

EPA, 1990. *Guidelines to pollution prevention: Selected Hospitals Waste Streams*. United States. Environmental protection agency: Washington DC.

EPA, 1992. *Waste works legislation* [Online]. Available at: http://www.wasteworks.org.uk/legislation/legislation_delal3.asp. Accessed 13/10/2009.

EPA, 2005. Noninfectious waste. State of Ohio Protection Agency: UK.

EPR Working group, 2008. [Online]. Available at: <http://www.eprworkinggroup.org/>. Accessed 11/07/2009.

ETLog Health Project, 2008, *HCW questionnaire* [Online]. Available at: <http://pre.etlog-health.com/projects/26/>. Accessed 05/12/ 2008.

ezeediabetes, 2008. *Public hospitals of South Africa, by provinces* [Online]. Available at: <http://www.ezeediabetes.co.za/publichospitalsbyprovincesouthafrica.asp>. Accessed 12/08/09.

Fava, J.A., Denison, B., Jones, B. (eds). 2001. *A technical framework for life cycle assessments*. Soc. Of environment Toxicology and Chemistry, Washington D.C. pp134.

Faye, H. 2007. *Best Practices in Health Care Waste Management: examples from four Philippines' Hospitals*. Philippines.

Fischer, D. 2007. *Legal Challenge of Implementing Sound Health Risk Waste Management in Gauteng*. Unpublished. Paper presented in Gauteng, Page 1-6.

Fouche, C.B. 2002. *Research strategies*. In De Vos, A.S. (Ed) *Research at the grassroots for social sciences and human service professions*. Van Schaik: Pretoria.

Franka, E., Zoka, A.E., Hussein, A. E., Hussein, A., Elbakosh, M. Arafa, A. and Ghenghesh, K. 2009. *Hepatitis B and hepatitis C virus in medical waste handlers in Tripoli*. *Journal of hospital infections*. 72(3): 258-261.

Fuggle, R.F. and Rabie, M.A. 1992. *Environmental management in South Africa*. Juta: Pretoria.

Gabela, 2007. *Health Care Waste Management in Public Clinics in the Ilembe District: A Situational Analysis and Intervention Strategy*. Durban: UKZN.

Garwal, B.S. 2007. *Environmentally responsible management of health care waste with a focus on immunization waste: a working draft*. HCWH. Washington DC.

Gauteng department of health, 2004. *Code of practice for health care waste management*. Johannesburg. South Africa.

GDACE, 2000. *Requirements for biodiversity assessments* [Online]. Available at: <http://www.iaia.co.za>. Accessed 09/12/2008.

GDACE. 2005. *Guidelines on sustainable health care waste management in Gauteng* [Online]. Available at: http://www.environment.gov.za/NWmsi/GDACE/Guidelines_M3.pdf. Accessed 04/10/2009.

GDACEL, 2000. *Status of HCW in South Africa* [Online]. Available at: http://www.environment.gov.za/NWMSI/hcw_starterdoc2000.pdf. Accessed 25 January 2009.

Godfrey, L. and Dambuza, T. 2006. Integrated waste management plans – a useful management tool for local government and bureaucratic burden? *WasteCon, 2006. Biennial International Waste Congress and Exhibition*. Somerset West, Cape Town.

Godfrey, L. and Nahman, A. *Are developing countries ready for First World Waste Policy Instruments?* Sardina 2007. Eleventh international waste management symposium. ESE. Italy.

Green guide, 2006. *Green guide* [Online]. Available at: <http://www.thegreenguide.com/doc/113/top10hospitals>. Accessed 31/08/2008.

GroundWork, 2006. *Health care waste in Southern Africa: A civil society perspective*. Durban, South Africa.

Hall, J.L. & McCoy, A.I. 2005. *Medical waste management, shredding of medical waste. Quarterly Journal on medical waste handling and processing*. 1(3):1-35.

Handy, C. 2002. What is a Business for? *Harvard Business Review*, December: 3 -8.

Hassan, M.M, Ahmed, S.A. Rahman, K.A. and Biswas, T.K. 2008. Pattern of medical waste management: existing scenario in Dhaka City, Bangladesh. *BMC Public Health*. 8(36):1-10.

Haverkate, B.R.W. 2002. Waste management strategy in the Netherlands; Part 1: Waste forms, *KG Report 20881/02.47417/P*, 8 May 2002.

HCWHA, 2004. *Nurses take action* [Online]. Available at: <http://www.medscape.com/viewarticle/555467>. Accessed 21/10/2009.

Health care coalition for emergency preparedness, 2009. *Managing hospital waste during a pandemic event*. [Online]. Available at: <http://www.healthcareprep.org/news/2009/5/2/managing-hospital-wasteduring-a-pandemic-event.html>. Accessed 23/10/2009.

Health Care Without Harm, 2001. *Non-incinerating medical waste treatment technologies: www.noharm.org*. Accessed 25/01/2009.

Health Systems Trust, 2007. *A barometer for District Hospital Management*. Health Systems Trust: Durban.

Heeks, R. 2007. *Information Systems and developing countries: Failure, Success, and Local Improvisation*. The Information Society, 18: 110- 112.

Henning, E. 2007. *Qualitative research methodology. Study guide 2007*. Rand Afrikaans University: Johannesburg.

Holmes, JR. 1984: *A review of municipal waste management practices in three South Asian Cities, in Management Solid Waste in Development Countries*, edited by JR Holmes. John Wiley & Sons.

Hunt, R.G.; Sellers, J.D.; Franklin, W.E. 2002. *Resource and environmental profile analysis: a life cycle environmental assessment for products and procedures*. Environ. Impact assess. Rev.12:245-269.

Hucker, J. 2008. *Turning point Somerset Guidelines for the safe handling and storage of clinical waste*. [Online]. Available at: www.nnef_policy/guidelines-for_for_safe_handling_06doc. Accessed 12/08/09.

Hunt, R.G.; Sellers, J.D.; Franklin, W.E. 2002. *Resource and environmental profile analysis: a life cycle environmental assessment for products and procedures*. Environ. Impact assess. Rev.12:245-269.

Human, E.H. 2005. *Solid waste reduction Management with special reference to developing countries*. UNISA: Pretoria.

Integrated Waste management Board, 2008. *Definitions of health care waste management* [Online]. Available at: <http://www.ciwmb.ca.gov.Wpw/define.htm>. Accessed 27/09/09.

International Council of Nurses, 2009. *Immunizations safety: Safe waste disposal practices save lives* [Online]. Available from: http://www.icn.ch/matters_immunizations.htm. Accessed 12/10/2009.

Ipwis. 2006. *The integrated pollutant and WIS* [Online]. Available at: http://www.capegateway.gov.za/xho/pubs/publication_info/1/120566. Accessed 12/10/2009.

Kayser, M. 2006. *Demonstrating and promoting best techniques and practices for reducing HCW to avoid environmental releases of dioxin and mercury*. UNDP: London.

Ketlogetswe, C.; Oladirang, M.T.; and Foster, J. 2004. Improved Combustion Processes in Medical Waste Incinerators for Rural Application. *African Journal of Science and Technology* (AJST). 5(1): 67 -72.

Klee Jnr. H (Ed). 2002. *Towards a sustainable cement industry. Executive summary to Battele Memorial Institute*. Conches-Geneva, Switzerland: World Business Council for Sustainable Development.

Komar Industries, 2009. *Medical waste management: autoclave sterilization*: <http://www.komaindustries.com/medical-autoclave.htm>. Accessed 25/01/2009.

Kristiansen, P. 2003. *The DPSIR Framework. Paper presented at the 27 to 29 September 2000 workshop on a detailed assessment of water resources to environmental change in Africa using river basin water*. UNEP. Nairobi.

Kristiansen, T. 2007. *Development of a national health care waste management policy for South Africa*. Pretoria: South Africa.

KZN Department of Health, 2008. *Policy for HCRW management*. Capital Towers: Pietermaritzburg.

KZN Parliamentary Monitoring Group, 2001. *Medical waste hearing: 27 February 2001* [Online]. Available at: <http://www.pmg.org.za>. 12/08/2009.

LaFaire, S. 2008. *Crises advice from GE'S Immelt. Stay committed to growth* [Online]. Available at: http://discussionleader.hbsp.com/hbr/hbreditors/2008_tumultous_times_ad.html. Accessed 27/09/2009.

Leedy, P.D. 2006. *Practical research, planning and design*. Sixth edition. New Jersey: Prentice Hall.

Le Van, 2000. *Life cycle assessment: measuring environmental impact*. USA Forest Products Society.

London Department of Health, 2006. *Health technical memorandum 07 – 01: safe management of health care waste, London: The stationary Office*. [Online]. Available at: http://www.dh.gov.uk/en/PublicationsandStatistics/PublicationsPoliciesAndGuidance/DH_063274. Accessed 14/09/2009.

Lukay, P.K.; Brijlall, J.A. and Thooe, M. 2004. *Gearing up for efficient pollution and waste management enforcement, Biennial Congress of the Institute of waste management of Southern Africa*. Wastecon 2004. 11 -15 October 2004. Sun City. South Africa.

Mangzvo, R.V. and Chinamasa, R. 2008. *Solid waste management: The case of Kwekwe City in Midlands Province, Zimbabwe*. Open University of Zimbabwe: Kwekwe.

Marshall, C. and Rossman, G.B. 1999. *Designing Qualitative Research*, London. SAGE publications.

Mathur. V.; Dwivedi. S.; Hassan. M.A., Misra. R.P. 2011: Knowledge, Attitude, and Practices about Biomedical Waste Management among Healthcare Personnel: A Cross-sectional Study. *Indian J Community Med*. 36(2): 143–145.

McDaniel, C. and Gates, R. 2002. *Marketing research with SPSS*. John Wiley & sons. UK.

Mayers K. & France, C. 1999: *Meeting the “Producer Responsibility” Challenge*. Greener Management International Springs: 51-68.

McInery, P. 2009. *Importance of recycling* [Online]. Available at: <http://www.essentialaction.org.waste/worldbank/ifcguidelinesmemo.htm>. Accessed 28/08/2008.

McRae, 1998. *The World Bank's dangerous medicines: promoting medical waste incineration in third world countries*. South Asia Region: Washington DC.

Merriam-Webster, 2009. *Model as a pattern* [Online]. Available at: www.worldcentral.com/cgi-bin-bin/student?model. Accessed 20/09/2009.

Molefe, G.S., Gcwensa, Q. Kristiansen, T. & Rogers, D.E.C. 2007. *Development of a National HCW Policy for South Africa*. South Africa.

Molefe, G.S., Gwensa, Q., Kristiansen, T. and Rogers, D. 2006. *Development of National Health Care Waste Management Policy for South Africa*.

Molina, F. 2007. *Waste Management Practices of Hospitals in Metro Manila*. College of Public Health, University of the Philippines: Philippines.

Morris, J. 1997. *Environmental Regulations by any other name?* England: ISSN 1085-9040.

Naledi, 2005. *An investigation into the management of public hospitals in South Africa: stressed institutions, disempowered management*. Research report commissioned by Department of Public Service and Administration. South Africa.

Neely, A.N., Maley, M.P., and Taylor, G.C. 2003. Investigation of a single use versus reusable infectious containers as a potential source of microbial contamination. American Journal of infectious waste containers as a potential source for microbial contamination. *American Journal of infection control*. Mosby, St. Louis. 3(1): 13-17.

Nepean, H.A. 2008. *Sydney West: Statement of duties*. Nepean & Sons: Sydney.

National Department of Health, 2008: <http://www.doh.gov.za/docs/tenders/hospitallist.pdf>. Accessed 14/12/ 2008.

Neuman, W.L. 2006. *Social Research Methods: Qualitative and Quantitative methods*. Allyn & Bacon: USA.

Ntlabezo, E.T. & Booyens, S.W. 2007. South African Nurse Managers' perceptions regarding cost containment in public hospitals. *Curationis*, 32 (2): 35-39.

Ntoampe, K. 2007. *Medical waste*. C. Directorate: Pollution and Management. Pretoria.

Nxumalo-Freedman, D. *Eastern Cape Health Care Challenges*. Paper presented in Port Elizabeth on the 13th of August 2008. DNF Waste. Eastern Cape.

OSPAR, 1992. *Convention for the protection of the marine environment of the North-Eastern Atlantic*, September 1992. *Medical waste journal*. 15(3): 1-21.

Otto, K. 2008. *Motivation to undertake an international health care waste study tour – November 2004*. [Online]. Available at: www.deat.gov/NWMSI. Accessed 13/09/2009.

Path, 2006. *Proposed handling and disposal of auto-disable syringes and safety boxes: a training module for clinic managers and immunization providers*. England.

Paul, A. & Strout. 1997. *Waste abatement: recycling, disposal practices can cast costs*. *Journal of Healthcare Resource Management*, 15 (7): 26-29.

Patil, G.V. & Pokhrel, K. 2005. Biomedical solid waste management in Indiana hospital: A case study. *Waste management*. 6(6): 592-599.

Phelan, T.J. 2006. Evaluation of scientific productivity. *The Scientist*, 14 (19): 39-40.

Pickford, J. 2007. Solid waste in hot climates in Feachman, R. et al, (eds). *Water, wastes, and health in hot climates*, John Wiley, New York.

Practice Greenhealth, 2008. *EPP Environmentally preferable purchasing for hospitals* [Online]. Available at: <http://www.cms.hze-online.org/ea/wastereduction/epp/>. Accessed 04/10/2009.

Purnell, G. 2009. *National waste quantification and waste information system*. RSA.

Raffles, D. & Hanks, K. 2007. *Handling of Health Care Waste policy*. NHS Trust: Oxford.

Ramabitsa-Siimane, T.S.M. 2006. *The identification of environmentally sound technologies for healthcare waste management in Lesotho*. Masters thesis, Department of Engineering and Technology Management, University of Pretoria: Pretoria.

Ramokate, T. 2007. *Knowledge and Practices of Doctors and Nurses about Management of Health Care Waste in Johannesburg Hospital in Gauteng Province*, South Africa. Johannesburg.

Robertson, G.L. 1998. *Food packaging: Principles and practice*. CRC Press: United Kingdom.

Russel, C.S. and Vaughan, W.J. 2006. The choice of pollution control policy instruments in developing countries: arguments, Evidence and Suggestions. *International Yearbook of Environmental and Resource Economics*, Vol. VII. Edward Elper: Cheltenham. U.K.

Saunders, M., Lewis, P., and Thornhill, A. 2005. *Research Methods for Business Students*. Pearson Hall: England.

Sharley, H. 2006. *Osborne Park Hospital Structure Plan: Final report*. Hames Sharley Pty.Ltd. UK.

Seward, P. 2007. *Groundwater matters: An introduction to groundwater occurrence and management*. Sanlamhof: RSA.

Silimela Africa, 2004. Using indicators to tract environmental changes [Online]. Available at: http://www.silimelafrica.com/index.php?option=com_docman&task=doc_download&gid=64&itemid=58. Accessed 13/10/2009.

Sniffer, 2007. Waste segregation. Free Environmental guidance. Net Regs. Northern Ireland.

South African Pharmacy Council, 2004. *Good pharmacy practice in South Africa*. SAPC, Arcadia: Pretoria.

Solano, E.S., Ranjthan, M.A., Barlaz, E.D., and Bril, E. 2002. Life cycle based solid waste management1: Model development. *Environmental Engineering*. 128(10): 981-992.

Speziale, H and Carpenter, D.R. 2003. *Qualitative research in Nursing: advancing the humanistic imperative*. Third edition. New York.

Suchitra, J.B. and Daschner, L. 1985. Impact of education on knowledge, attitudes, practices, among various categories of HCW on nosocomial infection. *Indian journal of medical microbiology*. 2007 25 (3) 181-187, India: Delhi.

Suezz, E. 1992. *Prevent pollution* [Online]. Available at: www.amazon.com/Dr-suessshop/b?i.e=UTF8&node. Accessed 12/10/2009.

Swart, A. 2007. *Training in Public Health Care Facilities for HCWM. School of Public Health*. Technikon Witwatersrand.

Taiwo, O.E.; Otieno, F.A.O.; and Venter, C. 2007. *Polokwane declaration – what progress has been made and are the set targets achievable?* IWWG International Waste Managing Group. Rhambos, Germany.

Taru, P. and Kyarega, A. 2005. Solid Waste Management. The case of Parirenyatwa Hospital, Zimbabwe. *Rev Biomed*, 16: 153- 158.

The Isipingo Declaration, 2002. *On eliminating the harmful impacts of HCW and incinerators in South African Countries, 5 – 8 April 2002*. Durban, South Africa.

The State of Eritrea Ministry of Health, 2004. *National Health Care Waste Management Plan. Final Report*. Ministry of Health. Canada.

Tilman, C. & Sandhu, R. 1998. *A model recycling program for Alabama*. Resources, Conservation and Recycling, 24: 183-190.

UNAIDS, 2007. *Government of South Africa, synergy project, malaria research programme of the MRC*. University of KZN. South Africa.

UNAIDS, 2002. *Report on the global HIV/AIDS epidemic*. [Online]. Available on: http://whqlibdoc.who.int/unaid/2002/global_report_2002.pdf. Accessed 27/09/2008.

UNEP (2006). *International source book on environmentally sound technologies for municipal, International Environmental Technology Center*. USA.

United Nations Environmental Program, 2007. *International sourcebook on environmentally sound technologies for municipal waste management*. [Online]. Available at: http://www.unep.or.jp/etc/Publications/TechPub-15/main_index.asp. Accessed 29/09/2009.

US EPA, 2003. *Municipal solid waste*. Columbia University: NYC.

Van Manen, M. 2002. (Ed) *writing in the dark: phenomenological studies in interpretive inquiry*. Althouse: Ontario, Canada.

Vermont Department of Environmental Conservation, 2001. *Procedure addressing regulated medical waste definitions and the handling and treatment of regulated medical waste (RMW)*. Vermont: USA.

Vosburgh, D. 2001. *Water service development plan: The status quo*. Directorate of Macro Planning: DWAF, Northern Cape.

Weir, E. 2002. *Hospitals and the Environment*. *Canadian Medical Association Journal*. 166, (13): 345-354.

Welman, B. and Kruger, V. H. 2002. *Advanced research methods: Scientific statistical methods*. Althouse: Ontario, Canada.

WHO, 2000. *Safe Health Care Management*. World Health Organisation, Geneva: Switzerland.

WHO, 2005(a). *Management of solid health care waste at the PHC centres. A decision making guide*. Geneva. Switzerland.

WHO, 2005(b). *Definition and characterisation of health care waste*. [Online]. Available at: http://www.who.int/water_sanitation_health/medicalwaste/002to019.pdf. Accessed 17/09/2009.

WHO, 2006. *Emergency Preparedness and response South East Asia earth quake and tsunami. Regional Office for South Asia* [Online]. Available at: <http://www.healthcarewaste.org/>. Accessed 05/10/2009.

WHO, 2007. *Management and disposal technologies for HCW* [Online]. Available at: http://www.int/water_sanitation_health/medicalwaste/061to076.pdf. Accessed 14/10/2009.

WHO, 2005(c). *HCWM technologies in medium-sized HCFs* [Online]. Available at: http://www.healthcarewaste.org/en/640_tech_medium.html. Accessed 05/10/2009.

Wikipedia, 2009: *Waste characterisation*. [Online]. Available at http://en.wikipedia.org/wiki/waste_characterisation. Accessed 23/09/2009.

Wilburn, S.Q. and Eijkemans, G. 2004. *Preventing needle stick injuries among health care workers* [Online]. Available at: <http://www.who.int/occupationalhealth/activities/5prevent.pdf>. Accessed 12/08/2009.

Williamson, D. 2008. *Health care waste management* [Online]. Available at: <http://www.duncanwil.co.uk/zero.html>. Accessed 21/12/2008.

Wilson, D.C. 1996: Stick or carrot? The use of policy measures to move waste management up the hierarchy. *Waste management & Research*, 14 (4): 385-398.

Wisconsin Department of Natural Resources, 2008. Waste reduction and recycling: A guide for Wisconsin Health Care. Madison: Washington DC. World Bank, 2002. *Guide to HCW management* [Online]. Available at: <http://www.essentialaction.org.waste/worldbank/ifcguidelinesmemo.htm>). Accessed 12/08/09.

Wright, R.E. 1991. *An investigation of the relative importance of factors influencing recycling behaviours*. Unpublished PHD thesis. Indiana, USA: Indiana University.

Yap, N.T. (Ed). 1999: *Cleaner production and consumption: challenges and opportunities in East Southern Africa*. Harare, Zimbabwe: Weaver Press Yourdictionary, 2004. *Definition of a model* [Online]. Available at: <http://www.yourdictionary.com/model>. Accessed 12/08/2009.

Appendix A:

Questions regarding the administrative, financial and monitoring structures

1	Is medical waste weighed at the point of generation?	Records for HCW generated and Records for HCW received from wards and Weighing of HCRW:
2	System to separate HCRW from General waste (segregation).	Segregation of hazardous from non-hazardous wastes.
3	What is the tonnage of medical waste generated per hospital per year?	Records for waste at each step of the HCW disposal process
4	Is medical waste weighed by the service provider when it is collected at the designated storage area, which is on the premises of the hospital?	Records for HCRW bags collected:
5	Does an employee of the hospital check and certify that the quantity as weighed by the service provider and as indicated on the collection certificate corresponds?	Register for HCW handed over to contractor
6	Question 5: Question 6: Is medical waste again weighed at the point of disposal by the service provider?	Records for HCW generated and Records for HCW received from wards and Weighing of HCRW
7	Does the incineration/disposal certificate indicate the quantity of the medical waste?	Records for HCW generated and Records for HCW received from wards and Weighing of HCRW

8	Does the hospital check that the quantity on the financial invoice is correct in terms of the collection certificate/internal manifests/documents before payment take place?	Records for HCW generated and Records for HCW received from wards and Weighing of HCRW
9	Does the quantity on the financial invoice correspond with the quantities on the incineration waste certificate issued by the service provider?	Records for HCW generated and Records for HCW received from wards and Weighing of HCRW
10	Is the Hospital Group, including the three hospitals in the study area, aware that they could contribute towards the NSSD1 Action plan and the South African Waste Management Information system?	Records for HCW generated and Records for HCW received from wards and Weighing of HCRW
11	Observation of Occupational Health and Safety Act	
12	Integrated HCW management plan and orientation and induction of staff, Detailed operating manuals or instructions for HCW staff	
13	The number of patients per day or per months could not be obtained from Hospital A, B and C.	