Development of Intervention Strategies for Management of Medical Waste in Vhembe District, South Africa

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Declaration

I, OLANIYI, Foluke Comfort hereby declare that this thesis titled **"Development of Intervention Strategies for Management of Medical Waste in Vhembe District, South Africa"** submitted to the Department of Public Health for the degree of Doctor of Philosophy in Public Health at the University of Venda has not been submitted previously for any other degree or examination at this University or any other institution, and that it is my own work in design and execution, all previous works by other people included in the thesis have been duly acknowledged and referenced.

..... 24-02-2020

Student's signature Date

We, the Promoters, certify that this declaration is correct.

..... 24/02/2020

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Emeritus Professor J. S. Ogola

..... 24/2/2020

Co- Promoter's signature Date

Dr. T.G. Tshitangano

Dedication

I dedicate this work to my husband, Dr. Joshua Edokpayi and my children, Eliezer Edokpayi and Timothy Edokpayi.

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Abstract

Medical waste is a special type of hazardous waste generated from healthcare facilities. Mismanagement of this waste has a negative impact on healthcare workers, patients and their relatives, medical waste handlers and the community. South Africa, like many other developing countries, is resource-constrained in the management of medical waste and poor practices have been reported across the country, especially in the urban health facilities that have received more attention from researchers. This study was conducted to explore the practices and challenges of medical waste management in Vhembe District, a largely rural district in Limpopo province and develop intervention strategies for better management of the waste in the District. A convergent parallel approach of mixed method design was adopted to achieve the objectives of this study. The target population included the main stakeholders of medical waste management in the district: the Department of Health, healthcare facilities and the waste management company responsible for the treatment and disposal of medical waste in Limpopo Province. The study population from the Department of Health included representatives from the medical waste management section while the waste management company was represented by the manager of the company in Limpopo Province. The samples for the healthcare facilities were drawn from fifteen randomly selected healthcare facilities in the district and included the administrative heads, medical waste generators and medical waste handlers. The study was conducted in three phases. Phase 1 was a qualitative study during which the administrative heads of the selected healthcare facilities, personnel directly involved in medical waste management at the healthcare facilities as well as the representatives from the Department of Health and waste management company were engaged in in-depth interviews. This phase also involved voice recording, observations, field documentation and taking of relevant pictures. Thematic content analysis was used to analyze the data obtained. During phase 2 (quantitative study), a semi-structured questionnaire was employed for data collection from medical waste generators and handlers at the healthcare facilities. A total of 229 questionnaires were retrieved from the participants and were analyzed with the Statistical Package for Social Sciences version 25.0. Descriptive statistical analyses were performed; Chi-square and Cramer's V tests were used to determine the associations between dependent and independent variables, as well as the strength of association where significant relationships exist. Statistical significant level was set at $p<0.05$ and the results are presented in tables and graphs. The results from both phases were interpreted and discussed simultaneously. Respondents and participants were assured of anonymity of their identities and confidentiality of the information they provided. They were given adequate information about the study and only those who volunteered participated in the study after appending their signatures on the informed

consent form. In phase 3, the Medical Research Council Framework was used to develop intervention strategies for improved medical waste management in Vhembe District based on the Strength, Weakness, Opportunity and Threat (SWOT) and Political, Economic, Social, Technological, Environmental and Legal (PESTEL) analysis techniques. The study revealed inefficient practices of medical waste management in all the healthcare facilities. Rate of medical waste generation was 338.15kg/day, 19.2kg/day and 15.5kg/day of HCRW from the hospitals, community health centers and clinics respectively. Segregation practices were poor, and only 28.4% of respondents rated their healthcare institutions as being excellent with medical waste segregation. The type of occupation was found to be significantly associated with exposure to training (p=0.000) and the level of knowledge about medical waste management (p=0.000). Also, the use of personal protective equipment was found to be significantly associated with training (p=0.011). Transportation and temporary storage were not done according to the recommendation in the guidelines and incineration was the main means of treatment of the waste. The final product of waste treatment is being disposed into an hazardous waste landfill. The challenges encountered in the process of managing medical waste include lack of adequate funding and budget for medical waste management, ineffective and irregular training of healthcare workers, non-compliance to medical waste management guidelines, insufficient bins, sub-standard central storage rooms, insufficient personal protective equipment and unavailability of Hepatitis B vaccine. The strength, weakness, opportunities and threats of medical waste management in Vhembe District were analyzed and specific intervention strategies were developed to improve on the strength, minimize the weakness, take advantage of the opportunity and combat the threats. The developed strategies were validated. This study provides the evidences of poor management of medical waste in Vhembe District, and shows the need for urgent intervention measures to be put in place. We therefore recommend that the intervention strategies proposed here be evaluated and implemented to mitigate the untoward effects of poor medical waste management among healthcare workers and the community as a whole.

Key words: *Clinics, community health centers, hazardous waste, healthcare workers, hospital, intervention strategies, medical waste management, public health, SWOT analysis, Vhembe District, waste generators*

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List of Acronyms and Abbreviations

CEO: Chief Executive Officer

CHC: Community Health Center

CPD: Continuing Professional Development

DEA: Department of Environmental Affairs

DEAT: Department of Environmental Affairs and Tourism

DoH: Department of Health

DPSEEA: Driving Force, Pressure, State, Exposure, Effect, and Action

EHP: Environmental Health Practitioner

EIA: Environmental Impact Assessment

HBV: Hepatitis B Virus

HCF: Health Care Facility

HCRW: HealthCare Risk Waste

HCWHA: Health Care without Harm Asia

HIV: Human Immunodeficiency Virus

HOD: Head of the Department

HPCSA: Health Professions Council of South Africa

HWSETA: Health and Welfare Sector Education and Training Authority

IPCC: Infection and Prevention Control Coordinator

NDoH: National Department of Health

NEMA: National Environmental Management Act

NEMWA: National Environmental Management Waste Act

OHSA: Occupational Health and Safety Act

PPE: Personal protective equipment

SANC: South African Nursing Council

SANS: South African National Standards

SAPC: South African Pharmacy Council

SOP: Standard Operating Procedure

SPSS: Statistical Package for the Social Sciences

VDM: Vhembe District Municipality

WHO: World Health Organization

WMC: Waste Management Company

CHAPTER ONE

OVERVIEW OF THE STUDY

1.1 Background

The growing quantity of waste being generated from healthcare facilities as well as the risk it poses to the community has raised much concern over the past few years. The risk is linked to the constituent of the healthcare waste (hereafter referred to as medical waste), which includes sharp objects, human tissues and other infectious materials (Patil, & Pokhrel, 2004). Thus, making it imperative that the waste be disposed safely without having any contact with the general public. Maseko (2014) listed poor medical waste management as one of the phenomena that has rendered the hospital environment unhealthy and unsafe for the community, rather than being a model of a healthy environment. Working or living in unhealthy environment has been implicated in the death of more than 12 million people annually (WHO, 2016). Poor medical waste management has also been implicated in an increase in the number of epidemics and medical waste-related diseases worldwide (Maseko, 2014). The World Health Organization (WHO) has traced several major health threats in the past to inappropriate management of medical waste (Harhay *et al.*, 2009).

Medical waste has been defined by the WHO as “all the waste generated within healthcare facilities, research-centers, and laboratories related to medical procedures; including the same types of waste generated from other scattered sources and homes” (Chartier *et al.*, 2014). These wastes are classified into two general classes: the general (or, non-hazardous) waste and the hazardous waste. The hazardous waste can be further sub classified into: sharps, infectious, pharmaceutical, cytotoxic, pathological, radioactive and chemical waste (Chartier *et al.*, 2014).

The general medical waste, which are comparable to domestic waste, usually constitute the bulk of medical waste (75 - 90%) and include waste generated from administrative works, packaging and maintenance works; while hazardous waste constitutes only between 10 - 25% of all medical waste (Yawson, 2014). The health risks posed by improper management of medical waste range from direct injury to humans from disposed used sharps and infections to indirect injuries from air, land, water and air pollution with toxic chemicals from the waste (Yawson, 2014). Many workers who handle medical waste and people who live in areas where medical wastes are discharged have been found to suffer from diseases like cholera and salmonellosis (Fei-Baffoe, 2010). This can be prevented if the waste generated are properly handled from the source of generation to the point of disposal.

1.2 Problem Statement

It has been reported that the medical waste management sector in South Africa is facing a lot of problems along the management chain from source to disposal (Vumase, 2009; Maseko, 2014). For instance, the healthcare facilities across the country generate an estimated 45,000 tons of waste annually of which only about 4,500 tons are hazardous. However, because waste is being mixed, it becomes necessary to treat all waste as hazardous, thus, increasing the cost of treatment (Jewaskiewitz, 2013). The Department of Environmental Affairs and Tourism (DEAT) in 2008 reported that the inability of the licensed medical waste management facilities in South Africa to cope with the enormous amount of medical waste being generated across the country has resulted into illegal dumping of the waste in unauthorized sites and envisaged that the situation will worsen because of the projected annual increment in medical waste generation rate of 1.5% nationally due to human population growth rate of 1.06%. The Sunday Times Newspaper in 2009 published many articles reporting the discovery of medical waste dumped in various unauthorized sites in South Africa and called the situation a time bomb (Sunday Times, 2009). The Institute of Waste Management in South Africa also warned that the situation may lead to a major disaster.

Mismanagement of medical waste poses much risk to healthcare workers and the public, especially children and commercial scavengers. Needle prick injuries with the risk of subsequent infection with blood-borne diseases like HIV and Hepatitis B have been reported among healthcare workers (Vumase, 2009). Children have been found scavenging on medical waste scattered on streets to find “toys”, like gloves to be used as balloons and a report has been made of children having to be treated with antiretroviral drugs after they were pricked with dumped used needles and some ate potentially lethal pills they found dumped at a field in Elsie’s River, Cape Town (Abor & Bouwer, 2008). Commercial waste scavengers have also been reported to visit dumping sites in search of recyclable materials and are thus exposed to sharps and other infectious materials when medical wastes are disposed with other municipal waste (Hangulu & Akinola, 2017).

Studies conducted in the past in urban healthcare facilities in the Limpopo Province have shown poor practices of medical waste management in all the facilities from the point of waste generation to disposal or transportation out of the healthcare facilities (Nemathaga *et al.*, 2008; Malebatja, 2013; Raphela, 2014). Also, there have been reports of illegal dumping of medical waste along with other municipal waste into water bodies and other unauthorized sites in Vhembe district. However, proper documentation of these practices is missing. A systematic study of medical waste handling from the point of generation through transportation to treatment and/or disposal is lacking in Vhembe District. Thus, it became an urgent task to consider the current practices of medical waste management from the healthcare facilities and the challenges being faced by all the stakeholders and develop intervention strategies needed to forestall the harmful effects of poor management of medical waste in the community.

1.3 Rationale for the Study

Poor medical waste management constitutes a huge public health problem in many developing countries where medical waste, despite its peculiarity is being treated and disposed as a part of municipal waste (Abor, 2007). Municipal waste management has received a great deal of attention from researchers in South Africa in the past while the issues of medical waste have been neglected, perhaps because it constitutes only a very small percentage of the total waste. A larger percentage of the few researchers that have investigated the practices of medical waste management in South Africa focused on the healthcare facilities in the urban areas and reported poor practices hinged on various challenges in most of the facilities (Maseko, 2014). The rural healthcare facilities have not received a similar scrutiny even though they are more likely to be facing more challenges than the urban facilities. This study focused on the rural healthcare facilities, including the ones located in remote villages with poor road access and explored the challenges being faced by all stakeholders in medical waste management with a resultant development of intervention strategies which could be adopted by all for improved medical waste management.

1.4 Significance of the Study

While the Department of Health of South Africa is working towards achieving the goal of a long and healthy life for all South Africans, waste generated from healthcare facilities can compromise the vision if it is not properly managed, by constituting an unsafe environment which becomes harmful for citizens and impact negatively on their health. Also, efficient management of medical waste is very relevant to sustainable development goal 3, which aims at substantially reducing the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination by 2030. This study presents the current status of medical waste management practices in Vhembe District as well as the challenges being faced by the stakeholders. This will hopefully assist the government with policy formulation and provide scientific data on which the review of the current guidelines can be based. The results of this study may also help the heads of healthcare facilities to become more intimate with their roles of implementation of the guidelines and ensure compliance by their members of staff.

Also, the intervention strategies developed at the end of the study is expected to provide medical waste generators and handlers with comprehensive information on the safe handling of medical waste and the risks associated with improper handling, thereby assisting them to work with safety consciousness and protect themselves from the dangers of medical waste. It is also hoped that the public will benefit from this study by having an environment free of toxic substances from medical waste.

1.5. Study Hypotheses

This study was framed on the following hypotheses:

1. Medical waste is ineffectively managed from the point of generation to disposal within Vhembe District healthcare facilities.
2. Medical waste transported out of Vhembe District healthcare facilities are not being properly disposed.
3. The challenges of medical waste management in Vhembe district is an evidence of lack of proper attention to medical waste issues by the provincial Department of Health.
4. Staff in healthcare facilities located in the remote areas face more challenges than those in urbanized areas in managing their medical waste.

1.6 Purpose of the Study

The purpose of this study was to investigate medical waste management practices, identify the challenges being faced by stakeholders and develop intervention strategies for the management of medical waste in Vhembe District.

1.7 Objectives of the Study

Specific objectives were set to achieve the purpose of this study. These objectives were divided into three phases based on the type of study design which was adopted.

Phase 1 (Qualitative)

1. To explore the availability, implementation and compliance to medical waste management guidelines in selected health facilities in Vhembe District.

Phase 2 (Quantitative)

2. To determine the medical waste generation, segregation, transportation and storage practices among healthcare workers in selected healthcare facilities in Vhembe District.
3. To identify the challenges being faced by waste generators in the process of medical waste management.
4. To compare medical waste management practices in the hospitals, clinics and community health facilities in Vhembe District, Limpopo Province.

Phase 3

5. To develop practical intervention strategies for medical waste management in Vhembe District.

1.8 Expected Outcomes

The following were the expected outcomes of this study:

a. Establishment of medical waste management practices in Vhembe District.
b. Identification of challenges facing medical waste management stakeholders.
c. Development of intervention strategies for management of medical waste in Vhembe District.

1.9 Theoretical Framework

The following theories were applied in this study

1.9.1 The Theory of Planned Behavior: This theory has been found to be a strong predictor of medical waste segregation practice among healthcare workers and waste segregation is a key step in the proper management of medical waste (Asadulla *et al.*, 2013). The theory states that "a person's behavior is highly determined by his or her intention (readiness), which is considered the most immediate determinant of behavior. Intention in turns depends on a person's attitude (feeling of favorableness or otherwise) towards the behavior, influence of subjective norms (perceived social pressure) and perceived behavioral control (perceived ability to perform a behavior)" (Ajzen, 1991 as cited in Akulume & Kiwanuka, 2016). Ajzen further explained that perceived behavioral control can influence behavior either directly or through intention. Perceived behavioral control comprises of internal and external factors that affect behaviors whether directly or through intention (Wise *et al.,* 2006).

The application of this theory in the issue of medical waste management lies in its inherent ability to describe the medical waste segregation behavior of the healthcare staff in relation to their intention or readiness to segregate the waste into their distinct categories. Their behaviors can also be influenced by internal factors such as their understanding of the different categories of the medical waste and the risks of mixing the waste together; and also by external factors like the availability of color-coded bins and liners for the different categories of medical waste.

This theory has been rated to be very useful as a guide in the design of intervention strategies to change a negative or maintain a positive human behavior having been proven to be one of the most predictive models to explain the human behavior (Rivis & Sheeran, 2003; Wise *et al.*, 2006; Ayodeji, 2010). Thus, it was very relevant in this work, both at the point of design of the data collection instrument and development of the intervention strategies.

1.9.2. Theory of Waste Management: The theory of waste management is founded on the expectation that the goal of waste management is to prevent waste from causing harm or injury to human or the environment (Pongrácz *et al.,* 2004). It contains conceptual analyses of waste, the actions taken upon waste as well as a holistic view of the goals of waste management. The theory seeks to promote waste minimization by analyzing different existing definitions of waste and introducing new, dynamic definitions in order to be able to construct a sustainable agenda for waste management (Pongrácz *et al.*, 2004).

To develop the theory, various definitions of waste proposed by different persons at different times were collated and reviewed. The word “discard” was found to be relatively common in most of the definitions either directly or indirectly; that suggests that “waste” are generally considered useless. However, in the face of reuse and recycling, many of these definitions will no longer be applicable to waste. The proponents of this theory concluded that simple manipulations can change a “waste” to “non-waste (Pongrácz *et al.*, 2004). Thus, they proposed a new definition for waste, bearing in mind that “waste” is dynamic and is dependent on time, place, resources and ownership.

According to Pongrácz *et al.* (2004), waste has been defined as “a thing that is, in the given time and place, in its actual structure and state, not useful to its owner, or an output that has no owner, and no purpose”. They also define waste management as “control of waste related activities, with the ultimate aim of resources conservation and protection of human health and the environment.”

Key concepts of this theory which find application in medical waste management debate are the definition of waste and waste categorization, reduction of the quantity of waste from source, turning waste into non-waste and preventing waste from causing harm to human and the environment (Pongrácz *et al.*, 2004). It also gives an insight into the prediction of outcomes of waste management options and the choice of waste management technique. This theory was applied in this study to the design of measurement instruments and the eventual design of the intervention strategies.

1.10 Structure of Thesis

This thesis consists of eight chapters as shown in Table 1.1 below:

Table 1.1. Structure of the Thesis

Chapter	Content	Status
One	Introduction of the thesis, a brief background, the problem statement, rationale for the study and the significance of the study. It also contains the purpose and objectives of the study as well as the expected outcomes from the study.	Not applicable
Two	A review of previous studies relevant to this thesis presented as a review paper titled: "A Review of Medical Waste Management in South Africa".	Published
Three	The methodology employed to obtain the results in this research.	In draft as a protocol
Four	Results and discussions 1 in a paper format titled: "Efficiency of Health Care Risk Waste Management in Rural Healthcare Facilities of South Africa: An Assessment of Selected Facilities in Vhembe District, Limpopo Province"	Published
Five	Results and discussions 2 in a manuscript format with the title: "Beyond the Point of Waste Generation: The Roles and Networking of Stakeholders to Achieve Safe Management of Health Care Risk Waste in Vhembe District Municipality"	Under Review
Six	Results and discussions 3 as a manuscript with the title: "Challenges of Effective Management of Medical Waste in Low-Resource Settings: Perception of healthcare workers in Vhembe District Healthcare Facilities"	Under Review
Seven	The proposed intervention strategies which were developed after the analyses, interpretation and convergence of both the qualitative and quantitative data. The strategies will be published as "Intervention Strategies to Improve Medical Waste Management in Vhembe District Municipality of Limpopo Province, South Africa" in an accredited journal.	In draft
Eight	A compilation of the summary of the research findings, the means of achieving each of the objectives, the limitations of the study and the contribution of the study to existing knowledge. It also contains the conclusions based on the study findings as well as recommendations for further research works.	Not applicable

References

Abor, P. A. (2007). Medical waste management practices in a Southern African hospital. *Journal of Applied Sciences and Environmental Management, 11(3),* 91-96.

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

Ajzen, I. (1991). "The theory of planned behavior," *Organizational Behavior and Human Decision Processes,* 50: 2, 179–211.

Akulume, M. and Kiwanuka, S. N. (2016). Health Care waste management Segregation Behavior among Health Workers in Uganda: An Application of the Theory of Planned Behavior. *Journal of Environmental and Public Health,* 2016 Article ID 8132306, 8 pages, 2016. doi:10.1155/2016/8132306.

Asadulla, M., Karthik, K. G., and Dharmappa, B. (2013). "A study on knowledge, attitude and practices regarding biomedical waste management among nursing staff in private hospitals in Udupi city, karnataka," *India International Journal of Geology, Earth and Environmental Science*, 3, 118–123.

Ayodeji, P. I. (2010). Exploring secondary school students' understanding and practices of medical waste management in Ogun, Nigeria. *International Journal of Environment and Science Education,* 5, 201–205.

Chartier, Y., Emmanuel, J., Pieper, U., Pruss, A., Rushbrook, P., Stringe,r R., Townend, W., Wilburn, S. and Zghondi, R. (eds.) (2014). *Safe management of waste from healthcare activities*. Geneva, Switzerland: World Health Organization, pp. 3-5.

Fei-Baffoe, B. (2010). *Household and industrial medical waste management* (Handout for MSc Environmental Science). Kumasi: Kwame Nkrumah University of Science and Technology.

Hangulu, L. and Akinola, O. (2017). Health care waste management in community-based care: Experiences of community health workers in low resource communities in South Africa. BMC Public Health. 17 (448). Retrieved from https://doi.org/10.1186/s12889-017-4378-5 on 10/08/2017.

Harhay, M.O., Halpern, S.C., Harhay, J.S. and Olliaro, P.L. (2009). Healthcare waste management: A Neglected and Growing Public Health Problem Worldwide. *Tropical Medicine and International Health*. 14 (11), 1414-7.

Jewaskiewitz, S. (2013). A challenging context. *Infrastructure news and service delivery.* Retrieved from http://www.infrastructurene.ws/2013/05/20/a-challenging-context/ on 20 February, 2017.

Maseko, Q. (2014). Critical evaluation of medical waste management policies, processes and practices in selected rural hospitals in the Eastern Cape. Unpublished Master's dissertation. Grahamstown: Rhodes University, pp. 37-141.

Malebatja, S.M. (2013). Knowledge and practices of health care workers on medical waste management disposal at George Masebe Hospital, Waterberg District, Limpopo Province, South Africa. Unpublished dissertation. Mankweng: University of Limpopo, pp. 34-36.

Nemathaga, F., Maringa, S. and Chimuka, L. (2008). Hospital solid waste management practices in Limpopo Province, South Africa: A case study of two hospitals. *Medical waste management, 28(7),* 1236-45.

Patil, G.V. and Pokhrel, K. (2004). Biomedical solid waste management in an Indian hospital: a case study. *Medical waste management,* 25, 595-599.

Pongrácz, E., Phillips, P. S. and Keiski, R. L. (2004). Evolving the Theory of Medical waste management: Defining key concepts. Medical waste management and the Environment II. Wit Press, pp. 472-478.

Raphela, S.F. (2014). Treatment and disposal of medical waste in rural and urban clinics within Polokwane municipality of South Africa. *Journal for New Generation Sciences,* 12 (2), 97-109.

Rivis, A. and Sheeran, P. (2003). Descriptive norms as an additional predictor in the theory of planned behaviour: a meta-analysis. *Current Psychology,* 22(3), 218–233.

Sunday Times. (2009) Medical waste found dumped in the backyard. 28 November 2009. Retrieved from https://www.iol.co.za/news/south-africa/medical- waste management-found-dumped-in-back-yard-466096 on 15/02/2017.

Vumase, B.S. (2009). An Evaluation of Operational and Administrative Procedures for Health Care waste management in Public District Hospitals of South Africa. Unpublished thesis. Durban: Durban University of Technology. Pp 117-185.

Wise, D., Goggin, K., Gerkovich, M., Metcalf, K., and Kennedy, S. (2006). "Predicting intentions to use condoms using gender, sexual experience, and the theory of planned behavior," *American Journal of Health Education,* 37: 4, 210–218.

World Health Organization. (2016). Newsroom: *An estimated 12.6 million deaths each year are attributable to unhealthy environments*. Geneva, Switzerland: WHO. Accessed from: https://www.who.int/news-room/detail/15-03-2016-an-estimated-12-6-million-deaths-each-year-are-attributable-to-unhealthy-environments on 25/03/2017.

Yawson, P. (2014). Assessment of solid waste management in healthcare facilities in the Offinso municipality. Unpublished Master's dissertation. Kumasi: Kwame Nkirumah University of Science and Technology. Pp 33-56.

CHAPTER TWO

LITERATURE REVIEW

This section is focused on the review of previous studies and documents regarding medical waste to explore the practices of medical waste management in the developed countries and developing countries. The past and current practices of medical waste management in South Africa alongside with the challenges being encountered by the stakeholders were discussed. It also includes the review of the policies and guidelines regulating the management of medical waste in South Africa, the theories applicable to medical waste management and the health impact of poor medical waste management on individuals and the community. The chapter resulted in a published article.

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REVIEW ARTICLE

A Review of Medical Waste Management in South Africa

Abstract

Background:

Poor medical waste management has been implicated in an increase in the number of epidemics and waste-related diseases in the past years. South Africa is resource-constrained in the management of medical waste.

Objectives:

A review of studies regarding medical waste management in South Africa in the past decade was undertaken to explore the practices of medical waste management and the challenges being faced by stakeholders.

Method:

Published articles, South African government documents, reports of hospital surveys, unpublished theses and dissertations were consulted, analysed and synthesised. The studies employed quantitative, qualitative and mixed research methods and documented comparable results from all provinces.

Results:

The absence of a national policy to guide the medical waste management practice in the provinces was identified as the principal problem. Poor practices were reported across the country from the point of medical waste generation to disposal, as well as non- enforcement of guidelines in the provinces where they exit. The authorized disposal sites nationally are currently unable to cope with the enormous amount of the medical waste being generated and illegal dumping of the waste in unapproved sites have been reported. The challenges range from lack of adequate facilities for temporary storage of waste to final disposal.

Conclusion:

These challenges must be addressed and the practices corrected to forestall the adverse effects of poorly managed medical waste on the country. There is a need to develop a medical waste policy to assist in the management of such waste.

Keywords: *Medical wastes*, *South Africa*, *Waste management*, *Practices*, *Challenges*, *Policy*.

1. INTRODUCTION

Medical waste, also referred to as healthcare waste has been defined by the World Health Organization (WHO) as “all the waste generated within healthcare facilities, research centres, and laboratories related to medical procedures; including the same types of waste generated from other scattered sources and homes” [1]. Waste management is defined as “all activities, administrative and operational, involved in the handling, treatment, storage, recovery and recycling (of healthcare general waste) and the disposal of waste (including transportation)” [2].

Medical wastes are classified into two general classes: the general or, non-hazardous waste and the hazardous waste. Hazardous waste can be further sub-classified into sharps, infectious, pharmaceutical, cytotoxic, pathological, radioactive and chemical waste [1]. The general waste, which is comparable to domestic waste, usually constitutes the bulk of medical waste (75 - 90%) and includes waste generated from administrative works, packaging and maintenance works; while the hazardous waste constitutes only between 10 - 25% [3].

In the developed countries, there are policies from the national to the regional and local levels guiding all stakeholders in the proper management of medical waste. For instance, a Teaching Hospital in Germany has 54 rules regarding medical waste management – 36 from the national government, 5 from the regional government and 13 from the hospital [4].

The enormous health risks to humans and the environment posed by medical waste range from direct injury to humans from disposing of used sharps to indirect injuries from land, water and air polluted with toxic chemicals from the medical waste. These risks arise from the inclusion of sharp objects, human tissues and other infectious materials in medical waste

[5]. Several studies have reported an increase in the number of epidemics and waste-related diseases due to poor medical waste management and several major health threats which occurred in the past have been traced to inappropriate management of medical waste [6, 7]. Globally, about 5.2 million people, including 4 million children die annually from waste-related diseases and the situation is likely to get worse if proper intervention is not put in place to avert further disaster [8]. Many workers who handle medical waste and people who live in areas where medical waste are discharged have been found to suffer from diseases like cholera and salmonellosis [9].

The quantity of waste being generated from health facilities has been on the increase in recent years due to an increase in the number of healthcare facilities catering for the increasing human population and the use of disposable medical products [10 - 12]. This increases the cost of treatment and disposal and thus exacerbates the problem of waste management [13]. That is why the South African National Standards [2] encourages the reduction and possible reuse of medical waste.

Most developing countries are unable to effectively manage their medical waste because of lack of resources, poor management of available resources and lack of transparency in administration [14, 15]. In South Africa, incineration is the most common method being used in the disposal of toxic medical waste; however, incinerators are known to pollute the air by releasing toxic metals to the atmosphere, polluting soil and surface water and the use of incinerators has been implicated in the disruption of human hormonal, immune and reproductive systems and cancers [16]. The lack of sufficient equipment to deal with the ever-increasing burden of medical waste has resulted in the dumping of a large quantity of the waste in illegal sites and sometimes burning within the premises of the health facilities (17). Uncontrolled burning of these waste may result in air pollution and toxic emissions from incomplete combustion which is both harmful to the public [16]. Despite the magnitude of the problem; practices, capacities and policies on dealing with medical waste management in many countries, especially in developing nations is inadequate, thus requires intervention [18].

This study, therefore, aims to critically review medical waste management in the nine provinces of South Africa in order to establish the practices, identify existing challenges and compare what obtains in the nine provinces. It also aims to look into the trend of medical waste management in South Africa to identify the areas of improvement over the years and where more attention is required.

2. RESEARCH METHOD

This review considers published works on medical waste management in South Africa within the last decade (2007 - 2017). A web search was done on databases such as Science Direct, Medline, Greenfile, Environment Complete and Health Source using the following keywords: “medical waste management in South Africa”, “healthcare waste management in

South Africa" and "hospital waste management in South Africa". The search was limited to journal articles to exclude other types of publications such as book chapters, newspaper articles and conference proceedings. It was also limited by the year of publication to exclude publications that were made before the year 2007. The initial search yielded a total of 1,183 research articles which were further assessed for their relevance to this study. Articles who dealt with solid waste management in households or other institutions aside health facilities were removed from the collection, as well as articles that focus on other issues in South Africa aside from medical waste management. Eventually, 35 articles which deal with the management of medical waste in the provinces of South Africa and published in accredited journals were selected for this review paper. Relevant dissertations, theses and publications by the Department of Health and provincial governments in South Africa were also consulted.

3. RESULTS AND DISCUSSION

This section reviews the rate of generation of medical waste in South Africa, the national policies guiding medical waste management in the country and the documented practices of medical waste management in each of the provinces of South Africa.

3.1 Medical Waste Generation in South Africa

The Republic of South Africa is made up of 9 provinces (Figure 2.1).

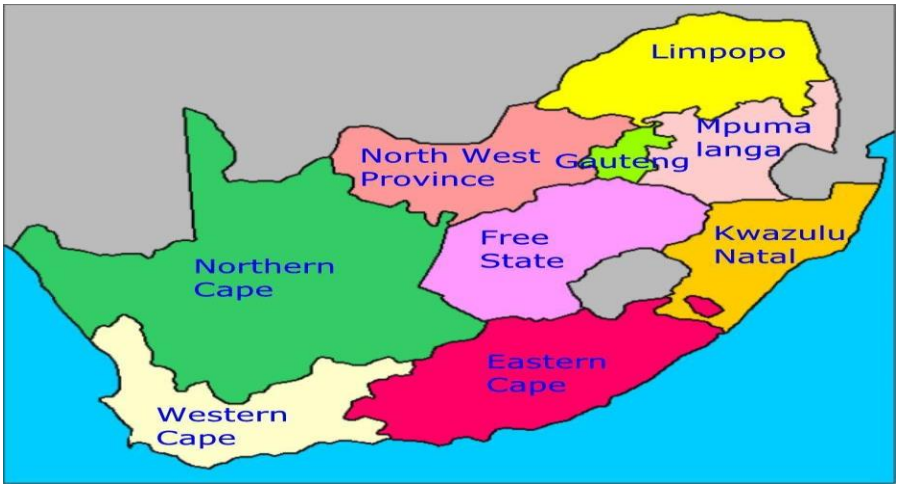

Figure 2.1: Map of South Africa showing the 9 Provinces (https://www.southafrica.to/provinces/provinces.html)

There has been a progressive increase in the quantity of medical waste being generated across South Africa from 42,000 tons per annum in 2007 to 45,000 tons per annum in 2013 [20]. Furthermore, an estimated increase in the generation of medical waste of 1.5% per annum has been envisaged due to the actual 1.06% growth rate of the human population [19]. The last most comprehensive estimation of medical waste generation from health facilities across the provinces of South Africa was done in 2006 and it showed that public facilities generate more waste than the private and Gauteng and KwaZulu-Natal Provinces generate more waste than

other provinces [19] (Figure 2.2).

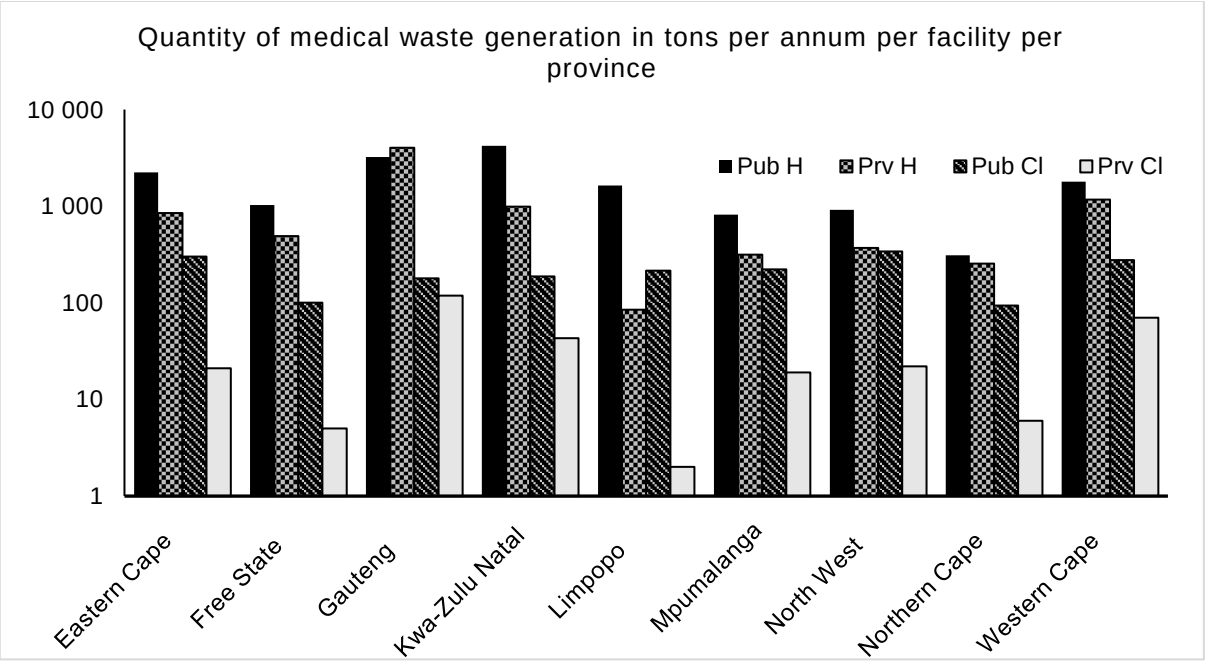

Figure 2.2: Estimated quantities of waste generation at health facilities: Pub H – public hospital, Prv H- private hospital, Pub Cl – public clinic, Prv Cl- private clinic [19].

3.2 National Policies Relating to the Medical Waste Management

Development and enforcement of a National Policy to guide the management of medical waste in a country is supposed to be spearheaded by the Department of Health [21] and supported by other relevant departments like the Department of Environment [22]. The policy should define in clear terms the different categories of medical waste and how to manage each of the categories; it should also address the important issues of training and provision of the necessary equipment. This will ensure uniformity in practice in all provinces of the country [7].

A review of the South African Department of Health Annual Reports in the last decade shows that the issue of medical waste has not been accorded the priority it deserves by the Department. There was no mention at all of the word “waste” in the reports of the years 2007/08 to 2010/11 [23 - 26]. In the report of 2011/12, “waste” was just mentioned in passing without any definition, plans or budget [27]. In 2013/14 annual report, it was documented that the Regulations for medical waste management were developed and approved for publishing in the government's Gazette for public comment [28], finalised in 2014/15 [29], approved by the Minister on 13 May 2015, but yet to be gazetted as at the time of writing the report in September 2016 [30]. This shows an obvious drag in the publishing and implementation of this policy while the health facilities continue to increase and generate more waste in the country which is not being properly managed. Furthermore, the Regulations exclude

radioactive waste which is also generated in some health facilities in the urban centres where tests and treatments relating to radiation are carried out [30]. The exclusion of radioactive waste in the Regulation is of concern because an improper disposal of radioactive waste poses a health risk to the workers and the public at large once it is released into the environment [31].

In South Africa, some of the national policies which can be applied to medical waste management include:

- Act 108 of 1996: This Act accorded every citizen of South Africa a right to a safe environment that is not harmful [32]. Improper disposal of medical waste infringes on this right because it may result in the pollution of land, water and air which renders the environment harmful;
- National Environmental Management: Air Quality Act 39 of 2004: This aims to protect the quality of air in the Republic by prevention of air pollution and environmental degradation. The regulation of emission standards of incinerators being used in medical waste disposal in South Africa falls under this Act;
- National Environmental Management: Waste Act 59 of 2008: This is concerned with the licensing process for specified waste activities, including medical waste in the Republic; and
- South African National Standards on Health Care Waste Management: This Standard deals with all aspects of medical waste management from generation to disposal of waste and also includes a guide to the training of staff; According to the Standard, medical waste must be separated at source of generation according to the risks they pose and temporarily stored in colour-coded containers; it also indicates that each health facility must ensure that their workers are trained in the identification and separation of various types of medical waste and contract the final treatment and disposal to an authorized company which should in return hand the facility a certificate of safe disposal [2, 33].

3.3 Medical Waste Management Chain

Key steps that have been identified in the management of medical waste [34] include segregation of waste from its source and storage in appropriate containers; transportation within and out of the health facilities; treatment and final disposal (Figure 2.3). There are challenges at each of the steps along this chain in South Africa.

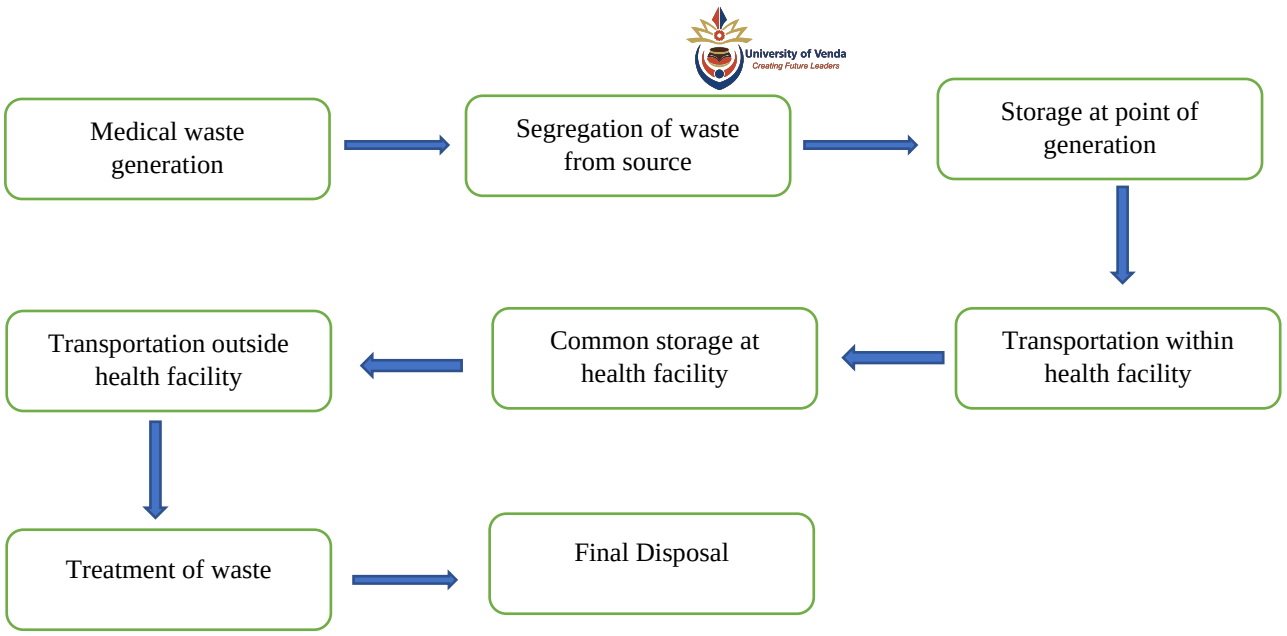

Figure 2.3. A flow chart showing the medical waste management chain "from cradle to grave".

3.3.1 Medical Waste Segregation and Storage

This first step in the waste management chain is the most important step because it determines the eventual quantity of waste that is to be treated and disposed of. In order to avoid accumulation of medical waste in the wards, theatres and other sites where they are generated, there is a need for designated storage areas within each of the wards and a central storage site for all the wards within the health facility where they can be temporarily stored before they are transported offsite [35]. The World Health Organization (WHO) prescribed that medical waste should be sorted and dumped into separate waste containers from the source, and afterwards stored in a safe place inaccessible to rodents and unauthorized people for a maximum of 48 hours and then transported to the treatment or disposal site [36]. If this guideline is strictly followed, the quantity of medical waste which is eventually passed to treatment/disposal facilities will be small and manageable. South African health facilities generate about 45,000 tons of medical waste annually, out of which only about 4,500 tons are hazardous [20]. But, while the waste is all mixed together, it becomes necessary to treat it as hazardous and cannot be recycled and reused without pre-treatment [20, 37].

The Department of Environmental Affairs and Tourism (DEAT) reported that health facilities in eight out of the nine provinces in South Africa do not classify or segregate their medical waste from source; thus, it is difficult to identify the categories of the waste being generated and make a proper budget on the materials needed for temporary storage and transportation out of the health facilities [38]. A poor knowledge of the characteristics of medical waste may be responsible for the poor segregation practice [39]. Most health facilities in Gauteng, Western Cape and Northern Cape Provinces have temporary storage areas in the facilities in the wards and central locked temporary storage facilities while other provinces only have central storage facilities and none in the wards [35].

3.3.2 Medical Waste Transportation

Transportation of medical waste within the health facility should be by means of trolleys and carts which are not used for any other purpose, and out of the facilities by suitable vehicles marked with biohazard symbol [36]. The frequency of collection of the waste from the wards to the temporary storage area within the facilities and out of the temporary storage area to the final treatment/disposal site will depend on the size of the hospital, a number of available equipment and workers. The workers involved in the transportation of medical waste should be trained on the different classification of the waste and their containers to help them in the handling of the waste and prevent them from mixing together different categories of waste which were previously segregated [35]. As at 2009, health facilities in only four Provinces (Gauteng, Western Cape, Eastern Cape and Northern Cape) had dedicated trolleys for the transportation of waste within and outside their facilities while in other provinces, health facilities make use of any available containers for the lack of dedicated equipment. However, in all but Limpopo province, there is a fixed collection schedule for the transportation of waste out of the facilities [36].

3.3.3 Medical Waste Treatment and Disposal

The methods which have been adopted for medical waste treatment and disposal include the traditional open dumping on lands or water bodies, deep burial, burning and the modern incineration, autoclaving, shredding, superheated stream sterilization, microwave disinfection, wet oxidation technology and electron beam gun technology [3]. Though the World Bank permits open burning of toxic waste as the last resort on the condition that the site of burning is in the rural area, far away from busy complexes to limit the number of people being exposed to the adverse effects of the event [40]; however, an indiscriminate burning of waste where it affects any person violates the constitution of South Africa (Act 108 of 1996).

Modern methods which are more environmental-friendlier were developed in order to minimize the risks posed to people and the environment by the traditional methods. However, many of the modern methods are very expensive and not available in many developing countries [7]. Though some of the new methods are being employed in some parts of the country, especially in the Gauteng Province, a larger part of South Africa still employ the traditional methods of open dumping, burning and the lowest standard of incineration to dispose their medical waste [19]. While some facilities dispose their waste within the health facility compound, others outsource the disposal to licensed treatment facilities [35]. However, there have been reports of sudden malfunctions, breakdown, planned and unplanned maintenances of equipment which interfere with proper waste disposal by the treatment facilities [41]. In Gauteng and Western Cape Provinces, all the facilities use reusable materials while in Mpumalanga, all the facilities use incineration, but in the other provinces, different practices were observed in different health facilities [35]. Also, medical

waste has been discovered indiscriminately and illegally dumped into water bodies, veld, the backyard of brick factories and even a beach parking lot in South Africa [42].

3.4 Techniques for Medical Waste Treatment and Disposal

The World Health Organization recommended that the choice of the mode of treatment and disposal of medical waste should be guided by cost-effectiveness, easy implementation and environmental friendliness [15]. The unique characteristics of the constituent of medical waste make it imperative that it be treated effectively before final disposal to make the end-product of the waste safe to the handlers and the public. Different modes of treatment have been employed for specific constituents of medical waste. That is why segregation at the point of generation is vital to make it easy for each group of waste to be passed to their different treatment sections. Final disposal is usually in a landfill.

The techniques which have been documented for treatment and disposal of medical waste include:

a. Open dumping/burning: This method is widely employed in many developing countries because it is cheap and easily available. However, open dumping/burning constitute a great risk to the public because it renders the dumped waste accessible to the public and scavengers. Burning is usually used to reduce the volume of waste and prevent its spread. However, toxic gasses can be released into the atmosphere during the burning process. The waste dump is also usually a source of injury to the community whether through direct contact or indirectly through land, water and air pollution [43].
b. Incineration: This is the choice of treatment for pathological wastes, sharps and other clinical wastes that cannot be reused, recycled or disposed of in a landfill. A standard incinerator uses high temperature to convert the waste into a minimal residue in the form of residual gases and ashes [15]. However, many incinerators being used in developing countries are made locally, designed poorly to use coal as fuel and are unable to achieve complete combustion of the waste; thus, resulting in an enormous quantity of ash [43]. The unburned waste and ashes are eventually disposed of at a landfill.
c. Autoclaving: A cheaper alternative treatment method to incineration is autoclaving. Autoclaving sharps and medical wastes contaminated with blood and other human secretions at an optimum temperature of 160°C help to rid the waste of bacteria. However, the autoclaved waste still need to be retreated using another means before final disposal [44]. Besides, there is a limit to the type of waste that can be autoclaved – large quantities of waste, large body parts and waste from chemotherapy treatment cannot be autoclaved because of the length of time required for the wastes to achieve the required optimum temperature [15].
d. Microwave disinfection: This is a modification of waste autoclaving which involves the

use of microwaves to provide heat for disinfection of medical waste. However, wastes containing metal objects cannot be microwaved to prevent the generation of dangerous sparks [45].

e. Landfilling: Standard landfilling requires more than a simple burial of waste in a shallow pit, it must be located and constructed in an authorized site approved by the government and not within the reach of unauthorized persons [3]. However, in many developing countries, landfills are operated like open dumping where all forms of waste are dumped and later burned [15]. Where the landfill is not properly constructed, erosion may cause the washing of the waste into water bodies, thus contaminating the water.

3.5 Medical Waste Management Practices in South African Provinces

In this section, the practices of medical waste management which have been documented in each of the provinces of South Africa is examined (Table 2.1). It should be noted that all the characteristics recorded per province may not be applicable to all the health facilities in the province, it only shows what was observed as at the time of different studies in the health facilities that were surveyed. However, many of the observations may be applicable to all health facilities in a particular province since the health facilities studied were selected randomly in order to increase their chances of being representative of the other facilities in the provinces.

3.5.1 Eastern Cape

In a nationwide study to evaluate the operational and administrative procedures for healthcare waste management in public district hospitals, this province was ranked lowest in terms of budgeting for medical waste management such as consumables, trolleys, buildings and collection [35]. In terms of segregation of hazardous from non-hazardous waste, health facilities in this province were found to be inadequate. They dispose of their medical waste through open burning on site [35]. A more recent study at the province identified other problems along the medical waste management chain including lack of policy, lack of training of staff and lack of equipment. Ignorance, poor segregation and handling of waste and lack of medical waste storage facilities expose the health workers to the hazardous effects of improperly managed medical waste [7].

Table 2.1. Medical waste management practices and challenges in South African provinces.

Province	Segregation	Temporary Storage Area	Transportation	Treatment and Disposal	Major Challenges	Reference
Eastern Cape	Inadequate	Insecure storage areas	Onsite transportation marginally adequate. Inconsistent transportation offsite	Open burning on site, illegal disposal on general landfills	Lack of policy, low budgeting, lack of staff training	[7, 35]
Free State	Inadequate	Storage areas are compliant with standards	Insufficiently dedicated trolleys for onsite transportation. Inconsistent transportation offsite	Burning	Lack of budget and training	[35, 48]
Gauteng	Adequate	Storage areas are compliant with standards	Dedicated trolleys are available for onsite transportation. Inconsistent transportation offsite	Out-sourcing to private companies		[35]
KwaZulu -Natal	Inadequate	Storage areas not compliant with standards	Insufficiently dedicated trolleys for onsite transportation. Inconsistent offsite transportation	Illegal dumping, burning	Lack of equipment	[17, 35, 50]
Limpopo	Inadequate	Storage areas are compliant with standards	Insufficiently dedicated trolleys for onsite transportation. Inconsistent offsite transportation	Burning, incineration, out-sourcing	Lack of training	[35, 51, 52]
Mpumalanga	Inadequate	Storage areas are compliant with standards	Insufficiently dedicated trolleys for onsite transportation. Inconsistent offsite transportation	Incineration	Lack of training and equipment	[35, 53, 54]
Northern Cape	Inadequate	Different available sites are used for storage	Onsite transportation marginally adequate. Inconsistent transportation offsite	Out-sourcing	Lack of treatment facilities	[35, 46]
North West	Adequate	Storage areas not constructed and operated according to standards	Dedicated trolleys are used onsite. Inconsistent transportation offsite	Out-sourcing	Insufficient personal protective equipment	[35, 47]
Western Cape	Inadequate	Poorly sanitized storage areas	Dedicated trolleys are used onsite. Daily transportation offsite	Incineration, autoclave, out-sourcing	Lack of manual for staffs	[35, 55]

3.5.2 Free State

The nationwide study conducted in 2009 identified the following problems regarding medical waste management in the province; instruction manuals were not provided to staff and medical waste was not being adequately segregated at the point of generation [35]. Though there were inconsistencies in the disposal methods across health facilities in the province, most of the facilities dispose of their waste by burning. Many health workers in this province blamed the poor practices of medical waste management on lack of budget and training [35]. A recent study in the province revealed that; medical personnel do not strictly follow the official guidelines in the treatment of medical waste; formal training for personnel was yet to be given a priority, there is a low level of environmental awareness; treatment of

medical waste was inappropriate at some sites, and the budget allocations for medical waste management was still grossly inadequate [48].

3.5.3 Gauteng

This province is one of the provinces in South African which developed provincial guidelines for medical waste management in their health facilities. The health facilities in this province were reported to be practising adequate segregation of hazardous from non-hazardous waste at the point of generation. However, the province was considered only marginally adequate in terms of provision of the medical staff with manuals on the proper handling of medical waste. All the health facilities studied in this province employ reusable containers for medical waste treatment. Final disposal is usually by out-sourcing to private companies or other bigger health facilities [35].

3.5.4 Kwazulu-Natal

A study done in this province in 2004 reported that about 45% of all medical waste generated in the province was unaccounted for, suggesting that the waste could have been illegally dumped, burned or buried in an undisclosed site [49]. Another study rated this province the best in the country with regards to the provision of immunization programmes for the health workers to protect them against the diseases which can be contracted from improper medical waste management and reported that the preferred method of medical waste disposal here is burning [35].

Recent study conducted in a community-based clinic in Durban where care is given to highly dependent patients many of whom are incontinent and/or bedridden reveals a gross misconduct as far as medical waste management is concerned [17]. The health workers were observed to sometimes expose themselves to hazardous waste by not wearing Personal Protective Equipment (PPE) like gloves while carrying out their caregiving roles. Also, the waste was not segregated at the point of generation and was temporarily stored in the bin meant for municipal waste [17]. This study identified a problem of transportation of waste offsite as the main reason for burying and burning medical waste within the compound of the health facility. The workers blamed the government for not providing the gloves, colour-coded plastics and dedicated vehicles for the transportation of waste from the health facility [17]. It was reported that all 30 clinics at a rural district in KwaZulu-Natal do not segregate medical waste at the point of generation and four of the clinics practice burning and burying of waste in shallow pits within the health facilities [50]. Some health workers have complained of inconsistent removal of waste from the health facilities by the municipality which sometimes results in waste being blown away by wind or scattered by dogs, exposing the infectious materials to the public and some children have been found scavenging on such waste in order to find “toys”, like gloves which they use as balloons. Commercial waste scavengers also visit the scattered waste in search of recyclable materials and are thus

exposed to sharps and other infectious materials. This constitutes a great health risk to the community especially because many of the patients that were being cared for in these homes are infected with HIV, Hepatitis B, Tuberculosis and other contagious diseases [17]. A report has been made of 48 children having to be treated with antiretroviral drugs at a South African hospital after they were pricked with dumped used needles and some ate potentially lethal pills they found dumped at a field in Elsie's River [16].

3.5.5 Limpopo

No uniformity of medical waste management was reported among the various health facilities in Limpopo province by previous national study conducted in South Africa [35]. Each facility seems to practice what is feasible based on available resources, especially since there are no national or provincial policies. Assessment of medical waste is carried out by the general orderlies and waste collectors since there are no infection control officers in the health facilities [35]. In another study conducted in selected health facilities in this province in 2008, non-separation of waste from the point of generation as well as an open dumping of incinerator ash were reported [43]. A later study conducted at a health facility in Waterberg district in 2013 showed that less than half (43%) of the health workers have adequate knowledge regarding the proper management of medical waste and only 49% of them practice "safe disposal" of medical waste [51]. Later, a walk-through survey conducted at clinics in Polokwane city reported that medical waste is not being segregated at the point of generation in many of the health facilities, there is insufficient transportation of waste offsite and some rural clinics were burning all kinds of waste within the health facilities [52].

3.5.6 Mpumalanga

A recent study in this province showed an inadequate knowledge of health staff regarding medical waste disposal. Some of the staff who claim to have adequate knowledge also admitted to poor disposal practices on account of lack of appropriate equipment [53]. More needle prick injuries among health workers were reported in this province than other provinces [35]. Needle pricks injuries were even reported among ward cleaners who do not handle needles; this suggest that they must have been injured by the needles that were disposed inappropriately by other staff that make use of needles, especially because they are the ones responsible for the transportation of the waste from the point of generation to the temporary storage areas [54]. In another study, it was observed that there is an inadequate budget for consumables, resulting in non-procurement of the needed equipment, segregation of medical waste at the point of generation is not being satisfactorily done and incineration is being used for final waste disposal [35].

3.5.7 Northern Cape

A report on a nationwide survey revealed that some urban health facilities in this province have infection control officers, but where they are not available, waste is assessed by the general orderlies, waste handlers, or most times (60% of the times), the waste are not assessed at all [35]. Most staff at the health facilities admitted a poor management of medical waste and attributed this to lack of budget [35]. A recent study conducted in 11 health facilities in the province revealed that 63.3% of the health workers correctly segregate medical waste at the point of generation [46]. However, many of the facilities do not have dedicated sites for onsite temporary storage of medical waste and transportation of the waste offsite is not carried out regularly [46]. The province do not have any treatment facilities, and thus have to transport their waste to other provinces for treatment and disposal [46].

3.5.8 North West

This province seems to be one of the best in the country in terms of medical waste management. A nationwide survey accorded it the highest score of 67% among the provinces in the area of budget for medical waste management necessities and the health staff were recorded to be practicing segregation of medical waste from source [35]. However, a disparity was recorded on the type of containers being used in the facilities across the province in the treatment of medical waste; while some facilities use disposable containers, others adopt the reusable ones. Some facilities dispose of their waste through other hospitals, while the rest outsource it to private companies [35].

3.5.9 Western Cape

An earlier study identified no quantification, no proper segregation of waste and non-labelling of containers with biohazard symbol as problems of medical waste management in this province [55]. A later study rated the province as being marginally adequate in the provision of manuals on medical waste handling for its medical staff with an improvement in the practice of segregation of hazardous from non-hazardous waste at the point of generation [35]. The province was also found to be marginally adequate in the provision of the required immunization for its staff. Reusable containers are being used by all the health facilities for medical waste treatment because of the availability of a provincial policy [35].

CONCLUSION

This study has shown that medical waste is being poorly managed in many health facilities in all the provinces of South Africa. An absence of a national policy to guide all the provinces in applying uniform practice of medical waste management may have contributed much to this, however, in the provinces and health facilities where guidelines have been developed to manage medical wastes, the guidelines are either not being enforced or there is no

sufficient equipment to manage the waste as recommended by the guidelines. This shows a need for formulation and enforcement of the national policy, the adequate budget for medical waste by the national government and the provincial government, regular training of health staff and waste handlers as well as construction and monitoring of treatment facilities and disposal sites.

In the course of this study, very few publications which detailed practices of medical waste management in South African health facilities were found; this necessitated consultation of unpublished dissertations and theses. On the contrary, more materials are available on the management of general waste. This suggests that there are fewer studies conducted on medical waste compared with general waste and that many studies on medical waste are not published. In the light of the dangers posed to the public posed by improperly managed medical waste, it becomes imperative that more studies be conducted in both rural and urban health facilities of all the provinces to discover the current practices and challenges of medical waste management. Results of such studies should be widely disseminated so as reach all stakeholders in order to improve the management of medical waste in South Africa.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

REFERENCES

[1] Chartier Y, Emmanuel J, Pieper U, Eds., *et al.* Safe management of waste from healthcare activities. 2nd ed. Geneva, Switzerland: World Health Organization 2014; pp. 3-5.

[2] SANS 10248-3 Management of Health Care Waste. Pretoria, South Africa: SABS Standards Division 2011.

[3] Yawson P. Assessment of solid waste management in healthcare facilities in the Offinso municipality. 2014; pp 33-56.

[4] Daschner F. Reduction and Utilization of Hospital Waste, with the Focus on Toxic and Infectious Waste (LIFE 96 ENV/D/10). EU-Project: Final Report, Freiburg 2000.

[5] Patil GV, Pokhrel K. Biomedical solid waste management in an Indian hospital: A case study. Waste Manag 2005; 25(6): 592-9. [http://dx.doi.org/10.1016/j.wasman.2004.07.011].

[6] Harhay MO, Halpern SD, Harhay JS, Olliaro PL. Health care waste management: A neglected and growing public health problem worldwide. Trop Med Int Health 2009; 14(11): 1414-7. [http://dx.doi.org/10.1111/j.1365-3156.2009.02386.x].

[7] Maseko Q. Critical evaluation of medical waste management policies, processes and practices in selected rural hospitals in the Eastern Cape. 2014; pp. 37-141.

[8] Akter N. Medical Waste Management: A Review Environmental Engineering Program. Thailand: School of Environment, Resources and Development, Asian Institute of Technology 2000; pp. 1-25.

[9] Household and industrial waste management (Handout for MSc Environmental Science) Kwame Nkrumah Science University of Science and Technology, Ghana. 2010.

[10] Arab M, Baghbani RA, Tajvar M, Pourreza A, Omrani G, Mahmoudi M. Report: The assessment of hospital waste management: A case study in Tehran. Waste Manag Res 2008; 26(3): 304-8. [http://dx.doi.org/10.1177/0734242X08093598].

[11] Mohee R. Medical wastes characterisation in healthcare institutions in Mauritius. Waste Manag 2005; 25(6): 575-81. [http://dx.doi.org/10.1016/j.wasman.2004.10.003].

[12] Taghipour H, Mosaferi M. The challenge of medical waste management: A case study in northwest Iran-Tabriz. Waste Manag Res 2009; 27(4): 328-35. [http://dx.doi.org/10.1177/0734242X08104132].

[13] Patwary MA, O'Hare WT, Sarker MH. An illicit economy: Scavenging and recycling of medical waste. J Environ Manage 2011; 92(11): 2900-6. [http://dx.doi.org/10.1016/j.jenvman.2011.06.051].

[14] Caniato M, Tudor T, Vaccari M. International governance structures for health-care waste management: A systematic review of scientific literature. J Environ Manage 2015; 153: 93-107. [http://dx.doi.org/10.1016/j.jenvman.2015.01.039].

[15] Hossain MS, Santhanam A, Nik Norulaini NA, Omar AK. Clinical solid waste management practices and its impact on human health and environment--A review. Waste Manag 2011; 31(4): 754-66. [http://dx.doi.org/10.1016/j.wasman.2010.11.008].

[16] Abor PA, Bouwer A. Medical waste management practices in a Southern African hospital. Int J Health Care Qual Assur 2008; 21(4): 356-64. [http://dx.doi.org/10.1108/09526860810880153].

[17] Hangulu L, Akinola O. Healthcare waste management in community-based care:

Experiences of community health workers in low resource communities in South Africa. BMC Public Health 2017; 17: 448.

[18] Jang YC. Infectious/ Medical/ Hospital waste: General characteristics in South Korea. Earth System and Environmental Sciences, Encyclopedia of Environmental Health 2011; pp. 227-31.

[19] Molefe GS, Gwensa Q, Kristiansen T, Rogers DEC. In Development of a National Health Care Waste Management Policy for South Africa. Pretoria, South Africa: Department of Environmental Affairs and Tourism 2006; pp. 4-6.

[20] Jewaskiewitz S. A challenging context. Infrastructure news and service delivery 2013. Retrieved from http://www.infrastructurene.ws/2013/05/20/a-challenging-context/ on 20 February, 2017.

[21] World Health Organization. Waste from healthcare activities. (Fact Sheet No. 253). Geneva, Switzerland 2015 http://www.who.int/mediacentre/factsheets/fs253/en/

[22] Bassey BE, Benka-Coker MO, Aluyi HS. Characterization and management of solid medical wastes in the Federal Capital Territory, Abuja Nigeria. Afr Health Sci 2006; 6(1): 58-63.

[23] Department of Health. Department of Health Annual Report 2007/08 Pretoria; South Africa. 2008.

[24] Department of Health. Department of Health Annual Report 2008/09 Pretoria: South Africa https://pmg.org.za/committee- meeting/11038/2017.

[25] Department of Health. National Department of Health Annual Report 2009/10 Pretoria; South Africa. 2010.

[26] Department of Health. National Department of Health Annual Report 2010/11. Pretoria; South Africa 2016 https://pmg.org.za/committee-meeting/13618/

[27] Department of Health. National Department of Health Annual Report 2011/12 Pretoria; South Africa. 2012.

[28] Department of Health. Annual Report 2013/14 Pretoria: South Africa. 2014; 49.

[29] Department of Health. National Department of Health Annual Report 2014/15. Pretoria; South Africa 2015 https://www.health-e.org.za /2015/10/20/ report-department-of-health-annual-report-201415/

[30] Department of Health. National Department of Health Annual Report 2015/16 Pretoria; South Africa. 2016.

[31] Manyele SV. Effects of improper hospital waste management on Occupational Health

and Safety. Afr News Occup Health Saf 2004; 14: 30-3.

[32] The Constitution of the Republic of South Africa Previously "Constitution of the Republic of South Africa, Act 108 of 1996", substituted by s 1 (1) of the Citation of Constitutional Laws, 2005 (Act No 5 of 2005) [Assented to 16 December 1996] The Department of Justice; South Africa. 2005; pp 9.

[33] SANS 10248 Management of Health Care Waste (Part 3): Management of healthcare risk waste from minor generators - Registered healthcare professionals and non-healthcare professionals. Pretoria, South Africa: Standards South Africa 2004; pp. 1-17.

[34] Johannesse LM, Dijkman M, Bartone C, Hanraban D, Boyer G, Chandra C. Healthcare waste management guidance note (Health Nutrition and Population Discussion Paper), Washington DC. 2000; pp. 4.

[35] Vumase BS. An Evaluation of Operational and Administrative Procedures for Health Care Waste Management in Public District Hospitals of South Africa. 2009; 117-54.

[36] World Health Organization Management of solid healthcare waste at primary healthcare centres (a Decision-Making Guide) Geneva, Switzerland. 2005; pp. 36-7.

[37] Ali M, Wang W, Chaudhry N, Geng Y. Hospital waste management in developing countries: A mini review. Waste Manag Res 2017; 35(6): 581-92. [http://dx.doi.org/10.1177/0734242X17691344].

[38] Department of Environmental Affairs and Tourism (DEAT). Program for the implementation of National Waste Management Strategy. 2000; 15.

[39] Gabela SD. Health Care Waste Management in Public Clinics in the Ilembe District: A Situational Analysis and Intervention Strategy. 2007; 69.

[40] World Bank. Guide to HCW management 2002. [Online]. Retrieved from http://www.essentialaction.org On 02/10/2017.

[41] Department of Environmental Affairs and Tourism (DEAT). Survey of Generation Rates, Treatment Capacities and Minimal Costs of Health Care Waste in the 9 provinces of RSA. Pretoria, South Africa: Department of Environmental Affairs 2008; p. 53.

[42] The Sunday Times. Medical waste found dumped in the backyard. 28 November 2009. Retrieved from https://www.iol.co.za/news/ south- africa/medical -waste-found-dumped-in-back-yard-466096 on 15 February, 2017.

[43] Nemathaga F, Maringa S, Chimuka L. Hospital solid waste management practices in Limpopo Province, South Africa: A case study of two hospitals. Waste Manag 2008; 28(7): 1236-45. [http://dx.doi.org/10.1016/j.wasman.2007.03.033].

[44] Jang YC, Lee C, Yoon OS, Kim H. Medical waste management in

Korea. J Environ Manage 2006; 80(2): 107-15. [http://dx.doi.org/10.1016/j.jenvman.2005.08.018].

[45] Windfeld ES, Brooks MS. Medical waste management - A review. J Environ Manage 2015 ; 163 : 98-108. [Http://dx.doi.org/10.1016/j.jenvman.2015.08.013].

[46] Motlatla MF. Assessment of healthcare waste management compliance in the Northern Cape Department of Health. 2015. http://hdl.handle.net/11462/1299.

[47] Mudau S. Towards environmentally sound healthcare waste management in the central district municipality of North West Province. 2007; 63-80.

[48] Mahasa PS, Ruhiiga TM. Medical Waste Management Practices in North Eastern Free State, South Africa. Hum Ecol 2014; 48(3): 439-50. [http://dx.doi.org/10.1080/09709274.2014.11906815].

[49] Leonard L. Healthcare waste in southern Africa: a civil society perspective. In Proceedings of the International Health Care Waste Management Conference and Exhibition. Johannesburg: South Africa 2004. Retrieved from https://www.researchgate.net/publication/277011966_Health_Care_Waste_in_Southern_Africa_A_civil_society_perspective on 04/09/2017.

[50] Gabela SD, Knight SE. Healthcare waste management in clinics in a rural health district in KwaZulu-Natal, South Africa. Epidemiol Infect 2010; 25: 19-21.

[51] Malebatja SM. Knowledge and practices of health care workers on medical waste disposal at George Masebe Hospital, Waterberg District, Limpopo Province, South Africa Master's diss Dept of Public Health, University of Limpopo, South Africa . 2013; 34-6.

[52] Raphela SF. Treatment and disposal of medical waste in rural and urban clinics within Polokwane municipality of South Africa. J New Gen Sci 2014; 12(2): 97-109.

[53] Makhura RR, Matlala SF, Kekana MP. Medical waste disposal at a hospital in Mpumalanga Province, South Africa: Implications for training of healthcare professionals. S Afr Med J 2016; 106(11): 1096-102. [http://dx.doi.org/10.7196/SAMJ.2016.v106i11.10689].

[54] Ream PSF, Tipple AFV, Salgado TA, *et al.* Hospital housekeepers: Victims of ineffective hospital waste management. Arch Environ Occup Health 2016; 71(5): 273-80. [http://dx.doi.org/10.1080/19338244.2015.1089827].

[55] Abor PA. Medical waste management at Tygerberg hospital in the western cape, South Africa PhD thesis Dept of Environmental Sciences and Technology, Cape Peninsula University of Technology, South Africa . 2007; 61-4.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This section presents a general overview of the study design adopted for this research. However, each of the manuscripts and articles still briefly stated the study design relevant to its development.

3.2 Research Design

A research design has been defined as a master plan which specifies the methods and procedures which are used to guide and conduct a research (Sekaran, 2009; Creswell, 2009; Creswell and Plano Clark, 2011). Gordon (1998) explained it as a strategic plan which sets out the broad outline and key features of the work to be undertaken including the methods of data collection and analysis. This study employed the mixed method approach which combines elements of both qualitative and quantitative approaches. It involves collecting and analyzing both qualitative and quantitative data in order to combine the strength of both approaches and gain more insights than could be gained from using either of the methods alone (Creswell, 2009). This method has been proven to improve the credibility of research results (Neuman, 2001).

3.3 Mixed Method Approach

According to Creswell and Plano Clark (2011), there are six possible designs which can be chosen from when using the mixed method approach based on the type of study, timing (concurrent or sequential) of data collection and analysis, level of interaction between two strands (independent or interactive), relative priority (equal or unequal priority) accorded to the different stages of the study and the point of interface and mixing strategies of the qualitative and the quantitative phases. The different designs include: convergent parallel design, explanatory sequential design, exploratory sequential design (instrument development design), embedded design, transformative and multiphase designs.

Based on the objectives of this study, the convergent parallel approach of mixed method was preferred. The approach assisted the researcher to gain a deep understanding of the target concept through different but complementary data obtained from qualitative and quantitative studies. Independent strands of qualitative and quantitative data were collected and analysed individually. After the analyses, the results were merged together during interpretation to determine the points of convergence and divergence, similarities and contradictions (Creswell & Plano Clark, 2011).

3.4 Study Setting

The Limpopo Province is the northernmost province of South Africa, sharing borders with Zimbabwe on the northern side, Botswana on the west and Mozambique on the east. It is known as the poorest province in the country with more than 70% of the population living below the national poverty line and more than 87% of the population living in the rural areas. The provincial headquarters is located at Polokwane. It is made up of 5 district municipalities and 25 local municipalities. There are more than 400 healthcare facilities (hospitals, clinics and health centers) serving the people of the province (Promotion of Access to Information Act manual, 2015). This study was conducted in the Vhembe district, a largely rural district municipality within the province, comprising of 4 local municipalities and accommodating 1,293,783 people. The district has a total of 167 healthcare facilities: 1 regional hospital, 1 specialized psychiatry hospital and 165 other facilities (Limpopo Vhembe District Profile Handbook, 2015) (Table 3.1). Collins Chabane local municipality was created out of Thulamela and Makhado local municipalities in 2016 and Mutale local municipality has been scrapped off. However, there have not been distinct clarification of healthcare facilities that fall under Collins Chabane Municipality as at the time of conducting this study. Healthcare facilities that are found in Malamule, the capital of Chabane Municipality was sampled under Collins Chabane Municipality

Table 3.1: Number of healthcare facilities in Vhembe district

Local Municipality	Number of				
	DH	Clinic	CHC	MC	Total
Thulamela	2	49	3	15	**69**
Collins Chabane					
Makhado	3	44	4	16	**67**
Mutale	1	16	1	6	**24**
Musina	1	3	0	2	**5**
Total	**7**	**112**	**8**	**39**	**165**

DH: District Hospital; CHC: Community Health Centre; MC: Mobile Clinic (From Limpopo Vhembe District Profile Handbook, 2015).

3.5 Sampling of Facilities

Due to the constraint of budget and time-frame for this study, the researcher decided to select the minimum number of healthcare facilities that will represent the different tiers of facilities available in Vhembe District – District hospitals, clinics and community health centers (CHCs). Mobile clinics were excluded because they do not have specific locations and they may not be easily accessible. Thus, a District hospital, 2 clinics and 1 CHC from each local municipality (15 healthcare facilities) were sampled, except for Thulamela Local Municipality where the

Regional Hospital was sampled because it is the largest hospital and the referral center to the other health facilities in the District. It is expected that a standardized procedure of medical waste management would be found in the regional hospital.

Purposive, non-probability sampling method was adopted to select a district hospital from each of the local municipalities. Purposive sampling method involves a deliberate choice of a sample with a purpose to include a predetermined category of objects of interest (Kudoma, 2013).

A simple, random sampling technique was adopted to select clinics and CHCs to be able to generalize the results to the entire Vhembe District. A list of all clinics and CHCs in Vhembe district municipality was obtained from Limpopo Provincial Government, Department of Health records (2017). The location of each clinic and CHC was searched for to place it in a local municipality. Clinics and CHCs that are located in Malamulele were placed under Collins Chabane Municipality because the local municipality is based in Malamulele. A code was assigned to each of the clinics per local municipality.

To sample the clinics at Thulamela Municipality, the code for each of the 49 clinics was written in a paper and folded. The papers were then all placed in a bowl and mixed, then 2 of the papers were picked to represent Thulamela clinics; the codes picked represented Lwamondo and Shayandima clinics. The same procedure was followed to sample CHCs in Thulamela. Sampling of clinics and CHCs in other local municipalities followed the same procedure, except in Musina where there are no CHCs (Table 3.2). Figure 3.1 shows the location of the selected healthcare facilities within the Vhembe District map.

Table 3.2: Sampled Healthcare Facilities

Local Municipality	**Category of healthcare facility**						
	DH	Name	**Clinic**	Name	**CHC**	Name	Total
Thulamela	1	Tshilidzini Regional Hospital	2	Lwamondo and Shayandima clinics	1	Thohoyandou health center	**4**
Collins Chabane	1	Malamulele DH	2	Malamulele and Mavambe clinics	1	Mphambo health center	**4**
Makhado	1	Elim DH	2	Levubu and Manyima clinic	1	Tiyani health center	**4**
Musina	1	Messina hospital	2	Madimbo and Masisi clinics	0		**3**
Total	**4**		**8**		**3**		**15**

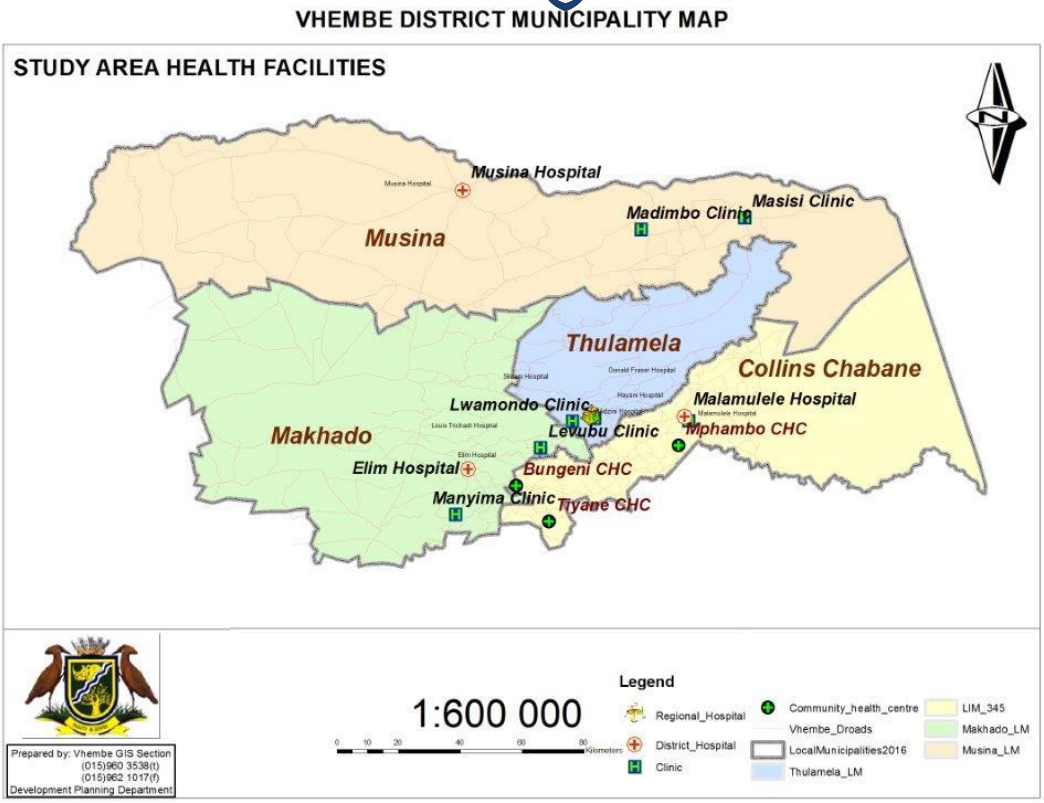

Figure 3.1: Map of Vhembe District showing the study areas

3.5.1 Coding of Healthcare Facilities

For the sake of anonymity during reporting of findings, each sampled healthcare facility was coded by rank as follows (Table 3.3):

Table 3.3: Coding of sampled healthcare facilities

Name of Health facility	Code by Rank
Tshilidzini Regional Hospital	VH1 (Vhembe Hospital 1)
Malamulele DH	VH2 (Vhembe Hospital 2)
Elim DH	VH3 (Vhembe Hospital 3)
Messina hospital	VH4 (Vhembe Hospital 4)
Lwamondo Clinic	VC1 (Vhembe Clinic 1)
Shayandima Clinic	VC2 (Vhembe Clinic 2)
Malamulele Clinic	VC3 (Vhembe Clinic 3)
Mavambe Clinic	VC4 (Vhembe Clinic 4)
Madimbo Clinic	VC5 (Vhembe Clinic 5)
Masisi Clinic	VC6 (Vhembe Clinic 6)
Levubu Clinic	VC7 (Vhembe Clinic 7)
Manyima Clinic	VC8 (Vhembe Clinic 8)
Thohoyandou Health Center	VHC1 (Vhembe Health Center 1)
Mphambo Health Center	VHC2 (Vhembe Health Center 2)
Tiyani Health Center	VHC3 (Vhembe Health Center 3)

3.6 Phases of the Study

This study was conducted in three phases. The first phase was a qualitative study and the second phase, a quantitative study. The findings of the two phases were used as a baseline for the third phase during which intervention strategies were developed for management of medical waste in Vhembe District.

3.6.1 Phase 1 (Qualitative study)

At this phase, the qualitative approach was employed to achieve the first two objectives of the study:

i. To explore the availability, implementation and compliance to medical waste management guidelines in selected healthcare facilities in Vhembe district; and

ii. To assess the medical waste management practices and challenges at the municipal levels in Vhembe district

The qualitative approach is a systematic approach that is used to describe life experiences (Gwimbi & Dirwai, 2003). It is best employed when an in-depth understanding of a phenomenon is required as it provides a better insight and can help to generate ideas and hypothesis which can be used to develop a background for subsequent quantitative research. Its goal of depth, richness and complexity is achieved through interviews, observation and document analysis (Kudoma, 2013).

3.6.1.1 Study Design

An exploratory, descriptive study was done to achieve the aforementioned-objectives. The approach helped the researcher to gain an in-depth understanding of the status of healthcare facilities as far as availability, implementation and enforcement of medical waste management guidelines are concerned and also describe the practices and challenges being faced by the relevant stakeholders.

3.6.1.2 Study Population, Sampling method and Sample

A population has been defined as a group of elements that possess characteristics of interest to a researcher and meets the specific characteristics which has been predetermined by a researcher (Polit & Beck, 2010). The population at this stage included the administrative heads of each of the selected healthcare facilities, head nurses and infection control officers (where available). A purposive sampling was used to select the eligible respondents and as many of them who consented to be interviewed participated in the study.

3.6.1.3 Inclusion Criteria

- Serving as the administrative head of a healthcare facility for a minimum of one year
- Head of departments whose staff generate or handle hazardous waste in the healthcare facility e.g. nurses, cleaners
- Infection control officer (where available)

3.6.1.4 Exclusion Criteria

- Heads of healthcare facilities who have not spent up to a year in office
- Heads of departments in the healthcare facilities whose staff generate general, rather than hazardous waste e.g. kitchen

3.6.1.5 Data collection Instrument

A semi-structured interview guide was used for qualitative data collection. A semi-structured interview guide is a schematic presentation of questions to be explored by the interviewer to keep the interview focused on the desired line of action (Jamshed, 2014). Interview guides help to explore many respondents more systematically and comprehensively and helps the interviewer to make an optimum use of interview time (DiCicco-Bloom & Crabtree, 2006). The semi-structured interview guide used in this study was developed with different sets of questions for the different categories of interviewees based on the objectives of this study and their roles in medical waste management. The guide contains a main question and follow up

questions for each category of respondents (Appendix 1). A voice recorder, a camera and a field note were also used to reinforce the findings.

3.6.1.6 Pre-test of instrument

Pre-testing is the administration of the data collection instrument to a small set of respondents from the target population that will not be used for the main study with the aim of identifying the problems with the instrument and finding possible solutions. It is ideally conducted in circumstances that are as similar as possible to the actual data collection circumstances. According to Grimm (2010), pre-testing a questionnaire is very necessary to reduce all kinds of errors associated with a survey research and it helps to improve the quality of data. Pre-test was conducted at Tshisaulu Clinic which was not a part of the healthcare facilities sampled for the main study.

3.6.1.7 Data Collection Procedure

The semi-structured interview guide was employed to conduct in-depth interview for the heads of the facilities, heads of nurses and cleaners and infection control officers (where available) in the healthcare facilities. The interviews were conducted during the working days (Mondays – Fridays) in the interviewees' offices at convenient times schedule by the interviewees. Each interview lasted between 15 - 30 minutes. The researcher guided the interview using the questions on the interview guide and followed new leads that arose from the interviewees' responses during the course of the interview. Most of the interviews were recorded, except in few cases where the interviewees consented to be interviewed on the condition that the interview would not be tape recorded. The recordings were later transcribed to develop the themes which were analyzed.

A field note was kept handy throughout the fieldwork to document all observations and a camera was used to take relevant pictures at different sites of the healthcare facilities (with the permission of the management of the facilities) to validate the responses of the respondents. On-site observation assisted the researcher to obtain a first hand, eye witness information regarding the medical waste management practices "from cradle to grave" (Kudoma, 2013) in the healthcare facilities. A combination of these measures helped to ensure the trustworthiness and credibility of the data collected.

3.6.1.8 Data Analysis

Data analysis involves organization and interpretation of raw data in order to extract useful information from it (Polit & Beck, 2008). Raw data generated for this study at this phase include: voice recordings, field documentations and pictures. The data was analyzed using the thematic content analysis which presents the key concepts of the respondent's account (Green & Thorogood, 2009). The following steps were followed:

a. The researcher listened to the recordings repeatedly and went through the field notes in order to understand the message. She then transcribed the recordings.
b. Important features in the transcripts and field notes were identified and coded systematically.
c. The codes were grouped and themes were developed from the groups. Similar themes were organized together.
d. The themes were reviewed against available data and each theme was described and interpreted.

3.6.1.9 Trustworthiness

The concept of trustworthiness in qualitative research as described by Guba and Lincoln (1985) involves credibility, transferability, dependability, and confirmability of the findings of the research (Maseko, 2014).

Credibility is a measure of the confidence of the researcher in the truthfulness of the results obtained (Guba & Lincoln, 1985). To achieve credibility of the findings in this study, the researcher has identified the eligible respondents at this phase of the study. The criteria for including respondents was to ensure that all the respondents are well familiar with the issues to be discussed. Privacy was ensured during the interview (by conducting it in their offices) and neither their names nor the names of their facilities were documented on the field note. These measures assured them that the result of the study will not implicate them or affect their jobs in any way; such that they could speak the truth about the subject of the interview.

Transferability is the degree to which the findings of the study can be applied to other groups and in different contexts (Guba & Lincoln, 1985). In this study, all the concepts used have been clearly defined such that if similar studies are performed in different locations under similar circumstances, comparable results can be obtained. The limitations encountered in the process of conducting this study have been clearly stated to serve the purposes of awareness and guidance for future researchers intending to conduct similar studies.

Dependability deals with the consistency of the findings when replicated with the same subjects or at different settings (Guba & Lincoln, 1985). This study involved more than one healthcare facility per category and at different settings. Triangulation which entails the use of multiple methods of data collection (interview and observation) was also be employed to ensure consistency of the findings. During the interviews, the researcher engaged the respondents for a sufficient time, observed them and asked clarifying questions to fully understand the concepts and ensure that the results are consistent.

Confirmability is the extent to which the research procedures and results are free from bias (Guba & Lincoln, 1985). This was ensured in this study by proper and consistent documentation of all the research procedures and data for easy access to check and recheck throughout the period of data analysis and writing of the thesis. Furthermore, the findings were compared with results from past, similar studies.

3.6.2 Phase 2 (Quantitative study)

Quantitative approach seeks to investigate statistical, mathematical and computational techniques in order to provide answers to questions regarding relationships between measurable variables, explain causation among variable, predict relationships between variables and generalize results (Kudoma, 2013). It is focused more on the numerical value of data generated and it seeks to achieve a reliable result through the pooling of a number of data. This is achieved mainly by using questionnaires. The objectives for this phase are:

i. To determine the medical waste generation, storage and transportation practices among healthcare workers in selected healthcare facilities in Vhembe district

ii. To identify the challenges being faced by waste generators in the process of medical waste management

iii. To compare medical waste management practices in the hospitals, clinics and community health facilities in Vhembe district, Limpopo Province.

3.6.2.1 Research Design

A cross-sectional, descriptive, survey design was adopted at this stage of the study. A cross-sectional survey involves the collection of data at a single point in time to capture what is happening with that group at that point in time (Mathers *et al.,* 2009). Mathers *et al.* (2009) further affirmed that a survey conducted on subjects randomly sampled from a specific population will yield a result that is representative of the whole population and can therefore be generalized.

3.6.2.2 Study Population, Sampling method and Sample Size

At this phase, the population included all medical waste generators and medical waste handlers in Vhembe district. The record from Vhembe District Municipality showed that there is a total of 6, 074 healthcare workers in the district, including the support staff (cleaners, managers, etc). A sample size of 375 was deducted from this number (total population) using the Slovin's formula and the sample size was spread over the facilities. The researcher ensured the inclusion of the following among the respondents: doctors, nurses, and cleaners (See Table 3.4).

Sample size

The sample size was calculated using Sloving's formula:

$$n = \frac{N}{(1 + Ne^2)} = \frac{6074}{(1 + 6074(0.05^2))} = 375.28$$

Table 3.4: Sampling frame

Health professional group	Number of staff	Sample
Doctor	159	40
Nurse	4, 403	252
Support staff	1, 481	81
Pharmacist	31	2
Total	**6, 074**	**375**

3.6.2.3 Data Collection Instrument

A structured questionnaire was employed for data collection at this phase. It was developed according to the objectives of the quantitative study and in line with similar previous studies. The instrument consists of 3 sections:

i. Section A (Demographic data): In this section, the socio-economic characteristics of the respondents are explored. Questions about age, gender, occupation, type of healthcare facility and year of experience of the respondents are asked in this section.

ii. Section B (Medical waste management practices): These section focuses on questions which allows the researcher to discover how medical waste is handled in the healthcare facilities where the respondents work. Some questions in this section include: "What types of wastes are generated at your healthcare facility?", "Is the hazardous waste generated segregated into various sub-categories?", "How do you transport medical waste within your facility (onsite)?" etc.

iii. Section C (Challenges of medical waste management): This section was structured to identify the challenges being faced at the healthcare facilities in the course of managing their waste. The types of questions asked include: "Is a guideline for management of medical waste available in your healthcare facility?", "Is there a schedule for regular training of staff about medical waste management in your healthcare facility?", "Are there sufficient equipment for proper management of medical waste in your healthcare facility?" etc.

The instrument was distributed to eligible respondents to complete.

3.6.2.4 Pre-test of the instrument

The questionnaire was administered to medical waste generators and handlers in Tshisaulu clinic before the main study. This helped the researcher to adjust the aspects of the instruments which need modification before it was applied in the main study.

3.6.2.5 Validity

Twycross and Shields (2004) defined "Validity" as the ability of an instrument to measure what it is intended to measure. It has two types which are: Face validity and Content validity (Bolarinwa, 2015). Face validity is usually ensured by a review of the instrument by experts in the field who will be able to ascertain that the instrument has been designed in such a way that it will be able to measure what it is intended to measure (Bolarinwa, 2015). Content validity on the other hand is concerned with the degree to which the instrument fully assesses or measures the construct of interest and it is usually achieved by rational analysis of the instrument by raters that are familiar with the construct of interest or experts on the research subject (Polit & Beck, 2006).

The questionnaire used in this study was developed after an extensive review of similar past studies and the construct of their questionnaires. To ensure its face validity, it was presented to the Promoters for their expertise reviews and further inputs. Also, a pre-test was conducted with it to ensure it captured the intended concepts.

3.6.2.6 Reliability

Reliability of an instrument is embedded in the repeatability and consistency of the findings of different studies done with the same instrument (Gwimbi & Dirwai, 2003). Methods that have been proposed to ascertain the reliability of an instrument include the test-retest approach (administering the same instrument on the same subjects after a time interval from the first test) and software (like Statistical Package for the Social Sciences (SPSS)) approach (Bolarinwa, 2015). With SPSS, Cronbach alpha (α) coefficient is used as a measure of internal consistency reliability of a set of data. In this study, the data collected from the pre-test was entered into the SPSS software and the Cronbach alpha (α) coefficient value of confirmed the reliability of the questionnaire.

3.6.2.7 Recruitment and Training of Research Assistants

A Master's students from the School of Environmental Sciences who was also conducting a study on management of medical waste in Thulamela Local Municipality, a subset of Vhembe District was trained as my research assistants. She was responsible for providing information to respondents about the purpose of this study, distribution and collection of completed questionnaires and support for respondents during questionnaire completion.

3.6.2.8 Data Collection Procedure

The eligible respondents were duly informed about the study through a detailed information letter and all who volunteered to participate were required to sign the informed consent forms. Afterwards, the questionnaires were distributed to them for completion. The researcher and her assistant waited for them to complete the questionnaires and provided assistance with the completion of the questionnaires where necessary. The completed questionnaires were collected immediately.

Healthcare workers on duty were directly observed to corroborate their responses in the questionnaires. The waste generators were observed on duty to assess their segregation practice and the bins were inspected (with photos taken) to determine if the correct category of medical waste was being dumped into the appropriate bin. All observations were documented in the observation checklist (See appendix 7). In the checklist, each healthcare facility was identified by its code (as shown in Table 3.4), rather than actual names to maintain anonymity of the facilities. Data collection lasted five months, from August to December, 2018.

3.6.2.9 Data Analysis

The information generated from the questionnaires were coded, entered into the Microsoft Excel Worksheet and imported into the Statistical Package for the Social Sciences (SPSS) software. Analysis was done using the SPSS version 25.0 (IBM SPSS Statistics Data Editor). Descriptive statistics like frequency and percentages were performed on the data. Pie charts and bar charts will be used to summarize some of the results. Furthermore, inferential statistics like Chi-square and strength of associations with the Cramer's V tests were performed.

3.6.3 Phase 3 (Design of Intervention Strategies)

Practical intervention strategies were developed after the analyses and interpretation of both types of data collected. The strategies are hoped to be applicable to hospitals, clinics and CHCs and assist the stakeholders in their efforts towards better medical waste management practices in the district.

3.6.3.1 Development of Intervention Strategies

The intervention strategies' development was based on the conclusions drawn from this study and the challenges observed. It was also informed by the theories of planned behavior and waste management. Representatives from healthcare facilities were carried along as much as possible through each step of the development of the strategies to facilitate their acceptance and implementation. The strategies were also presented to them after the development, for their evaluation and input during feedback sessions. This was done to validate the strategies.

3.6.3.1.1 Stages of Development of Intervention Strategies

The Medical Research Council (MRC) Framework for design of intervention strategies in the field of Health as described by Bleijenberg *et al.* (2018) was employed. The Framework has been credited as being the most cited guidance for developing and evaluating complex interventions (Bleijenberg, *et al.*, 2018). It involves seven stages as follows:

a. **Problem identification:** The first step in developing a sustainable intervention is to identify the existing problem. It is necessary to understand the extent and the impact of the problem to obtain a clear picture of the prevailing situation, such that the intervention will be appropriate and alleviate or at least reduce the impact of the problem. The proponent of the Framework recommended that a qualitative approach, using in-depth interview should be employed to understand the problem. This recommendation was adopted in this study by conducting in-depth interviews for heads of healthcare facilities to gain a good understanding of the problems of medical waste management in Vhembe District Municipality. In addition, a quantitative approach with the use of questionnaires among waste generators and handlers in the district assisted to understand the problem better from a different perspective.

b. **Systematic identification of evidence:** Once the problem has been identified, a systematic review and analyses of previous interventions regarding the problem is necessary to be acquainted with what works with whom, and what does not work. This will provide the researcher with answers regarding the potential effectiveness of the interventions.

c. **Identification of relevant theory:** At this stage, a theory is identified which will serve as the basis for the development of the intervention. When a single theory is not found sufficient to cover the entirety of the proposed intervention, multiple theories can be employed or gaps in theories can be filled by the development of new theories. Two theories have been identified to be employed in this study: the theory of planned behavior and the theory of waste management. These were combined and applied during development of data collection instruments and development of the intervention strategies.

d. **Determination of needs:** The needs and preferences of the recipient of the intervention must be put into consideration in the process of developing the intervention, in order to pre-determine which aspects of the strategies will be embraced the more. Through the in-depth intervention of heads of healthcare facilities, their needs and preferences were identified, such that the intervention strategies were tailored to meeting those specific needs.

e. **Examination of current practice and context:** The existing practice on the subject in question is essential to understand the context of implementation of the new strategy. The recipients, facilitators and policies under which the intervention will be implemented must be understood for the intervention to be acceptable and practiced. In this study,

through the methods of data collection and observation, the existing practice regarding medical waste management in Vhembe District was discovered and the intervention was tailored to fit in to the prevailing context.

f. **Modelling the process and outcomes:** This involves modelling the active components of the intervention by synthesizing the knowledge gathered from previous studies. A flowchart can be generated which starts with the input activities to intermediate results and eventually ends with the final outcomes. Keeping a proper document of all activities throughout the period of data collection to data analyses and conclusions helped to achieve this.

g. **Design of intervention strategies:** Intervention strategies were eventually extracted from the model and their development followed the SWOT (Strength, Weaknesses, Opportunity and Threat) model. The strategies state explicitly the proposed steps to be taken towards better management of medical waste in Vhembe District. The stakeholders at each stage of the intervention were identified and the context of application of the intervention were described, such that the interventions can be replicated in similar contexts.

3.7 Validation of the Strategies

At the end of the strategies' development, the researcher organized feedback sessions with representatives of the Provincial Department of Health and the waste management company, as well as some selected healthcare facilities in Vhembe District. During this session, the findings of the study were disclosed and the strategies were presented to them for critical evaluation and validation.

3.8 Ethical Considerations

The following ethical protocols were considered and duly followed throughout the course of conducting this study since human subjects were involved:

3.8.1. Permission to conduct the study

The ethical clearance to conduct this study was obtained from the University of Venda Health, Safety and Research Ethics Committee. Afterwards, an approval to conduct the study at the healthcare facilities was obtained from Limpopo Provincial Department of Health and Vhembe District. The approval letters from the Department and District were presented to the heads of selected healthcare facilities (Chief Executive Officers of Hospitals and Managers of Clinics) to obtain their permissions to conduct the study in their facilities.

3.8.2 Informed consent

The principle of informed consent in research means that the potential respondents will be made to understand that they are being involved in a research and what is required of them. Important information about the study was provided to the intending participants and respondents through the information letter (appendix 3). The information was to guide them to decide on whether or not they will volunteer to participate in the research (Smith, 2003). Written informed consent was obtained from all of them by appending their signatures on the consent forms before the questionnaires were administered to them (appendix 4).

3.8.3 Voluntary Participation

This concept is concerned with the ability of each individual to exercise his or her power of will freely to decide on whether to participate in a study or not without the employment of any external force like coercion, force, deceit or duress (Hogan, 2008). Participation in this study was strictly voluntary as clearly stated in the letter of information. Respondents were not begged, coerced, pressurized or threatened in any way to make them participate in the study. Also, no rewards were promised to intending respondents.

3.8.4 Confidentiality

Mills *et al.,* (2010) defined confidentiality as the safeguarding of all information obtained in confidence during a research study, whether orally during data collection or in written form during analysis of data. The respondents in this study were assured (through the information letter) that all the information they provide would be treated confidentially. Completed questionnaires were handled by only the researcher and kept safe afterwards. All data collected were used for the research purpose only and no information was divulged to any unauthorized person.

3.8.5 Anonymity

Mills *et al.* (2010) defined anonymity as a concept which deals with the protection of the identity of research participants. The respondents in this study were not requested to provide any information that could lead to their identification (e.g. name) on the questionnaires or during the interview.

3.8.6 The Right to Withdraw

The respondents were duly informed that they were free to withdraw from the study at any point they so wished without any force or coercion to stop them from doing so.

REFERENCES

Bleijenberg, N., Man-van Ginkel, J.M., Trappenburg, J.C.A., Ettema, R.G.A., Sino C. G., Heim, N., Hafsteindóttir, T. B., Richards D. A., and Schuurmans M. J. (2018). Increasing value and reducing waste by optimizing the development of complex interventions: Enriching the development phase of the Medical Research Council (MRC) Framework. *International Journal of Nursing Studies*, 79:86-93.

Bolarinwa, O.A. (2015). Principles and methods of validity and reliability testing of questionnaires used in social and health science researches. *Nigerian Postgraduate Medical Journal,* 22:195-201.

Creswell, J.W. (2009). *Research design: Qualitative, qualitative and mixed method approaches. 3rd Ed.* South Africa: Sage Publications, Inc. Pp 145-220.

Creswell, J.W. and Plano Clark, V.L. (2011). Designing and conducting mixed method research (2nd Ed.). Thousad Oaks, CA: Sage Publications, Inc.

DiCicco-Bloom, B. and Crabtree, B.F. (2006). The qualitative research interviews. *Medical Education,* 40:314–21.

Green J. and Thorogood N. (2009). Qualitative Methods for Health Research. SAGE Publications: London.

Gordon, M. (1998). Research design: A dictionary of Sociology. *http://wwwencyclopedid.com accessed 5 March 2013.*

Grimm P. (2010) Pretesting a Questionnaire. In J. Sheth and N. Malhotra (Eds.), Wiley International Encyclopedia of Marketing. Chichester, UK: John Wiley & Sons, Ltd.

Guba, E.G and Lincoln, Y.S. (1985). *Naturalistic Inquiry*. Newbury Park. CA: Sage Publications.

Gwimbi P and Dirwai C 2003: *Research methods in Geography and Environmental Studies.* Harare: Zimbabwe Open University.

Hogan S. (2008). *Voluntary participation*. In Lavrakas P.J. (Ed.). Encyclopedia of Survey Research Methods. Thousand Oaks, CA: SAGE Publications.

Jamshed S. (2014). Qualitative research method-interviewing and observation. *Journal of Basic and Clinical Pharmacy,* 5(4): 87–88.

Kudoma, B. (2013). An evaluation of clinical waste management in Gaborone city council healthcare facilities. Unpublished Master's dissertation. Pretoria: University of South Africa.

Limpopo Provincial Government, Department of Health records (2017). 2017- A year of healthy living towards a healthy lifestyle for all. Retrieved from http://www.doh.limpopo.gov.za/clinics#vhembe on 22/05/2018.

Limpopo Vhembe District Profile Handbook (2015). Retrieved from https://www.health-e.org.za/wp-content/uploads/2013/06/Vhembe-District-Fin.pdf.date on 05/06/2017.

Maseko, Q. (2014). Critical evaluation of medical waste management policies, processes and practices in selected rural hospitals in the Eastern Cape. Unpublished Master's dissertation. Grahamstown: Rhodes University; pp. 37-141.

Mills J. A., Durepos G. and Wiebe E. (2010). Anonymity and confidentiality. *Encyclopedia of Case Study Research.* Retrieved from: https://archive.org/stream/2.encyclopediaofcasestudy Research/2.encyclopediaOfCaseStudyResearch_djvu.txt.on 05/08/2017.

Neuman, L.W. (2001). *Social research methods: qualitative and quantitative approaches*. Boston: Allyn and Bacon.

Polit, D. F. and Beck, C. T. (2006). The content validity index: Are you sure you know what's being reported? Critique and recommendations. *Research in Nursing and Health*, 29:489-97.

Polit, D. F. and Beck, C. T. (2008). *Nursing research: principles and methods*. 7th ed. Philadelphia: Lippincott.

Polit, D.F. and Beck, C.T., 2010. *Essentials of nursing research: Appraising evidence for nursing practice*. Lippincott Williams & Wilkins.

Promotion of Access to Information Act (PAIA), Limpopo Department of Health and Social Development. (2015). South Africa, Pretoria: Government Printer.

Sekaran, U. (2009). *Research methods for business (2nd Ed).* New York: Willey.

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

Smith, D. (2003). Five principles for research ethics. *American Psychological Association*, *34 (1),* 56.

Twycross, A. and Shields, L. (2004) Validity and reliability- what's it all about? Part 1: validity in quantitative studies. *Paediatric Nursing*, 16 (9), 28.

CHAPTER FOUR

PRESENTATION OF STUDY FINDINGS 1

This chapter presents some results from the study which made the researcher to accept the first hypothesis of this study that medical waste is ineffectively managed from the point of generation to disposal within Vhembe District healthcare facilities. The chapter has been published in International Journal of Environmental Research and Public Health.

International Journal of ***Environmental Research and Public Health***

MDPI

Article

E*ffi*ciency of Health Care Risk Waste Management in Rural Healthcare Facilities of South Africa: An Assessment of Selected Facilities in Vhembe District, Limpopo Province

Abstract: Waste generated from healthcare facilities is a potential source of health risks to the public, if it is not properly handled from the point of generation to disposal. This study was conducted to assess the efficiency of healthcare risk waste (HCRW) management in Vhembe District of Limpopo Province, South Africa. Fifteen healthcare facilities were selected in Vhembe District for this study. Data were obtained through in-depth interviews, semi-structured questionnaires, observation and pictures. Qualitative data were thematically analyzed, while the quantitative data were analyzed using the Statistical Package for the Social Sciences, version 25. In all the healthcare facilities; mismanagement of HCRW was noted at different points along the management chain. Poor segregation, overfilling of waste bins, inappropriate transportation and storage of waste in substandard storage rooms were observed in the facilities. All the waste from the district are transported to a private-owned treatment facility outside the district, where they are mainly incinerated. Enforcement of healthcare risk waste guidelines, provision of standardized equipment for temporary storage, empowerment of each healthcare facility to treat at least some of the waste, and employment of non-burn techniques for treatment of waste are recommended for more efficient management of healthcare risk waste in Vhembe District.

Keywords: healthcare risk waste; open burning; cradle to grave; waste management

1. Introduction

Medical waste has been defined by the World Health Organization (WHO) as “all waste generated within healthcare facilities, research-centers, and laboratories related to medical procedures; including the same types of waste generated from other scattered sources and homes” [1]. A larger proportion (75–90%) of this waste, comparable to household waste and which can be managed along with other types of municipal waste are referred to as healthcare general waste, while the smaller percentage (10–15%), which constitute risks to the environment and human health are referred to as health care risk waste (HCRW) [2]. HCRW is also subdivided into various sub-categories based on the source, nature and effects of the waste: Infectious, sharps, pathological, chemical, radioactive, pharmaceutical, cytotoxic, and genotoxic waste [1].

Sharps waste include instruments that can cause cuts and puncture wounds. They include needles, scalpels, broken glasses, knives, etc.

Vials waste are bottle containers of injectable medications, which have been emptied. When they are intact, they are classified as hazardous waste because of their content. They are not disposed along with sharps unless they are broken. However, they are also not disposed with other infectious waste because of their potential to break and cause puncture injuries. They are separately disposed into puncture-proof containers.

Infectious waste comprises blood-stained materials, used syringes without needles, dialysis disposable equipment, materials containing excretions, waste from theatres and autopsies.

Pathological waste consists of human and animal tissues and organs e.g., placenta, amputated limbs, and resected internal organs.

Pharmaceutical waste includes expired, unused or contaminated pharmaceutical products also known as obsolete stock.

For the purpose of treatment, these wastes can also be sub-classified into: hazardous waste (waste which poses any form of risk to the waste generator, handler and the community, for example, pharmaceutical and chemical wastes) and biohazardous waste (waste which carries the risk of transmission of infections: infectious waste and sharps, which are contaminated with human tissue or body fluids). The mode and cost of treatment and disposal of hazardous and bio-hazardous waste are different.

Improper management of HCRW from the point of generation to disposal has been linked with health hazards to waste generators, handlers, and the community [3]. Healthcare workers are faced with the risk of being pricked by improperly disposed sharps waste and this exposes them to blood-borne infectious diseases notable among which are: Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS) and Hepatitis. Needle prick injuries have been reported among both HCRW generators (nurses, doctors), handlers (cleaners) and scavengers who manually sort waste disposed on landfills from

healthcare institutions [4,5].

A needle stick injury from an infected patient exposes a victim to 30% risk of contracting Hepatitis B virus and 0.3% risk of contracting HIV [5]. Other health risks include chemical burns, exposure to toxic pharmaceutical products and air pollution during treatment of such waste if burns methods like open burning or incineration are employed [5]. Furthermore, metals and toxic substances like dioxins which have been linked to cancer, immune system disorders, diabetes, and birth defects are released into the environment when HCRW are treated with incinerators which do not comply with standard emission standards [6]. With open dumping or dumping of waste in water bodies, contamination of drinking water can occur and expose the public to the risk of a wide range of infections. These risks can be minimized or completely eliminated if the waste is properly managed.

Management of HCRW involves a safe handling of the waste from the point of generation to the point of treatment and eventual disposal with minimal contact with the generators and handlers as well as the community. This involves minimization and segregation from source, safe transportation, temporary storage, offsite transportation, treatment and disposal. Each of these important stages have guidelines and standards controlling them which must be observed for the waste to be said to have been handled properly.

In South Africa, waste prevention, minimization and reuse were accorded a priority consideration on solid waste management [7]. This shows that the country regarded the reduction from source as a very important step in the management of any type of solid waste. The Department of Environmental Affairs (DEA) of South Africa has been on the forefront of drafting waste (including HCRW) management guidelines in South Africa, as well as monitoring and conducting relevant studies on the subject nationwide [8]. The Department has drafted a policy document, which recognizes the Acts of South Africa which serve as the bedrock upon which the HCRW management policies are framed. The document also included guidelines on handling, storage, transportation and disposal of HCRW management as well as standards for the equipment to be employed in HCRW management. From this document, the Department of Health (DoH) of each province of South Africa has extracted their own guideline documents, with more details on the definition, handling, segregation, containerization, onsite transportation, and storage of HCRW within their healthcare facilities [9].

The Health Professional Council of South Africa has also developed a comprehensive healthcare risk waste management guideline booklet for healthcare professionals [10]. The guideline provided a full definition of HCRW and classified the waste into the various sub-categories. It also discusses the risks of mismanagement of the waste to the society and highlighted the roles and responsibilities of each health worker in proper HCRW management. Details on proper handling of the waste from the point of generation to final disposal can also be assessed in the booklet.

The continual rise in the quantity of HCRW being generated from healthcare facilities

has been linked to consistent population growth, which results in an increase in the number of people who require the services of healthcare facilities and the encouragement of disposable medical equipment over reusable ones [8,11]. In 2008, the Department of Environmental Affairs and Tourism (DEAT) of South Africa reported that with an envisaged annual increase in human population by 1.06%, the rate of generation of HCRW in South Africa will also increase annually by 1.5%, using the 42,200 tons generated in 2007 as a template [8]. However, the quantity of waste generated from the country exceeded this projection because in 2014 and 2017; 44,139 tons and 48,749 tons, respectively were generated [12,13].

More demand for reusable equipment with refillable packaging, as opposed to disposable equipment has been reported in America and other parts of the world due to the availability of modern technologies for sterilization and disinfection [11]. This would greatly assist to achieve the source-reduction goal of HCRW management. Efficient management of HCRW requires a lot of resources [14], thus, many developing, resource-constrained countries are reportedly facing many challenges of managing their HCRW [15]. Previous studies on HCRW management in different provinces of South Africa have mainly focused on hospitals [16–19] while smaller healthcare facilities like clinics and community health centers are rarely included in the studies. The same trend has been observed in Limpopo Province.

The Limpopo province of South Africa is a largely rural province with more than 87% of people in the province living in the rural areas [20]. The province is made up of five District Municipalities and 25 local municipalities. This study included the three basic categories of healthcare facilities (hospitals, clinics, and community health centers) in Vhembe District of Limpopo Province and it was conducted to assess the efficiency of HCRW management in Vhembe District in terms of compliance to HCRW management guidelines, HCRW segregation, onsite transportation, onsite temporary storage of HCRW, and the final disposal of HCRW generated from Vhembe District Healthcare facilities.

2. Methods

A mixed method approach was employed to collect both qualitative and quantitative data from 15 healthcare facilities in Vhembe District Municipality of Limpopo Province, South Africa. Both types of study approaches were used to validate the results obtained. There have been many reports of poor management of HCRW from health institutions in Limpopo Province, as well as Vhembe District Municipality in the past [19,21,22], as well as undocumented reports of discovery of HCRW in some water bodies in the District. The District is made up of 4 local municipalities and 126 public healthcare facilities including District Hospitals, Clinics and Community Health Centers (Figure 4.1). There are also private owned surgeries, laboratories, pharmacy stores and other sources where HCRW are generated in small quantities, however, the public institutions were selected for ease of

access.

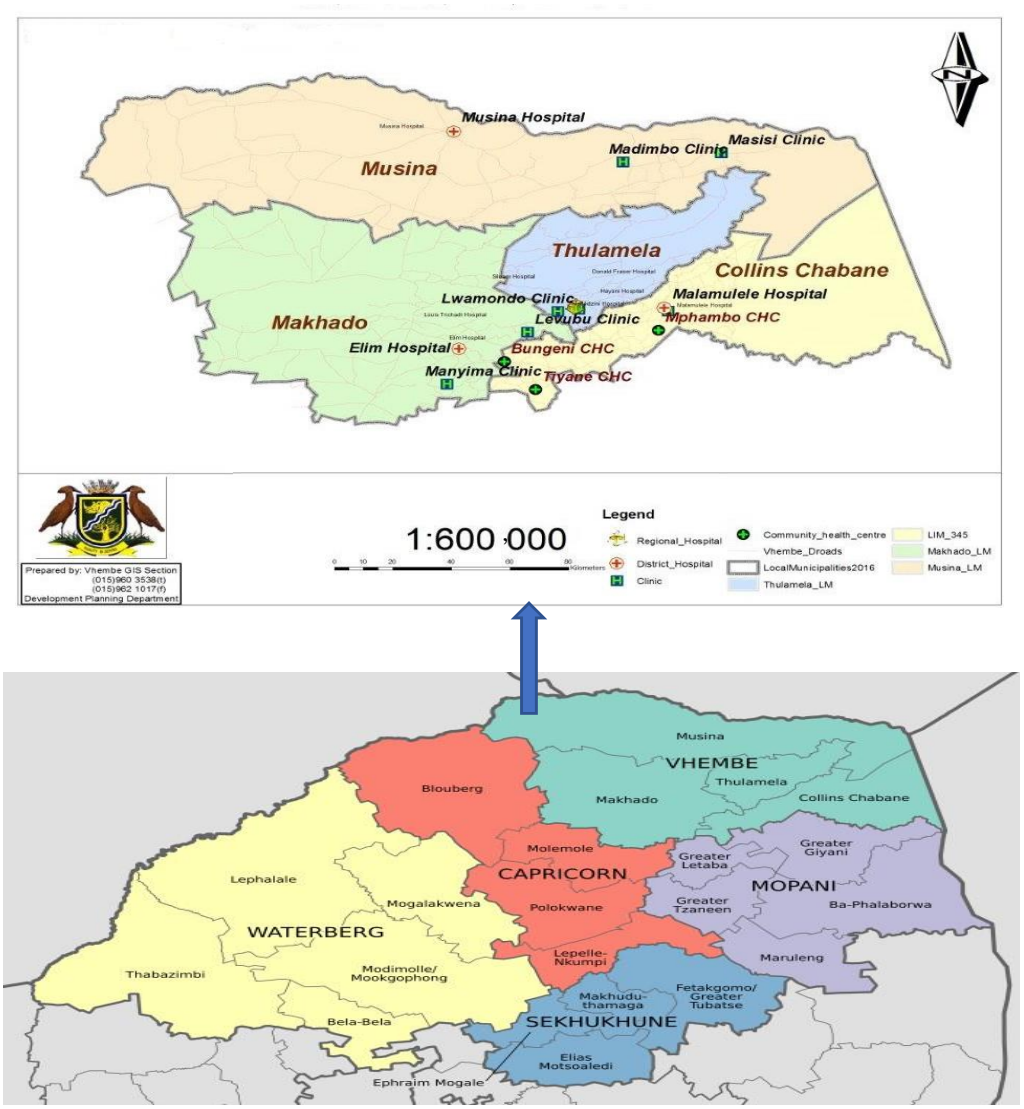

Figure 4.1. Map of Vhembe District within Limpopo Province showing the study areas.

A District hospital (DH), 2 clinics and 1 community health center (CHC) were randomly selected from each of the local municipalities for this study to ensure that the result can be generalized to the entire District. Thus, 4 District hospitals, 8 clinics and 3 CHCs were sampled, because one of the local municipalities had no community health centers. The population included all administrative heads of the selected facilities and HCRW generators and handlers in the facilities. A record obtained from the Department of Health section of the Vhembe District municipality just before data collection shows that there are 6074 health workers in the district, including the support staff (cleaners, community health workers, etc.).

The Sloving's formula

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

where *n* = sample size, *N* = total population and e = margin of error, set at 0.05 was used to calculate the sample size from this figure to obtain a sample size of 375, which was distributed over the different categories of HCRW generators and handlers (Table 4.1).

Table 4.1. The sampling frame

Category of Health Worker	Population	Sample
Nurses	4403	252
Support staff	1481	81
Doctors	159	40
Pharmacy staff	31	2
Total	**6074**	**375**

An interview guide was used to collect qualitative data from Infection Prevention and Control Practitioners (IPCCs) and Environmental Health Practitioners (EHPs) at the hospitals, as well as the managers of the clinics and community health centers. The interviews were conducted with consent and recorded on tape. For the purpose of anonymity, the participants were identified with codes, rather than names. The code is made up of the position of the participant and a unique number (The Managers were coded as Manager 1–7; IPPC 1–3 and EHP 1–4). Thematic analysis was employed for the qualitative data.

A total of 413 questionnaires were initially printed for distribution. This is because 38 questionnaires (10% of 375) were added to the original sample size to accommodate non-responses and invalid questionnaires, which lack vital information. However, many questionnaires were not returned; thus, the researcher ended up administering more than 500 semi-structured questionnaires to obtain only 229 which were well completed and fit for analysis. The initial plan was to administer the questionnaires and wait to collect them, however, most healthcare workers, especially doctors and nurses were unable to complete the questionnaires immediately because of their duties, thus, the researcher had to leave the questionnaires with them and return at a set date to pick them up. Many of the questionnaires were lost in this process and some were retrieved uncompleted, necessitating the administration of the same to another volunteered healthcare worker. The 229 completed questionnaires account for a response rate of 61.1%. Analysis was done using the Statistical Package for the Social Sciences (SPSS), version 25. A digital camera and an observation checklist were handy throughout the field work to record all observations and take relevant pictures in order to validate or reject the responses obtained during the interviews and through the questionnaires.

Ethical clearance and permission to conduct the study were obtained from University of Venda Research Ethics Committee, Limpopo Provincial Department of Health, Vhembe District Executive Manager, Chief Executive Officers of all the hospitals and the Managers of Clinics and Community Health Centers before data collection was commenced.

3. Results

In Limpopo Province, the DoH developed a guideline for HCRW management and made the guideline available at all healthcare facilities in the province. The Department also contracted a waste management company for transportation of HCRW out of every public healthcare facility, treatment and disposal of the waste. The Department is responsible for the payment of all the equipment supplied by the waste management company, treatment cost of HCRW as well as Personal Protective Equipment (PPE) and immunization for health workers.

3.1 Demographic Characteristics of Respondents

A total of 229 healthcare workers (150 professional nurses, 11 student nurses, 28 doctors, 28 cleaners, 10 community health workers and two pharmacy staff) participated in this study. The population was dominated by females (*n* = 194: 84.7%) and their ages range between 18 and 64 years (mean = 40.0). With the exception of the student nurses who had only been at the hospitals for two weeks, more than half (*n* = 132, 65.67%) of the other respondents had 1–10 years of professional experience; while 39 (19.40%) had 11–20 years and 30 (14.93%) had 21–30 years professional experience in their respective healthcare facilities.

3.2 Healthcare Risk Waste Generation

The rate of generation of HCRW in healthcare facilities of Vhembe District of Limpopo Province is dependent on the type (or hierarchy) of healthcare facility, the type of services being rendered, the number of patients attended to on a daily basis and whether or not there is provision for admission of patients. In the literature, the quantity of HCRW generated is usually calculated in terms of “daily HCRW mass per bed per day” [14]. However, the rate of generation of HCRW in this study was calculated based on “mass per patient per day” to be able to accommodate the healthcare facilities sampled in this study, which do not have “beds” as they do not admit patients.

In all the healthcare facilities in Vhembe District, the local municipal governments are responsible for the disposal of healthcare general waste, which they pick up from each facility at scheduled days of the week, when they pick up domestic waste from other houses within the local municipalities. However, a waste management company has been contracted to pick up HCRW from all the public healthcare facilities in Limpopo Province for subsequent treatment and disposal.

Measurement of the quantity of HCRW generated is not done directly at the facility level, but the measurement is taken by the representative of the waste management company in the presence of a representative of the healthcare facility, usually the Environmental Health

Practitioners in the hospitals and any delegated nurse at clinics and CHCs. A copy of the record of the quantity of the HCRW collected is then left at the healthcare facility. These records are usually kept in a waste management folder. These records were then assessed to calculate the average quantity of HCRW generated in each of the sampled facilities.

The regularity of weighing is directly proportional to the frequency of visit of the waste management company to the healthcare facility. The company has different schedules for the healthcare facilities based on the quantity of HCRW they generate: in the District hospitals, the waste is weighed twice or three times a week, while at the clinics and CHCs, the schedule is either weekly, fortnightly or, rarely, monthly. However, these disparities were adjusted while calculating the quantity of waste generated based on the figures obtained at each facility at different times, to have a uniform ground for all the facilities. The calculation was finalized on a daily basis.

In the district hospitals, which provide all forms of medical treatments including surgeries—more than 600 patients are attended to every day (this number includes patients on admission and outpatients), an average of 338.15 kg of HCRW is generated every day. This accounts for 0.54/kg per patient per day. The services provided by the clinics include treatment of common and chronic illnesses such as common cold, sexually transmitted infections, high blood pressure, diabetes, as well as some acute disorders and antenatal care services. Some of them also run Youth friendly clinics, HIV Voluntary Counselling and Treatment services. While some of the clinics conduct delivery services for women in labor, others close to hospitals do not conduct deliveries, but refer their patients in labor to the nearest hospital. The clinics do not provide in-patient admission services except for post-natal women, who are admitted for observation after delivery and discharged after being certified stable within a few hours of delivery. With an estimated number of 83–155 patients and clients (clients are those who visit the hospital for counselling and testing purposes, which may not require any form of treatment)

visiting a clinic per day, each clinic generates an average of 15.5 kg of waste daily.

The services provided by the CHCs are similar to those obtainable at the clinics. However, these facilities tend to serve more people in the community than the clinics as they attend to as many as 350–400 patients and clients per day. They also do not also provide in-patient admission services, except for post-natal women who are delivered within their facilities. Each of these facilities generate an average of 19.2 kg per day.

Table 4.2 shows the average number of patients being seen at the healthcare facilities on a daily basis with their HCRW generation capacities.

Table 4.2. Healthcare risk waste (HCRW) generation figures in Vhembe District.

Rank of Facility	Average Number of Patients Per Day	Types of HCRW Generated/kg/day				
		Sharps	Vials	Infectious	Pathological	Total
DH	631	13.75	12.4	277.0	35.0	**338.15**
Clinic	119	3.7	2.8	8.3	0.7	**15.5**
CHC	375	6.0	3.4	6.0	3.8	**19.2**

DH: District Hospital; CHC: Community Health Center

Healthcare staff in Vhembe District do not understand how the terms “minimization and reduction of waste” apply to medical waste. Participants were surprised to hear about the issue of reduction of HCRW. When an Environmental Health Practitioner (EHP) was asked how they achieve waste minimization in her healthcare facility, she laughed when she responded:

> *“No, we don’t do those here. It’s not easy to minimize waste, is it not medical waste? It’s not easy. People are getting sick every day, that’s why we cannot. We can’t minimize diseases, no, no, no. You need to see how many people are being admitted into the hospitals”* (EHP 2).

An IPCC had the same disposition.

> *“Reduce waste?... that would not be in our capacity. I mean, we are following the guideline. The guideline says, “take a bottle, put it in the container, we will come and collect”, that’s all”* (IPCC 1).

3.3 Healthcare Risk Waste Segregation and Filling of Temporary Storage Bins

The equipment supplied to Vhembe District healthcare facilities for temporary storage of HCRW include labelled color-coded bins (yellow bins with red liners for infectious waste, labelled yellow bins for sharps and vials waste and green bins for pharmaceutical waste). These are to assist the staff to effectively segregate medical waste from source, such that general waste and the various sub-categories of HCRW are dropped into separate containers at the point of generation. The EHPs in the hospitals and the managers at clinics and CHCs acquire these equipment from the service provider, store them temporarily in their offices or stores and distribute to the various sites where they are needed in their healthcare facilities. In the hospitals, IPCCs often assist or oversee the activities of the EHPs in this regard. These staff are also responsible for record keeping of the receipt and use of the equipment.

Good segregation practices depend on the knowledge of an HCRW waste generator about the various subcategories of HCRW. Almost all the respondents (n = 204, 92.3%) indicated that they generate both HCGW and HCRW in their facilities. However, on the question on identification of the various subcategories of HCRW, the nurses and cleaners

excelled in the identification, while most of the doctors could not identify all the subcategories. There is a statistically significant difference in the level of knowledge of nurses and cleaners about HCRW categories as compared with doctors ($p = 0.000$).

All the respondents claim that they segregate medical waste from general waste and they also segregate HCRW into their different sub-categories from the point of generation. However, when asked to rate HCRW segregation practices in their facilities, 65 (28.4%) rated their facilities "excellent", while a larger percentage rated them "good" ($n = 73$, 31.9%) or "very good" ($n = 72$, 31.4%). Only 4 (1.7%) respondents rated their facility "poor". Some of the respondents who rated their facilities "poor" were engaged in verbal discussions on the reason why they rate their facility so, and the common response was:

> *"We are trying, but, we are not perfect. Sometimes, we forget"* (Respondents to questionnaires).

The Clinic Managers, EHPs and IPCCs were asked if healthcare staff in their facilities always comply to the HCRW guidelines in terms of waste segregation and filling of bins, they all ascertained that they frequently witness poor segregation of general waste from HCRW, as well as mixing different categories of HCRW. However, some nurses blame the mixing on patients, doctors and student nurses. Filling of the temporary storage bins beyond the recommended and demarcated level have also been noticed. Below are extracts from the interviews conducted for them:

"Yes, we do comply, but sometimes we do find mistakes of mixing general waste and medical waste and also mixing of other sub-categories of medical waste" (Clinic Manager 1).

"Mixing of vials and sharps—sometimes, you find that they are not segregating the waste properly. Another thing is that we find that the waste bins are full beyond the limits that we are expected not to exceed" (CHC Manager 1).

". . . the thing is, at the Paediatric's ward, they are admitting children and their mothers. The mothers are not trained on how to segregate the waste, so the mothers are the ones mixing the waste . . . I don't know how we can train them . . . maybe staff members can give them a lecture of 5 min to mothers each and every morning, because today, it's one mother, next day, it's another one, so, you have to do it every day, for it to work. In other wards, they do comply" (EHP 4).

"They mix general and medical waste. Sometimes, sharps with medical (infectious) waste. As you can see in our office, we are having different kinds of bins, each of them has its own designation. Each of them has also been assigned to different wards . . . but it happens that when you check the waste, you will find the bandages in the sharps container, where they are not supposed to be, sometimes, they complained that it is the doctors or the student nurses . . . and most of the time, it's just the staff's attitude. It's not something that you can say you can't do. It's not difficult" (IPCC 2).

With further probing on the attitudes of healthcare workers to training on healthcare risk waste management, doctors were identified as a group of profession who do not attend trainings on HCRW management whenever a call was made for such, because they usually claim that they are very busy.

> *"Every time, they say 'we are busy'. Okay, the service provider will say, "okay, tell us, make an appointment, we can come any day, specifically for you doctors", but the reply will be "Ah, there is this infection control nurse. She is going to tell us everything", but, every time, they are busy, you won't get them"* (IPCC 2).

A doctor in one hospital confirmed her statement when he was given a questionnaire to complete.

He said:

> *"These questions are not relevant to doctors. You should ask the nurses and cleaners. As for me, I have nothing to do with waste. Each morning, I come to find an empty waste bin at my work station, see my patients, drop the waste and leave. The next morning, I find the bin empty again, whatever happened to the waste is not part of my job description"* (A doctor).

Some pictures taken onsite confirmed the mixing of general and HCRW waste, mixing of the various subcategories of HCRW and inappropriate filling of the HCRW bins (Figure 4.2).

(a) (b) (c) (d)

Figure 4.2. Healthcare risk waste (HCRW) used gloves mixed with general waste in a general waste bin (**a**); mixing of infectious waste (soiled cotton wool) with sharps (glass tube) and vials waste (**b**); mixing of general waste (paper package of syringe) with sharps (needles) (**c**) and filling of HCRW bin beyond the recommended level (**d**). (Source: Field work).

3.4 Temporary Storage

Sharps waste are temporarily stored in puncture-proof containers, while other types of HCRW are separately stored in color-coded bins at the point of generation. In some of the facilities, some staff were observed to be without personal protective equipment and some categories of HCRW were not dumped into the appropriate bins. Some of the temporary storage bins were not properly closed and yet they were being put to use.

Shortage of personal protective equipment and HCRW management equipment were reported by some staff in the clinics and community health centers (Figure 4.3).

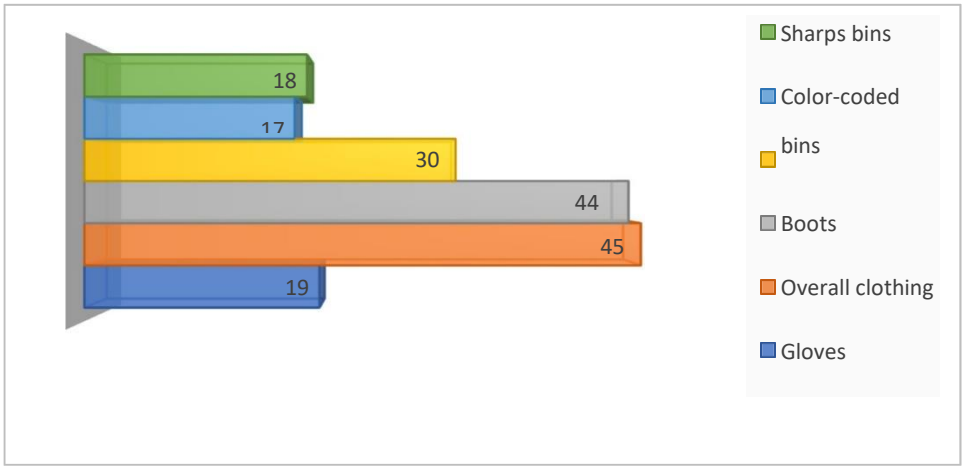

Figure 4.3. Number of healthcare staff who reported insufficient equipment for HCRW segregation and transportation and personal protection.

However, all the EHPs and IPCCs reported sufficiency with temporary storage equipment in the hospitals.

"I make requisition for the bins from the service provider, but, it is the cleaners who distribute them to the wards wherever they are needed. So, we don't have shortage" (EHP 2).

"Yes. I don't have problems with the bins" (IPCC 1).

"We have enough bins" (IPCC 3).

While some participants reported malfunction of some of the bins—lids not closing properly and broken pedals, the EHPs and IPCCs ascertained that there is nothing wrong with the lids, only that the staff are ignorant on how to close them.

"Sometimes, you find that the lids are not fitting properly" (CHC Manager 1).

". . . you can find that the containers or bins for collecting waste are not functioning well, like when you are not supposed to use your hand to open the bin, but you find that the pedal is not working" (Clinic Manager 2).

"I think it's the personnel who do not know how to close the lids properly. I always help them and show them how to close it. I was once called at the Maternity ward because they could not close the lid. The problem is not with the equipment." (EHP 1).

"The only problem, perhaps, is that the staff need training every now and then on how to use the bins, some of them are not competent, so they break the pedals. When the company comes, they stress much to demonstrate . . . but, it's improving now" (IPCC 1).

In some facilities, the equipment was being put to other use, like fetching water for washing cars or as containers of water in the bathrooms. An EHP lamented about this when she was asked "What are the challenges you have been facing while discharging your duties on HCRW management?":

"My major challenge is with the medical waste equipment, what I found is that, they do not use them for specific purposes. If I say, these are for sharps, sometimes, you find people using them to wash cars, sometimes, they are using them maybe to store their polishes, I have been trained to write out those ones that are outdated, old ones and all that. But, come again two weeks' time, you will still find out they are using them for the wrong things. I get tired of talking to them, but I am trying. Sometimes, they order more bins than they need, keep them in their store and use them for other purposes. Even if I close them, they cut out the lids. They cut, so that they can open it, I almost fainted . . . " (EHP 2).

All these were confirmed during field work (Figure 4.4).

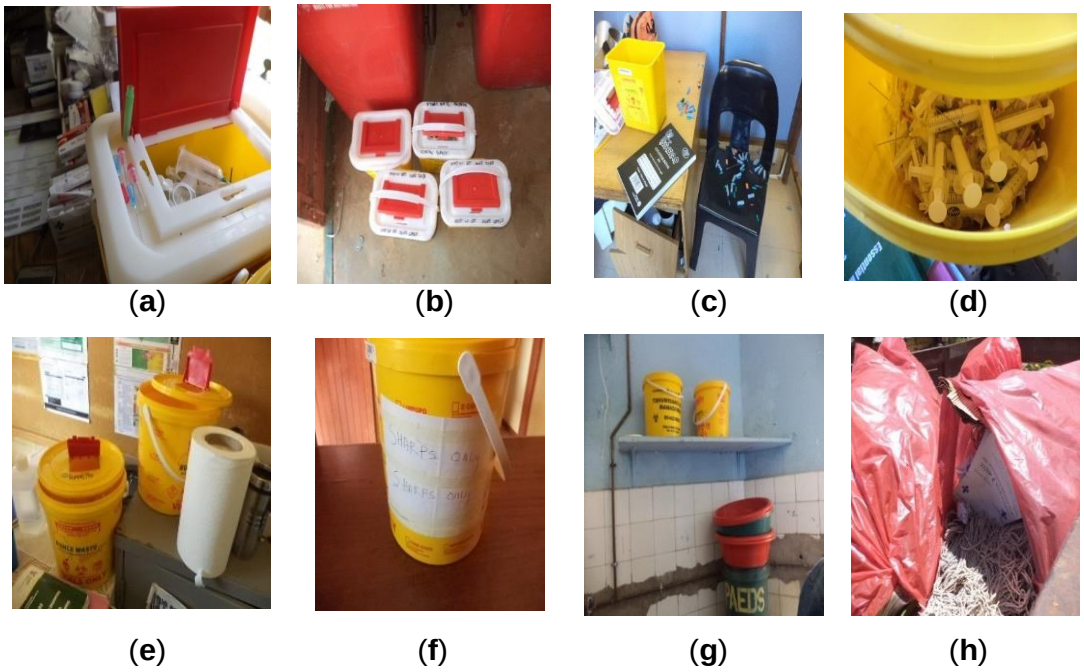

Figure 4.4. Poor healthcare risk waste handling. Careless dropping of sharps waste on top of the waste bin (**a**); improper closure of the lids of containers for sharps waste (**b**–**e**); accidental spillage of sharps waste due to improper closure of the lid (**c**); a bin for temporary storage of vials waste, relabeled to be used for storage of sharps (**f**); temporary storage equipment being used as water containers in the bathroom (**g**) and inappropriate use of red liners for storage of general waste (**h**). (Source: Field work).

3.5 Onsite Transportation

Transportation of HCRW from the point of generation to the central storage areas of healthcare facilities in Vhembe District is a duty of cleaners and ward aides. In some very remote clinics, volunteers from the community assist to carry out these duties. Majority of the respondents (*n* = 164, 71.6%) stated that they make use of dedicated trolleys (large wheelie bins: Figure 4.5a) for this purpose, while 28 (12.2%) and 22 (9.6%) respondents respectively indicated that they use any available container for the transportation or the waste is being manually carried to the central storage room by the cleaners. In a facility, a trolley which was being used for dressing of wounds was observed also being used to transport HCRW to the central storage room (Figure 4.5b).

(**a**) (**b**) (**c**) (**d**)

Figure 4.5. Onsite transportation of HCRW: Wheelie bin in the sluice room of a healthcare facility (**a**); medication trolley being used to transport HCRW to the central storage area (**b**); HCRW being transported out of healthcare facility with wheelie bins (**c**) and overfull wheelie bins and some with faulty locks (**d**). (Source: Field work).

Infectious waste is transported to the HCRW treatment facility in the wheelie bins while new bins are supplied to the healthcare facilities (Figure 4.5c). The wheelie bins are equipped with locks to ensure that they can be locked after infectious HCRW has been stored in them. To the question, "how do you transport your waste from the point of generation to the central storage area?", an IPCC responded:

> *"The service provider has provided us with the bins. They call it the wheelie bins—the red, big ones. Every ward is having the bin and they keep them in the sluice rooms. After dropping medical waste there, they wheel it from the wards into the central storage area somewhere there (pointing in the direction of the site of central storage area)"* (IPCC 3).

However, some of the wheelie bins were found to have broken locks while some were too full to be lockable (Figure 4.5d).

3.6 Central Storage

All the HCRW generated in every section of the healthcare facilities are transported to a central storage site within the facility from where the waste management company picks them up. In the district hospitals, these sites are small buildings with sufficient space dedicated for this purpose alone. However, in the clinics and CHCs, the storage rooms are usually old toilets or old incinerator rooms converted to storage areas or a simple fence without a roof, but with a door or an iron gate. In some clinics, the same room is being used for the storage of gardening and cleaning materials. In all the facilities, there are danger signs at the

entrance of the rooms or posted on the doors to keep unauthorized persons away. These signs were provided by the waste management company on contract with Vhembe District.

More than half of the respondents (*n* =172, 75.1%) claimed that they were aware that they have central storage areas in their facilities and the storage areas are not accessible to the public. In one hospital, the researcher and her assistant were not allowed to move close to the storage room "for safety purposes". We were told that access to the room can only be granted if we were properly dressed in protective gowns with gloves, boots and face mask. But, such was not the case in the clinics and CHCs where some of the central storage areas were found to be without functioning doors, keys or roofs or with broken windows which make access to them easy.

To the question: "Is your central storage room secure and up to the recommended standard?", some managers responded:

> *"Yes, we do have a particular site which is always locked. We gave our cleaners the responsibility to collect those full buckets, so, it means that the professional nurse or who is responsible for the consultation will close that lid and from there the cleaner will collect the bucket and take it to where it is supposed to be stored until the service provider collects it"* (CHC Manager 1).

> *"...we also don't have good storage areas, we improvised, we just found a room to store the waste, not even having a locker"* (Clinic Manager 2).

> *"The door is there but it does not have a locker, it's not really up to the standard. We are just happy that we have a storage, because at first, we were using one of the toilets, we are just happy because it's not tissue waste, because the refrigerator is inside. But because the storage room is not locked any person can come in, which is not safe for the community as well"* (Clinic Manager 3).

A manager of a CHC expressed her concern over the lack of a standard central storage room in their healthcare facility:

> *"We have a case when a man from the community sneaked into our central storage room because the lock is bad. He opened the buckets where we kept the sharps and vials, poured the needles and vials on the floor and ran away with the buckets. You can imagine the risks we are exposed to when we tried to put those things in other bins"* (CHC Manager 2).

Figure 4.6 shows the conditions of some central storage areas.

(**a**) (**b**) (**c**) (**d**)

(**e**) (**f**) (**g**) (**h**)

Figure 4.6. Central storage areas for healthcare risk waste. HCRW storage rooms with doors, but, without locks (**a**, **b**); HCRW storage room without a door (**c**); HCRW stored in the same room with cleaning and gardening equipment (**d**); HCRW storage room with a broken window (**e**); an old incinerator room converted to storage area (**f**); HCRW storage area with a gate, a low fence but, without a roof (**g**); HCRW being stored by the corner of a wall, not in a secure room (**h**). (Source: Field work).

3.7 Offsite Transportation

HCRW generated in healthcare facilities in Vhembe District are transported out of the facilities by the waste company on contract with the district. This company has an agreement with each facility about how frequently they need to collect waste, based on the size of the facility and the quantity of waste they generate. Thus, waste is being collected from the district hospitals two or three times a week and from the clinics and CHCs, weekly, fortnightly or monthly. The schedule is constant in the hospitals where there are specific days of the week when the waste is picked up in the morning. When the Environmental Health Practitioners were asked if waste company always adhere to their scheduled time of picking the waste, they responded:

> *"Always. They never fail. Even if the days fall on public holidays, we will come to find that they have collected the waste"* (EHP 2).

> *"No. They don't fail. At all, at all. Even during holidays, they do come"* (EHP 3).

However, in the clinics and CHCs, the schedule is not as constant. Some managers claim that they are only sure the company will come once in two weeks, but they are not sure of any particular day they would come. Others claim the service providers are regular,

visiting weekly, fortnightly or once in three weeks. Few respondents (*n* = 43, 18.8%) claim that their waste was not being removed offsite regularly, although none of the facilities reported ever having an overload of HCRW. A manager was asked: “Do you sometimes have an overload of HCRW in the central storage room before they are picked up?”, she responded in the negative.

> *“No, even though they come fortnightly, when we have a load of medical waste, we do call them even though it is not due time for them. They indicated that ‘you can even call us if you have an overload of medical waste”* (CHC Manager 1).

3.8 Treatment and Disposal

The waste management company has been saddled with the responsibility of treating and disposing all HCRW generated in the District. Each local municipality is also expected to dispose the general waste generated from the facilities like other household waste. A total of 180 (78.6%) respondents claim that they do not dispose any waste at all in their facilities because the Municipality officers pick up the general waste for disposal while the service provider takes care of the HCRW. However, 32 (14%) affirmed that they dispose some of the waste in their facilities by burning (7%) or incineration (6.6%). Few staff (*n* = 17, 7.4%) are unsure whether any type of waste is being disposed in their facilities.

In some clinics and CHCs, small areas were observed within the compounds where some waste were being burnt (Figure 4.7).

Figure 4.7. Burning sites within Vhembe healthcare facilities. (Source: Field work).

3.9 Record Keeping

The EHP in the hospitals and managers in the clinics and CHCs are responsible for the keeping of the records of the quantity of HCRW generated and turned over to the waste company. The record is a form completed by the representative of the waste company, which shows the quantity of each category of HCRW present at the central storage room

whenever the waste is being taken away for treatment and disposal. This form is completed each time the waste management company visits the healthcare facility and a copy is left with the EHP or the manager. At the end of every month, EHPs make a compilation of all the records to derive the monthly figure of HCRW generation in the hospital. This is not done at the clinics and CHCs.

The waste management company also sends a copy of the certificate of destruction to the District office on a monthly basis. The certificate contains information on how much of HCRW was transported out of Limpopo Province and the mode of treatment. EHPs, IPCCs and managers have access to these certificates through the District office. However, one of the EHPs and some managers are not aware of the existence of such a certificate and they do not have copies in their files. Below are extracts from the interviews when the participants were asked if they usually receive certificate of destruction from the waste management company.

> *"Yes. I also have that one. I get it from the District. The service provider sends the certificate of destruction to the District and the District forward it to me"* (EHP1).

> *"Yes, they do. They are with the EHP and I also have my copies. They send the certificate to e-mails"* (IPCC 1).

> *"They email me the certificate"* (Clinic Manager 2).

> *"No. We only have the service level agreement that they will be working with us. They don't provide us with anything that shows that we did this with the medical waste"* (CHC Manager 1).

> *"No. They don't. I heard that there is a certificate, I have never seen it but I have heard about it. I think the certificate is via the District and I don't know how regularly they give them"* (Clinic Manager 3).

When the question was posed to an EHP, she shook her head in disbelief/confusion. After the researcher explained to her the content of the certificate and why it should be obtained, she asked:

> *"Should that be every month or every year?" . . . what an interesting question! I will make a follow-up on that . . . or, maybe the infection control has that certificate"* (EHP2).

3.10 Budget for Healthcare Risk Waste Management

The Provincial Department of Health is responsible for the acquisition of HCRW

management equipment, as well as payment for the cost of treatment and disposal of HCRW. The healthcare facilities are not directly involved. The IPCCs and EHPs attested to this.

> *"The Provincial Government. We order from the service provider, they deliver and then take the invoice to the provincial office"* (IPCC 3).

> *"The Department of Health in the Province. When I make the request, the service provider gives me a list of what they supply which I submit to the Department"* (EHP 1).

4. Discussion

This study included more nurses as participants than healthcare staff from other professions. This is because nurses are usually more in number in healthcare facilities; they actually make up 72.5% of all the health workers on the register of Vhembe District Municipality [23].

Infectious waste was discovered as the major type of HCRW being generated at healthcare facilities in Vhembe District, as confirmed by other similar, previous studies [21,24]. This is understandable because most of the types of HCRW produced at healthcare facilities fall under this category and some of them are bulky, for example, diapers and other materials contaminated by excreta, linings from maternity wards contaminated with blood. In the hospitals, pathological waste is the next most bulky subcategory of HCRW generated, while this is not the case in clinics and health centers where only few deliveries are conducted and surgeries are not carried out.

Minimization of HCRW is not being practiced in Vhembe District. An IPCC claimed that they were simply following the guidelines. A scrutiny of the Provincial guideline confirms that there were no detailed instructions on how to reduce HCRW, though the document clearly states that: "Health care risk waste to be minimized and separated effectively in such a manner that the environment is not polluted" [25]. Also, the training manual provided by the waste management company does not address the issue of HCRW minimization. This means that this important step of HCRW management has been relegated to the background and would not be discussed whenever there is a training about HCRW management at the healthcare facilities. HCRW minimization has been proven to be effective in the reduction of the cost of HCRW treatment by up to R20,000 per month [4]

This study confirmed that mixing general waste and HCRW, as well as mixing of various sub-categories of HCRW occurs in healthcare facilities in Vhembe District. Some healthcare staff are unable to identify all the various categories of HCRW. Identification of the different

subcategories of HCRW and segregating them into various appropriate containers from source is the key towards achieving the exact quantity of HCRW, which reach the treatment plant. Once HCRW has been mixed at source, it must remain mixed until it reaches the treatment facility because sorting of the waste into different categories after it has been mixed exposes whoever attempts to sort it to the risk of injuries from sharps or contact with hazardous chemicals. Mixing general waste with HCRW has been identified as a reason for a high cost of treating HCRW because once mixed, the entire waste stream has to be treated as hazardous [4,26].

Poor segregation practices among healthcare workers noted in this study has also been variously reported in many developing countries and linked to ignorance of the risks and costs associated with such practice and apathy towards the issue of HCRW management [9,27]. This increases the cost of treatment and disposal of such waste. Moreover, mixing different categories of HCRW, for example, mixing infectious waste (like bandages) with hazardous waste (like medication vials) requires that the mixed waste has to be first disinfected before being treated as hazardous waste. This amounts to a high cost of treatment, as it has been reported that it costs about three times more to treat infectious waste compared with other forms of hazardous waste from healthcare facilities [6].

This study identifies doctors as being the main category of healthcare profession more culpable in the mixing of HCRW, like other previous, similar studies [9,27,28] and uncovers the reason for this finding, as the attitude of doctors towards training on HCRW management: many doctors do not accept a responsibility of waste management as a part of their job description in their capacity as HCRW generators [19], therefore, they do not place any priority on attending trainings on HCRW management. Meanwhile the HPCSA recommends continual training for healthcare workers to keep themselves up to date with the latest scientific knowledge on the management of HCRW [10]. The Department of Health must make more deliberate efforts to train doctors, because training has proven fruitful in helping to improve doctors' attitudes and practices towards HCRW management [29,30]. The use of attendance of HCRW management training programs as a way of generating continuing professional development (CPD) points for doctors could be an incentive to encourage them to attend the trainings [31].

It is noteworthy that in Vhembe District healthcare facilities, cleaners and volunteers are the ones assigned with the responsibility of transporting HCRW from the point of generation to the central storage area, according to this study. In some facilities, nurses were reported to be transporting the waste and this makes them susceptible to carrying infectious organisms back to the patients they take care of in the wards [4]. However, the fact that some waste handlers have to manually transport the waste from the point of generation to central storage rooms in remote healthcare facilities is a point of concern because of the risk

of injuries to their legs and feet in cases of spill, or puncture wounds if the waste contain sharps, like needles, especially when they are not well protected by safety boots.

Most central storage areas visited during the field work for this study do not meet up with the recommendations for a standard central storage room of a healthcare facility, which include among others: easy access by HCRW handlers and the service providers, sufficient space for storage of HCRW until transportation outside the facility, secured lock to prevent unauthorized access, appropriate ventilation and lighting [24]. This is because there was no plan for such structures while building the facilities. In most cases, old public toilets or store rooms for gardening are being improvised, as HCRW central storage rooms. In cases where there were no secure locks, relatively free access to the rooms poses a risk to members of the community who may not have knowledge about the risks of HCRW.

All HCRW generated from healthcare facilities in Vhembe District are being transported out of the District to a waste treatment center located in Capricorn District, another District Municipality in Limpopo Province. No part of the waste is being treated onsite. This practice has been reported to increase the cost of treatment of HCRW, which could be minimized if at least some of the waste is treated onsite [32]. Efficient onsite treatment modalities which do not require special training like shredding of sharps, disinfection and microwave can be employed in the healthcare facilities within the District to reduce the quantity of HCRW that is transported to the waste treatment facility. This would greatly reduce the cost of transportation, as well as allow the treatment facility to easily cope with the reduced quantity of waste it has to treat. However, the Department of Health must be willing to provide the initial cost of installation of these treatment modalities in the healthcare facilities.

According to the reports on the treatment certificates obtained from the waste management company, disinfection and incineration are the only methods being employed for treatment of HCRW transported out of the healthcare facilities in the District. Non-burn techniques are now being encouraged for the treatment of HCRW, to avoid the negative consequences of incineration, which include air pollution and release of toxic substances to the environment [6]. These techniques include:

a. Low-heat thermal processes which involves the use of thermal energy at temperature range between 100 °C and 180 °C in moist or dry environment to destroy pathogens. This temperature is high enough to destroy most micro-organisms and yet not enough to cause combustion. Autoclaves and microwaves operate using this technique [6,33].
b. Chemical processes where chemicals and disinfectants like sodium hypochlorite, sodium dioxide, peracetic acid or lime solution are react with the waste to destroy the constituent pathogens [6,34].
c. Biological processes: enzyme mixtures are used to decompose organic matters [4,6].

d. Irradiative processes: ionizing radiation and ultraviolet sources are used to destroy the micro-organisms e.g., electron beam radiation technology. However, this is an expensive technique [4,6].

e. Mechanical processes which involve reducing the volume of the waste or rendering the waste unrecognizable, e.g., grinding, shredding, mixing, agitation, etc. [6]. However, after using this type of technique, another treatment method must be applied to render the waste non-hazardous.

Some of these non-burn techniques have been adopted in some provinces of South Africa including Gauteng and North West [12].

Some types of healthcare general waste, mostly boxes for packaging of medications were being burnt in some clinics and CHCs. The managers complained that the boxes were too big to be packed into local municipal waste carriage vehicles, hence the need to get rid of them at the healthcare facilities. However, the practice of open burning causes air pollution, which renders the environment unsafe. This practice is not acceptable because it violates the constitution of South Africa, which states that every South African has a right to a safe environment, which is not harmful [35].

The "polluter pays principle" of HCRW management states that "the waste generator must accept the complete financial culpability for the responsible handling storage, transportation, treatment and disposal of waste" [36]. Since the Provincial Department of Health is responsible for the payment of all the cost incurred in the management of medical waste generated by all public healthcare facilities in the Province, the Department must monitor all the activities of the waste management company on contract with them, to ensure that all the waste generated in the province is properly treated and safely disposed, to prevent further incidences of illegal dumping of untreated healthcare risk waste in the province.

Conclusions

This study has shown that HCRW is not being efficiently managed in Vhembe District of Limpopo Province, South Africa. It is recommended that the guidelines for management of HCRW are enforced and compliance ensured at all levels and among all the staff. Efforts at training of HCRW generators, with special attention on doctors should be intensified. Some form of treatment of HCRW should be permitted and encouraged in each healthcare facility and non-burn techniques of management of HCRW should be embraced in Limpopo Province.

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References

1. Chartier, Y.; Emmanuel, J.; Pieper, U.; Pruss, A.; Rushbrook, P.; Stringer, R.; Townend, W.; Wilburn, S.; Zghondi, R. (Eds.) *Safe Management of Waste from Healthcare Activities*, 2nd ed.; World Health Organization: Geneva, Switzerland, 2014; pp. 3–9, ISBN 978-92-4-154856-4.
2. Yawson, P. Assessment of Solid Waste Management in Healthcare Facilities in the Offinso Municipality. Master's Thesis, Kwame Nkirumah University of Science and Technology, Kumasi, Ghana, 2014; pp 33-56.
3. Hangulu, L.; Akinola, O. Health care waste management in community-based care: Experiences of community health workers in low resource communities in South Africa. *BMC Public Health* **2017**, *17*, 448.
4. Vumase, B.S. An Evaluation of Operational and Administrative Procedures for Health Care Waste Management in Public District Hospitals of South Africa. Ph.D. Thesis, Durban University of Technology, Durban, South Africa, 2009, Pp 117-185.
5. World Health Organization. Fact Sheet (Health-Care Waste) 2018. Available online: https://www.who.int/ news-room/fact-sheets/detail/health-care-waste (accessed on 4 March 2019).
6. Jorge, E.; Hrdinka, C.; Ryder, R.; McKeon, M.; Berkemaier, R. *Non-Incineration Medical Waste Treatment Technologies in Europe*; Health Care Without Harm Europe: Prague, Czech Republic, 2004; pp. 6–35.
7. Ogola, J.S.; Chimuka, L.; Tshivhase, S. Management of municipal solid wastes: A case study in Limpopo Province, South Africa. In *Integrated Waste Management*; Kumar, S., Ed.; InTech: Rijeka, Croatia, 2011; Volume 1.
8. Department of Environmental Affairs and Tourism. *Program for the Implementation of National Waste Management Strategy. Starter Documents for Health Care Waste*; Department of Environmental Affairs and Tourism: Pretoria, South Africa, 2008.
9. Maseko, Q. Critical Evaluation of Medical Waste Management Policies, Processes and Practices in Selected Rural Hospitals in The Eastern Cape. Master's Thesis, Rhodes University, Grahamstown, South Africa, 2014; pp. 37-141.
10. Health Professional Council of South Africa. *Guidelines for Good Practice in the Healthcare Profession. Guidelines for the Management of Healthcare Waste*; Booklet 12; Health Professional Council of South Africa: Pretoria, South Africa, 2016; pp. 1-16.

11. Sharley, H. *Osborne Park Hospital Structure Plan: Final Report*; Hames Sharley Pty. Ltd.: Warrington, UK, 2006.
12. Department of Environment Affairs. Health Care Risk Waste Treatment Figures for 2014. Available online: http://sawic.environment.gov.za/documents/4946.pdf (accessed on 1 March 2019).
13. Department of Environmental Affairs. South Africa State of Waste Report. First Draft Report. 2018. Available online: http://sawic.environment.gov.za/documents/8641.pdf (accessed on 1 March 2019).
14. Caniato, M.; Tudor, T.; Vacari, M. Assessment of health-care waste management in a humanitarian crisis: A case study of the Gaza Strip. *Waste Manag.* **2016**, *58*, 386–396.
15. Hossain, M.S.; Santhanam, A.; Nik Norulaini, N.A.; Omar, A.K. Clinical solid waste management practices and its impact on human health and environment: A review. *Waste Manag.* **2011**, *31*, 754–766.
16. Mahasa, P.S.; Ruhiiga, T.M. Medical waste management practices in north eastern Free State, South Africa. *Hum. Ecol.* **2014**, *48*, 439–450.
17. Olaifa, A.; Govender, R.D.; Ross, A.J. Knowledge, attitudes and practices of healthcare workers about healthcare waste management at a hospital in KwaZulu-Natal. *S. Afr. Fam. Pract.* **2018**, *60*, 137–145.
18. Makhura, R.R.; Matlala, S.F.; Kekana, M.P. Medical waste disposal at a hospital in Mpumalanga Province, South Africa: Implications for training of healthcare professionals. *S. Afr. Med. J.* **2016**, *106*, 11.
19. Malebatja, S.M. Knowledge and Practices of Health Care Workers on Medical Waste Management Disposal at George Masebe Hospital, Waterberg District, Limpopo Province, South Africa. Master's Thesis, University of Limpopo, Mankweng, South Africa, 2013, pp. 34-36.
20. Limpopo Department of Health and Social Development. *Promotion of Access to Information Act (PAIA)*; Government Printer: Pretoria, South Africa, 2015.
21. Nemathaga, F.; Maringa, S.; Chimuka, L. Hospital solid waste management practices in Limpopo Province, South Africa: A case study of two hospitals. *Waste Manag.* **2008**, *28*, 1236–1245.
22. Raphela, S.F. Treatment and disposal of medical waste in rural and urban clinics within Polokwane municipality of South Africa. *J. N. Gener. Sci.* **2014**, *12*, 97–109.
23. Vhembe District Municipality, Department of Health and Social Development. *Vhembe District Municipality Records*; Vhembe District Department of Health Publisher: Thohoyandou, South Africa, 2017.
24. Reenen, B. (Ed.) *IUSS Health Facility Guides: Infrastructure Design for Waste*

Management in Healthcare Facilities (Abridged); IUSS: Pretoria, South Africa, 2014.

25. Limpopo Provincial Government, Department of Health and Social Development. *Health Care Risk Waste Guidelines*; Limpopo Provincial Department of Health: Polokwane, South Africa; p. 4.
26. Jewaskiewitz, S. A Challenging Context. Infrastructure News and Service Delivery. 2013. Available online: http://www.infrastructurene.ws/2013/05/20/a-challenging-context/ (accessed on 20 February 2017).
27. Ramokate, T.; Basu, D. Health care waste management at an academic hospital: Knowledge and practices of doctors and nurses. *S. Afr. Med. J.* **2009**, *99*, 6.
28. Kuchibanda, K.; Mayo, A.W. Public health risks from mismanagement of healthcare wastes in Shiyanga Municipality health facilities, Tanzania. *Sci. World J.* **2015**, *2015*, 981756.
29. Kumar, R.; Somrongthong, R.; Ahmed, J. Effect of medical waste management trainings on behavior change among doctors versus Nurses and paramedical staff in Pakistan. *J. Ayub Med. Coll. Abbottabad* **2016**, *28*, 493–496.
30. Rudraswamy, S. Hospital Waste Management among the Staff of Dental Hospitals. Masters' Thesis, Oxford Dental College Hospital and Research Center, Bangalore, India, 2010.
31. Otto, K.; Clements, J. *Survey of Generation Rates, Treatment Capacities and Minimal Costs of Healthcare Waste in the 9 Provinces of RSA*; Department of Environmental Affairs and Tourism: Pretoria, South Africa, 2008.
32. Eastern Cape Development Corporation. *Feasibility Plan for a Hazardous Waste Treatment Facility in the Eastern Region of the Easter Cape*; Eastern Cape Development Corporation: East London, South Africa, 2017.
33. Zimmermann, K. Microwave technologies: An emerging tool for inactivation of biohazardous material in developing countries. *Recycling* **2018**, *3*, 34.
34. Voudrias, E.A. Technology selection for infectious medical waste treatment using the analytic hierarchy process. *J. Air Waste Manag. Assoc.* **2016**, 663–672.
35. South African Government. *The Constitution of the Republic of South Africa*; South African Government: Cape Town, South Africa, 1996; p. 9.
36. Sherman, A. Waste Management in Public Hospitals. Department of Health, Province of Kwazulu Natal 2016. Available online: https://docplayer.net/14395490-Health-care-waste-categories.html (accessed on 1 April 2019).

CHAPTER FIVE

PRESENTATION OF STUDY FINDINGS 2

This chapter reports the roles of the main stakeholders of medical waste management in Vhembe District and analyses their networking to achieve the common goal of efficient management of medical waste in the district. It is under review by the journal of BMC Public Health for publication.

Beyond the Point of Waste Generation: The Roles and Networking of Stakeholders to Achieve Safe Management of Health Care Risk Waste in Vhembe District Municipality

Abstract

Background: The peculiarity of Healthcare Risk Waste (HCRW) makes it mandatory that it must be treated and disposed specially to protect healthcare workers and the community from its hazardous effects. Safe management of this type of waste requires the contributions of many different stakeholders. This study was conducted to analyse the specific roles of all the stakeholders involved in HCRW management from generation to disposal in Vhembe District of Limpopo Province, South Africa.

Method: This study employed a qualitative research design. The stakeholders of HCRW management in Vhembe District of Limpopo Province, South Africa, were identified, namely: Department of Health, Healthcare facilities, Limpopo and the waste management company responsible for the treatment and disposal of medical waste in Limpopo Province. A total of 17 participants who are directly involved in HCRW management were purposively selected to represent these stakeholders. These participants were interviewed to gain an in-depth understanding of the roles of all the stakeholders, both within and outside healthcare facilities where the waste is generated. Data was thematically analysed.

Results: The responsibility of drafting and enforcing HCRW guidelines in the Province, training and protection of healthcare staff, payment of all the cost incurred in the management of HCRW and monitoring of HCRW treatment and disposal was accorded to the Provincial Department of Health. Each healthcare facility is expected to avail the staff for training and ensure compliance with the guideline. The waste management company's roles are to train all healthcare workers, provide all the equipment necessary for HCRW segregation and onsite transportation, transport the waste to their treatment facility in appropriate vehicles and conduct the treatment and disposal of the waste according to environmentally acceptable

standards. Communication gaps were found among these stakeholders, resulting in inefficient management of HCRW in Vhembe District

Conclusion: The roles of the stakeholders are interdependent on one another, therefore, a strong network must be established among them to improve on the current state of HCRW management in Vhembe District.

Keywords: *Healthcare risk waste, rural health facilities, Department of Health, Stakeholder, Vhembe District*

1. Introduction

Waste generated from healthcare facilities is peculiar because of its composition, which renders it hazardous to the waste generators, handlers, patients and the community if not properly managed (WHO, 2018). A large percentage (75-90%) of the waste (general waste) are comparable to the waste generated from home and are thus treated as other types of municipal waste. However, the remaining little part of the waste, which is hazardous, known as Healthcare Risk Waste (HCRW) requires special handling, treatment and disposal, to avoid risks to the generators, handlers and the entire community (Yawson, 2014). A safe management of HCRW requires technical, financial and human resources (Caniato *et al.*, 2016) which are lacking in many developing countries; thus, there have been reports of poor and ineffective management of such waste in many developing countries including South Africa (Njue *et al.,* 2015; Oyekale & Oyekale, 2017; Deress *et al.*, 2018; Olaifa *et al.*, 2018; Niyongabo *et al.*, 2019).

The problems of poor management of medical waste in developing countries have been attributed to poor policy implementation, inadequate training of healthcare workers, poor attitudes of healthcare workers to training and lack of sufficient resources among others (Kuchibanda & Mayo, 2015; Olaifa *et al.*, 2018) . These are responsible for poor segregation of the various categories of HCRW from the point of generation, unsafe onsite transportation techniques, improper onsite temporary storage of HCRW in the healthcare facilities, poor treatment and disposal practices including burning, use of non-environmentally compliant incinerators and illegal dumping (Njue *et al.,* 2015; Hangulu & Akinola, 2017a; Niyongabo *et al.*, 2019; Olaniyi *et al.*, 2019).

An effective management of HCRW begins from the making of the relevant policies and ensuring their compliance. It also involves proper handling from the point of generation to the point of eventual disposal. Shrivastava *et al* (2015) emphasized that a proper management of

HCRW requires a good collaboration between different stakeholders who must understand their individual roles and perform them. The World Health Organization (WHO) recommends that stakeholders for medical waste management be drawn from health, industry and public sectors and each stakeholder must identify the priorities of HCRW management (Chartier *et al.*, 2014).

The important stakeholders which have been identified in the network of HCRW management include the ministry of health, municipalities, solid waste management councils and healthcare (Caniato *et al.*, 2015), ward councillors (policy makers), managers and educators who oversee medical waste management activities (Hangulu and Akinola, 2017b). In South Africa, the Department of Environmental Affairs and Tourism (DEAT) and the Health Professions Council of South Africa (HPCSA) are involved in the policy making and drafting of guideline documents, detailing the steps on how to handle HCRW safely from generation to disposal (DEAT, 2008; HPCSA, 2016). The Provincial Department of Health (DoH) in each of the province in the country is considered the medical waste generator through the healthcare facilities and thus are expected to enforce the guidelines and ensure compliance within all the healthcare facilities in the province. In many provinces of South Africa, the responsibility of medical waste treatment and disposal has been contracted to private waste management companies. This makes these companies important stakeholders also.

This study was conducted to identify the stakeholders of HCRW management in Vhembe District, describe their roles and contributions to HCRW management in the District and how their networking impact on the safe management of HCRW in the District. At the beginning of this study in Vhembe District, selected healthcare facilities were visited to obtain background information about the relevant stakeholders regarding management of medical waste in the District. Three major stakeholders were identified, viz: The Department of Health, Limpopo Province, the healthcare facilities and the private waste management company.

2. Method

2.1 Research Design

This study adopted a descriptive qualitative design to be able to obtain an in-depth understanding of the roles of the stakeholders and how the roles are intertwined to achieve a good management of medical waste in the District (Tolley *et al.*, 2016). Since semi-structured interviews were conducted for the participants, the researcher was also able to gain an insight into their challenges and the problems of networking with other stakeholders to achieve the common goal of proper medical waste management in the District.

2.2 The study setting

Vhembe District Municipality (VDM) is one of the five district municipalities of Limpopo Province, South Africa. The Limpopo Province is the northernmost province of South Africa, sharing borders with Zimbabwe on the northern side, Botswana on the west and Mozambique on the east. It is known as the poorest province in the country with more than 70% of the population living below the national poverty line and more than 87% of the population living in the rural areas. There are more than 400 healthcare facilities (hospitals, clinics and health centres) serving the people of the province (Promotion of Access to Information Act manual, 2015). The Limpopo Provincial Department of Health (DoH) is responsible for all the public healthcare facilities, including the treatment and disposal of the waste they generate. Each facility generating waste in excess of 20kg per day is also mandated to register with the Department of Environmental Affairs (DEA). The DoH keeps all medical waste records from all the public healthcare facilities in the province. These altogether generate an average of 1, 569.24 tonnes of hazardous medical waste annually (Records for the years 2016 -2019 obtained from DoH, Limpopo, medical waste management section). All the waste generated from these facilities are transported out of the facilities, treated and disposed by a private waste management company which has been contracted by the DoH for that purpose. No HCRW is treated or disposed onsite. However, waste generated from the private sources are not monitored by the DoH, because the generators are directly responsible for their treatment and disposal.

The VDM is a largely rural district municipality within the province, comprising of 4 local municipalities and accommodating about 1,293,783 people. The district has a total of 167 government healthcare facilities: 1 regional hospital, 1 specialized psychiatry hospital and 165 other facilities (Limpopo Vhembe District Profile Handbook, 2015) as well as many private-owned healthcare facilities scattered throughout the municipality. The bulk of medical waste being generated in VDM come from these healthcare facilities, while some other are from other sources like private-owned laboratories and homes (Chartier *et al.*, 2014). Fifteen healthcare facilities were purposively selected for the purpose of this study. The selected facilities include 1 hospital, 2 clinics and 1 community health centre (CHC) from each of the local municipalities, except for one local municipality where there are no CHCs. This is to ensure that each hierarchy of healthcare facility is well represented in the study. The Provincial Department of Health and the Waste Management Company (WMC) were also included in the study as the other major stakeholders.

2.3 Study participants

A total of 17 participants were recruited in this study. Two personnel who are responsible for medical waste management in the DoH, Limpopo Province and a representative from the waste management company were purposively selected to participate in the study. From the healthcare facilities, health workers who are directly involved in HCRW management in each of the selected facilities were also purposively selected: 7 Managers from the clinics and CHCs, 4 Environmental Health Practitioners (EHPs) and 3 Infection and Prevention Control Coordinators (IPCCs) at the hospitals. For the purpose of anonymity, the name of the selected healthcare facilities do not feature in the results, however, participants were assigned sequential numbers according to their position for identification purposes (For example, the managers were referred to as Manager 1, Manager 2, up to Manager 7. The same was done for the other professionals).

Interviews were conducted for all these participants after having obtaining informed consent from them. The interviews were recorded using a voice recorder, transcribed verbatim in English language and analysed by following the six steps of thematic analysis as described by Braun and Clarke (2006). First, we familiarized ourselves with the data through reading of the transcripts over and over. While doing this, we actively searched for recurring patterns to assist us arrive at the themes and subthemes from each of the sets of stakeholders in the next step. In the subsequent steps, we generated the themes and the codes, grouped the themes and identified the subthemes, which are presented as the results of the study. Then, the networking of the stakeholders was derived from the results.

3. RESULTS

3.1 Roles of the Department of Health

Table 5.1 summarizes the roles of DoH according to the themes and subthemes gathered from the study.

Table 5.1: Roles of DoH in Healthcare Risk Waste Management in Vhembe District

Themes	Sub-themes
Policy formulation and training	Formulation and of HCRW management guideline Monitoring and sponsorship of healthcare workers for training
Staff protection	Provision of personal protective equipment Hepatitis B immunization
HCRW management equipment	Temporary storage equipment Central storage areas within the healthcare facilities

Theme 1: Policy formulation and training

Sub-theme 1: Formulation of HCRW management guideline: All the participants identified the Limpopo Provincial Department of Health as the one responsible for the provision of a guideline document for management of HCRW in their facilities. The document is drafted by the section of the Department who deals with issues of medical waste management and is made available to the healthcare facilities after it has been approved by the Head of the Department (HOD). The participant from the DoH stated:

"We draft the guideline from here in accordance with the Regulations that govern HCRW management in South Africa. These Regulations include the NEMA (National Environmental Management Act), National Health Act, SANS (South African National Standards) code 10248, part 1, OHSA (Occupational Health and Safety Act) and the NEMWA (National Environmental Management Waste Act). After drafting the guidelines, we present it to the HOD for approval and signature, it is only after then we can make it available for use at the healthcare facilities through the District offices. We usually review the guidelines at the expiry of the contract we award to the waste management company, usually every three years. The current guideline document was drafted in 2017, however, we are working on the new one which would be ready soon" (DoH Rep 1).

Participants from the waste management company and the healthcare facilities also attested to this claim:

"The policy document is drafted by the Department, but we also have our own training manual, which is a similar document to the guideline. We just try to simplify the concepts and include pictures, to make training and learning easier for us and the healthcare workers" (WMC Rep).

'We have the guideline document from the Provincial Department of Health' (Manager 2).

'We have the one (Guideline) that is a Departmental one' (IPCC 1).

Sub-theme 2: Monitoring and sponsorship of healthcare workers for training: The DoH is also responsible for the training of healthcare workers on proper handling of HCRW from the point of generation to storage in the healthcare facilities where the waste await transportation to the treatment site by the waste management company. The participants' comments on this are as follows:

"We are supposed to conduct the trainings, but, we have contracted it out to the waste management company on contract with us. However, we sponsor every healthcare worker who participates in the training. We also monitor the trainings by asking the waste management company to submit a copy of the training manual to us and we sometimes attend the training sessions without prior notice to the trainers, such that we are able to assess the quality of the training and the number of participants" (DoH Rep 1).

When he was asked on how they ensure that healthcare workers participate actively in the training, he responded:

"We are aware some healthcare workers do not show interest in the trainings and some only participate passively, so, we have accredited the training with relevant health professional bodies in the country, like the Health and Welfare SETA [Health and Welfare Sector Education and Training Authority (HWSETA)], HPCSA (Health Professions Council of South Africa), SANC (South African Nursing Council) and SAPC (South African Pharmacy Council). Through the accreditation, we are able to offer CPD (Continuing Professional Development) points to those who attends the training. Also, we give out two different types of certificates to participants after the training: certificate of participation and certificate of competence. Only those who perform well in the assessment test after the training receive the later certificate. This encourage the healthcare workers to participate actively in the training. We also demand to have copies of the attendance registers, so that we can know how many workers have been trained" (DoH Rep 1).

He commented further on the schedule of conduction of the training:

"In the hospitals, all the staff are trained on a specific scheduled date. However, for the clinics and primary healthcare centres, we conduct the trainings at sub-district levels, where there are groups of many clinics because of the size of the healthcare workers we have in those facilities. The clinics are many, but the number of staff is few, so, we group them. We don't have to schedule a training for only 3 or 5 staff" (DoH Rep 1).

Other participants also agreed that the Department is responsible for the training, though some participants from the healthcare facilities stated that the training has not been regular and many healthcare workers have not had the privilege to attend such trainings:

"Yes, the Department is responsible for the training, though it is conducted by the service provider (WMC). But, the trainings are not regular. Sometimes, we have it once in a year or twice. At the time of the training, we can only delegate some of our staff to attend, everyone cannot leave the clinic at the same time because we also have to attend to the patients. So, you find out many of our staff are yet to be trained" (Manager 3).

Theme 2: Staff protection

Sub-theme 1: Provision of Personal Protective Equipment (PPE): All the participants stated that the PPE is provided by the DoH. While an EHP claimed that they have enough PPE in his healthcare facility, other participants stated that they usually have shortage of the equipment. Some reported on shortage of equipment and delay in the supply after ordering for them. However, the DoH representative showed his surprise at such an accusation. He said he has never received any report about shortage of PPE in any of the healthcare facilities.

"We get the PPE from the Pharmacy and we have enough. They are being supplied by the Department" (EHP 4).

"No. We don't have enough PPE. We were given protective clothing somewhere 5 years ago but, the cleaners don't have some -like the boots. But, they do have the gloves, masks and plastic aprons" (Manager 6).

"No, we don't have masks. We are running short of masks. Everything is out of stock. We are ordering, the stock is not coming. With the aprons, it's better because we are using the plastic ones. We are using those old masks, but, we don't have a problem with gloves. Also, the cleaners don't have boots" (Manager 7).

"*We do order those things directly from the Department. Some months back, there was a problem, they said they were introducing a new system and the new system is difficult to learn … so, we ran short of masks, but those who are supposed to wear boots are having boots since every pair is for 3 years. They purchase once for 3 years. I mean the cleaners, the ward attendants, those who clean in the wards. And they have long gloves, not like those which are used by nurses, and the gloves are reusable, not discarded after single use"* (IPCC 3).

"The Department supplies the healthcare facilities with PPE. It is not part of our duties" (MWC Rep).

"I am not aware that there is shortage of PPE in any of the healthcare facilities. I think there is a communication gap there. If they order for those things, we will ensure that they are supplied, because it is our duty to ensure that they are protected as they perform their duties" (DoH Rep 1).

Sub-theme 2: Hepatitis B Immunization: The participants from the DoH and healthcare facilities stated that the Provincial DoH is responsible for the provision of the vaccine through the District Municipality. However, as at the time of collecting data for this study, most of the participants stated that the vaccine has not been available in a long time, consequently, many of their staff are not fully immunized and some new staff have not received the first dose of the vaccine. Only 2 participants indicated that their staff were all fully immunized.

"The Department is responsible for the vaccination, but it is not available in the Province now. We will make it available to the healthcare facilities as soon as we have it" (DoH Rep 1).

"We were immunized a long time ago, but some did not complete the course, some are not yet immunized, like the new appointed ones because the vaccine is no longer here. I am not sure of when a new batch will be available" (Manager 3)

'Our new staff is not yet immunized' (Manager 5)

'The vaccine has not been available in a long time, but, all the staffs who are yet to be immunized will get the vaccine as soon as it is available' (IPCC 2).

'We have all been immunized for hepatitis B' (Manager 1).

'Yes. Immunization is done up to date for all the staff. I do not know where our Pharmacist get the vaccines from, but, I know it is not available from the Department for now. The register is available if you want to see it' (IPCC 3).

Theme 3: HCRW management equipment

Sub-theme 1: Temporary storage equipment: The participants stated that the DoH is responsible for the payment of all the consumables they use for HCRW management, like the colour-coded bins, red liners for infectious waste and the wheelie bins for onsite transportation

of the waste to the central storage areas. The IPCCs and EHPs explained that they order for those equipment from the WMC, but the invoices go to the DoH for payment:

"The Provincial Government pays. We order the bins from the service provider, they deliver and then take the invoice to the provincial office" (IPCC 3).

"When I make the request, the service provider gives me a list of what they supply which I submit to the Department" (EHP 1).

Sub-theme 2: Central storage area within the healthcare facility: The DoH representative disclosed his awareness about the state of central storage areas in the healthcare facilities in the Province. He noted that he has conducted a study about it which he has presented to the Department for further action. However, the Department is currently resource-constrained to build standard central storage areas in all the healthcare facilities. However, it is a goal they are hoping to achieve as time goes on. The WMC representative also affirm the problem, suggesting that the Department needs to at least put some temporary measures in place for proper HCRW storage until they are able to build standard structures.

While some participants in the healthcare facilities commented that they think their central storage rooms are up to the standard, others expressed their displeasure about the status of the central storage areas in their healthcare facilities. Some stated that they do not have rooms specifically built for that purpose, and as such, they had to use old toilets and other areas in the facilities to store the waste.

"We are also aware of the problem of substandard storage areas. I have personally conducted a study around the province, and I have presented my findings and recommendations to the Department. None of our healthcare facilities have a standard central storage area. While some are manageable, many are grossly sub-standard. But, we are working on it –the project will be handled by the Infrastructure section, but, it will have to be a long-term goal because of the enormous resources needed" (DoH Rep 1).

"I have also noticed that there are no standard central storage rooms in most of the hospitals and clinics. I think the Department should look into it and at least provide a temporary measure – like installing containers with good vents and plumbing works outside, for HCRW storage in the facilities, until they are able to build standard structures" (WMC Rep)

'The central storage room is very secured. It is spacious enough to contain all the waste we generate and it is always locked. Only the security personnel have the keys. Whenever anyone

needs access to the room, for example the cleaners, when they want to put the waste in there, they have to call the security. They also make sure that they record whatsoever they put in there.' (EHP 2).

'It is always locked with key. There is a man who has been saddled with the responsibility of collecting the general waste and also making sure that the central storage area is always under lock and key' (IPCC 3).

'The storage room is outside and it is secured. It is always locked because we have improvised the toilet for the store room. We must keep it locked so that our patients who want to use the toilet will not go there' (Manager 7).

'We don't have a good storage area, we improvised, we just found a room to store the waste, not even having a locker. The door is there but it does not have a locker. It's not up to the standard, but, we are just happy that we have a storage, because at first, we were using one of the toilets, we are happy because we don't have to store the tissue waste in the room, we store them in the refrigerator. However, since the storage room is not locked, any person can come in, which is not safe for the community as well' (Manager 4).

3.2 Roles of Healthcare Facilities

The roles performed by the healthcare facilities to ensure proper management of HCRW are summarized in the Table 5.2.

Table 5.2: Roles of Healthcare facilities in Healthcare Risk Waste Management in Vhembe District

Themes	Sub-themes
Compliance with guideline	Accessibility of guideline document Segregation practices Overfilling of temporary storage bins
Training	In-service trainings Poor attitude of HCRW generators to training
Enforcement of compliance	Measures to ensure compliance

Theme 1: Compliance with guideline

Sub-theme 1: Accessibility of guideline document: The DoH representative commented that they usually make the guideline document available to all healthcare facilities after the approval of the Head of Department, through the District offices. In the hospitals, a copy of the document can be found in every ward for easy accessibility by healthcare workers. However, in the clinics and CHCs, only 1 copy is available in the entire facility, however, the managers claim that the other staff know how to access it.

"After drafting the guidelines, we present it to the HOD for approval and signature, it is only after then we can make it available for use at the healthcare facilities through the District offices." (DoH Rep 1).

"It (the guideline) is available in all the wards" (IPCC 1)

"We have only one copy, but anyone can access it" (Manager 3).

"It is not distributed in all the cubicles, it is in our waste management file. But, they know where to access it if they need it." (Manager 6).

Sub-theme 2: Segregation practices: The participants attested to the fact that healthcare staffs are aware of the principles of segregation. However, they also admitted to mixing of HCRW by some staff and patients.

"Everyone is aware that waste generated everyday must be segregated, there are containers for segregation" (Manager 1).

"They comply, just that we have a problem with the patients, because you can find that they can throw things anywhere, but we are helping them on how to separate waste, with the staff there is no problem" (Manager 3).

"In the segregation part, it's only occasional. People are busy, you understand? Sometimes, it happens" (EHP 4).

Sub-theme 3: Overfilling of temporary storage bins: While some of the participants stated that the staff usually comply with the specification of the guideline on the filling of the bins for temporary storage of waste, others indicated that they have sometimes found the bins filled beyond the demarcated line. However, the WMC Rep stated that they do not open the bins after collection from the healthcare facilities. They dispose the bins along with the waste, so,

filling beyond the recommended mark only poses risks to the HCRW generators and handlers at the healthcare facilities.

"We rarely have a problem with overfilling of bins, because there is a line on the containers, people know that when this line is reached, they have to close the lid" (IPCC 1).

"Our staff are compliant, they do not fill the bins beyond the demarcated line" (Manager 5).

*"You may find that they (HCRW generators) are overfilling the bins. There are enough bins, but, I think they were not trained about it" (*EHP 1*).*

"Sometimes, they fill the bins beyond the recommended line" (EHP 2).

'Nurses usually overfill the bins, though there is a line to demarcate the maximum level the bin should be filled up to' (EHP 3).

"We don't open the bins after collection from the hospitals and clinics. So, we don't even know if they are overfilled. But, overfilling of the bins, especially the ones containing sharps, can be dangerous to healthcare workers" (WMC Rep).

Theme 2: Training

Sub-theme 1: In-service trainings: To reinforce the trainings organized by the Department of Health, the IPCCs and Managers reported that they conduct in-service trainings for the staffs to keep them updated on HCRW guidelines. However, none of the healthcare facilities has a regular schedule for the training. In 2 of the hospitals, the IPCCs extracted Standard Operation Procedures (SOPs) from the Provincial guidelines, according to the peculiarity of their health institutions. Their responses on how they ensure that their staff are trained are found below:

"We remind ourselves by in-service training among ourselves, sometimes, a staff is called for training at the District, where we assign one of the staff to go there and update the others" (Manager 1).

"We have got our own SOP based on the Departmental guidelines. We *have made it more clearer by quoting time frame and other things, so that it becomes adaptable to our hospital"*(IPCC 1).

Sometimes, the in-service training is planned to be conducted at a specific time for all the staff; at other times, it is done for an individual staff when a wrong practice is observed.

"We usually do our in-service trainings on Wednesdays, because all staffs are on duty on that day. Those ones who are going off and those ones who are coming in, we all meet on Wednesdays. So, we utilize those days for in-service trainings, though we don't have it every Wednesday" (Manager 6).

"We do a daily checking, if there are mixing, we in-service each other that we must not mix the waste" (Manager 5).

To the question of who conducts the in-service training, a manager responded:

"We delegate. Sometimes, the training can be done by a professional nurse, sometimes, it can be done by our cleaners. Our cleaners are learned, so because they are the ones who collect waste, they are the ones who identify the problems, so, we delegate them and say "based on the challenges that you are encountering, we need an in-service training" (Manager 6).

Theme 2: Poor attitude of HCRW generators to training: Two of the participants complained of poor attitudes of HCRW generators to training on HCRW management.

"Once every year, service provider comes and do in-service training. We too, EHP and infection prevention and control nurses, we give ourselves time for training, maybe once in a week, in a ward that we have identified that they are having problems. In other wards, they will say "it is not us, it's the doctors". We realize that this is serious attitude. Our colleagues doesn't take us serious, even when they see us in the wards for rounds. They don't see any mistake, even when they have mixed" (IPCC 3).

"Well, I think it is ignorance. Because, if we are reinforcing every time and they are still doing the wrong things, it means they are ignorant" (Manager 7).

Theme 3: Enforcement of compliance

Measures to ensure compliance: In the clinics, the managers are responsible for enforcement of the guidelines, while the IPCCs are playing a similar role in the hospitals. The following are the responses of participants when asked who takes up the responsibility of ensuring compliance to the guidelines at the healthcare facilities:

"I am the one" (Manager 4).

"The Manager and the coordinator of waste management" (Manager 7).

"The infection prevention and control officer" (EHP 3)

A manager and an IPCC explain how they work to ensure compliance:

"I sometimes delegate people to make sure that they train every staff so that they can know what is it that should be done, but, after the in-service training, I have to make sure that they comply by revising with them" (Manager 4).

"We do inspections. We have got an inspection team, every unit must be inspected at least once in a month. Every unit must have a record of compliance for the month" (IPCC 1).

Participants were asked if they impose any fines on the staffs who do not comply with the guidelines or give incentives to those who comply, to encourage them. Below are their responses:

"No. We only congratulate those who comply and give notice to those who don't" (EHP 3).

"When I enter a ward to inspect and find mistakes, I tell them. After that, I write a report to be taken to the CEO, then, he will communicate with the staff. We do not impose any fines or incentives" (EHP 2).

However, a participant noted that the poor attitude of staff towards proper segregation can be attributed to a lack of fine for non-compliance.

"When you find out that medical waste has been mixed at some wards and you try to correct them, some will say, 'Yes, we do mix. Isn't it that it doesn't affect our pay, and they won't deduct anything?' I just assume that, maybe if there is any form of punishment, like deducting money from salaries, maybe they will comply" (IPCC 3).

3.3 Roles of the Waste Management Company

The waste management company provides the final treatment and disposal services (Table 5.3).

Table 5.3: Roles of Waste Management Company in Healthcare Risk Waste Management in Vhembe District

Themes	Sub-themes
Training	Provision of training manuals Conduction of trainings at healthcare facilities
Provision of Equipment	Supply of temporary storage and onsite transportation equipment Transportation of HCRW to the treatment and disposal center
Treatment and disposal	Treatment and disposal of all HCRW collected from the Province Documentations of HCRW generated, treated and disposed

Theme 1: Training

Sub-theme 1: Provision of training manuals: The waste management company has provided a training manual on HCRW to all the public healthcare facilities which contains detailed

information on waste segregation, containerization, color-coding and protective clothing. They have also provided the facilities with colorful posters to serve as visual aids to assist with HCRW segregation.

"We have our own training manual, which is a similar document to the guideline" (WMC Rep).

"We have a training manual from the service provider' (Manager 6).

The training manual basically contains information on the definition and categories of HCRW and the steps of waste management. It also details the colour-coding system for the bins and includes some notes on the importance and use of protective clothing and what to do in cases of accidents. However, the manual is lacking in information about occupational and environmental risks of poor management of HCRW. It provides no information about the various types of diseases which could be transmitted when medical waste is not properly handled.

Sub-theme 2: Conduction of trainings at healthcare facilities: Participants affirmed that the waste management company has been responsible for organizing training sessions for them.

"We conduct trainings on medical waste management at one hospital at a time, but with the clinics, we group them and train them at the sub-district levels. Our trainings are accredited by relevant professional bodies in South Africa and we offer CPD points to participants" (WMC Rep).

'*Once every year, the service providers come, call all the health facilities around and do the trainings and demonstrations on how to close the lids*' (IPCC 3).

'*Our contractor (the service provider) are the ones who take the trainings. They send representatives to conduct the training*' (EHP 4).

Theme 2: Provision of Equipment

Sub-theme 1: Supply of temporary storage and onsite transportation equipment: When participants in the healthcare facilities were asked how they usually acquire the equipment for HCRW storage and onsite transportation, they responded that the equipment are usually supplied by the waste management company, which they also referred to as the service provider. The WMC Rep also confirmed their report.

"The service provider supplies and gives me a list of what they supply which I submit to the Department" (EHP 1).

"We order them from the service provider" (Manager 7).

"We supply those equipment to the healthcare facilities. It is a part of our contract. When we receive an order from any of the healthcare facilities, we try to supply what they request for within 24 hours" (WMC Rep).

Sub-theme 1: Transportation of HCRW to the treatment and disposal centre: The waste management company is also responsible for transportation of HCRW from the central storage areas in all the healthcare facilities to the treatment facility of the company (offsite transportation). The frequency of transportation differs from one healthcare facility to another due to the size of the facility and the quantity of waste they generate. In the hospital, offsite transportation is done twice or three times a week, while in the clinic and the community health centres, it is done weekly, fortnightly or monthly. The WMC representative explained that the regularity of offsite transportation of waste from each facility is dependent on the quantity of waste they generate, and the schedule time for pick up is usually indicated in the contract they sign with the company. However, if a facility is having excess of HCRW, they can call upon the WMC anytime outside their regular, schedule time.

"Our duty begins from the point of transporting the waste from the central storage rooms at the healthcare facilities. We use large trucks which are marked by the biohazard symbols and which are dedicated for that purpose only. We are concerned with only the risk waste, we do not deal with general waste, because the municipalities are the ones in charge of that" (WMC Rep).

"They come to pick the waste three times a week - Mondays, Wednesdays and Fridays" (IPCC 1).

"Twice a week - Tuesdays and Thursdays" (IPCC 3).

"They come once in a week – every Tuesday. They don't delay" (EHP 2).

"They come, every two weeks on Wednesdays" (Manager 2).

"The service provider collects fortnightly. When we have a load of medical waste, we do call them even though it is not due time for them. They indicated that you can even call us if you have an overload of medical waste" (Manager 6).

Theme 3: Treatment and disposal

Sub-theme 1: Treatment and disposal of all HCRW collected from the Province: All waste generated from all the healthcare facilities are treated at the treatment facility of the service provider. Participants from the healthcare facility do not know what happens to the waste after it has left their healthcare facilities, except that they have a certificate usually returned to them by the WMC, which says the waste was treated by disinfection and incineration and then safely disposed. The participant from the WMC stated that they use both the burn and non-burn techniques for the treatment of the waste:

"We use the incinerator for the treatment of anatomical, pharmaceutical and infectious waste. However, we also use the non-burn techniques like the autoclave and a converter machine (H2000) for the treatment of sharps and vials. We destroy the waste along with their containing bins to avoid the risk of pricks and infections. We do not open the bins at the treatment site, we only weigh the bins and then load them onto the machines" (WMC Rep).

The final disposal of the ash is done into an hazardous landfill site:

"We transport the resulting ash generated from the treatment of all the waste to an hazardous land fill site at Gauteng Province because we don't have such a landfill in Limpopo Province, and we cannot dispose it into a general landfill site because of the nature of the waste" (WMC Rep).

Sub-theme 2: Documentations of HCRW generated, treated and disposed: The WMC documents all records of HCRW collected, treated and disposed by their company. They share these records with the DoH and the healthcare facilities through the districts. However, some clinics and community health centres do not have the safe disposal certificates:

"The WMC submits copies of the records of the quantities of HCRW they pick up from each healthcare facility in the Province, as well as the safe disposal certificates to the Department. We compare these records with the ones we obtain from the healthcare facilities through the districts, so that if there are differences, we will know" (DoH Rep 1)

"When the service provider comes to pick the waste from our central storage areas, they usually check the weight of all the waste and give us a copy of the form. One of our nurses is usually designated to stay with them, cross-check the weights and collect a copy of the form for filing" (Manager 6).

"They (service provider) usually submit a copy of the safe disposal certificate to the District, from where they forward a copy to my mail" (Manager 4)

"I don't know about disposal certificate. All we have is the forms where they have documented the quantity of waste they took from our clinic. Maybe they can have the certificate at the district office" (Manager 4).

3.4 Stakeholder Analysis

Knowledge of the current state of HCRW: The WMC was found to have the highest level of knowledge about the state of HCRW and the risks posed by the management of such waste. They are also more familiar with the best practices for the treatment and disposal of each category of the waste. It is thus not surprising that the DoH has contracted them to take up the responsibility of training the healthcare workers. The representatives from the DoH were also noted to have an appreciable knowledge on the status of HCRW management in the Province as a whole and Vhembe District specifically. They are well acquainted with the data from the District about the quantity of waste generated, the number of staff trained, etc. The level of knowledge on HCRW management was at the lowest at the healthcare facilities. Many workers do not pay much attention to waste because they do not consider it as a part of their job description.

Priority: The DoH placed an utmost priority on HCRW segregation from the point of generation, thus, they intensified the training of healthcare workers and promptly make payments for segregation equipment whenever the invoices for such are submitted. However, in the healthcare facilities, the workers seem to be more concerned about their safety, and as such placed a higher priority on the PPE, Hepatitis B immunization and standard central storage areas. It was difficult to detect where the priority of the WMC lies as the participant did not stress any issue over the other.

Degree of influence: From the result presented above, it is obvious that the DoH is the most important stakeholder of HCRW management in the District because the Department weird the most influence on the other two stakeholders. The DoH employs and pays the salary of healthcare workers, they also contracted the WMC and pay for all their services. Thus, the Department retains the power to determine the fate of each of the healthcare worker and the status of the contract of the WMC at any period. This power and influence places the Department at a hedge over the other two main stakeholders. However, the influence of the

DoH on overall management of HCRW in the District is limited by the fragmented structure of the Department. The waste management sector of the Department is also dependent on other sectors like the finance and infrastructure to function optimally. Thus, many actions towards improved management of HCRW proposed by the waste management sector cannot be realized without the readiness of the other sectors. This might consequently result in delays in implementation of important plans.

The healthcare facilities (HCFs) also hold a pivotal role as HCRW management stakeholders, because they determine the quantity of HCRW which leaves their facilities to the WMC. Since the Department pays for the treatment of the waste per kilogram of waste, the HCFs determine the eventual cost of HCRW treatment and disposal. Through proper segregation, they can minimize the quantity of HCRW they generate. However, their influence on both DoH and WMC is limited. The WMC also has a limited degree of influence on either the DoH or the HCFs. Though the company contributes the skills, human resources for training and provides the equipment needed, their services are limited by the contract. They spontaneously lose their influence on the fate of HCRW in Vhembe District as soon as their contract is terminated.

The Department of Environmental Affairs (DEA) also holds some stake in the issue of HCRW management. They conduct Environmental Impact Assessment (EIA) for the WMC before the latter can be allowed to implant an incinerator and they are also responsible for monitoring the WMC's activities to ensure that the environment remains safe. However, their specific roles on HCRW management is not clearly defined in this study, because despite many attempts made by the researcher, she was unable to get the audience of any representative from the DEA for an interview.

3.5 Stakeholder Networking

This study has helped to identify the main stakeholders involved in management of HCRW in Vhembe District and their specific roles. These roles are intertwined and interdependent one on other. Figure 5.1 shows the network of their roles.

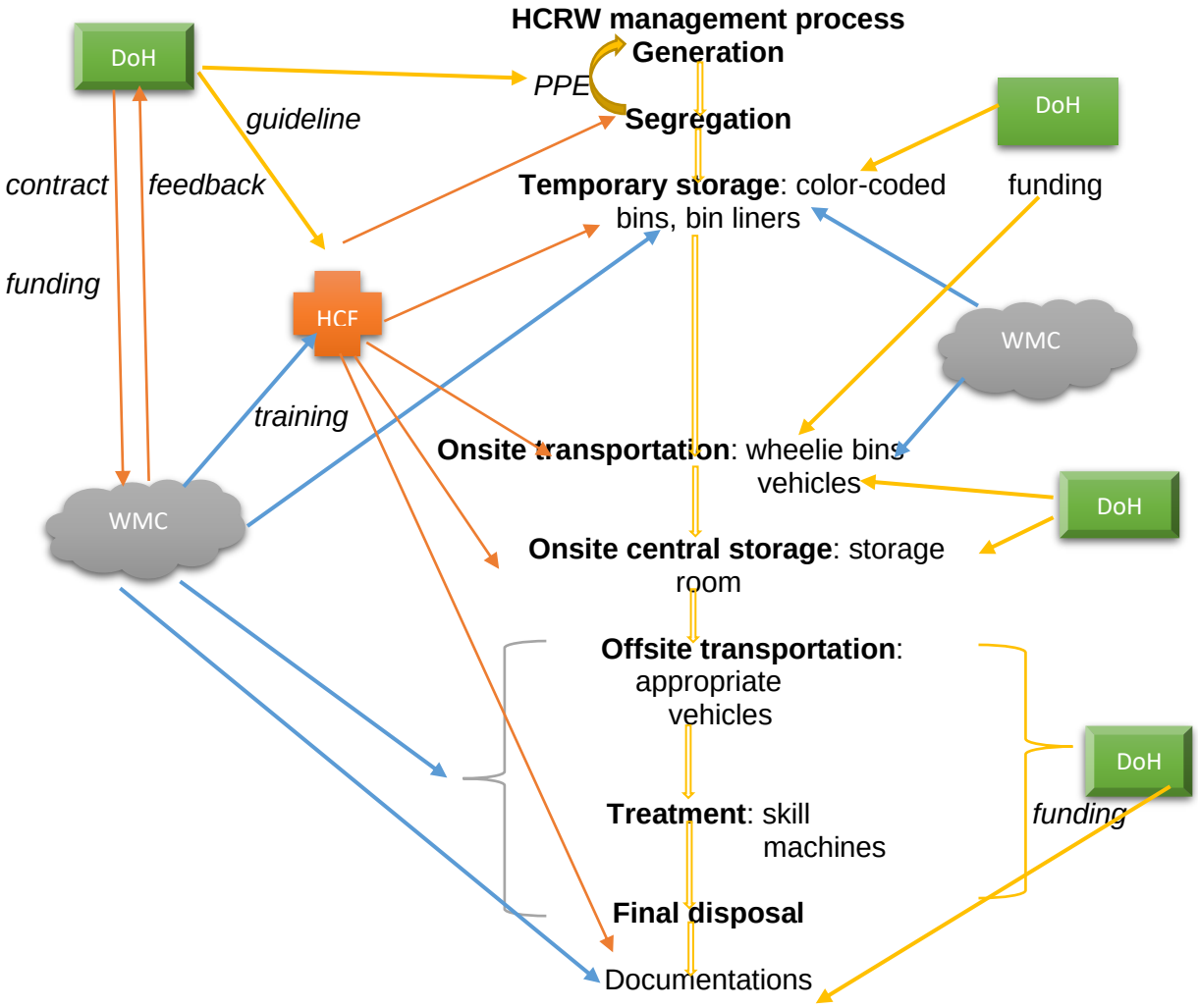

Figure 5.1: The roles of stakeholders in HCRW management in Vhembe District Municipality and the interdependence of the roles on one another.

Legend: DoH – Department of Health, HCF – Healthcare facility, WMC – Waste Management Company.

Discussion

The successful management of HCRW in Vhembe District depend on the interactions of the aforementioned stakeholders, which is based on their understanding of HCRW management project and their willingness to ensure its success (Liang *et al.*, 2017). However, the disparity in the priorities of the stakeholders and the communication gap have impacted negatively on the proper management of HCRW in the District. While the Department was commended to have been efficient with regular provision of guideline on HCRW management for the province, as well as the payment of all costs incurred in the process of HCRW management in the District, some participants in the HCFs bitterly complained about insufficient PPE and unavailability of Hepatitis B vaccine. Insufficient supply of PPE has also been reported in another province of South Africa (Mahasa & Ruhiiga, 2014) and in the absence of basic PPE

like gloves, healthcare workers have been forced to improvise with plastic bags or handle HCRW with their bare hands because it is difficult for them to manipulate their fingers to work when their hands are covered with plastic bags (Hangulu & Akinola, 2017). This practice obviously exposes them to the dangers of contracting diseases through bloodborne pathogens prominent among which are Human Immunodeficiency Virus (HIV), Hepatitis B and Hepatitis C (Mastorakis *et al.*, 2010). Hossain *et al.* (2013) have advocated that the use of PPE could minimize accidental exposure to these viruses and minimize their transmission among healthcare workers.

The unavailability of Hepatitis B vaccine for healthcare workers in Vhembe District is also a cause for concern as the virus rank high among viruses which can be easily contracted by healthcare staffs and could also be transmitted to patients through infected healthcare workers (Rossouw *et al.*, 2014; Lewis *et al.*, 2015). Healthcare workers who work directly with patients have been reported to have a higher prevalence rate of seropositivity to Hepatitis B, compared to those who do not (Lewis *et al.*, 2015) and pre-employment vaccination has been indicated as a means of reducing the menace of this virus among healthcare workers (Rossouw *et al.*, 2014). Makwakwa *et al.* (2014) reported a low rate (15.4%) of full immunization of healthcare workers against Hepatitis B in Gauteng Province of South Africa, this shows that this problem is not limited to the Limpopo Province. Some recent studies conducted in other African countries (Sierra Leone and Tanzania) also showed low immunization against Hepatitis B among health workers and thus their vulnerability to Hepatitis B infection (Qin *et al.*, 2018; Shao *et al.*, 2018).

Most of the healthcare facilities do not have standard central storage facilities for the temporary storage of HCRW until it is transported offsite by the waste management company. Security is compromised in many of the storage rooms, thereby making the stored waste accessible to rodents and unauthorized individuals. This puts the healthcare workers, patients and their relatives, as well as the nearby community at risk of injuries and infection. A similar challenge has been reported in other parts of the country (Maseko, 2014; Motlatla, 2015).

In the hospitals of Vhembe District, the administrators generally do not consider themselves a part of HCRW management team. They are of the opinion that the responsibility lies with the EHPs and IPCCs. Thus, they subconsciously dissociate themselves from waste management. This is not expected as the guideline from the Department of Health clearly states that the Chief Executive Officers and Managers are prominent members of the waste management team in the healthcare facilities (DoH publication, 2017). In a similar study in KwaZulu-Natal province of South Africa, Olaifa *et al.* (2018) reported poor monitoring and supervision of HCRW management practices. This will definitely impact negatively on the management of

the waste considering the fact that the administrators weird a strong influence on the healthcare workers. Lakbala and Lakbala (2013) affirmed that it is the duty of the heads of healthcare facilities to ensure that the guideline documents are accessible to all the staff and also organize and monitor the training of staff to ensure that they understand and comply with the instructions in the guideline. Inadequate participation of the administrators in the issues of HCRW management would result in mismanagement of the waste (Kuchibanda & Mayo, 2015).

Poor segregation practices were observed in all the facilities. This shows a lack of proper knowledge of the risks involved with poor segregation among healthcare workers and emphasizes the need for effective and continuous training. This practice is consistent with many other any previous reports in South Africa (Mahasa & Ruhiiga, 2014; Hangulu & Akinola, 2017; Nemathaga *et al.*, 2008; Raphela, 2014). Mixing of HCRW was sometimes blamed on patients and their relatives, whom participants claim that they were not trained on HCRW segregation. This can be minimized by a display of HCRW segregation messages in local languages (Shivalli & Sanklapur, 2014).

Compliance of staff to HCRW management guidelines is not satisfactory in all the healthcare facilities, though the HPCSA requires all healthcare practitioner to comply to the guidelines (HPCSA, 2016). Even some healthcare workers who have attended training sessions on HCRW management still do not fully comply with the guideline. Yenesew *et al.* (2012) reported that training of healthcare workers on HCRW management is significantly associated with their risk perception of healthcare waste. They stressed that the odds of adequate risk perception of healthcare waste was 2 times higher among healthcare workers who have a high knowledge about the diseases which are transmissible through poor management of HCRW than among those who do not have the knowledge. An adequate risk perception translates to full compliance with HCRW guidelines. We therefore recommend that a section should be included in the training manual, which details the risks of poorly managed HCRW including the diseases that could be transmitted to the healthcare workers and other members of the community. This should help to improve the compliance.

Conclusion

This study has described in details the roles of the main stakeholders in HCRW management in Vhembe District and analysed the networking between them. However, based on the lapses observed, the authors recommend that the communication gap between the stakeholders of HCRW management in Vhembe District be bridged to allow for a better management of HCRW in the District and in the province. This may be achieved through regular meetings

organized by the DoH, where each of the stakeholders can voice their concerns and priorities, such that all the concerns may be reviewed holistically and attended to. The safety of healthcare workers must be regarded as a matter of utmost importance by supplying adequate PPE and ensuring that all staff are immunized against Hepatitis B. A possession of the guideline document by each healthcare worker might result in improved compliance. Since the training schedules from the DoH are widely spaced in order to cover all the healthcare facilities, in-service trainings within each facility should be intensified to make every HCRW generator familiar with his/her role and responsibilities in HCRW management.

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Conflicts of Interest

The authors declare no conflicts of interest.

References

Braun V, Clarke V. (2006). Using thematic analysis in Psychology. Qual Res Psychol. doi:10.1191/1478088706qp063oa, 3:2, 77-101.

Caniato M, Tudor T, Vaccari M. Assessment of health-care waste management in a humanitarian crisis: A case study of the Gaza Strip. Waste manag. 2016; 58:386-396. doi: 10.1016/j.wasman.2016.09.017.

Caniato M, Tudor T, Vaccari M. Understanding the perceptions, roles and interactions of stakeholder networks managing health-care waste: A case study of the Gaza Strip. Waste Manag. 2015; 35:255-64. doi: 10.1016/j.wasman.2014.09.018.

Chartier Y, Emmanuel J, Pieper U, Pruss A, Rushbrook P, Stringer R, Townend W, Wilburn S, Zghondi R, eds. Safe management of waste from healthcare activities. Geneva, Switzerland: World Health Organization, 2014; 48-66.

Department of Environmental Affairs and Tourism. Survey of Generation Rates, Treatment Capacities and Minimal Costs of Health Care Waste in the 9 provinces of RSA. Department of Environmental Affairs: Pretoria; South Africa 2008; 53.

Deress T., Hassen F., Adane K. and Tsegaye A. (2018). Assessment of Knowledge, Attitude, and Practice about Biomedical Waste Management and Associated Factors among the

Healthcare Professionals at Debre Markos Town Healthcare Facilities, Northwest Ethiopia. Journal of Environmental and Public Health, Volume 2018, Article ID 7672981, 10 pages. https://doi.org/10.1155/2018/7672981.

Hangulu L, Akinola O. (2017). Perspectives of policy-makers and stakeholders about health care waste management in community-based care in South Africa: a qualitative study. BMC Health Services Research, 17:290. DOI 10.1186/s12913-017-2236-x.

Hangulu L, Akinola O. Health care waste management in community-based care: Experiences of community health workers in low resource communities in South Africa. BMC Public Health 2017; 17 (448). doi.org/10.1186/s12889-017-4378-5.

Health Professional Council of South Africa. Guidelines for good practice in the healthcare profession. Booklet 12. Pretoria: South Africa 2016; pp. 1-16.

Hossain M.S., Rahman N.N, Balakrishnan V., Puvanesuaran V.R, Sarker M.I. and Ab Kadir M.O. (2013). Infectious Risk Assessment of Unsafe Handling Practices and Management of Clinical Solid Waste. Int. J. Environ. Res. Public Health 2013, 10, 556-567; doi:10.3390/ijerph10020556.

Kuchibanda K, Mayo AW. Public Health Risks from Mismanagement of Healthcare Wastes in Shinyanga Municipality Health Facilities, Tanzania. The Scientific World Journal 2015, Article ID 981756, 11 pages. doi.org/10.1155/2015/981756.

Lakbala P, Lakbala M. Knowledge, attitude and practice of hospital staff management. Waste Management and Research 2013; 31(7) 729–732. doi: 10.1177/0734242X13484190.

Lewis JD, Enfield KB, Sifri CD. Hepatitis B in healthcare workers: Transmission events and guidance for management. World J. Hepatol 2015; 7(3): 488–497.

Liang X, Yu T, Guo L. Understanding Stakeholders' Influence on Project Success with a New SNA Method: A Case Study of the Green Retrofit in China. Sustainability. 2017: 9, 1927; doi:10.3390/su9101927.

Limpopo Provincial Government, Republic of South Africa, Department of Health (2017). *Health Care Risk Waste Guidelines*; Limpopo Provincial Department of Health: Polokwane, South Africa; pp. 1-15.

Limpopo Vhembe District Profile Handbook (2015). Retrieved from https://www.health-e.org.za/wp-content/uploads/2013/06/Vhembe-District-Fin.pdf.date on 05/06/2017.

Mahasa PS, Ruhiiga TM. Medical Waste Management Practices in North Eastern Free State, South Africa. Hum. Ecol 2014; 48(3); 439-450.

Makwakwa N., Fernandes L., Francois G., De Schryver A., van Sprundel M., Mphahlele M.J., Burnett R.J. (2014). Hepatitis B vaccination coverage of healthcare workers at Chris Hani Baragwanath hospital, Gauteng Province, South Africa. A poster presentation to the 16th International Journal of Infectious Diseases 21S on Thursday, April 3, 2014.

Maseko Q. (2014). Critical evaluation of medical waste management policies, processes and practices in selected rural hospitals in the Eastern Cape. Master's diss., Dept. of Environmental and Developmental Sociology, Rhodes University, South Africa, pp. 37-141.

Mastorakis N.E., Bulucea C.A., Oprea T.A., Bulucea C.A., Dondon P. (2010). Environmental and health risks associated with biomedical waste management. Development, Energy, Environment, Economics, 5:3; 287-295.

Motlatla MF. (2015). Assessment of health care waste management compliance in the Northern Cape Department of Health. Master's diss. Faculty of Health and Environmental Sciences, Central University of Technology, Free State, South Africa. pp. 65-80.

Nemathaga F, Maringa S, Chimuka L. (2008). Hospital solid waste management practices in Limpopo Province, South Africa: A case study of two hospitals. Waste Manage, 28(7), 1236-45.

Niyongabo E., Jang Y., Kang D. and Sung K. (2019). Current treatment and disposal practices for medical wastes in Bujumbura, Burundi. Environ. Eng. Res. 2019; 24(2): 211-219. https://doi.org/10.4491/eer.2018.095.

Njue, PM., Cheboi, KS., Shadrak O. (2015). Adherence to Healthcare Waste Management Guidelines among Nurses and Waste Handlers in Thika Sub-county- Kenya. Ethiop J Health Sci. 2015 Oct; 25(4): 295–304.

Olaifa, A., Govender, R.D. and Ross, A. (2018). Knowledge, attitude and practices of healthcare workers about healthcare waste management at a District Hospital in kwaZulu-Natal. South African Family Practice, 60:5, 137-145.

Olaniyi, F.C.; Ogola, J.S.; Tshitangano, T.G. (2019). Efficiency of Health Care Risk Waste Management in Rural Healthcare Facilities of South Africa: An Assessment of Selected Facilities in Vhembe District, Limpopo Province. *Int. J. Environ. Res. Public Health*, *16*, 2199. doi:10.3390/ijerph16122199.

Oyekale A.S. and Oyekale, T.O. (2017). Healthcare waste management practices and safety indicators in Nigeria BMC Public Health 17:740. doi: 10.1186/s12889-017-4794-6.

Promotion of Access to Information Act (PAIA), Limpopo Department of Health and Social Development. (2015). South Africa, Pretoria: Government Printer.

Qin Y, Li B, Zhou Y, Zhang X, Li L, Song B *et al*. Prevalence and associated knowledge of hepatitis B infection among healthcare workers in Freetown, Sierra Leone. B*MC Infectious Diseases* 2018; 18:315 doi.org/10.1186/s12879-018-3235-1.

Raphela SF. Treatment and disposal of medical waste in rural and urban clinics within Polokwane municipality of South Africa. J. New Gen. Sci. 2014; 12 (2): 97-109.

Rossouw TM, van Rooyen M, Louw JM, Richter KL. Blood-borne infections in healthcare workers in South Africa. S Afr Med J 2014;104(11):732-735. doi:10.7196/SAMJ.8518.

Shao ER, Mboya IB, Gunda DW, Ruhangisa FG, Temu EM, Nkwama ML *et al*. Seroprevalence of hepatitis B virus infection and associated factors among healthcare workers in northern Tanzania. *BMC Infectious Diseases* 2018; 18**:**474 doi.org/10.1186/s12879-018-3376-2.

Shivalli S, Sanklapur V. Healthcare Waste Management: Qualitative and Quantitative Appraisal of Nurses in a Tertiary Care Hospital of India. The Scientific World Journal 2014, Article ID 935101, 6 pages. doi.org/10.1155/2014/935101.

Shrivastava SR, Shrivastava PS, Ramasamy J. Emphasizing the role of stakeholders in the safe disposal of biomedical wastes. J Clin Sci. 2015 ;12:57-8.

Tolley EE, Ulin PR, Mack N, Succop SM, Robinson ET. (2016). Qualitative methods in public health: a field guide for applied research (2nd Ed.). Wiley.

World Health Organization. Facts sheets - Health-Care Waste. Geneva: WHO, 2018. https://www.who.int/news-room/fact-sheets/detail/health-care-waste (accessed 7 May 2019).

Yawson, P. (2014). Assessment of solid waste management in healthcare facilities in the Offinso municipality. Unpublished Master's dissertation. Kumasi: Kwame Nkirumah University of Science and Technology, pp 33-56.

Yenesew M.A, Moges H.G, Woldeyohannes S.M. (2012). A cross sectional study on factors associated with risk perception of healthcare workers toward healthcare waste management in health care facilities of Gondar Town, Northwest Ethiopia. Int J Infect Control 8, 1-9. http://dx.doi.org/10.3396/ijic.v8i3.024.12.

CHAPTER SIX

PRESENTATION OF STUDY FINDINGS 3

This chapter unveils the challenges hindering proper management of medical waste in Vhembe District of South Africa from the healthcare workers' perspective. The chapter is presented as an article for publication in an accredited journal.

Challenges of Effective Management of Medical Waste in Low-Resource Settings: Perception of healthcare workers in Vhembe District Healthcare Facilities

Abstract

Waste generated from healthcare facilities must be safely managed from the point of generation to disposal to protect the waste generators, handlers and the community from their potential harmful effects. Many developing countries face various challenges in an attempt to manage medical waste properly and most of these challenges lie within the healthcare facilities. Healthcare workers generate the waste and are responsible for the initial handling, thus, their perceptions and knowledge are very essential to achieve a proper management of the waste. This study was conducted to investigate the challenges of effective management of medical waste in Vhembe District Municipality of Limpopo Province, South Africa from the healthcare workers' perspective.

The convergent parallel approach of mixed method design was adopted in this study. In-depth interviews were conducted for Managers of nine selected clinics and community health centres as well as Infection Prevention and Control Coordinators and Environmental Health Practitioners of four public hospitals in the District to gain insight into the challenges they perceive are facing them in their respective healthcare facilities, relating to medical waste management. Self-administered questionnaire was also employed to obtain data from medical waste generators and handlers to obtain their own views as well. Qualitative data was thematically analysed and Statistical Package for the Social Sciences version 25 was used to analyse the quantitative data.

The challenges identified by the healthcare workers include poor understanding of medical waste management guidelines and poor compliance with its instructions; lack of effective, regular training; poor attitudes of medical waste generators and insufficiency of waste management equipment as well as standard central storage rooms.

Most of the challenges reported were found to be linked to inadequate training of healthcare workers on the risks posed by poor management of medical waste to the healthcare workers

and the community as a whole. To achieve an effective management of medical waste in low-resource settings, efforts should be intensified at training the healthcare workers adequately and providing the necessary equipment.

Keywords: medical waste management, low-resource settings, compliance, attitude, training.

1. Introduction

Waste generated from healthcare facilities often contain potentially infectious and toxic substances (Niyongabo *et al.*, 2019). Medical waste therefore is classified as an important hazardous waste, second only to radiation waste (Wafula *et al.*, 2019). This necessitates that this type of waste must be managed with utmost care, and its generators and handlers must be guided by necessary regulations and guidelines. These guidelines are formulated by the World Health Organization (WHO) as well as appropriate and delegated authorities in different countries. In South Africa, the Department of Environmental Affairs and Tourism (DEAT), Department of Health (DoH) and Health Professions Council of South Africa (HPCSA) are involved in the formulation and enforcement of the policy in healthcare facilities and medical waste treatment facilities in South Africa (DEAT, 2006; HPCSA, 2016; DoH publication, 2017).

Efficient management of medical waste involves many processes which begin at the point of generation and ends at the point of final disposal of the waste. Most of these processes take place within the healthcare facilities and are determined by the healthcare workers who generate and handle the waste. Thus, their understanding of the intricacies of medical waste and the risks associated with poor handling and management of the waste, which forms their perceptions are very pivotal to a safe management of the waste (Kagonji & Manyele, 2016) and subsequently the safety of the environment with respect to medical waste.

Many researchers have reported poor management of medical waste in developing countries, including countries where there are well documented National Medical Waste Management Plans like Kenya, Lesotho, Nigeria and Angola (Sartaj & Arabgol, 2015; Njue *et al.,* 2015; Oyekale & Oyekale, 2017; Hassan, *et al.*, 2018). Non-enforcement of the policies, lack of adequate budget for policy implementation (Maseko, 2014), inadequate knowledge of healthcare workers, non-quantification of the waste at healthcare facilities, poor segregation, improper methods of treatment and disposal, lack of adequate and regular training of healthcare workers and poor attention to issues of medical waste management by Heads of healthcare facilities, medical waste generators and handlers are some of the challenges which have been identified in the process of managing medical waste in the developing countries (Olaifa et al, 2018; Kuchibanda & Mayo, 2015).

In South Africa, challenges like poor compliance to medical waste management guidelines from Provincial Departments of Health, poor segregation, lack of adequate equipment, insecure storage areas, lack of regular training, poor disposal methods like burning and incineration (using old technologies which do not comply with air emission standards and thus not environmentally friendly) as well as dumping of medical waste in unauthorized sites have been documented (Nemathaga et al., 2008; Vumase, 2009; *The Sunday Times*, 2009; Malebatja, 2013; Raphela, 2014; Hangulu & Akinola, 2017).

Just as the process of medical waste management begins from the waste generators (healthcare workers who work directly with patients like the doctors and nurses), so does the negative consequences of poor medical waste management begin from them. Blood borne infections like Human Immunodeficiency virus (HIV), Hepatitis B (HBV) and Hepatitis C (HCV) are commonly reported as the most common infections transmitted to healthcare workers through pricks from used needles on infected patients (Mastorakis *et al.*, 2010; WHO, 2018). Other possible consequences to healthcare workers are transmission of gastrointestinal infections like cholera through contact with waste stained with stool and vomitus from infected patients, respiratory infections, skin infections, meningitis, etc. (Mastorakis *et al.*, 2010, Hossain *et al.*, 2013). Healthcare workers, including medical waste handlers like the cleaners are also vulnerable to the toxic, genotoxic, corrosive, flammable, explosive, teratogenic and mutagenic actions of chemical and pharmacological waste (Mastorakis *et al.*, 2010) on their skins, mucous membranes and even their unborn babies when they indiscriminately come in contact with those substances through breakage of medication vials, spills, expired and unused medications.

Apart from healthcare workers, other humans in the community can also be affected by poorly managed medical waste, directly or indirectly. When such waste is inappropriately disposed in water, buried without proper disinfection or openly dumped, it becomes accessible to unauthorized individuals like scavengers and children, who are thus exposed to injuries and infections (Abor & Bouwer, 2008; Hangulu & Akinola, 2017). Water and soil pollution could also occur which tampers with the water and soil quality, causing pollution (WHO, 2018; Manzoor & Sharma, 2019). Furthermore, some common treatment methods of medical waste like incineration cause air pollution (Jorge *et al.*, 2004).

Many healthcare workers are unaware of these risks and so do not take the issues of proper management of medical waste seriously. Yenesew *et al.* (2012) has shown that an adequate risk perception of healthcare workers to medical waste is significantly associated with their knowledge about the diseases transmitted by poor management of medical waste. This study

was conducted to investigate the challenges of medical waste management in Vhembe District Municipality (VDM) of Limpopo Province, South Africa as perceived by the healthcare workers, mainly the medical waste generators and handlers. VDM was selected for this study out of the five District Municipalities of Limpopo Province because of many previous reports of poor management of medical waste in health institutions of the District.

2. Method

Vhembe District is made up of 4 local municipalities and 165 public healthcare facilities including Hospitals, Clinics, Community Health Centres (CHCs) and Mobile Clinics. There are also private owned surgeries, laboratories, pharmacy stores and other sources where medical waste is generated in small quantities which were excluded from this study for ease of access. Mobile clinics were also excluded because they do not have specific locations.

From each of the local municipalities, a hospital, 2 clinics and 1 community health centre (CHC) were randomly selected for this study to ensure the representation of each hierarchy of health facility in the study sample. Thus, 4 hospitals, 8 clinics and 3 CHCs were sampled, as one of the local municipalities has no community health centre. The study population is made up of administrative heads as well as medical waste generators and handlers from the selected facilities. As at the time of conducting the study, there were 6, 074 health workers in the District, including the support staff (cleaners, administrators, etc). The Sloving's formula was used to determine the sample size as follows:

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

where n=sample size, N=total population and e=margin of error, set at 0.05

$$n = \frac{N}{(1 + Ne^2)} = \frac{6074}{(1 + 6074(0.05^2))} = 375.28$$

This sample size was distributed over the different categories of medical waste generators and handlers.

The convergent parallel approach of mixed method was employed for the study. In-depth interviews were conducted for Infection Prevention and Control Coordinators (IPCCs), Environmental Health Practitioners (EHPs) and Managers from the clinics and CHCs. Their consents were obtained before the interviews were conducted and a voice recorder was used to record the conversations. Small group discussions were also conducted for groups of nurses and cleaners in some of the facilities. Thematic analysis was employed for the qualitative data.

A semi-structured questionnaire was employed to obtain information from medical waste generators and handlers in all the facilities about the challenges they face while trying to manage medical waste. An information letter which detailed all the necessary information about the study was distributed to eligible respondents and those who volunteered to participate in the study were required to sign the informed consent forms before being given the questionnaires. Questionnaires were self-administered by the researcher and her assistant, however, only 229 were fit for analysis after data cleaning, this accounts for a response rate of 61.1%. Analysis was done using the Statistical Package for the Social Sciences (SPSS), version 25. A digital camera and an observation checklist were also kept handy throughout the field work to record all observations and take relevant pictures in order to validate or reject the responses obtained through the interviews and questionnaires.

3. Results

3.1 Sociodemographic characteristics of participants and respondents

Participants: The four EHPs were all interns who were on contract to work in the hospital for only 1 year, a period of their community service. As at the time of conducting this study, they have held the position for 7-11 months. Three IPCCs who volunteered for the interviews are nurses with various professional qualifications in the field of Nursing. They have worked in that capacity for 1, 5 and 7 years respectively in their hospitals. From the eleven clinics and CHCs, only seven Managers were available for the interviews at the time of visits to their healthcare facilities. The Managers are also professional nurses and have occupied the managerial positions for a mean duration of 10.6 years (Range: 4 -26 years).

Respondents: A total of 229 healthcare workers completed the questionnaires. This number consisted mainly of professional nurses (n=150, 65.5%) (Figure 6.1). There were more female respondents (n=194: 84.7%) and their age ranged from 18 to 64 years (mean = 40.0 years). Regarding professional experience, more than half (65.67%) of the respondents had 1-10 years', 39 (19.40%) had 11-20 years' and 30 (14.93%) had 21-30 years' professional experiences in their respective healthcare facilities. The student nurses have spent only about two weeks in the hospitals as at the time of data collection, however, they were allowed to participate in the study because they were recommended by the operational managers in their wards to be knowledgeable about medical waste management processes.

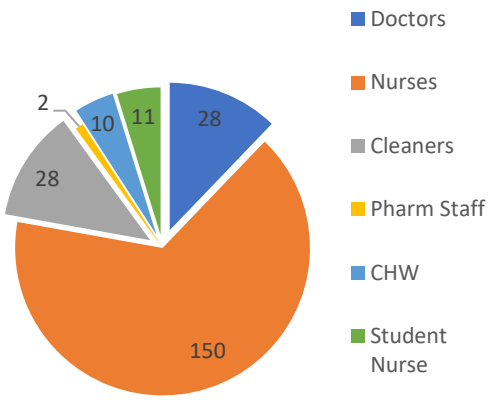


Figure 6.1: Professional categories of respondents consisting mainly of nurses. CHW: Community Health Workers.

3.2 Availability of medical waste management guideline document in the health facilities and accessibility of staff to the document

A medical waste management guideline drafted by the Department of Health (DoH), Limpopo Province was found in all healthcare facilities in the province. Also, a training manual on medical waste management prepared by the waste management company on contract with the DoH to treat and dispose the waste generated from public health facilities is also available in the healthcare facilities. In the hospitals, every ward is equipped with at least one of these documents for easy access by the healthcare workers. However, in the clinics and CHCs, only one copy of these documents kept in a "Waste Management" file in the Managers' offices. Apart from the documents, two of the four hospitals have also extracted a Standard Operating Procedure (SOP) from the guidelines which they have adapted according to the peculiarities of their own facilities. The SOP is a simplified and summarized version of the guideline, to make it easier for the staff to access the information and it is made available in every ward. One of the IPCCs has this to say:

"We have the one (guideline) *that is a Departmental one. But, we also have got our own extracted from the Departmental one. It's based on what the Departmental is saying, but, we have made it more clearer by quoting time frame and other important things peculiar to us, so that it becomes adaptable, but, it is based on the Departmental guideline. The SOP is available in all the wards" (IPCC 1).*

In another hospital, the SOP was seen pasted on the wall in the maternity ward. However, out of the eleven clinics and CHCs where data were collected, only one clinic was found to have the SOP, which was kept in the Waste Management folder in the Manager's office. The

Manager of a CHC explained her effort and challenges of extracting an SOP from the Departmental guideline:

"I have been trying to extract an SOP for us in this health centre from the provincial guideline and the training manual from the service provider (waste management company)*, but, there are many other issues to attend to. It is still in my mind to do it and paste it in all cubicles, because I have realized that staffs do not come to the office here to access the information in the guidelines. That is why they have not been fully compliant"* (CHC Manager 1).

While completing the questionnaires, majority of the respondents (n=199; 86.9%) stated that a guideline for medical waste management is available in their institutions, while only 12 (5.2%) and 7 (3.1%) respectively responded in the negative or that they were not sure. Regarding accessibility, the respondents indicated that the guideline document is available only in the office of the Head of the facility (n=51; 22.3%), in every ward (n=136; 59.4%) or every staff has a personal copy (n=9; 3.9%).

3.3 Training

The respondents and participants in this study identified the Department of Health and the service provider (waste management company) as those in charge of training healthcare worker on the appropriate management of medical waste. However, most of them stated that there was no regular schedule for such training and the interval between a training section and another one may be as far as one year, consequently, some of the healthcare facilities have devised another means of training their own staff which they refer to as "in-service training". These in-service trainings are more regular and usually provided for staff who are found to be mishandling medical waste. In some clinics, the in-service training is done every week. In the hospitals, the in-service trainings are conducted by EHPs and IPCCs whenever they go on routine inspection rounds in the wards, especially when they find something wrong, e.g. mixing of different categories of medical waste. In the clinics and CHCs, the trainings are conducted by Managers, assigned nurses or sometimes cleaners. Apart from the in-service trainings, some healthcare facilities send their staff members in turns for training on medical waste management outside their facilities and whoever has been trained is expected to train the other staff on his/her return. Below are excerpts from the interviews:

"Yes. we have our own schedules and the Department is also training at least once a year. The company which has been contracted to collect the waste also organize such trainings. We had a training in September or August this year (2018)*"* (IPCC1)*.*

"The people who are conducting the in-service training are from the service provider. From the Department, we are being directed that we must comply with what the service provider is telling us" (Clinic Manager 2).

"We usually do our in-service trainings on Wednesdays because all staff are on duty on that day. Those who are going off and those who are coming in, we all meet on Wednesdays. Sometimes, the training can be done by a professional nurse, sometimes, it can be done by our cleaners. Our cleaners are learned, and since they are the ones who collect waste, they are the ones who identify the problems, so, we delegate them to in-service train us based on the challenges that they are facing" (CHC Manager 1).

"We remind ourselves by in-service training among ourselves, sometimes a staff is called for training at the District, where we assign one of the staff to go there for training and update the other staff" (Clinic Manager 1).

Among the respondents, more than half (n=161, 70.3%) indicated that they have been trained on medical waste management while 52 (22.7%) said they have not been trained. Among those who have been trained, the cleaners have the highest percentage (87.5%), followed by community health workers (81%), nurses (79.6%) and doctors (38.5%).

3.4 Attitudes of health workers to issues of medical waste management

In the hospitals, the responsibility of ensuring compliance and monitoring of staff for proper medical waste management fully rest on the IPCCs and EHPs. They are also responsible for the ordering of medical waste segregation equipment and keeping of records of medical waste transported out of their facilities. The Managers perform these duties in the clinics and CHCs, though they sometimes delegate one of the nurses to be responsible for infection control, which includes waste management for a specific period of time.

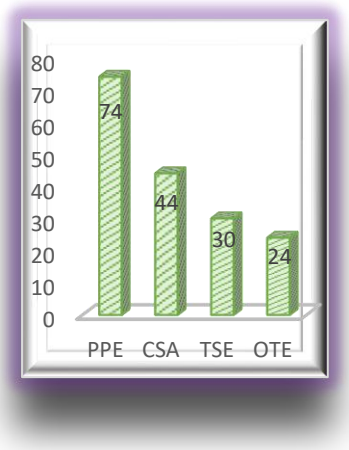
Most medical waste generators in the healthcare facilities do not consider the management of medical waste as a part of their job description, thus, they displayed a poor attitude to training and do not make a good effort to comply with the instructions in the guideline. An IPCC complained about the attitude of healthcare workers to training and segregation of medical waste into various sub-categories at source when she was asked to clarify if healthcare workers segregate poorly because of lack of knowledge.

"No, they know exactly 150%, it's the attitude. Once every year, the service provider comes and do in-service training. We too, EHP and infection control nurses, give ourselves time, maybe once in a week, to conduct training in a ward that we have identified that they are having problems. Most of the times, they will put the blame on the student nurses or the doctors. If we find out they have mixed waste, we would call the operational manager in charge

of the ward there and then and show him/her the waste which has been mixed. But, some will say "Yes, we do mix, since it doesn't affect our pay, and they won't deduct anything from our salaries. So, we know the problem is staff attitude" (IPCC 2).

3.5 Sufficiency of medical waste management equipment

The personal protective equipment (PPE) which includes gloves, face masks, aprons and boots are directly supplied to the healthcare facilities by the Department of Health. These equipment prevent the healthcare workers from direct contact with medical waste at the point of generation and while transporting it from one place to another within the healthcare facilities. However, other equipment for the temporary storage of medical waste (colour-coded bins) and onsite transportation (wheelie bins) are supplied to the healthcare facilities by the waste management company. To the question of whether there are sufficient equipment for proper management of medical waste in their facilities, more than a half of the respondents (n=144, 62.9%) responded in the affirmative, while 67 (29.3%) ticked the option "no". However, during the group discussion sessions with small groups of nurses and cleaners, many staff agreed that they do not have sufficient equipment and adequate storage facilities (a standard central storage area within the healthcare facility). Seventy-four (32.3%) respondents identified PPE as the equipment in short supply, while varying numbers of healthcare workers also identified some other equipment (Figure 6.2).



Key

PPE: Personal Protective Equipment

CSA : Central Storage Area

TSE : Temporary Storage Equipment (i.e. colour-coded bins)

OTE: Onsite Transportation Equipment

Figure 6.2: Number of respondents who indicated insufficiency of equipment and storage facilities.

The leading response about the reason for insufficiency of the equipment is that they were not been regularly supplied by the Department of Health (n=11, 4.8%). Non-replacement of old, reusable equipment (n=4, 1.7%) was another reason. Most of the respondents did not respond to the question. When asked whether they have enough equipment for medical waste management, a Manager expressed her frustration:

"*We don't have. Everything is out of stock. We are ordering, but, the stock is not coming. With the aprons, it's better because we are using the plastic ones. We are also using those old masks. But, we don't have a problem with gloves" (Clinic Manager 3).*

Another problem reported is with faulty equipment, especially the bins for temporary storage (faulty pedals or lids) and central storage rooms which are not built up to the standard (Figure 2).

"I can't say yes because you can find that the containers or bins for collecting are not functioning well, like when you are not supposed to use your hand to open the bin, but you find that the pedal is not working, so I cannot say they are sufficient, because sometimes we do run short of gloves. We are supposed to have containers or bins for general waste, but we are using the ordinary buckets, improvising, you can also find that the containers don't have lids. We also don't have good storage areas, we just find a room to store the waste, not even having a locker. Serious challenge is on shortage of equipment and they are not of quality and storage room not of the standard. Our central storage area has a door but it does not have a locker, it's not really up to the standard" (Clinic Manager 2)

When she was asked how they make sure that unauthorized people do not have access to the storage area, she responded:

"I am not sure, we are just happy that we have a storage, because at first, we were using one of the toilets, we are just happy because it's not tissue waste, because the refrigerator is inside. But because the storage room is not locked any person can come in, which is not safe for the community as well" (Clinic Manager 2).

However, some other Managers, IPCCs and the EHPs said they have sufficient equipment because they order directly from the service provider who supply them within few days of their order and send the bill to the Department of Health for payment.

More than half of the respondents (n=172, 75.1%) claimed that their storage areas are secured and not accessible to the public. However, an observation of most of the central storage areas except 3 of the Hospitals and few Clinics showed that they were not up to the required standards. Some did not have specific storage areas and they had to store their medical waste in the same room where they keep their cleaning and gardening tools (Figure 6.3).

a

b

Figure 6.3: Faulty bins and sub-standard central storage area. a. faulty temporary storage equipment: bins for sharps not properly closed

b. inadequate central storage area, where medical waste is stored alongside with cleaning and gardening tools. **(Source: Field work)**

A Manager of a CHC explained the consequence of a lack of standard central storage on the health workers and the community.

"We have a case when a man from the community sneaked into our central storage room because the lock is bad. He opened the buckets where we kept the sharps and vials, poured the needles and vials on the floor and ran away with the buckets. You can imagine the risks we were exposed to when we tried to put those things in other bins" (CHC Manager 2).

3.6 Occupational Health Concerns

The Occupational Health practitioner in one of the hospitals reported that she has received 40 reports of needle prick injuries among health workers in the past 12 months, 14 of which were from the hospital where she works and the others from other clinics around. Thirty-eight of those involved were medical waste generators (doctors, nurses, student nurses and community health workers) who got pricked while they were trying to discard the needle after use, one was a medical waste handler (cleaner) who got pricked while trying to transport the waste onsite and the last person was a gardener who got pricked by a needle lying on the floor when she tried to clean outside of the wards.

Despite the number of needle pricks, only one of the hospitals boldly claimed that all their staff are immunized against Hepatitis B up to date. In that hospital, the IPCC said their Pharmacist had to source for it outside Limpopo Province because the vaccine has not been available in the Province in a long time. Below are responses from participants on the availability of Hepatitis B vaccine in their healthcare facilities and immunization of their staff against the virus:

"The only thing we immunize against is hepatitis, but now we don't have the vaccine. The Department does not have it. It's out of stock for now, I don't know the reason, but I think it is being attended to. But, for now, we are not vaccinating. Though by routine, every staff member must be vaccinated against Hepatitis B" (IPCC 1).

"The vaccine has not been available in a long time, but, all the staffs who are yet to be immunized will get the vaccine as soon as it is available" (IPCC 2).

"Yes, many staff are immunized, but, that was a long time ago. You know with Hepatitis B they are not supposed to be immunized just once, some did not complete the course, some, they

are not yet immunized, like the new appointed ones because the vaccine is no longer here. I am not sure when we would be supplied next" (Clinic Manager 3).

We have the challenge of immunizing the staff against Hepatitis B. We are not getting enough support from the District. Because, it's like they have taken it as if it is our responsibility to

ensure that we immunize our staff. Sometimes, you find out that we utilize the vaccine whenever they are available. Sometimes they tell us that those vaccines are nearly to expire, let's just vaccinate the staff. I think there is no enough support for the clinics. We can immunize the staff now and then when it's time to immunize again, you find out that we don't have the vaccine. So, we are immunizing our staff, but, it's like we are not following the proper procedure, the way it should be done. If the District could coordinate the immunization by saying it is time for all the staffs to be immunized and also announce to say "all of you who were immunized that time, it is time again", that is the support we want. Because there is a Manager who is responsible for health, and we as Managers in the clinics, we do have multi responsibilities which we must take care of. So, sometimes, you find that we do immunize and when it is time to immunize them again, we do forget, you find out we are not following protocol as expected" (CHC Manager 3).

4. Discussion

This study presents the main challenges of medical waste management in Vhembe District from the healthcare workers' perspective. A major concern is the poor compliance of healthcare workers to medical waste management instructions as stipulated in the guidelines. Though guideline documents are available in all the healthcare facilities studied, access to these documents by staff members is relatively poor as the documents are kept in the files in the clinics and CHCs. In the hospitals, nurses have more access to them than doctors because a copy each was kept in each ward. This same observation was reported by Ramokate and Basu (2009) in their study conducted at Johannesburg hospital.

With regards to training, more respondents (70.3%) in this study claimed to have been trained on medical waste management compared with the result of a recent study conducted in KwaZulu-Natal Province where only 48.3% were reported to have had formal training on medical waste management (Olaifa *et al.*, 2018), yet, many staff indicated that there is no schedule for regular training on medical waste management in their facilities. With a lack of regular training, it is not unexpected, as has been reported in other studies, that many healthcare staff do not have an adequate knowledge about medical waste (Ramokate & Basu, 2009; Makhura et al., 2016; Olaifa *et al.*, 2018), especially about the subcategories. Without

this knowledge, a proper segregation of waste at source is not expected. Thus, it is not surprising that proper medical waste segregation

is not achieved in any of the facilities studied. Other previous studies have also documented poor segregation practices among healthcare workers ((Nemathaga et al., 2008; Raphela, 2014). Training has been documented to improve proper medical waste management practices among healthcare workers (Yenesew *et al.*, 2012; Wafula *et al.*, 2019).

Poor segregation practices may be due to a lack of adequate knowledge about the sub-categories of medical waste. Previous studies have shown that healthcare workers who have high and moderate knowledge about the various sub-categories of medical waste are more likely to have an adequate perception of the risks inherent in the waste and are thus more likely to manage the waste better than those who have low knowledge (Yenesew *et al.*, 2012). Also, healthcare workers who consider the issue of medical waste management as important are more likely to handle it better than those who do not (Wafula *et al.*, 2019). We hope that adequate training with emphasis on the subcategories of medical waste and the risks it holds for its generators and the environment would help improve the attitudes of healthcare workers towards medical waste management.

Insufficiency of temporary storage bins and waste bins with faulty lids and pedals also predisposes healthcare workers to mismanage the waste they must generate in the process of carrying out their duties. Some bins for infectious waste were found in wards and cubicles with non-functioning pedals, making it obligatory that the waste generator must manually open them before disposing the waste; other bins for sharps waste were found in the central storage rooms with their contents clearly visible because the lids did not close properly. The use of these faulty temporary storage equipment puts the healthcare workers and waste handlers at risk of coming into undue contact with the waste and getting injured or contracting infections.

Furthermore, the central storage areas for onsite storage of waste in most of the facilities were found to be below the standard. Where a storage area does not have a functioning lock, or with broken windows, the security of such site is compromised and it becomes inadvertently accessible to everyone. This puts the community at risk of coming into contact with such waste and subsequently being exposed to their toxic content.

Many respondents complained of lack of sufficient personal protective equipment, especially gloves, boots and masks. This is of a great concern considering the high incidences of needle prick injuries reported by the Occupational Health Practitioner. A single needle prick from an infected patient puts an healthcare worker at a 30% risk of contracting Hepatitis B (WHO, 2018), unfortunately, Hep B immunization has not been available throughout Limpopo

Province for a long time before this study was conducted. Thus, many healthcare workers are not protected against this deadly virus.

Conclusion

This study has revealed the challenges encountered in healthcare institutions of Vhembe District Municipality in the process of managing medical waste. To achieve an improvement in the management of medical waste in the District, the guidelines should be made more accessible to all healthcare workers and training must be made more regular. Personal protective equipment as well as other equipment for proper management of medical waste must be provided and the central storage areas built according to standards. Hepatitis B vaccine should also be made available as soon as possible to protect the staff.

Authors' Contribution: OLANIYI F.C conceptualized the study, collected and analyzed the data. She also drafted the first manuscript. OGOLA J.S provided guidance on data analysis and drafting of manuscript. Review and editing of the original manuscript were done by OGOLA J.S and TSHITANGANO T.G. All authors approved the final manuscript.

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Conflicts of interest: The authors declare no conflicts of interest

References

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

Department of Environmental Affairs and Tourism: (http://sawic.environment.gov.za/documents/486.pdf, 2006 (Accessed 28/02/2019).

Hangulu L, Akinola O. Health care waste management in community-based care: Experiences of community health workers in low resource communities in South Africa. BMC Public Health 2017; 17 (448). https://doi.org/10.1186/s12889-017-4378-5 (Accessed 10/08/2017.

Hassan A.A., Tudor T. and Vaccari M. (2018). Healthcare Waste Management: A Case Study from Sudan. *Environments* 5, 89.

Health Professional Council of South Africa. Guidelines for good practice in the healthcare profession. Guidelines for the management of healthcare waste. Booklet 12. Pretoria; 2016; pp. 1-16.

Hossain M.S., Rahman N.N, Balakrishnan V., Puvanesuaran V.R, Sarker M.I. and Ab Kadir M.O. (2013). Infectious Risk Assessment of Unsafe Handling Practices and Management of Clinical Solid Waste. Int. J. Environ. Res. Public Health 2013, 10, 556-567; doi:10.3390/ijerph10020556. http://dx.doi.org/10.3396/ijic.v8i3.024.12.

Jorge, E.; Hrdinka, C.; Ryder, R.; McKeon, M. and Berkemaier, R. (2004). Non-Incineration Medical Waste Treatment Technologies in Europe; Health Care Without Harm Europe: Prague, Czech Republic, pp. 6–35.

Kagonji I.S. and Manyele S.V. (2016). Analysis of Health Workers' Perceptions on Medical Waste Management in Tanzanian Hospitals. Engineering, 2016, 8, 445-459. http://dx.doi.org/10.4236/eng.2016.87042.

Kuchibanda K., Mayo A.W. Public health risks from mismanagement of healthcare wastes in Shiyanga Municipality health facilities, Tanzania. The Sci World J. 2015; 981756. doi: 10.1155/2015/981756.

Limpopo Provincial Government, Republic of South Africa, Department of Health (2017). *Health Care Risk Waste Guidelines*; Limpopo Provincial Department of Health: Polokwane, South Africa; pp. 1-16.

Makhura R.R., Matlala S.F., Kekana M.P. Medical waste disposal at a hospital in Mpumalanga Province, South Africa: Implications for training of healthcare professionals. S Afr Med J. 2016; 106 (11) 1096-102.

Manzoor J., Sharma M. (2019). Impact of Biomedical Waste on Environment and Human Health. *Environmental claims journal*, 31, 4, 311–334. https://doi.org/10.1080/10406026.2019.1619265.

Maseko Q. (2014). Critical evaluation of medical waste management policies, processes and practices in selected rural hospitals in the Eastern Cape. Unpublished Master's dissertation. Grahamstown: Rhodes University, pp. 37-141.

Malebatja, S.M. Knowledge and practices of health care workers on medical waste disposal at George Masebe Hospital, Waterberg District, Limpopo Province, South Africa 2013. Master's Diss. Dept. of Public Health, University of Limpopo, South Africa.

Mastorakis N.E., Bulucea C.A., Oprea T.A., Bulucea C.A., Dondon P. (2010). Environmental and health risks associated with biomedical waste management. Development, Energy, Environment, Economics, 5 (3) (2011), 287-295.

Nemathaga F, Maringa S, Chimuka L. Hospital solid waste management practices in Limpopo Province, South Africa: A case study of two hospitals. Waste Manage. 2008; 28(7), 1236-45.

Niyongabo E., Jang Y., Kang D. and Sung K. (2019). Current treatment and disposal practices for medical wastes in Bujumbura, Burundi. Environ. Eng. Res. 2019; 24(2): 211-219. https://doi.org/10.4491/eer.2018.095.

Olaifa A., Govender R.D., Ross A.J. Knowledge, attitudes and practices of healthcare workers about healthcare waste management at a hospital in KwaZulu-Natal. S A Fam Pract. 2018; 60(5): 137-145.

Ramokate T., Basu D. Healthcare waste management at an academic hospital: knowledge and practices of doctors and nurses. S Afr Med J. 2009; 99 (6).

Raphela SF. Treatment and disposal of medical waste in rural and urban clinics within Polokwane municipality of South Africa. J. New Gen. Sci. 2014; 12 (2): 97-109.

The Sunday Times. Medical waste found dumped in the backyard. 28 November 2009. https://www.iol.co.za/news/south-africa/medical-waste-found-dumped-in-back-yard-466096 (Accessed 15/02/2017).

Vumase BS. An Evaluation of Operational and Administrative Procedures for Health Care waste management in Public Hopitals of South Africa 2009. Unpublished thesis. Durban: Durban University of Technology, pp 117-185.

Wafula S.T., Musiime J. and Oporia F. (2019). Health care waste management among health workers and associated factors in primary health care facilities in Kampala City, Uganda: a cross-sectional study. BMC Public Health 19:203. https://doi.org/10.1186/s12889-019-6528-4.

World Health Organization (2018). Fact Sheet (Health-Care Waste). Accessed from https://www.who.int/news-room/fact-sheets/detail/health-care-waste on 05/01/2020.

Yenesew M.A, Moges H.G, Woldeyohannes S.M. (2012). A cross sectional study on factors associated with risk perception of healthcare workers toward healthcare waste management in health care facilities of Gondar Town, Northwest Ethiopia. Int J Infect Control 8, 1-9.

CHAPTER SEVEN

DEVELOPMENT OF INTERVENTION STRATEGIES FOR MANAGEMENT OF MEDICAL WASTE IN VHEMBE DISTRICT, SOUTH AFRICA

In this chapter, we present the proposed intervention strategies which were developed after the analyses, interpretation and convergence of both the qualitative and quantitative data. The chapter was submitted as *"Intervention Strategies to Improve Medical Waste Management in Vhembe District Municipality of Limpopo Province*" to the journal of Environments for possible publication.

Intervention Strategies to Improve Medical Waste Management in Vhembe District Municipality of Limpopo Province, South Africa

Abstract: Poor and ineffective management of medical waste from the point of generation to disposal in Vhembe District Municipality of Limpopo Province has been reported in some recent studies. Poor management of medical waste poses enormous threats to healthcare workers, patients and the entire community. Various interventions have been employed to improve medical waste managements in different countries to mitigate the effects of poor management of such waste. Based on the identified strength, weakness, opportunity and threat analysis, this paper presents the intervention strategies developed to improve management of medical waste in Vhembe District, using the Medical Research Council framework. The strategies were validated through feedback meetings with stakeholders from the Department of Health, waste management company and healthcare facilities.

Keywords: Vhembe District Municipality, medical waste management, intervention strategies, SWOT analysis, PESTEL analysis.

1. Introduction

The importance of safe management of medical waste from the point of generation to disposal cannot be overemphasized, considering the deleterious effects of poor management of such waste on healthcare staff, patients and the community as a whole (WHO, 2018). However, a safe management of medical waste requires a lot of resources, thus, many developing countries are unable to meet the requirements and as such face a lot of challenges managing their medical waste (Caniato *et al.*, 2016). Unlike what happens in developed countries, many malpractices regarding the handling of medical waste at healthcare facilities and waste

management companies have been reported in different developing countries, South Africa inclusive (Bassey *et al.*, 2006; Njue *et al.,* 2015; Wafula *et al.*, 2019; Olaniyi *et al.*, 2019).

A past study attributed an increase in epidemic outbursts and other health threats to poor management of medical waste (Harhay *et al.*, 2009). The deaths of About 5.2 million people, including 4 million children have been reported annually as a result of waste-related diseases and the situation was envisaged to get worse if proper intervention strategies are not formulated and diligently implemented (Akter, 2000). In South Africa, children and scavengers visit dump sites for recyclable materials, and when medical waste are openly dumped, some materials from the waste are taken back to the community without being properly disinfected (Hangulu and Akinola, 2017). An incidence like this has resulted in the need to treat some children with antiretroviral medications after they were pricked with needles dumped at the bank of a river (Abour and Bouwer, 2008).

To circumvent these harmful effects of poor medical waste management, appropriate intervention strategies must be put in place for proper management of such waste. For such interventions to be efficient, all stakeholders must be duely carried along in the formulation and implementation of such interventions and they must all be ready to play their parts (Shrivastava *et al.*, 2015). In South Africa, the important stakeholders include the Department of Health, healthcare facilities (especially the medical waste generators and handlers in the facilities) and the waste management companies which are on contract with the Department of Health to treat and dispose all medical waste generated in the different provinces.

Various strategies have been suggested for improved management of medical waste in developing countries. Olaifa, Govender and Ross (2018) recommended regular trainning of healthcare workers to familiarize them with the requirements for safe handling of medical waste according to the guidelines. Ara, Bashar and Tamal (2018) also described a multi-modal, muti-center intervention (MMI) through which they achieved a successful enhancement in the attitudes of nurses towards infection control in Bangladesh. The MMI consists of training with visual aids, introduction of colour-coded waste bins, formation of an infection control team, colourful posters, monitoring and feedback. Other researchers have also applied the SWOT (Strength, Weakness, Opportunity, Threat) strategies to the management of medical waste (Ankur *et al.*, 2016; Putra *et al.*, 2017).

In Limpopo Province of South Africa, both old and recent studies have reported improper handling and disposal management of waste generated from healthcare facilities (Nemathaga *et al.*, 2008; Malebatja, 2013; Raphela, 2014). Most of these reports were from studies conducted in urban healthcare facilities and they simply detailed the practices of medical waste management in the specific healthcare facilities where they conducted their studies.

The reports have remained basically the same over the years despite the various recommendations provided at the end of each of those studies.

A recent study in Vhembe District of Limpopo Province described the current practices of medical waste management in hospitals, clinics and community health facilities in the Districts as well as the challenges of managing medical waste in the District (Olaniyi *et al.*, 2019). In the light of that study, intervention strategies are proposed to improve the management of medical waste in the District. The development of the intervention strategies was guided by the Medical Research Council (MRC) Framework for the design of intervention strategies in the field of health sciences as adapted and described by Bleijenberg *et al.* (2018).

2. Methods

The Medical Research Council (MRC) Framework for Design of Intervention Strategies

The MRC framework was initially published in 2000 and has been updated systematically since then (Craig *et al.*, 2008). It has been credited as being the most cited guidance for developing and evaluating complex interventions in public health (Bleijenberg *et al.*, 2018) and it has been employed in developing a self-help guide for depression (Lovell *et al.*, 2008) as well as intervention strategies for infant feeding to prevent childhood obesity (Lakshman *et al.*, 2014) and improvement of adherence to high blood pressure treatment through the use of short message services (SMS) (Bobrow *et al.*, 2018). Bleijenberg *et al. (*2018) proposed a modified/simplified form of the framework, which is made up of seven phases, beginning from identification of the problem and culminating at the point where the intervention strategies are designed (Figure 7.1). The application of the phases in in this paper is presented below:

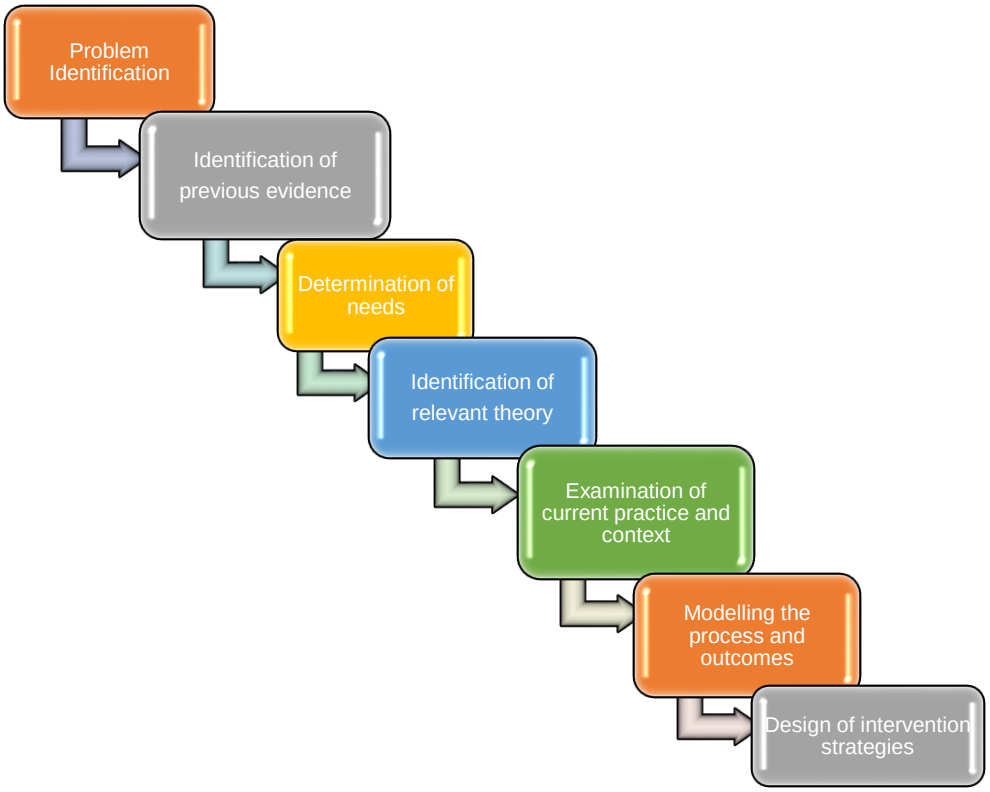

Figure 7.1. MRC's phases of development of intervention strategies

Phase 1: Problem identification

There are only two published studies currently available on the problems of medical waste management in Vhembe District Municipality, South Africa. The studies are from Nemathaga *et al.* (2008) and Olaniyi *et al.* (2019). The earlier study was focused on two selected hospitals in the District, and while the authors observed that the waste management practices in the hospitals were mainly based on the guideline document provided by the Department of Health, they also noted that the guidelines were not fully followed, especially with respect to segregation of the various types of solid medical waste at the point of generation, substandard central storage areas and final treatment and disposal of medical waste. Both hospitals treated their medical waste onsite - a small percentage of the waste (about 9%) was being treated by autoclaving, while the anatomical waste (human tissues, foetuses and placenta) were incinerated. The incinerators were old and did not comply with environmentally friendly standards; also, the incinerator ash, generated after incomplete combustion of the waste, were dumped openly near the incinerators rather than in landfills as recommended by the Department of Health. Furthermore, both hospitals operate landfills within the hospital premises, where infectious medical waste are dumped along

with general waste and burned together openly. Waste minimization and recycling were not prioritized (Nemathaga *et al.*, 2008).

These practices constitute human health and environmental hazards: Unauthorized individuals, insects and rodents, many of which are disease vectors, could easily gain access to the waste in the landfills before they are burned, thereby increasing the chances of transmission of diseases. Also, open burning of all forms of waste together, rather than being compacted and covered daily with a layer of soil, also result in generation of toxic substances like furans and smoke which cause air pollution (Nemathaga *et al.*, 2008). Incineration emits various pollutants including dioxins which have been linked to cancer, immune system disorders, diabetes, birth defects, and other health effects. Also, incineration ash at the bottom of the incinerator after burning often contain heavy metals which may leach and is thus potentially hazardous. The “fly ash” which escapes during burning may also contain toxic substances (Jorge *et al.*, 2004). The communities around the hospitals are the most affected by these hazards.

In the more recent study, Olaniyi *et al.* (2019) studied medical waste management practices in fifteen healthcare facilities (including four hospitals, eight clinics and three community health centres) in Vhembe District Municipality (VDM). They also reported poor compliance with the medical waste management guidelines, in terms of waste segregation from source, overfilling of the waste bins, transportation of waste to the central storage areas in inappropriate manners and substandard central storage areas at the healthcare facilities. However, as at the time of the recent study, medical waste was no longer treated or disposed onsite in any healthcare facility in VDM, rather, they are all transported to a waste management company which has been contracted by the Limpopo Provincial Department of Health to treat and dispose all the medical waste generated in the Province. However, some of the facilities still practice open burning of some parts of their general waste.

The persistence of implementation gap of medical waste management guidelines in the District over many years has necessitated the need to develop practical intervention strategies to mitigate the impacts of improperly managed medical waste in the community.

To gain an in-depth understanding of the current problems of medical waste management in VDM, a qualitative study was conducted in 15 healthcare facilities in the District. VDM is made up of four local municipalities. In each of these local municipalities, a hospital, two clinics and a community health centre (CHC) was sampled for the study, except in one local municipality where there are no CHCs. In-depth interviews were conducted for Infection Prevention and Control

Practitioners (IPCCs) and Environmental Health Practitioners (EHPs) in the selected hospitals as well as the Managers in the clinics and CHCs, since they are the ones who are directly involved with medical waste management in their respective healthcare facilities. Focus group discussions were also conducted with groups of nurses and cleaners, to understand their roles and challenges as medical waste generators and handlers, respectively. To corroborate the findings, medical waste generators and handlers were observed as they perform their duties and the waste bins were inspected for the appropriateness of the waste dumped therein.

The respondents to the interviews indicated that despite the availability of medical waste management guidelines in all their healthcare facilities, compliance to the recommendations therein is poor among medical waste generators and handlers. They suggested many possible reasons for the non-compliance, including lack of regular training, poor understanding of healthcare staff about their roles in medical waste management and their poor attitudes to trainings on the subject, insufficient personal protective equipment and color-coded bins for proper waste segregation at source and sub-standard central storage rooms in the facilities among others.

Phase 2: Systematic identification of previous evidence

A web search was made on Science Direct, PubMed, Environment complete, Medline, and Health Source for intervention strategies which have been previously adopted for the management of medical waste. The keywords used for the search include: “intervention strategies for management of medical waste”, “strategies for clinical waste management” and “intervention strategies for management of healthcare risk waste”. The search was restricted to materials (articles in academic journals, book chapters, magazines, etc) in the last 5 years (from 2015). The initial search from all the databases yielded a total of 10, 727 articles, after which materials which deal with interventions and strategies for other problems, as well as those which deal with non-medical types of waste (municipality, agricultural and electronic waste) were excluded. After further scrutiny and removal of irrelevant and duplicate materials, 169 articles, which deal directly with management of medical waste were selected.

A prominent intervention strategy which has been applied effectively in various settings is the training of healthcare professionals. This approach, alone or in synergy with other strategies has reportedly resulted in a significant improvement in the knowledge and practices of healthcare workers regarding medical waste management (Kumar *et al.*, 2015; Kumar *et al.*, 2016a; Kumar *et al.*, 2016b; Tabash *et al.*, 2016; Hosny, *et al.*, 2018).

A multi-modal, muti-center intervention (MMI) strategy consisting of training with visual aids, introduction of colour-coded waste bins, formation of an infection control team, colourful posters, monitoring and feedback was described by Ara, Bashar and Tamal (2018) as an

attempt to enhance the nurses' attitudes towards infection control in Bangladesh. The MMI strategy was reported to be successful as it resulted in an improved use of gloves (from 14.6% - 57.6%), biomedical waste segregation (from 1.8% to 81.3%) and consequently a reduction in needlestick injury (from 6.2% to 0.6%). Minimization strategies to reduce waste in pharmaceutical products involving de-prescription, medication review and drugs take-back programs were proposed by Afanasjeva and Gruenberg (2019).

Another novel health care waste management system which was implemented in all rural healthcare facilities in Kyrgyztan and has been reported to have lowered the cost of healthcare risk waste treatment by 33% is a system that involves training, using autoclavable containers for waste segregation, safe transport and temporary storage, mechanical needle removers, recycling of sterilized plastic and metal parts, cement pits for anatomical waste, composting of garden wastes, autoclave treatment of infectious waste, equipment maintenance, management by safety and quality committees and proper documentation (Toktobaev *et al.*, 2015).

Shen *et al*, (2017) also described a combination of various strategies, with which they were able to achieve a reduction in the quantity of waste generated in the intensive care unit of a hospital by 13.2%. Their strategies involve training, creation of waste classification-related slogans and posting promotional posters to help healthcare workers correctly classify medical waste into the various sub-categories, promoting the use of appropriate containers and establishing an environmental protection pioneer team for the monitoring of the waste.

Based on the assertion that the environment and health are interdependent and inseparable, Stedile *et al.* (2018) have proposed the application of the DPSEEA (Driving Force, Pressure, State, Exposure, Effect, and Action) model to the management of health care waste. They reported that the model is relevant in the monitoring and improving the methods of managing health care waste. They further stated that the model is an important analytical tool for both medical waste management and planning actions that will minimize risks, particularly chemical and biological, thereby resulting in environmental health and protection.

In the DPSEEA model, the *driving force* are related to the factors that affect the generation rates of health care waste. Such factors include urbanization and population growth rates, employment and income rates, hospitalization rates, morbidity and mortality rates. The *pressure* is due to an

increase in health care services at the healthcare facilities as well as an increase in the demands for the appropriate treatment and disposal of medical waste. This results in the *state* (situation) of environmental contamination by infectious and chemical waste, risk of increased occupational injuries and increased risk of infections. This situation results in the *exposure* of

the population to the polluted environment; The *effects* of this is an increase in the rate of infections, hospitalization, sharps injuries and transmission of infections. Actions (intervention strategies) are put in place at each stage of this model, to combat the various challenges (Stedile *et al.*, 2018). This model is summarized in Figure 7.2.

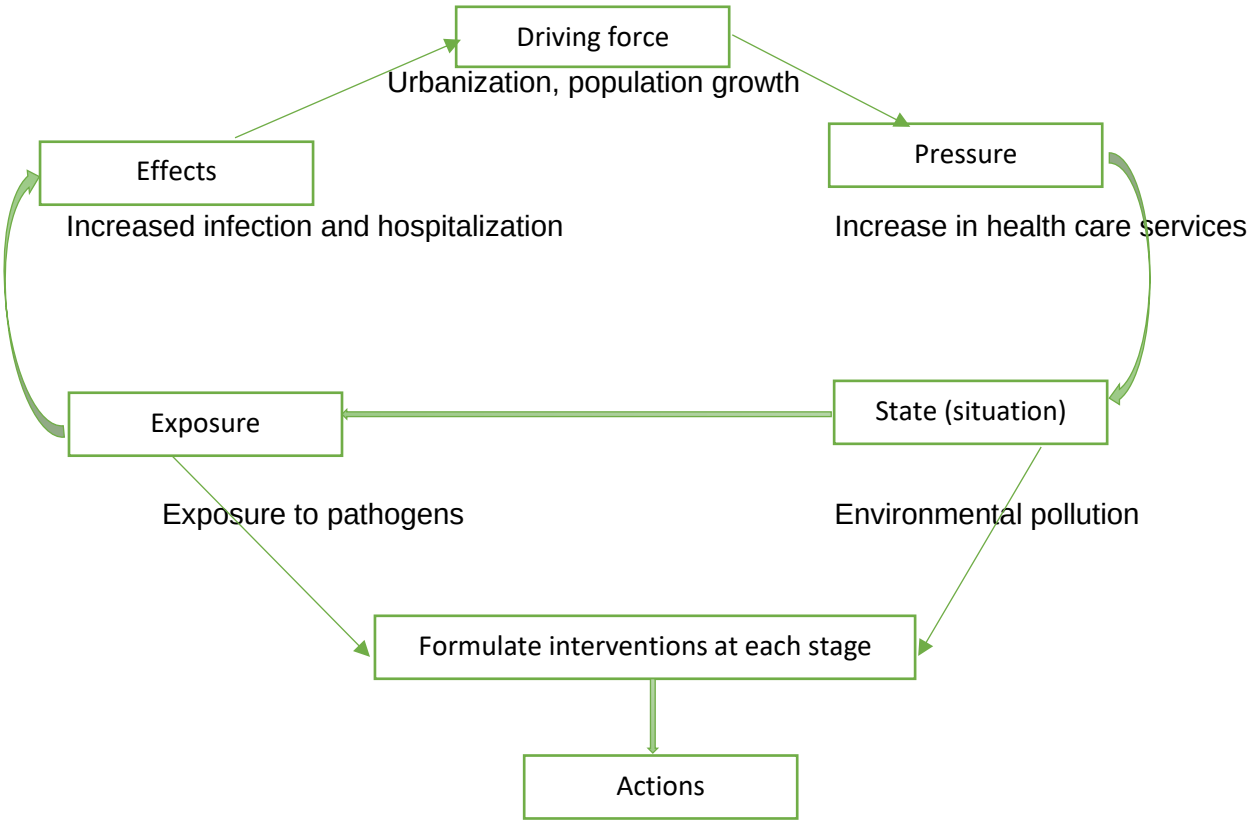

Figure 7.2. Application of DPSEEA model for management of medical waste, adapted from Stedile *et al.*, 2018.

Human factors, management strategies and availability of appropriate infrastructures have been documented as important factors, which must be carefully considered before attempting to implement an intervention strategy, because they could be barriers to proper management of medical waste (Delmonico *et al.*, 2018). Tabrizi *et al.* (2018) also affirmed that stakeholders' involvement as well as evidence-based planning are required for a successful implementation of an intervention strategy. These explain the rationale behind the suggestions of policy

formation and training of healthcare workers as major factors for a successful implementation of a medical waste management strategies.

Phase 3: Identification of relevant theory

Two theories were identified to be relevant to this study: the theory of waste management and the theory of planned behaviour. The principles of these theories were combined and applied during development of data collection instruments and to develop the intervention strategies.

i. The theory of Waste Management: The theory of waste management is founded on the expectation that the goal of waste management is to prevent waste from causing harm or injury to human or the environment (Pongrácz *et al.*, 2004). It contains conceptual analyses of waste, the actions taken upon waste as well as a holistic view of the goals of waste management. The theory seeks to promote waste minimization by analyzing different existing definitions of waste and introducing new, dynamic definitions in order to be able to construct a sustainable agenda for waste management (Pongrácz *et al.*, 2004).

Key concepts of this theory which find application in medical waste management debate are the definition of waste and waste categorization, reduction of the quantity of waste from source, turning waste into non-waste and preventing waste from causing harm to human and the environment (Pongrácz, *et al.*, 2004). It also gives an insight into the prediction of outcomes of waste management options and the choice of waste management technique.

ii. The theory of planned behaviour states that “a person’s behaviour is highly determined by his or her intention”. Intention in turns depends on a person’s attitude (feeling of favourableness or otherwise) towards the behaviour, influence of subjective norms (perceived social pressure) and perceived behavioural control (perceived ability to perform a behaviour)” (Ajzen, 1991 as cited in Akulume and Kiwanuka, 2016). Perceived behavioural control can influence behaviour either directly or through intention. Perceived behavioural control comprises of internal and external factors that affect behaviours whether directly or through intention (Wise *et al.*, 2006).

This theory has been rated to be very useful as a guide in the design of intervention strategies to change a negative or maintain a positive human behaviour having been proven to be one of the most predictive models to explain the human behaviour (Rivis and Sheeran, 2003; Wise *et al.*, 2006; Ayodeji, 2010).

The application of this theory in the issue of medical waste management lies in its inherent ability to describe the medical waste segregation behaviour of the healthcare staff in relation to their intention or readiness to segregate the waste into their distinct categories. Their behaviours can also be influenced by internal factors such as their understanding of the

different categories of the medical waste and the risks of mixing the waste together; and also, by external factors like the availability of color-coded bins and liners for the different categories of medical waste. The theory has been found to be a strong predictor of medical waste segregation practice among healthcare workers and waste segregation is a key step in the proper management of medical waste (Asadulla *et al.*, 2013).

Phase 4: Determination of needs

The next step to be able to develop cost-effective, feasible and acceptable intervention strategies is to gain an in-depth understanding of the needs and perceptions of the recipients and the providers of the intervention about the problem. An insight into their preferences and capacities is also very important, to increase the chances of adoption of the proposed strategies (Bleijenberg *et al.*, 2018). The recipients of the proposed intervention strategies for medical waste management are medical waste generators and handlers, while the providers are the Department of Health and the waste management company on contract with the Department.

These needs were determined through the qualitative and quantitative studies conducted in the fifteen selected healthcare facilities in VDM. Personnel who are directly involved with medical waste management in their respective facilities (Managers, IPCCs and EHPs) were interviewed and questionnaires were distributed to medical waste generators and handlers (doctors, nurses, cleaners and pharmacy staffs) to understand their perceptions about the problem of medical waste management, their needs, preferences and capacities. (Olaniyi *et al.*, 2019)

The healthcare workers admitted that the medical waste they generate is not being managed properly due to some challenges they face which include ignorance of many of them on the segregation, temporary storage and transportation of the waste within their health facilities. They blamed this on the lack of regular training of the members of staff on the risks improper handling of medical waste poses to them, their patients and the community. However, some IPCCs claimed

that the staff have the necessary knowledge on important issues about medical waste, since they (infection control team) are making great efforts to educate them, rather, it is the poor and careless attitudes of the medical waste generator that is responsible for their mismanagement of the waste. This could be attributed to the fact that many of the medical waste generators, especially the doctors do not view management of medical waste as a part of their job description, consequently, they usually claim that they are too busy to attend trainings on medical waste management whenever such trainings are organized (Olaniyi *et al.*, 2019).

Other challenges they raised were about the insufficiency of personal protective equipment and temporary storage equipment (color-coded bins) for proper segregation of the waste as well as a lack of standard, well ventilated and secure rooms for temporary storage of waste in their healthcare facilities. These problems are more pronounced in the clinics and CHCs than in the hospitals (Olaniyi *et al.*, 2019).

While the managers, IPCCs and EHPs have been trying to train and re-train the staff by conducting in-service trainings, the medical waste generators indicated that they expect the trainings to be conducted directly by the Department of Health. An IPCC also reiterated this expectation, the reason being that health workers are less attentive when they are being trained by a co-worker within the same facility, with whom they are already familiar. She hoped that the case would be different if a neutral person from the Department is to conduct the training. Also, since the Department of Health supplies the personal protective equipment directly and the color-coded bins indirectly through the waste management company, the health workers believe that the Department should increase their effort on ensuring that all the equipment are always made available in sufficient quantities.

Phase 5: Examination of current practice and context

The proposed intervention strategies are to be implemented in Vhembe District healthcare facilities, thus, the current strategies they have adopted to mitigate their medical waste management problems were examined. To improve the knowledge of staff and consequently their attitudes towards proper management of the waste, the hospitals' managements have accorded the responsibility of in-service trainings, monitoring and documentations to the IPCCs and EHPs. These personnel are expected to visit the wards regularly for inspection and monitoring of medical waste segregation and storage activities. Whenever they discover any irregularities, they are mandated to make a report to the head of the unit as well as the hospital management, such that necessary amendments can be made. In the clinics and CHCs, the managers are responsible for

these duties. In some clinics, nurses are delegated in turns as infection control nurses for a particular period (usually weekly), during which they perform these roles and report back to the managers. Sometimes, the cleaners are given the opportunity to address the nurses about the challenges they face when various categories of medical waste are mixed together, to sensitize them towards better segregation practices. The following is an excerpt from the interview conducted for a manager at a CHC:

"We usually do our in-service trainings on Wednesdays, because all staffs are on duty on that day. Those ones who are going off and those ones who are coming in, we all meet on Wednesdays. So, we utilize those days for in-service trainings. Sometimes, the training can

be done by a professional nurse, sometimes, it can be done by our cleaners. Our cleaners are learned, so because they are the ones who collects waste, they are the ones who identify the problems, so, we delegate them and say 'based on the challenges that you are encountering, we need an in-service training'" (CHC Manager 1).

To circumvent the challenges of insufficient equipment, reusable plastic gloves and aprons are being used by cleaners in some of the healthcare facilities. When the color-coded bins for a particular category of medical waste (usually sharps) are in short supply, especially in the clinics, they usually substitute by re-labelling bins made for another category of waste (usually vials waste) as "Sharps", such that sharps waste can be disposed into such a container. The main challenge of this substitution is that medical waste generators often forget the relabelling and drop both the originally intended type of waste and the new type of waste into the "new bin", resulting in unintentional mixing of the waste (Figure 7.3).

a. b. c.

Figure 7.3. Substitution of bins and mixing of waste (a) re-labelled to be used as a sharps' bin (b), resulting in the mixing of sharps and vials in the same bin (c) (Source: Field work).

In the healthcare facilities where there are no specific storage rooms specifically built for the purpose of temporary storage of medical waste in the facilities, old toilets were converted to serve the same purpose. Unfortunately, some of the toilets do not have a good door and functional locks, thus, it becomes difficult to keep unauthorized patients, who knew the room was formerly a toilet away from the "new storage rooms", despite the warning signs placed by the door. In some other clinics, the medical waste are stored in the same rooms with the gardening and cleaning tools being used in the facilities. This means the cleaners and gardeners have to come in contact with the stored waste more frequently than required (Figure 7.4).

a. b. c. d.

Figure 7.4. Substandard central storage rooms: An old toilet being used as a medical waste storage room (a), a storage room without a functioning lock (b) and storage rooms containing medical waste, gardening and cleaning tools (c and d) (Source: Field work).

Despite all these efforts, there are still lapses in the management of medical waste in the facilities. With respect to trainings, the healthcare workers who are mostly exposed to the trainings are the nurses and the cleaners, because they are the ones usually in the wards whenever the inspections are done. Doctors who are also medical waste generators were reportedly difficult to get to attend the trainings, because they usually claim to be very busy and also do not consider waste management as a part of their job description. A doctor mentioned to the researcher when he was handed a questionnaire to complete that the questions should have been directed to the nurses and cleaners, because he does not have anything to do with waste.

Regarding the personal protective equipment, some managers complained that they have placed different orders for the equipment from the Department, but the stocks are not made available.

"We don't have masks. Everything is out of stock. We are ordering, the stock is not coming. With the aprons, it's better because we are using the plastic ones, we are using the plastic aprons. But, with the masks, we use those old masks. But, we don't have a problem with gloves. Also, the cleaners don't have boots" (Clinic Manager 7).

Thus, the barriers which could hinder the implementation of the proposed intervention strategies include the poor attitudes of some medical waste generators (especially doctors) to training, the fact that many medical waste generators are very busy with their main duties and have little or no time to attend trainings on medical waste management and the non-availability of necessary equipment for personal protection, proper segregation and temporary storage of medical waste in the healthcare facilities.

The prospective facilitators of the proposed intervention strategies in the healthcare facilities are the IPCCs, EHPs and the Managers, since they have been previously involved in the

taking up of those roles and are acquainted with the modes and challenges of trainings. They would be better adjusted to the new strategies, rather than involving entirely new personnel for the job. All these factors are considered while developing the intervention strategies.

Phase 6: Modelling the process and outcomes

A questionnaire was developed and distributed to the medical waste generators in order to be able to identify the determinants of effective management of medical waste in their health facilities. The questionnaire included questions about their socio-demographic characteristics, their knowledge, practice and the challenges they face regarding medical waste management. The data was analysed using the Statistical Package for the Social Sciences (SPSS) version 25. Chi squared tests were performed to determine the association of the determinants of medical waste management with the sociodemographic characteristics of respondents, their knowledge and practice of medical waste management as well as the challenges they have identified. Where p-values were significant, Cramer's V test was further performed to determine the strength of such associations. Only associations that are significant are reported in this paper and the determinants that are strongly associated with proper medical waste management are boldened (Table 7.1).

Table 7.1: Associations of determinants of medical waste management in Vhembe District health facilities

Variables tested	X^2 value	p-value	Cramer's V	Inference of the strength of association
Segregation of medical waste				
Rank of health facility	6.044	0.049	0.172	Weak association
Onsite transportation				
Rank of health facility	12.659	0.049	0.178	Weak association
Gender	9.208	0.027	0.244	Moderate association
Occupation	19.323	0.029	0.188	Weak association
Number of years of experience	**121.688**	**0.008**	**0.461**	**Strong association**
Training	9.712	0.021	0.225	Moderate association
Nature of central storage area	18.165	0.006	0.206	Moderate association
Use of PPE*	8.397	0.038	0.200	Moderate association
Onsite disposal				
Rank of health facility	14.971	0.005	0.174	Weak association
Occupation	**42.956**	**0.000**	**0.377**	**Strong association**
Number of years of experience	**86.993**	**0.008**	**0.464**	**Strong association**
Nature of central storage area	11.441	0.022	0.161	Weak association
Use of PPE	6.895	0.032	0.174	Weak association
Training				
Rank of health facility	10.154	0.006	0.218	Moderate association
Gender	12.262	0.000	0.240	Moderate association
Occupation	**31.922**	**0.000**	**0.387**	**Strong association**
Use of PPE	**51.806**	**0.011**	**0.463**	**Strong association**
Availability of guideline	**16.962**	**0.000**	**0.308**	**Strong association**
Schedule for training	**48.838**	**0.000**	**0.481**	**Strong association**

X^2: Chi-square value; p-value: level of significance taken as 0.05; PPE: Personal protective equipment.

Table 7.1 above shows a significant relationship, though with a weak association between segregation practices and the rank of healthcare facility. Proper segregation is more likely to be done at the hospitals than at the clinics and CHCs, this may be due to in part to the fact that the color-coded bins are always available in the hospitals, while they are sometimes in short supply in the other healthcare facilities. The presence of EHPs and IPCCs who are

dedicated to regular training of staff, inspections, feedbacks and record keepings in the hospitals may also have contributed to this better practice.

A significant relationship was also demonstrated between the transportation practices of medical waste within the healthcare facilities and the rank of the facilities, occupation, training of staff, gender of health worker, the nature (appropriateness) of the central storage area and the use of PPE. The transportation of medical waste from the point of generation within the healthcare facilities to the central storage area, from where the waste is picked up by the waste management company, is carried out by cleaners who are under the instructions of nurses. Thus, the nurses and cleaners are more knowledgeable about how the waste should be transported and the equipment to be used, than the doctors. The fact that these cleaners and nurses are mostly females could have been responsible for the significance of this factor with gender. Also, the practice is better in the hospitals and among those who have undergone trainings on medical waste management. The most important factors linked with proper onsite transportation of medical waste are the number of the years of experience of the health worker, gender and training.

The practice of onsite disposal is significantly associated with the rank of healthcare facility, occupation, number of years of experience, the nature of the central storage area and the use of PPE. The association is stronger with occupation and the number of years of experience, which can be related to training. Onsite disposal of medical waste is more likely to occur in the clinics and CHCs than in the hospitals. Where the central storage areas are built to the standard, the chances of onsite disposal are reduced.

Training is significantly associated with the rank of healthcare facility, gender, occupation, regular schedule for training, knowledge of availability of guideline document in the facility and the use of PPE. More staff in the hospitals, notably the females, nurses and cleaners have received some form of training on medical waste management issues. In the healthcare facilities where there are regular schedules for training, more of the staff admitted that they have been trained and they also attested to the fact that medical waste management guidelines are available in their facilities. Those who have been trained are more likely to make use of PPE. Other variables tested did not show significant results.

Thus, from the analysis of quantitative data, the following factors are found to be significantly associated with proper management of medical waste: The rank of healthcare facility, gender, occupation, number of years of experience, availability of guidelines in the healthcare facilities, regular schedule for training, training of staff, use of PPE and the nature of onsite central storage area.

A causal modelling approach (Hardeman, 2005) was used to hypothesize the link between the determinants of medical waste management and the behaviours of healthcare workers who generate and handle the waste. If the link is strengthened, it will result in a proper management of the waste and multiple health outcome, both short and long term outcomes, including staff protection and a safe environment (Figure 7.5).

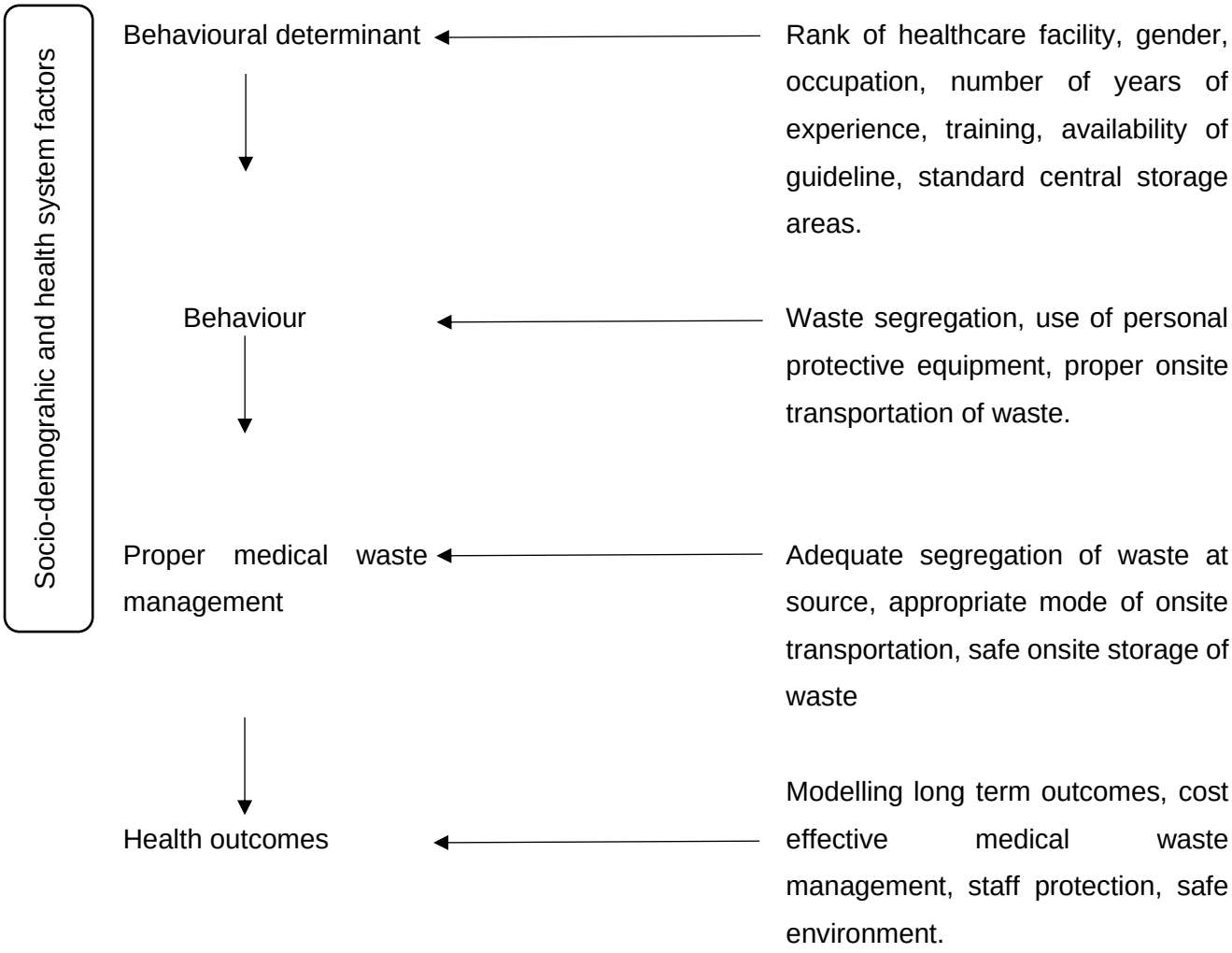

Figure 7.5. Hypothesized causal pathways and measures for evaluation for medical waste management.

Phase 7: Design of intervention strategies

Intervention strategies for improved medical waste management in VDM was developed based on the SWOT (Strength, Weakness, Opportunity and Threat) and PESTEL (Political, Economic, Social, Technological, Environmental and Legal) analyses strategies. SWOT analysis is a useful tool for strategic planning and management in organizations. It views an organization as existing in two distinct environments, one being itself (internal) and the other, the outside (external) environment (Guret and Tat, 2017). Since the organization interacts with both the internal and external environment, factors within both environments can affect the organization, therefore, they must all be considered in planning and management. The internal factors are inherent in the strengths and weaknesses of the organization, while the external factors are related to the opportunities and threats which exist; therefore, the SWOT analysis attempts to critically look into all these factors and harness them together for maximum benefits of the organization.

SWOT analysis provides a general perspective views of an organization and proffers general solutions, upon which specific solutions can be built. It has been used widely in business development and management (Guret and Tat, 2017), management of technology (Nazarko *et al.*, 2017) and the design of intervention strategies for improved medical waste management (Ankur *et al.*, 2016; Putra *et al.*, 2017). Analysis of the internal components of SWOT are used to identify the strength and weaknesses of an organization in terms of resources, capabilities and competencies (Sammut-Bonicci & Galea, 2015). Gurel and Tat (2017) also identified human capabilities, finacial resources and research potentials as measures of the strength or weakness of an organization.

Sammut-Bonicci and Galea (2015) define “resources” as the tangible and intangible inputs which are required to produce a product or service. The tangible inputs include raw materials, premises, machineries and equipment, while human resources, finances, technology and distribution networks constitute the intangible inputs (Sammut-Bonicci & Galea, 2015). The financial, managerial and infrastructural resources of an organization are very pertinent to determine the strenght and weaknesses of such an organization. The internal components of medical waste management at Vhembe District Municipality will be analysed based on the human resources, competencies, financial resources and research potentials. Other parameters will fall into at least one of these categories.

PESTEL is a complimentary analytical tool to SWOT which helps to identify the trends of the external factors and expand on their analysis. Mullerbeck (2015) recommended that SWOT and PESTEL should be used together to achieve a stronger analysis. In this study, the external

factors (opportunities and threats) which lie within political, economic, social, technological, environmental and legal factors concerning medical waste management are considered to develop feasible and applicable intervention strategies for a better management of the waste in Vhembe District.

A. Internal Factors' Analysis

Human Resources: The human resources involved in the management of medical waste in Vhembe District include the staff in charge of medical waste management in the DoH, waste management company's staff, administrators in the healthcare facilities, IPCCs and EHPs and the healthcare workers who generate the waste.

Strength: Each of these groups of human resources have specific roles, which when performed well will result in a safe management of medical waste in the District. Considering a safe management of medical waste as a project, its monitoring and financing is spear-headed by the delegated staff from the DoH, the administrators at the healthcare facilities oversee the management processes in their facilities while the IPCCs and EHPs are involved in the in-service training and close-monitoring of healthcare staff's practices. The administrators and workers of the waste management company on contract with the Limpopo provincial Department of Health are skilled in the treatment and disposal of all the medical waste generated in the province. Thus, Vhembe District is not lacking in the human resources needed to manage its medical waste.

Training of healthcare staff is aimed at improving their attitudes towards medical waste management. This is in consonance with the theory of planned behaviour which states that a person's behaviour is related to his intention, and that internal and external factors affect a person's behaviour. The internal factors which can affect the behaviour of healthcare workers towards medical waste segregation and proper temporary storage include their understanding of the different categories of hazardous medical waste and the risks of mis-management of the waste. Their attitude can be improved by reinforcing this knowledge through regular training. Furthermore, regular communication and feedbacks among these stakeholders can help to identify the weak links, real and potential challenges in the process of medical waste management, such that those areas can be strengthened promptly and adequately, to prevent lapses in the management of the waste.

Weakness: There is a communication gap among these groups of human resources, such that information is not easily passed from one group to another. Many healthcare workers in

Vhembe District are yet to participate in the accredited training on medical waste management, being conducted by the waste management company because of the rotational nature of the training which makes it irregular at each healthcare facility. Whenever a training is scheduled at a hospital or a sub-district (for multiple clinics and community health centers), only few staff will be nominated to attend the training while the others have to stay back in the healthcare facilities to attend to patients. Though, the staff who attend the training are mandated to give a feedback to others, a direct participation in the training will provide healthcare workers with better understanding than getting a report from another person who attended the trainings. Since only one waste management company facilitates the training throughout the province which has more than 400 healthcare facilities, a hospital or a sub-district do not have access to the training for more than two times in a year. This schedule has left many healthcare workers untrained. This is perhaps the reason for the poor attitudes displayed by many of the staff towards management of medical waste and the subsequent poor practices of minimization, segregation and temporary storage of medical waste in the healthcare facilities, which were reported in the previous chapters.

Training of healthcare workers in all the healthcare facilities should be regularized and intensified. The workers could be motivated to attend the trainings by providing certificates and awarding CPD points for such attendance. Detailed information on the health risks associated with poor medical waste management should also be included in the training manual, to sensitize the staff towards protecting themselves, their patients and the entire community. The Administrative staff of each healthcare facilities should also be urged to get more involved in the monitoring of medical waste management practices in their facilities.

Competencies: This involves the knowledge, skills and commitment of the human resources to the project.

Strength: The analysis of the quantitative data showed that most healthcare workers (86.9%) are aware that guideline documents and/or SOPs on medical waste management are available at their healthcare facilities. These workers, including most cleaners are learned, thus, they are able to interact with the documents and understand the messages directly. In addition to this, the waste management company also produced colorful posters with pictures to be pasted in strategic points in healthcare facilities to assist healthcare workers remember the various categories of hazardous medical waste and the specific color-coded bin assigned to each category. The personnel in charge of waste management within the healthcare facilities (The IPCCs, EHPs and Managers) should ensure that each healthcare worker duly interact with the guideline documents and are very familiar with their content by possibly

organizing regular small group discussions on waste management guidelines. This will hopefully improve their competencies.

Weakness: Despite the awareness of the availability of the guideline documents, many healthcare workers are not acquainted with the information therein, because they do not have a direct access to the documents. While the staff in the hospitals have a better access because a copy of the documents is kept in each ward, those in the clinics and community health centers can only access it in the office of the manager. Many of them claim to be very busy during the working hours that they do not have time to go and get the document from the offices. Also, a lack of commitment of healthcare workers is revealed by their poor attitude towards training, waste minimization and segregation. Inconsistent compliance with the guidelines renders them yet unskilled in the management of medical waste. In the hospitals, inspections of healthcare workers and the waste bins for compliance is done daily (every morning) or twice a week, depending on the size of the hospitals and the number of staff in the infection control unit, thus, staff in each ward are aware of their coming and could do the right things in preparation for their visits. However, the correct practice may not be sustained throughout the day or during the days when the inspection team would not be visiting.

A better outcome can be achieved if each healthcare staff has a personal copy of the guideline document, which he/she could refer to outside the working hours. Regular monitoring of healthcare workers on duty through unscheduled and unannounced visitations to the wards and cubicles by the infection control team are also recommended. If their visits are less predictable, the healthcare staff are more likely to be more diligent to comply with the guidelines more often. The knowledge accrued through accredited trainings, in-service trainings and reading through the guideline documents can only be transformed into skills with frequent practice of the recommendations in the guideline documents. Also, incorporating discussions about medical waste management in all the important meetings in the healthcare facilities will help to reinforce the importance of proper management of medical waste within the healthcare facilities and also address any challenges identified in the process on time.

Financial Resources: This deals with the availability of funds and material resources needed to execute the project. For management of medical waste, funds are needed to sponsor healthcare workers' training, and to purchase the temporary storage equipment, personal protective equipment, transport equipment as well as building of central storage rooms in each healthcare facility.

Strength: The DoH is committed to provide all the necessary finance to fund the management of medical waste in the province. Thus, healthcare facilities are not directly responsible to finance the treatment and disposal of the waste they generate, so, every facility has equal access to medical waste management infrastructure. The DoH should accord medical waste management the attention it deserves, such that an adequate budget is provided for its cause at the beginning of each financial year.

Weakness: The DoH is financially constrained, thus, it is unable to provide standard central storage areas in all the healthcare facilities in the province currently. In the hospitals, temporary storage equipment (color-coded bins) are usually in sufficient quantities, however, clinics and community health centers usually experience shortage in the bins and are sometimes forced to substitute one for another.

As a short-term measure, the DoH could provide secure, well-ventilated metal containers with plumbing works to serve as temporary storage areas for medical waste until standard storage rooms will be built, especially in the clinics and CHCs where the storage rooms are in very bad shapes. The managers in the clinics and community health centers, where insufficient equipment is reported should keep a “minimum stock records” of color-coded bins, liners and other consumables, such that they could order before the stock is exhausted and avoid having shortage of equipment.

Research Potentials: This is concerned with the inherent possibilities of generating research works from the project.

Strength: Medical waste management is a very viable topic of research due to the international nature of the waste - medical waste is being generated, treated and disposed all over the world. Research interests are focusing on the new technologies on better management of the waste in environmentally-friendly manner to reduce the levels of soil, water and air pollution. Almost anyone (healthcare workers and independent researchers) can initiate studies on medical waste and propose ways of improving on the current practices based on the available resources.

Weakness: Data on medical waste generation, treatment and disposal are often considered as confidential, thus, it is difficult for researchers to get access to them. Even after getting the required permission from the Head of Department of the DoH and the relevant Districts, some information are still hoarded, especially the financial aspect. Thus, researchers might not be

able to get all the data they need to project on a long-term generation rate and plan on cost-effective treatment and disposal systems, since they do not have a baseline to work on.

There is still a wide disparity in the mode of management of medical waste in developing and developed countries. Relevant information should be released to interested researchers, such that they can be able to conduct their studies in details. Detailed research and necessary collaborations may help bridge this gap, such that the waste can be better managed, even in resource-constrained developing countries.

Table 7.2 shows a summary of the strategies developed from the analysis of SWOT internal factors.

Table 7.2: Proposed Intervention Strategies from SWOT Internal Factors' Analysis

Factor	Strength	Weakness	Strategies
Human resources DoH staff, HCF Administrators Healthcare workers, EHPs and IPCCs MWC staffs	Clearly defined roles for each category. Synchronization of roles to achieve a common goal. Availability of training sessions.	Poor communication. Irregular training schedules. Lack of vital information in the training manual. Many untrained staff. Poor attitudes of healthcare workers. Apathy of HCF Administrative staff.	➢ Regular feedback meetings between the DoH, HCF and WMC. ➢ Intensify and regularize accredited training. ➢ Provide incentives to healthcare workers to attend the trainings. ➢ Improve on the content of the training manual. ➢ HCF Administrators to get more involved.
Competencies Knowledge Skills Commitment	Guideline documents and posters. Ability of staff to read and understand. Skills of medical waste treatment and disposal.	Poor access to the guideline. Lack of commitment of healthcare workers. Inconsistent compliance with the guideline document.	➢ Each healthcare worker should have a personal copy of the guideline document. ➢ Unannounced visits to the wards and cubicles. ➢ Organizing small group discussions on medical waste management. ➢ incorporating discussions about MWM in all HCF meetings.
Finances Funds Material resources	DoH provides all the required funds.	Financial constraint at the DoH. Shortage of bins at some HCFs.	➢ Adequate budget for medical waste management. ➢ Metal containers at HCFs as a temporary measure for central storage rooms (especially in the clinics and CHCs). ➢ Keeping of "minimum stock records" of bins (clinics and CHCs).
Research Potential	International interests in medical waste research. Healthcare workers and independent researchers.	Medical waste data treated as confidential.	➢ Almost anyone can initiate a research on medical waste management. ➢ Release relevant information to interested researchers. ➢ Encourage suitable collaborations.

B. External Factors' Analysis

Political Factors: These are the laws and policies which regulate the principles of medical waste management in South Africa, as well as the extent to which the government and policy makers are likely to intervene on the subject (Sammut-Bonicci & Galea, 2015).

Opportunities: Management of medical waste as one of the important solid waste streams is a concern in South Africa, as revealed by the various policies formulated by the Department of Environmental Affairs (DEA) and other relevant bodies to deal with the waste (DEAT, 2008). The constitution of South Africa (Act 108 of 1996) on Environment states that: "everyone has the right to an environment that is not harmful to their health or well-being, and to have the environment protected through reasonable legislative and other measures to prevent pollution and ecological degradation". Poorly treated and/or disposed medical waste constitute land, water and air pollution and thus a threat to the environment. The Air Quality Act 39 of 2004 is focused on the prevention of air pollution and environmental degradation as well as the regulation of emission standards of incinerators being used in medical waste disposal in South Africa.

The National Environmental Management Waste Act (NEMWA) 59 of 2008 deals with the licensing process for specified waste activities, including medical waste and South African National Standards (SANS) on Health Care Waste Management (SANS 10248, Part 3) provides a guideline on all aspects of medical waste management from the point of generation to disposal of the waste including a guide on training of staff. Also, the Health Professions Council of South Africa (HPCSA) also have regulations to guide medical waste handling and management (HPCSA, 2016).

Private organizations like the Green Scorpions and Newspaper companies (Sunday Times, 2009) have also shown a great deal of interest in issues of medical waste management in South Africa in the past, by uncovering and publishing various malpractices being perpetrated in the industry. These are evidences that medical waste management actions are being closely watched in the country and the existence of these laws in public domains empowers neutral individuals (like patients' relatives, visitors to healthcare facilities and researchers) to be aware if medical waste is not properly handled and lodge complaints to the appropriate quarters. This would assist the concerned stakeholders to fix whatever issues are reported.

Threats: In South Africa, there is no policy that is specifically designed for medical waste management. Regulations for the management of the waste are usually embedded in other

waste management policies. Also, neither the DEA nor DoH is directly involved in the treatment and disposal of medical waste, it is usually contracted to private waste companies throughout the country. There have been reports of breach of contracts and mismanagement of medical waste from some of these private companies in different provinces of the country in the past, resulting in the cancellation of their contract and the employment of other companies.

Considering the importance of this type of waste according to the level of risk it poses, a separate policy which is focused solely on management of medical waste is desirable, so that its content can be easily accessible to the relevant stakeholders and interested citizens of the country. Also, the government, through the DEA and/or the DoH should closely monitor the treatment and disposal process of medical waste by the waste management company.

Economic Factors

Opportunities: Safe management of medical waste is cheaper than treating the diseases that could be caused by poor management of the waste, like gastrointestinal infections, which could occur and cause an epidemic if medical waste is dumped into water bodies and viral infections (like HIV and HBV) which could be contracted when pricked with needles which have been used on infected persons. Also, treatment of medical waste is a process which includes multiple steps like transporting the raw waste and the treated residue from one point to another, storage, loading machines, records, office works etc. Thus, the process creates job opportunities for people at various levels and with various skills and abilities. Drivers, technicians, accountants, clerks and even uneducated people who could help sort out the different packages of medical waste and load them unto the machines at treatment facility centers can all find employment opportunities in the medical waste management industry.

Threats: The cost of management of medical waste will increase as its quantity increases. More color-coded bins and transportation equipment will be required and the cost of treatment and disposal will increase, because these costs are calculated based on the weight of the waste to be treated and disposed. Also, waste in excess of the capability of the treatment machines may result in frequent breakdown of the machines. Unlike other forms of solid waste which have economic potentials through recycling, the infectious nature of medical waste renders it unsuitable for recycling, thus, it must be disposed safely after treatment. Furthermore, the residual ash of treated medical waste cannot be disposed into regular landfills, because of their potential to contain hazardous substances, thus, they are disposed into hazardous landfills, which is more costly than the regular ones.

Minimization of medical waste by promoting reusable over disposable medical equipment, as well as adequate segregation of medical waste from the point of generation will reduce the quantity of the waste that eventually goes for treatment and disposal. This will in turn reduce the cost of management.

Social Factors: These are the social and physical conditions of the environment which affect medical waste management.

Opportunities: Many healthcare facilities in Vhembe District are situated on wide expanses of land, which allows for sufficient space to construct central storage areas at a safe distance away from wards, cubicles and other offices, such that access by unauthorized individuals will be restricted. This means the Department of Health does not need to acquire extra portions of land for this purpose whenever they are ready to build the standard central storage areas.

Threats: Rodents, dogs and monkeys are found within and around the premises of many healthcare facilities in Vhembe District. These animals may get access into the central storage rooms where they are not standardized, and scatter the waste, while looking for food.

Building of standard central storage areas in all healthcare facilities is of a paramount importance. Also, empowerment of each healthcare facility (especially the hospitals which generate large quantities of waste on a daily basis) to be able to treat some of the waste they generate through disinfection or the use of a microwave which does not require high level of technology, will reduce the quantity of waste that is being stored in the central storage room. Hossain *et al.* (2013) recommended that healthcare risk waste should be disinfected at the point of generation, to minimize the risks of nosocomial infections.

Technology

Opportunities: Capturing the record of medical waste generation, treatment and disposal on the computer allows for easy sharing of the data between the stakeholders. The waste management company has a soft record of all the waste collected from each healthcare facility in Limpopo Province, which they share with the DoH. The DoH in turns shares this information with the healthcare facility through the District Municipalities. Using the available technologies like analytical software or experts in such technology, the Department would be able to use these records to monitor the trend of medical waste generation, project on the expected quantity to be generated in the future, make appropriate plans and allocate sufficient funding.

Threats: This study discovered no technological threats to medical waste management in Vhembe District. However, in all the healthcare facilities in Vhembe District, except in one hospital, all the records on medical waste generation, treatment and disposal were found in hard copy documents. The records were not imputed into the computer and some were unable to interpret what is written in the hard documents. Accessibility, analysis and sharing of data is more difficult when they are only saved as hard copy documents.

The Managers of clinics and community health centers, as well as the Environmental Health Practitioners and Infection Prevention Control Coordinators should be trained on the use of computers, such that they could input the quantity of the waste they generate on a weekly or monthly basis. They could also generate relevant graphs and easily discover the trends of waste generation.

Environmental Factors

Opportunities: Since there are no treatment and disposal activities within the healthcare facilities, the environment of the facilities should be safe. Transport of waste from one point to another within the facilities is usually done with large bins which are fitted with wheels for easy movement (wheelie bins). This is to ensure that there are no spills during the transportation. The Department of Environmental Affairs (DEA) also conducts Environmental Impact Assessment (EIA) test at the waste management company, to ensure that their treatment equipment comply with environmental standards and thus does not constitute any health risks to the people in the environment. Medical waste handlers and the waste management companies should adhere strictly to the recommendations on waste transportation as stipulated in the guidelines to ensure a safe environment.

Threats: Poorly managed medical waste can constitute environmental pollution. This can occur in cases of spills during transportation from the point of generation to the central storage area within the health care facilities, especially in the few clinics and community healthcare centers where the cleaners transport the waste to the storage area manually, or with faulty bins. In a hospital, a vehicle was being used to transport waste from the wards to the central storage room, however, the vehicle was not marked with a biohazard symbol, and it is also being used for other purposes, like transportation of gas cylinders to the kitchen. If a vehicle used to transport medical waste was not properly cleaned and disinfected before being used for another purpose, there is a risk of exposure to spilled medical waste or fluid, which can result in transmission of infection. Also, substandard central storage areas can constitute

environmental pollution if rodents gain access into the rooms and pick up some of the waste which they could drop in an open space.

To circumvent this problem, healthcare workers in the clinics and CHCs must stop using faulty bins for transporting waste within their facilities. In the hospitals where vehicles are used, they should be marked with biohazard symbols and be dedicated for medical waste transportation only.

Legal Factors: This refers to individual rights and entitlements in the workplace.
Opportunities: Employees' rights to protection (HBV Vaccination, PPE). Each employee is entitled to safety. Each healthcare facility should make the wellbeing of healthcare workers a priority and ensure that those who are yet to be immunized against Hepatitis B are duly vaccinated. Also, the Administrators must ensure that there are always sufficient personal protective equipment for their staff.

Threats: The "polluter pays principle" requires that a person who generates waste is responsible to ensure that the waste is safely disposed. This makes the DoH responsible for all the medical waste generated in all the healthcare facilities in the Province. However, since the responsibility of treatment and final disposal of medical waste has been passed on to a WMC through a contract, the company thus becomes accountable also according to the terms of the contract. This implies that if either of them do not play well its own parts, there will be some deficiencies in the line of management of the waste. Each stakeholder must therefore ensure the fulfillment of their own parts of the contract.

Table 7.3 shows a summary of the strategies developed from the analysis of SWOT external factors.

Table 7.3: Proposed Intervention Strategies from SWOT External Factors' Analysis

Factor	Opportunities	Threats	Strategies
Political Factors DEA, DoH, HPCSA Private organizations Newspaper companies	The constitution of South Africa. Air Quality Act 39 of 2004. NEM Waste Act 59 of 2008. SANS 10248, Part 3. Newspaper publications.	No policy specifically designed for medical waste management only.	↓ Empowerment of the public to recognize improper management of medical waste and report appropriately ↓ Draft and implement a separate policy for management of medical waste only, for easy access. ↓ DEA and DoH to monitor more closely the treatment and disposal of medical waste by the WMC.
Economic Factors	Job opportunities. Reduced cost of managing medical waste-related diseases.	Increased cost of treatment. Equipment breakdown. No possibility of recycling.	↓ Minimize medical waste. ↓ Promote the use of reusable over disposable medical equipment. ↓ Adequate segregation of waste at the point of generation.
Social Factors Social and physical environmental conditions	Sufficient space to construct standard Central Storage Areas in HCFs.	Rodents, dogs and monkeys within and around the premises of many HCFs.	↓ Build standard central storage areas in all HCFs. ↓ Empower each HCF to be able to treat some of its waste (especially the hospitals).
Technology Use of computer for data capturing	Easy data sharing among stakeholders. Convenient monitor of the trend of medical waste. Projection and budget allocation.	No technological threats, except for the non-use of technology in some HCFs.	↓ The DoH should use technology to interpret available data and use it to monitor waste generation trends, project into the future and make appropriate plans. ↓ Train clinic and CHC managers, EHPs and IPCCs on the use of computer to capture data and generate trends in the form of graphs.
Environmental Factors	No treatments within HCFs. EIA test at the WMC by the DEA.	Environmental pollution from spills. Unauthorised access to the CSA.	↓ Strict adherence to waste transportation guidelines. ↓ No use of faulty bins for onsite transportation (clinics and CHCs). ↓ Vehicles conveying medical waste must be dedicated and marked with biohazard symbol (Hospitals).
Legal Factors	Employees' rights to protection (HBV Vaccination, PPE).	Both the DoH and WMC are jointly responsible for a proper management of medical waste.	↓ Ensure that all healthcare worker are vaccinated against Hepatitis B Virus. ↓ Ensure sufficient PPE is provided in all HCFs. ↓ Each stakeholder must fulfil their own parts of the contract.

Proposed Stakeholders and Timeline for Implementation of the Strategies

The intervention strategies proposed above have been divided into three timelines based on the envisaged feasibility of achieving them. They are to be implemented by the main stakeholders of medical waste management in Vhembe District. Table 7.4 highlights the strategies with the timeline proposed for their implementation and the specific stakeholders to implement them.

Table 7.4. Proposed Timeline and Stakeholders for Strategies' Implementation		
Short-term Strategies		
SWOT Parameter	**Strategy**	**Stakeholder**
Poor attitude of healthcare workers to training.	Provide incentives to healthcare workers to attend the trainings.	DoH, WMC
Lack of vital information in the training manual.	Improve on the content of the training manual	WMC
Apathy of HCF Administrative staff.	HCF Administrators should get more involved.	HCF
Poor access to the guideline.	Each healthcare worker should have a personal copy of the guideline document.	DoH, HCF
Inconsistent compliance with the guideline document.	Incorporate discussions about medical waste management in all HCF meetings.	HCF
Shortage of bins at some HCFs.	Keep "minimum stock records" of bins.	HCF
Increased cost of treatment.	Minimize medical waste; adequate segregation	HCF
Environmental pollution	Do not use faulty bins for onsite transportation.	HCF
Intermediate term Strategies		
Clearly defined roles for each category of human resources	Regular feedback meetings.	DoH, HCF and WMC.
Availability of training sessions.	Intensify and regularize accredited training.	DoH and WMC
Financial constraint at the DoH.	Metal containers at HCFs as a temporary measure for central storage rooms.	DoH
Increasing interests in medical waste research.	Release relevant information to interested researchers.	DoH and HCF
FNo policy specifically designed for medical waste management only.	Draft and implement a separate policy for management of medical waste only, for easy access.	DoH
Reduced cost of managing medical waste-related diseases.	Promote the use of reusable over disposable medical equipment.	DoH and HCF
Non-use of technology in some HCFs.	Train clinic and CHC managers, EHPs and IPCCs on the use of computer to capture data and generate trends in the form of graphs.	DoH, WMC
Long-term Strategies		
Government not managing medical waste directly.	DEA and/or DoH to take over treatment and disposal of medical waste.	DoH
Sufficient space to construct standard Central Storage Areas in HCFs.	Build standard central storage areas in all HCFs. Empower each HCF to be able to treat some of its waste.	DoH

Validation of the Strategies

This section reports the processes involved in the validation of the strategies developed for an improved management of medical waste in Vhembe District Municipality, Limpopo Province, South Africa. All the stakeholders in medical waste management in the Province (Department of Health, healthcare facilities and the waste management company) were duly carried along during the development and validation of the strategies. A member check technique (Birt et al., 2016) was adopted to validate the results of the study and the strategies developed.

Member checking involves the presentation of the research findings to the participants to seek their comments and validation (Birt et al., 2016). It “ensures that the participants’ meanings and perspectives are represented and not curtailed by the researchers’ agenda and knowledge” (Tong et al., 2007). Member check consists of a range of activities including the return of transcripts from the interviews to participants, conducting another interview based on the analysed data and allowing them to modify the transcripts by deleting aspects which no longer describe their experiences and possibly adding new information if needed (Birt et al., 2016). An improved form of member check (Synthesized member checking) provides participants with the opportunity to interrogate with the results, make comments and add to the findings, even after many months of the interview (Birt et al., 2016).

Method

The results of both quantitative and qualitative studies in this research, as well as the intervention strategies developed, were presented to the stakeholders in their workplaces, viz: Healthcare facilities (two hospitals and a sub-district office, where participants from the clinics and community health centres converge, were selected from the healthcare facilities from where data was collected), the Department of Health and the waste management company.

The presentations took place in the board room of the first hospital, the office of the Director of risk management in the second hospital, the general office at the sub-district and the offices of the representatives of the Department of Health and the waste management company. The sub-district office, rather than individual clinic and community health centres, was chosen because it affords the researcher the opportunity to meet with many managers of the clinics and community health centres at the same time.

The study findings and the proposed strategies were prepared in the form of power point slides for easy presentation to all the members of the audience at the same time. The participants of the member validation include: the hospital Chief Executive Officer, the clinical director, director of risk management, managers of different wards in the hospital, nurses, infection control practitioners and the personnel in charge of research and training. After the presentation by the researcher, the participants were allowed to critique the presentation, assess whether the results represent their experiences and whether the proposed strategies would be applicable and useful in the context of their practice.

The data obtained at the healthcare facilities and the developed strategies were also discussed with representatives from the Department of Health and the waste management company to confirm or otherwise the information obtained from the healthcare facilities and to also receive comments from them regarding the strategies as to what parts of it are feasible and which ones are not, based on their previous experience in managing medical waste in the province.

Results

After the presentation to each group of participants, they all agreed that the results reflect their experiences as at the time of data collection and even as at the time of the validation meeting. The responses from each stakeholder are discussed as follows:

A. Responses from participants from healthcare facilities (HCF)

i. Medical waste segregation: The researcher has reported poor segregation of medical waste and overfilling of the temporary storage bins. In agreement with the results, the participants responded:

"We cannot disagree with you that our staff do not always segregate the waste at the point of generation according to the recommendation in the provincial guideline. We know that mixing of waste happens and we are working towards reducing the occurrence" (HCF Participant 1).

"With the overfilling of temporary storage bins beyond the ¾ mark, we are sensitizing the members of staff not to fill beyond the recommended line for their safety. But, many are still indulging in the practice" (HCF Participant 2).

ii. Onsite transportation: Wheelie bins are used for this purpose in many of the healthcare facilities. But, in one of the hospitals, a vehicle is being used, though it is neither dedicated for medical waste transportation only, nor is it marked with a biohazardous symbol.

"We do not use a vehicle for the transportation of medical waste from the cubicles to the central storage area, because our facility is small, and our cleaners can easily pick up the waste and drop them in the storage area" (HCF Participant 3).

"We have a vehicle for transportation of medical waste from the wards to the central storage area. But, unfortunately, we cannot dedicate it to medical waste transportation only for now, because we also need it for the transportation of other things like the dirty linens to the laundry and gas to the kitchen. We may work towards having a dedicated vehicle for medical waste only, but, that would be a long term goal" (HCF Participant 4).

iii. Training: When the issue about regular training was discussed, the participants unanimously agreed that the training has not been regular or efficient. Not all the staff have been trained because they have to select representatives from each clinic or hospital ward each time the training is to be conducted, so that the patients are catered for while the training session is ongoing.

"All the staff have not been trained, because the training is conducted only once or twice in a year. Each time the trainers come, we have to choose a delegate from each ward to attend the training, so that others can continue their work. Since we also rotate ourselves in the wards, you may find out that a nurse is in the female ward during the last training period, and has now been posted to emergency in the next period. She may not be selected to attend the training at any of those periods" (HCF Participant 6)

"It is true that trainings on medical waste management are not conducted regularly, even when there is a call for training, all of us cannot attend at the same time because we need to attend to patients who come for consultation. Besides, different categories of healthcare professionals are combined together for the training, so, we think that is not proper" (HCF Participant 5).

"Trainings are conducted by the Department of Health, and sometimes by the waste management company. You have correctly observed that doctors have less knowledge about medical waste

management than nurses and cleaners, it is because doctors usually claim to be busy and do not attend the trainings" (HCF Participant 6).

iv. Existing communication gap among the stakeholders: The participants stated that they do not communicate with the Department of Health about their challenges regarding medical waste management.

"We are seriously having a problem with communicating with the Department (of Health). It's like in the hospitals, we are on our own. There is little or no communication between us. They are up there, and we are down here. Maybe we can henceforth communicate with them through the District office, because we have now realized how important the issue of medical waste management is, but, I am not sure if we can go to the Department directly as a healthcare facility" (HCF Participant 7).

"Well, we try to communicate our challenges to the sub-district, but we know they cannot do anything by themselves, unless they are given instructions from the Department. But, we do not communicate directly with the Department" (HCF Participant 3).

iv. Substandard central storage areas: All the participants agreed that their facilities' central storage areas for medical waste are below the recommended standard. They also claim to be aware about the risks inherent in having improper central storage areas.

"I think the problem is because central storage areas were not included in the plans of our clinics and community health centres. We know the ones we have are substandard, but we are managing it, what can we do?" (HCF Participant 8).

"We are aware of the dangers of having improperly locked central storage rooms. We do our best to keep it inaccessible to unauthorized people, but, we hope the Department can build us a standard storage room with time" (HCF Participant 9)

With respect to the strategies, the participants commented that the strategies developed are good and applicable in the context of their practice. They were positive that if the strategies are strictly followed, there will be an improvement in the management of medical waste in the entire province. However, they noted that all of the strategies cannot be implemented at once due to financial constraints, but if the plans are divided into immediate, short-term and long-term goals, we may be able to achieve them all eventually. Below are extracts from their comments:

"We understand the strategies you are proposing, and we can see that they are good and feasible. But, it will require each and every stakeholder to play its own part. As for us, we are ready to play

our parts, because we have realized that the issue of proper management of medical waste is very important" (HCF Participant 7).

With regards to the aspect of the strategies that focus on training, a participant said: *"Yes, we need an emphasis on the issue of training. We need the Department to look into it, make it more regular and effective. This is possible and it will help each staff to manage the waste better"* (HCF Participant 5).

When the participants were asked to comment on whether it is necessary to have an Environmental Health Practitioner in charge of each of the subdistrict, one of them said:

"It is important for us to have staff who are dedicated to the issues of medical waste management in our facilities. Those who can place a priority on regular inspections and conduction of in-service training for our staff. The Managers have been trying to do that, but they also have other duties to attend to, so, having an Environmental Health Practitioner in each sub-district like you suggested would be very good. I believe it will make us more efficient in managing our waste" (Participant 5).

On the issue of central storage areas, the participants also saw the building of standard storage areas in all the facilities as a feasible strategy, however, they commented that it might be better to have it as a long-term goal, while in the interim, they can make do with what they currently have or an improved version of it.

"Well, I believe it is possible for the Department to build standard central storage rooms in all of our healthcare facilities. However, the challenge would be about funding, because we have many healthcare facilities in the District. I think we can present the proposal to the Department, so that they can have it as a long-term goal, include it in the annual budget and possibly build the storage areas one after the other, because giving out the entire contract at once may be very expensive. In the meantime, we must try to improve on what we currently have, such that it would not constitute a nuisance to us (healthcare workers) and the environment" (Participant 9).

B. Responses from participants from the Department of Health

When the findings from the research were presented to the representatives from the Department of Health, they also agreed with the findings that pertain to them and agreed with the proposed strategies for improved management of waste in the entire Limpopo Province. They revealed that they have also been working in line with some of the strategies suggested in this study, notably on the matters of efficient training and standard central storage areas.

"Yes, you are right to say that many of our healthcare staff do not handle medical waste as has been specified in the guideline. Since we became aware of this, we have also tried to raise the standard of the training. The Department encourages every healthcare worker to participate in the training and pays the waste management company for each staff who attends the training. We have also decided to include an assessment test immediately after the training sessions to discourage passive attendance. Those who perform well in the test are given certificates of competence beside the certificate of participation which are given to all the participants. Also, we have accredited the training programmes with relevant recognized health professional bodies in South Africa, such that CPD (Continuing Professional Development) points can be obtained through the training. All these initiatives are to encourage more healthcare workers to attend and participate fully in the training" (DoH Participant 1).

When the challenges in the healthcare facilities about central storage areas were presented to them, he responded:

"Hmmmm…we are also aware about this and we are working on the solution, not only in Vhembe District Municipality, but in the whole of Limpopo Province. We have designed a model of a standard central storage area which we have presented to the Head of the Department. The responsibility of building the structures falls on the Infrastructure section of the Department. But, looking at the number of healthcare facilities that we have, this may not be something we can achieve overnight." (DoH Participant 1)

Commenting on the strategies as a whole, the second participant said:

"We are very happy to have a researcher who has come up with beautiful ideas like this. We have also been working on some of them and we agree with each of your proposed strategies, except the one about the use of reusable medical instruments instead of the disposable ones. The reusable thermometers for example put the patients at risk of cross-infections if the thermometers are not properly disinfected after each use. We were using the reusable ones in the past, but now, we have stopped using them. Apart from that, all other strategies are welcomed and they are feasible if all the stakeholders are keen on playing their parts. Our hospitals and environment would be a safer place for all of us" (DoH Participant 2).

B. Responses from participants from the Waste Management Company (WMC)

The representative of the waste management company was also engaged in a discussion where the findings from the healthcare facilities were related to him, and the proposed strategies

presented to him. He agreed that he had observed some of the challenges at the healthcare facilities and some have been reported to him. He also believes that the proposed strategies would help improve the management of medical waste in the Province. His comments were mainly on the central storage areas from which his company picks medical waste from as well as the treatment and disposal methods.

"I am aware that many healthcare facilities in Vhembe District Municipality do not have standard central storage area for medical waste. Though, our own duty is to transport the waste from the facilities, treat and dispose them, I have suggested to the Department of Health on improving the standards of the central storage areas in the healthcare facilities. If there is not enough funds to build entirely new structures in all the facilities now, the Department can install metal containers with vents for proper ventilation which would be lockable to serve as temporary central storage rooms for medical waste. Such containers should be fitted with plumbing works and basins of water outside, so that anyone who drops waste there cab duly wash his/her hands afterwards" (WMC Participant).

About the overall proposed strategies, he commented:

"These strategies are good and they are feasible. All we need is commitment from those who are involved in medical waste management, from the point of generation. We are trying our best to intensify the training and improve on it, so that we can bridge the knowledge and practice gaps we have observe in some of our participants" (WMC Participant).

Strategies' Validation Conclusion

The strategies developed proved to be authentic, useful and feasible in the healthcare facilities, Department of Health and the waste management company. Thus, the researcher concludes that the strategies would assist Vhembe District Municipality, as well as other District Municipalities in Limpopo Province to achieve a better management of medical waste.

Conclusion

The study which prompted the development of these strategies revealed mismanagement of medical waste in Vhembe District, a cause for concern and immediate intervention to forestall the harmful effects of poor medical waste management. The MRC framework for development of complex intervention strategies was adopted and the intervention strategies were developed using the SWOT and PESTEL analysis techniques. These strategies will hopefullly improve medical waste management practices in Vhembe District and possibly applicable to other District Municipalities in Limpopo Province of South Africa.

Reference

Afanasjeva, J., Gruenberg K. (2019). Pharmacists as environmental stewards: Strategies for minimizing and managing drug waste. Sustainable Chemistry and Pharmacy, 13:4; 100164.

Ajzen, I. (1991). "The theory of planned behavior," *Organizational Behavior and Human Decision Processes,* 50: 2, 179–211.

Ankur, M., Rahul, D., Jayeshbhai, K. (2016). Situational analysis of Bio-medical waste management of Tertiary care centre and Common Bio-medical Waste Treatment Facility of South Gujarat. Int J Res Med. 2016; 5(3); 7-10.

Akter, N. (2000). Medical Waste Management: A Review. Environmental Engineering Program, School of Environment, Resources and Development, Asian Institute of Technology, Thailand.

Akulume M. and Kiwanuka S. N. (2016). Health Care waste management Segregation Behavior among Health Workers in Uganda: An Application of the Theory of Planned Behavior. *Journal of Environmental and Public Health,* 2016 Article ID 8132306, 8 pages, 2016. doi:10.1155/2016/8132306.

Ara, L., Bashar, F., Tamal, M.E.H., Siddiquee, N.K.A., Mowla, S.M.N., Sarker, S.A. (2019). Transferring knowledge into practice: a multi-modal, multi-centre intervention for enhancing nurses' infection control competency in Bangladesh. Journal of Hospital Infection, 102 (2): 234 – 240.

Asadulla M., Karthik K. G., and Dharmappa B. (2013). "A study on knowledge, attitude and practices regarding biomedical waste management among nursing staff in private hospitals in Udupi city, karnataka," *India International Journal of Geology, Earth and Environmental Science*, 3, 118–123.

Ayodeji P. I. (2010). Exploring secondary school students' understanding and practices of medical waste management in Ogun, Nigeria. *International Journal of Environment and Science Education,* 5, 201–205.

Bassey B.E., Benka M.O. and Aluyi H.A. (2006). Characterization and management of solid medical waste in the Federal Capital Territory, Abuja, Nigeria. Afr Health Sci; 6(1): 58-63.

Birt, L., Scott, S., Cavers, D., Campbell, C. and Walter, F. (2016). Member Checking: A Tool to Enhance Trustworthiness or Merely a Nod to Validation? Qualitative Health Research 26(13) 1802–1811.

Bleijenberg, N., Man-van Ginkel, J.M., Trappenburg, J.C.A., Ettema, R.G.A., Sino C. G., Heim, N., Hafsteindóttir, T. B., Richards D. A., and Schuurmans M. J. (2018). Increasing value and reducing waste by optimizing the development of complex interventions: Enriching the development phase of the Medical Research Council (MRC) Framework. *International Journal of Nursing Studies*, 79:86-93.

Bobrow, K., Farmer, A., Cishe, N., Nwagi, N., Namane, M., Brennan, T. P., … Levitt, N. (2018). Using the Medical Research Council framework for development and evaluation of complex interventions in a low resource setting to develop a theory-based treatment support intervention delivered via SMS text message to improve blood pressure control. *BMC health services research*, *18*(1), 33. doi:10.1186/s12913-017-2808-9.

Caniato, M.; Tudor, T. and Vacari, M. (2016). Assessment of health-care waste management in a humanitarian crisis: A case study of the Gaza Strip. *Waste Manag. 58*, 386–396.

Craig P., Dieppe, P. Macintyre, S., Michie, S., Nazareth, I. and Petticrew M. (2008). Developing and evaluating complex interventions: the new Medical Research Council guidance. *British Medical Journal*, vol. 337, p. a1655.

Delmonico, D.V.G., Santos, H.H.D., Pinheiro, M.A., de Castro, R. and de Souza R.M. (2018). Waste management barriers in developing country hospitals: Case study and AHP analysis. Waste Manag. Res. 36(1):48-58. doi: 10.1177/0734242X17739972.

Guret, E., Tat, M. (2017). SWOT Analysis – A Theoretical Review. The Journal of International Social Research, *10 (51),* 995-997.

Hangulu L, Akinola O. Health care waste management in community-based care: Experiences of community health workers in low resource communities in South Africa. BMC Public Health 2017; 17 (448). Accessed from https://doi.org/10.1186/s12889-017-4378-5 on 10/08/2017.

Hardeman, W., Sutton, S., Griffin, S., Johnston, M., White, A., Wareham, N.J., Kinmonth, A.L. (2005). A causal modelling approach to the development of theory-based behaviour change programmes for trial evaluation. *Health Education Research*, vol. 20, pp. 676–687, 2005.

Harhay, M.O., Halpern, S.C., Harhay, J.S. and Olliaro, P.L. (2009). Healthcare Waste Management: A Neglected and Growing Public Health Problem Worldwide. Trop Med Int Health, 14:1414-7.

Hosny, G., Samir, S., and El-Sharkawy, R. (2018). An intervention significantly improve medical waste handling and management: A consequence of raising knowledge and practical skills of health care workers. Inyternational Journal of Health Sciences, 12 (4) 56 -66.

Hossain M.S., Rahman N.N, Balakrishnan V., Puvanesuaran V.R, Sarker M.I. and Ab Kadir M.O. (2013). Infectious Risk Assessment of Unsafe Handling Practices and Management of Clinical Solid Waste. Int. J. Environ. Res. Public Health 2013, 10, 556-567; doi:10.3390/ijerph10020556.

Jorge, E.; Hrdinka, C.; Ryder, R.; McKeon, M. and Berkemaier, R. (2004). Non-Incineration Medical Waste Treatment Technologies in Europe; Health Care Without Harm Europe: Prague, Czech Republic, pp. 6–35.

Kumar, R., Somrongthong, R. and Ahmed, J. (2016). Effect of Medical Waste Management Trainings On Behavior Change Among Doctors Versus Nurses And Paramedical Staff In Pakistan. Journal of Ayub Medical College, Abbottabad. 28(3):493-496.

Kumar, R., Somrongthong, R. and Ahmed, J. (2016). Impact of waste management training intervention on knowledge, attitude and practices of teaching hospital workers in Pakistan. Pak J Med Sci.32(3):705-710.doi: http://dx.doi.org/10.12669/pjms.323.9903.

Kumar, R., Somrongthong, R. and Shaikh, B.T. (2015). Effectiveness of intensive healthcare waste management training model among health professionals at teaching

hospitals of Pakistan: a quasi-experimental study. BMC Health services research, 15:81. DOI 10.1186/s12913-015-0758-7

Lovell, K. Bower, P., Richards, D. Barkham, M., Sibbald, B., Roberts, C., Davies, L., Rogers, A., Gellatly, J. and Hennessy, S. (2008). *Developing guided self-help for depression using the Medical Research Council complex interventions framework: a description of the modelling phase and results of an exploratory randomised controlled* trial. BMC Psychiatry, 8 (1) 91.

Malebatja, S.M. (2013). Knowledge and Practices of Health Care Workers on Medical Waste Management Disposal at George Masebe Hospital, Waterberg District, Limpopo Province, South Africa. Master's Thesis, University of Limpopo, Mankweng, South Africa.

Mullerbeck, E. (2015). SWOT and PESTEL. In: Mullerbeck, E. & Thorpe, I. (Eds.) *Knowledge Exchange Toolbox - Group methods for sharing, discovery and co-creation.*. New York, USA: UNICEF. Pp 136-147.

Nazarko J., Ejdys J., Halicka K., Magruk A., Nazarko L. and Skorek, A. (2017). Application of Enhanced SWOT Analysis in the future-oriented Public Management of Technology. Procedia Engineering, 182 (482-490).

Nemathaga, F.; Maringa, S.; Chimuka, L.(2008). Hospital solid waste management practices in Limpopo Province, South Africa: A case study of two hospitals. *Waste Manag.*, 28, 1236–1245.

Njue, PM., Cheboi, KS., Shadrak O. (2015). Adherence to Healthcare Waste Management Guidelines among Nurses and Waste Handlers in Thika Sub-county- Kenya. Ethiop J Health Sci. 2015 Oct; 25(4): 295–304.

Olaifa A, Govender RD, Ross AJ. (2018). Knowledge, attitudes and practices of healthcare workers about healthcare waste management at a hospital in KwaZulu-Natal. S A Fam Pract.; 60(5): 137-145.

Olaniyi, F.C.; Ogola, J.S.; Tshitangano, T.G. (2019). Efficiency of Health Care Risk Waste Management in Rural Healthcare Facilities of South Africa: An Assessment of Selected Facilities in Vhembe District, Limpopo Province. *Int. J. Environ. Res. Public Health*, *16*, 2199. doi:10.3390/ijerph16122199.

Pongrácz, E., Phillips, P. S. and Keiski, R. L. (2004). Evolving the Theory of Medical waste management: Defining key concepts. Medical waste management and the Environment II. Wit Press; pp. 472-478.

Putra, G.N.G, Surata, S.P.K., Agung, G.A.A. (2017). Medical waste management strategy in the inpatient primary health care center with system approach: a SWOT Analysis. Bali Medical Journal (*Bali Med J*) 2017, Volume 3, Number 3 (IBL Conference 2017 Special Issue): S33-S39.

Lakshman, R., Griffin, S., Hardeman, W., Schiff, A., Kinmonth, A.L., Ong, K.K. (2014). Using the Medical Research Council Framework for the Development and Evaluation of Complex Interventions in a Theory-Based Infant Feeding Intervention to Prevent Childhood Obesity: The Baby Milk Intervention and Trial. Journal of Obesity, vol. 2014, Article ID 646504, 10 pages. https://doi.org/10.1155/2014/646504.

Raphela, S.F. (2014). Treatment and disposal of medical waste in rural and urban clinics within Polokwane municipality of South Africa. *J. N. Gener. Sci.*, *12*, 97–109.

Rivis A., Sheeran P. (2003). Descriptive norms as an additional predictor in the theory of planned behaviour: a meta-analysis. *Current Psychology,* 22(3), 218–233.

Shen, M.Y., Chang, C.C., Li, M.Y. and Lin, J.H. (2017). Decreasing the Output of Biomedical Waste in the Intensive Care Unit. Hu Li Za Zhi 64(5):81-90. doi: 10.6224/JN.000071.

Sammut-Bonicci, T, Galea, D. (2015). SWOT Analysis. In *Wiley Encyclopaedia of Management*. Cooper, C.L. (Ed.). John Wiley & Sons, Ltd.

Sunday Times. (2009) Medical waste found dumped in the backyard. 28 November 2009. Retrieved from https://www.iol.co.za/news/south-africa/medical- waste management-found-dumped-in-back-yard-466096 on 15/02/2017.

The National Environmental Management. Air Quality Act (Act No. 39 of 2004) Standards and Regulations. Department of Environmental Affairs. South Africa, Pretoria.

Shrivastava SR, Shrivastava PS, Ramasamy J. Emphasizing the role of stakeholders in the safe disposal of biomedical wastes. J Clin Sci. 2015;12:57-8.

Stedile, L.N.R., Schneider, V.E, Nunes, M.W. and Kappes A.C. (2018). Application of the DPSEEA Model to Healthcare Waste Management. Cien Saude Colet 23(11):3683-3694. doi: 10.1590/1413-812320182311.19352016.

Tabash, M., Hussein, R.A., Mahmoud, A.H., El-Borgy, M.D. and Abu-Hamad, B.A. (2016). Impact of an intervention programme on knowledge, attitude and practice of healthcare staff regarding pharmaceutical waste management, Gaza, Palestine. Public Health. 138:127-37. doi: 10.1016/j.puhe.2016.04.001.

Tabrizi, J.S., Saadati, M., Heydari, M., Rezapour, R. and Zamanpour, R. (2018). Medical waste management improvement in community health centers: an interventional study in Iran. Prim Health care Res Dev. 20:1-6. doi: 10.1017/S1463423618000622.

The Constitution of the Republic of South Africa Previously "Constitution of the Republic of South Africa, Act 108 of 1996", substituted by s 1 (1) of the Citation of Constitutional Laws, 2005 (Act No 5 of 2005) [Assented to 16 December 1996] The Department of Justice; South Africa. 2005.

Toktobaev, N., Emmanuel, J., Djumalieva, G., Kravtsov, A. and Schuth T. (2015). An innovative national health care waste management system in Kyrgyzstan. Waste Manage Res. 33(2):130-8. doi: 10.1177/0734242X14565209.

Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. International Journal for Quality in Health Care, 19, 349–357.

Wafula, ST., Musiime, J. Oporia, F. (2019). Health care waste management among health workers and associated factors in primary health care facilities in Kampala City, Uganda: a cross-sectional study. *BMC Public Health* vol 19, Article number: 203 (2019).

Wise D., Goggin K., Gerkovich M., Metcalf K., Kennedy S. (2006). "Predicting intentions to use condoms using gender, sexual experience, and the theory of planned behavior," *American Journal of Health Education,* 37: 4, 210–218.

World Health Organization (2018). Fact Sheet (Health-Care Waste). Accessed from https://www.who.int/news-room/fact-sheets/detail/health-care-waste on 04/03/2019.

CHAPTER EIGHT

SUMMARY, RESEARCH OUTPUTS, CONCLUSIONS, CONTRIBUTION TO KNOWLEDGE, RECOMMENDATIONS AND LIMITATIONS

8.1 Preamble

The previous (seventh) chapter described the development of intervention strategies for management of medical waste in Vhembe District Municipality (VDM) and how the strategies were validated. This chapter summarizes the entire study by linking the objectives of the study with the methods used to achieve them and the results. It gives an overview of the link between the qualitative and the quantitative studies; discusses the contribution of this study to the body of existing knowledge and highlights the conclusions arrived at by the end of the study. It also describes the limitations encountered in the course of conducting the study and makes recommendations for policy, for healthcare facilities and for further research studies.

8.2 Summary

The purpose of this study was to explore medical waste management practices, identify the challenges being faced by stakeholders and develop intervention strategies for the management of medical waste in VDM.

The objectives were:

a. To explore the availability, implementation and compliance to medical waste management guidelines in selected healthcare facilities in VDM.
b. To determine the medical waste generation, storage and transportation practices among healthcare workers in selected healthcare facilities in VDM.
c. To identify the challenges being faced by waste generators in the process of medical waste management.
d. To compare medical waste management practices in the hospitals, clinics and community health facilities in VDM, Limpopo Province.
e. To develop practical intervention strategies for medical waste management in VDM.

8.2.1 Summary of how objective 1 was accomplished

The availability, implementation and compliance to medical waste management guidelines in selected health facilities in VDM was explored through the use of a mixed method of data

collection. During the quantitative study, a pool of data was obtained from the medical waste generators and handlers within the selected healthcare facilities to obtain an accurate and reliable result on the subject. However, since an in-depth understanding was also required, a qualitative method of data collection was used to compliment the quantitative data.

For the quantitative study, a questionnaire was developed for medical waste generators and handlers from the fifteen healthcare facilities selected for the study in the VDM. Doctors, nurses and pharmacy staff are considered as medical waste generators while the cleaners are mainly medical waste handlers, though the generators also handle the waste at the point of generation. The Sloving's formula was used to determine a sample size of 375 from the total number of 6, 074 healthcare workers in VDM as at the time of collection of data for this study. The questionnaire contains close-ended questions about the availability and accessibility of medical waste management guidelines in the healthcare facilities:

"Is a guideline for management of medical waste available in your healthcare facility?
Yes [ ] No [ ] Not sure [ ]"

"If "yes", how accessible is the guideline? It is in the office of the Head of the facility [ ] It is available in every ward [ ] Every staff has a personal copy [ ]"

Other questions were also asked to determine their compliance with the guideline. Such questions are related to their practices of medical waste segregation, transportation and onsite storage which will be discussed later under the second objective. The questionnaires were distributed to them at their respective healthcare facilities by the researcher and her assistance. They waited while the respondents complete the questionnaires, so that they could give further explanations and assistance to the respondents whenever there is a need for it. However, some respondents did not complete the questionnaires immediately and this led to the loss of many of the questionnaires. More than 500 questionnaires were distributed, but, only 229 were suitable for analysis after the ones with many missing information were excluded. This accounts for a response rate of 61.1% when calculated based on the sample size.

During the qualitative study, the personnel in charge of medical waste management in the hospitals [Environmental Health Practitioners (EHPs) and Infection Prevention and Control Coordinators (IPCCs)] and the clinics and community health centres (Managers) were interviewed to obtain an in-depth understanding of the subject. The main question posed at them is *"Is there a medical waste management guideline in this facility and do the workers always comply with the guideline?"*. This was followed by other probing questions.

During the interviews, the participants all reported that medical waste management guidelines are available in their healthcare facilities and they are accessible to the staff. In the hospitals, a copy of the guideline can be found in every ward, while in the clinics and community health centres (CHCs), the document can only be found in the Manager's office, but the staff are aware about its availability and they can access it anytime they so wish. However, all the participants stated that the staff do not fully comply with the recommendations for proper medical waste management as stipulated in the guidelines.

8.2.2 Summary of how objective 2 was accomplished

The second objective was "to determine the medical waste generation, segregation, transportation and storage practices among healthcare workers in selected healthcare facilities in VDM". The relevant data needed to achieve this objective was also collected through a mixed method approach. The questionnaire distributed to the medical waste generators and handlers contains questions related to their medical waste generation, storage and transportation activities in their respective healthcare facilities. The questions include both open and close-ended questions like:

a. Generation: "*What types of wastes are generated at your healthcare facility?*

General waste only [ ] General and hazardous waste [ ] Hazardous waste only [ ]"

"What types of hazardous waste are generated at your healthcare facility? Tick all appropriate categories" (This question was followed by a table which lists the various categories of hazardous medical waste with options of "yes", "no" and "not sure").

b. Segregation*: "Is waste generated in your healthcare facility segregated into general and hazardous waste? Yes [ ] No [ ]"*

"Is the hazardous waste generated segregated into various sub-categories? Yes [ ] No [ ]"

"How do you rate segregation of medical waste in your facility? Poor [ ] Good [ ]
Very Good [ ] Excellent [ ]"
"If you do not segregate, provide reasons for not segregating your waste……"

c. Transportation: *"How do you transport medical waste within your facility (onsite)?*

Dedicated vehicles [ ] Dedicated trolleys [ ] Any available container [ ] By hand [ ]"

d. Storage*: "Where do you store medical waste awaiting transportation to the disposal sites?*

In the wards [ ] outside the wards [ ] at a designated place [ ]"

"How secured is your temporary storage area?

Not accessible to any unauthorized persons [ ] Accessible to everyone including patients and relatives [ ]"

"How frequently are the waste removed from your facility? Daily [ ] Weekly [ ] Irregularly [ ] Fortnightly [ ]"

A qualitative study was also conducted to confirm or reject the information obtained through the questionnaires. The participants confirmed the responses got through the questionnaires, however, they were able to give more detailed explanations as to the reasons why the staff do what they do. Healthcare workers were also observed on duty to see how they segregate and transport the medical waste from the points of generation to the central storage rooms. Furthermore, an inspection of each healthcare facility was conducted by the researcher and her assistant in the company of the EHP, IPCC or the Manager, to assess the medical waste bins and the central storage areas for medical waste. With the permission of the Chief Executive Officers (CEOs) of the hospitals and Managers of the clinics and CHCs, relevant photos were taken, which have been displayed at appropriate sections in chapters 4 - 7.

Statistical tests were performed on the quantitative data using the statistical package for the social sciences (SPSS) version 25, and the qualitative data was thematically analysed. The results were synthesized together to understand the practices of medical waste generation, segregation, transportation and storage practices in VDM healthcare facilities. These were described in details in chapter 4.

8.2.3 Summary of how objective 3 was accomplished

The third objective of this study was **"**to identify the challenges being faced by waste generators in the process of medical waste management". While conducting the literature search at the beginning of this study, the challenges of medical waste management which have been previously identified from other studies conducted in other developing countries including South Africa were found to be related to unavailability of guideline documents, inadequate knowledge of healthcare workers due to lack of regular training, insufficiency of personal protective equipment, waste segregation equipment, etc. Thus, the questions regarding the challenges were focused on these problems.

The specific challenges confronting the healthcare workers in VDM with regards to medical waste management were identified from the medical waste generators directly through the questionnaires distributed to them. The following questions were posed to them:

"Is a guideline for management of medical waste available in your healthcare facility?

Yes [ ] Not sure [ ] No [ ]"

"If "yes", How accessible is the guideline? It is in the office of the Head of the facility [ ] It is available in every ward [ ] Every staff has a personal copy [ ]"

"Have you received any training in clinical waste management? Yes [ ] No [ ]"

"Is there a schedule for regular training of staff about medical waste management in your healthcare facility? Yes [ ] Not sure [ ] No [ ]"

"Are there sufficient equipment for proper management of medical waste in your healthcare facility? Yes [ ] Not sure [ ] No [ ]"

"If there are "no" sufficient equipment, which equipment is lacking or insufficient? Tick all the appropriate boxes". This question was followed by a list of equipment required for an effective medical waste management with spaces for the respondents to tick if any of them is insufficient.

"If you have ticked any equipment, why do you think the supply of the equipment is insufficient? Not supplied by the Department of Health [ ] Wastage/ Improper handling [ ] Frequent breakdown [ ] Non-replacement of old, re-usable equipment [ ]"

"Do you usually experience a delay in the transportation of waste offsite?

Yes [ ] Not sure [ ] No [ ]"

If "yes", what factors do you think are responsible for the delay? Poor access to the healthcare facilities [ ] Breach of contract by the service providers [ ]"
"Do you think there is a need for improvement with medical waste management at your facility? Yes [ ] Not sure [ ] No [ ]"

"If yes, what types of improvement do you think are needed?....."

During the interviews, the participants were also asked *"What are the challenges you face in the process of managing medical waste in this healthcare facility" or "Please, share with me some of the challenges that you have encountered in managing medical waste in this facility".* Through an observation checklist, the challenges identified during the "facility tours" were also documented. Thus, the challenges were identified at the level of the healthcare facilities and they are described in details in Chapter 5.

8.2.4 Summary of how objective 4 was accomplished

"To compare medical waste management practices in the hospitals, clinics and community health facilities in VDM, Limpopo Province" was the fourth objective. This objective was included because previous studies on medical waste management in VDM have been focused only on the hospitals (which are all located in the urbanized, easily accessible areas of the District), however, the Limpopo Province of South Africa is considered to be predominantly rural with 87% of the population living in the rural areas. Most of these people, especially in VDM, access healthcare through the clinics and CHCs (many of which are located in remote villages with poor road networks), which are closer to them than the hospitals. The researcher intended to check if the practices of medical waste management in all these healthcare facilities is comparable, or if it is significantly different.

This objective was achieved by the distribution of the sampled facilities over all the local municipalities of Vhembe District and ensuring that each of the different tiers of healthcare facilities is represented in the sample: from each of the four local municipalities, a hospital, two clinics and a community health center were included in the study. The same data collection instruments were administered to the same categories of healthcare workers in all the healthcare facilities. The Data analysis reveals some significant differences in medical waste management practices in the urbanized as compared with the remotely located healthcare facilities in terms of access to the guideline documents, the regularity of training, availability of equipment and regularity of waste transportation offsite.

8.2.5 Summary of how objective 5 was accomplished

The final objective of this study was "to develop practical intervention strategies for medical waste management in VDM". This was done using the Medical Research Council's (MRC) framework for development and evaluation of complex intervention strategies as described by Bleijenberg *et al.* (2018). The seven stages of this framework were duly followed, and the

strategies were eventually developed based on the Strength, Weaknesses, Opportunity and Threat (SWOT) analysis techniques.

From the analysis of both the quantitative and qualitative data, the strengths and weaknesses (internal factors) and the opportunities and threats (external factors) of medical waste management in VDM were identified. These were synergized to arrive at practical intervention strategies which could be applied by the District and possibly the entire province, for an improved management of medical waste. Representatives from the Department of Health and the waste management company on contract with the Department were involved in the development of the intervention strategies.

The expected outcomes from this study were:

i. Establishment of medical waste management practices in VDM.

ii. Identification of challenges facing medical waste management stakeholders.

iii. Development of intervention strategies for management of medical waste in VDM.

These were all achieved at the end of the study.

8.3 Research Outputs

This study has generated the following outputs:

i. Two published papers: “A review of medical waste management in South Africa”, published by Open Environmental Sciences Journal in 2018 and “Efficiency of Health Care Risk Waste Management in Rural Healthcare Facilities of South Africa: An Assessment of Selected Facilities in Vhembe District, Limpopo Province” published by the International Journal of Environmental Research and Public Health in 2019.

ii. Three conference presentations: A paper from this study titled: “A Review of Medical Waste Management: A Case Study of South Africa” was presented at the 33rd International Conference on Solid Waste Technology and Management, Annapolis, USA, March 12-14, 2018. Two other papers were presented at the 14th Population Association of Southern Africa (PASA) Conference in July 10-12, 2019, titled: “Challenges of Effective Management of Medical Waste In Low-Resource Settings: A Case Study Of Vhembe District Health Facilities” and “Health Care Risk Waste Management in Rural Health Facilities of Limpopo Province: The Interplay of Responsibilities of Department of Health, Healthcare Facilities and Waste Management Company”.

iii. Three other manuscripts have been drafted for publication in accredited journals, out of which two have been submitted to accredited journals, and the other one would be submitted soon.

8.4 Conclusions

At the end of this study, based on the results achieved following a rigorous data collection and analysis processes, the researcher has drawn the following conclusions:

- The management of hazardous medical waste is ineffective in all the healthcare facilities of VDM.
- Health workers in the clinics and CHCs face more challenges than those working in the hospitals.
- There are insufficient equipment for proper management of medical waste in the healthcare facilities, especially the personal protective equipment and segregation equipment (color-coded bins).
- The central storage rooms for temporary storage of medical waste awaiting transportation offsite are not constructed in a standard way in many healthcare facilities of VDM.
- Many healthcare workers in VDM display apathetic attitudes towards training on management of medical waste.
- Healthcare workers in VDM exhibit poor compliance with medical waste management guidelines.
- There is a communication gap between the main stakeholders of medical waste management in the District, namely: healthcare facilities, Department of Health and the waste management company.
- The annual budget for medical waste management in VDM is insufficient to address all the current issues of managing the waste.

These show that there is a need for urgent intervention to improve on the management of medical waste in the District to mitigate the untoward effects of such waste on the people and the environment.

8.5 Contribution to Knowledge

In the past, most studies conducted on waste management are focused on municipal waste. However, the issues of medical waste management has gained the attention of many researchers recently, both in the fields of public health and environmental sciences because poor management of the waste affects both the health of humans and the quality of the environment. The few studies which have been published so far on medical waste are mainly conducted in the hospitals while some of the studies were conducted on isolated clinics and community based care centers.

While the current study has recorded very similar results with previous similar studies, the current research has moved a step further by involving both easily accessible and remotely located healthcare facilities in a single study, such that the findings were compared. Also, while other studies have simply reported the medical waste management practices and ended with recommendations for improvement; intervention strategies were developed at the end of this study which could be employed to improve on the practices of medical waste management and mitigate the impacts of poorly managed medical waste in VDM. Given that the practices and challenges are similar in other District Municipalities of Limpopo Province, the strategies could also be applied there as well as in other similar settings in South Africa.

8.6 Recommendations

This study has revealed the practices and challenges of medical waste management in VDM. It has also revealed the important stakeholders that contribute to a good management of the waste as well as the roles each of them is expected to perform. The Department of Health and the healthcare facilities can be referred to as the principal or permanent stakeholders, while the waste management company can be referred to as a temporary or transient stakeholder, because their involvement in management of the medical waste generated in the province is limited by the duration of their contract. Thus, the following recommendations are directed to the principal stakeholders as well as those who might be interested in further research of medical waste management in Limpopo Province.

8.6.1 Recommendations for policy makers/Department of Health

1. Create a strong link/feedback relationship between the government, healthcare facilities and the waste management company.

2. Allocate a sufficient budget annually for management of medical waste.

3. Support the DEA in the monitoring of the activities of the waste management company.

4. Encourage and sponsor researches which are focused on improving medical waste management.

8.6.2 Recommendations for healthcare facilities.

1. Encourage all healthcare workers to participate actively in the medical waste management trainings organized by the Department of Health or the waste management company.

2. Conduct regular in-service trainings on medical waste management in your healthcare facilities.

3. The Environmental Health Practitioner or Infection Prevention and Control Coordinator in the hospitals and the Managers in the clinics, should keep a stock chart, to ensure that they order for medical waste management equipment on time, to avoid shortage of equipment.

4. Ensure that all healthcare workers comply with the recommendations on the medical waste management guidelines.

5. Communicate promptly with the Department of Health whenever they face any challenges with regards to medical waste management.

8.6.3 Recommendations for future research

1. Evaluation of the strategies developed at the end of this study should be carried out, to determine its effectiveness in Vhembe and other District Municipalities of Limpopo Province.

2. Further studies to calculate HCRW volume in Limpopo Province and how its storage, treatment and disposal contribute to emissions of greenhouse gases in the country.

8.7 Limitations

Necessary efforts were made to ensure that this study is valid and credible (through the use of triangulation during data collection) and that the intervention strategies developed would be practical enough and easy to implement. However, the following limitation are acknowledged in the study.

First, this study was conducted only in one District Municipality (DM) out of the five District Municipalities in Limpopo Province. The strategies were developed based on the data captured in VDM only, which may or may not be comparable with what obtains in the other DMs. If the practices and challenges of medical waste management are similar in all the DMs, then, the strategies could be applied across the board, but, in settings where the practices are different, the strategies may not be applicable.

Secondly, the MRC recommends a good involvement of all the relevant stakeholders during the strategies' development phase. While representatives from the Department of Health, Limpopo Province and the Waste Management Company were duly involved during the development of the strategies, the researcher could not travel round all the healthcare facilities where data was collected to involve them in the development, due to lack of funds and the constraint of time (the duration of the PhD is only three years).

Finally, also due to the time constraints, the intervention strategies, though validated, could not be evaluated for effectiveness and subsequently implemented. Thus, it is recommended that future researchers look into the possibility of evaluation and implementation of the strategies. The evaluation could also be carried out as a post-doctoral study by the researcher.

APPENDICES

Appendix 1: Information Letter

Dear Research Respondent,

Thank you for showing interest in this study. This letter is to provide you with all the necessary information about this study. If after going through the letter, you choose to participate, you will be required to sign the consent form at the end of this letter. Thank you.

Title of the Research Study: Development of Intervention Strategies for Management of Medical Waste in Vhembe District, South Africa

Principal Investigator: OLANIYI, Foluke Comfort (*MB; BS, MPH*)

Co-Investigator: Prof Ogola JS (*PhD*)

Brief Introduction and Purpose of the Study

Poor management of medical waste from the point of generation to disposal poses a health risk both to health workers and the public. Lack of segregation of general and hazardous medical waste has resulted in the generation of an enormous quantity of medical waste from health facilities in South Africa, with subsequent illegal dumping of some of the waste as the licenced treatment/disposal facilities are unable to cope with such a huge quantity. Medical waste has been reportedly found dumped in unauthorized sites in Vhembe District, alongside with municipal waste. The purpose of this study is to investigate the practices of medical waste management in Vhembe District and the challenges being faced by stakeholders in the process of managing medical waste, such that a practical intervention may be developed to assist with medical waste management in the district.

Outline of the Procedures

The study will be conducted in three phases: During the first phase, an in-depth interview will be conducted for the Heads of some selected health facilities, heads of nurses, infection control officers, the personnel involved in medical waste management in each of the local municipality in Vhembe District. The interviews will be conducted during the working days (Mondays – Fridays) at designated places agreed upon by both the researcher and the interviewees, possibly in the interviewees' offices or a general/board room. The lunch time will be chosen for the interviews in order not to interfere with the interviewees' official duties and each interview will last a maximum of 40 minutes.

During the second phase, a questionnaire will be used to obtain data from medical waste generators and handlers in the selected health facilities. The questionnaires will be distributed

to them at the health facilities, local municipal offices or other venues which are convenient for them. The researcher and her research assistants will wait for them to complete the questionnaires and provide assistance with the completion of the questionnaires where necessary. The completed questionnaires will be collected immediately.

The third phase will be to develop practical intervention strategies for medical waste management in Vhembe District.

Risks or Discomforts to the Respondent: Participation in this study involves no risk. Only your time is needed to either participate in the interview or complete the questionnaire.

Benefits: This study does not provide any direct benefits to respondents**.** However, outcome of the study is expected to be of benefit to the district by providing a framework upon which guidelines can be designed, health workers by providing them with more enlightenment with regards to the risks involved with poor medical waste management to help them better comply with available guidelines and the general public will be free from an environment polluted with toxic medical waste.

Reason(s) why the Respondent May Be Withdrawn from the Study: The decision to participate in this study or not is entirely yours to make. You are also allowed to withdraw from it at any point if you so wish. Your identity will be kept anonymous. Your name or that of your health facility will not be requested for at any time during the study.

Remuneration: None

Costs of the Study: This study does not cost you any money should you decide to participate

Confidentiality: Any information you give will be kept strictly confidential and used for research purposes only. The questionnaire you complete will only be accessible to the researcher, statistical analyst and supervisors. Afterwards, it will be kept under lock and key.

Research-related Injury: This study does not pose any risk of injuries to the respondents.

If you have any questions, please contact me (Investigator: Olaniyi F. Comfort) on +27612177991 or foluolaniyi@yahoo.com or the University Research Ethics Committee Secretariat on 015 962 9058. Complaints can be reported to the Director: Research and Innovation, Prof GE Ekosse on 015 962 8313 or Georges Ivo.Ekosse@univen.ac.za.

Appendix 2: The Consent Form

Development of Intervention Strategies for Management of Medical Waste in Vhembe District, South Africa

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher (Olaniyi, F. Comfort), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number:
- I have also received, read and understood the above written information regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerized system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

Date Time Signature of respondent

…… …… ……..

I, OLANIYI, Foluke Comfort herewith confirm that the above respondent has been fully informed about the nature, conduct and risks of the above study.

Full Name of Researcher

…… Date…… Signature……

Appendix 3: The Interview Guide

Development of Intervention Strategies for Management of Medical Waste in Vhembe District, South Africa

A. Representative from the Department of Health

Main question: What are the roles of the Department of Health in ensuring efficient management of medical waste in Limpopo Province?

Probing questions:

a. What is the trend of medical waste generation in Limpopo in the past 5 years?
b. How regularly is the medical waste management guideline from the Department revised?
c. Are there some challenges which you have noticed or which have been reported to you about management of medical waste in the province?
d. Is the Department taking active steps towards training of healthcare workers on management of medical waste, supervising them and getting a feedback from them?
e. How does the Department relate with the waste management company on contract with them?
f. Does the DoH work with the Department of Environmental Affairs as regarding medical waste management?
g. Is the Department facing any challenges with improving medical waste management in the province?

B. Hospital Chief Executive Officer/Clinical Director/Head of Nursing services/ Clinic Manager

Main question: Is there a medical waste management guideline in this facility and do the workers always comply with the guideline?

Probing questions:

a. What is the source of the medical waste management guideline being used in this facility?
b. How accessible is the guideline to members of staff?
c. Is there a schedule for training of staff on medical waste management?
d. Have the staff been compliant to all the instructions on the guideline all the time?
e. If the answer to (c) is “no”, why not?
f. Who is responsible for enforcing the implementation of the policy among the staffs?

g. Have there been incidences of injuries related to medical waste in your facility in the past 12 months?
h. Are all health workers in this facility protected against health hazards of improper medical waste?
i. What are the challenges you face in the process of managing medical waste in this healthcare facility?
j. What are the initiatives taken for effective management of medical waste in this facility?
k. What do you think can be done to improve the efficiency of medical waste management in this facility?

C. Infection prevention and control coordinator/Environmental health practitioner .

Main question: Is medical waste generated in this facility properly managed?

Probing questions:

a. Is there a regular documentation of medical waste generated and treated in this facility?
b. If you outsource your waste for treatment and disposal, do you always receive the certificate of destruction from the treatment facilities?
c. Are there sufficient equipment for personal protection of all staffs, temporary storage and transportation of medical waste in this facility?
d. Do all staffs always segregate the medical waste from source?
e. What measures are employed in this facility to minimise, reuse and recycle medical waste?
f. How do you ensure that all staffs comply with the guidelines on waste segregation, temporary storage and transportation?
g. Are there adequate equipment for the temporary storage of medical waste until it is collected for treatment/disposal?
h. Is the temporary storage room secure and inaccessible to unauthorized persons?
i. How often is medical waste collected from this facility to treatment/disposal site?
j. If medical waste is not collected as per schedule what do you do with it?
k. Please, share with me some of the challenges that you have encountered in managing medical waste in this facility
l. What do you think can be done to improve the efficiency of medical waste management in this facility?
m. Have you worked as in this capacity in other health facilities before now?
n. If (m) is “yes”, can you compare what obtains here with what happens in other facilities where you have worked before?

D. Representative of the waste management company

Main question: How is hazardous medical waste generated from Limpopo healthcare facilities treated and disposed?

Probing questions:

a. What are your roles as a company concerning medical waste management in the province, according to your contract?
b. What types of techniques do you employ for the treatment of medical waste?
c. How do you ensure optimal functioning of your treatment equipment?
d. How do you ensure environmental safety while treating the medical waste?
e. Have you encountered or noticed any challenges in the process of carrying out your duties in the healthcare facilities?
f. Where do you dispose the final product of medical waste treatment?

Appendix 4: Questionnaire

Development of Intervention Strategies for Management of Medical Waste in Vhembe District, South Africa

My name is OLANIYI, Foluke Comfort, a PhD student at the Department of Public Health, University of Venda. I am carrying out a study on the practices and challenges of medical waste management in South Africa with a focus on Vhembe district health facilities and municipalities. This study is a requirement for my doctorate degree in public Health at the University.

Information collected through this questionnaire will be treated confidentially and the results will be used for academic and research purposes only. Participation in this survey is voluntary and you can withdraw from the study without any obligations, however, you do not stand to derive any direct benefit from participation neither does participation in it exposes you to any risks or harm.

SECTION A (Demographic data)

PLEASE, TICK IN THE MOST APPROPRIATE BOX WHERE APPLICABLE.

1. Rank of your healthcare facility: District hospital [ ] Clinic [ ] Community Health Center [ ]

2. Gender: Male [ ] Female [ ]

3. Age: ……..

4. Occupation: Nurse [ ] Cleaner [ ] Laboratory Staff [ ] Doctor [ ] Pharmacy staff [ ] Other [ ]

Specify----------

5. For how long have you been working in this healthcare facility? ……

SECTION B (Medical waste management practices)

6. What types of wastes are generated at your healthcare facility?

General waste only [ ] General and hazardous waste [ ] Hazardous waste only [ ]

7. What types of hazardous waste are generated at your healthcare facility? Tick all appropriate categories

Type of waste	Yes	No	Not sure
Infectious			
Sharps			
Pathological			
Genotoxic			
Pharmaceutical			
Radionuclide			

8. Is waste generated in your healthcare facility segregated into general and hazardous waste? Yes [ ] No [ ]

9. Is the hazardous waste generated segregated into various sub-categories? Yes [ ] No [ ]

10. How do you rate segregation of medical waste in your facility?
Poor [ ] Good [ ] Very Good [ ] Excellent [ ]

10. If (8) is no, provide reasons for not segregating your waste
……
……
……
……

11. Where do you store medical waste awaiting transportation to the disposal sites?
In the wards [ ] outside the wards [ ] at a designated place [ ]

12. How secured is your temporary storage area?
Not accessible to any unauthorized persons [ ] Accessible to everyone including patients and relatives [ ]

13. How do you transport medical waste within your facility (onsite)? Dedicated trolleys [ ] any available container [ ]

14. Do you dispose the waste at your healthcare facility? Yes [ ] No [ ]

15. If yes, how? Burning [ ] Incineration [ ] Deep burial [ ] Microwave [ ] Open dumping [ ]

16. If no, how frequently are the waste removed from your facility? Daily [ ] Weekly [ ] Irregularly [ ]

17. Who is responsible for removal of hazardous medical waste from your facility? Municipal government [ ] Facility administrators [ ] Private company [ ]

18. Do you use personal protective equipment (PPE) when handling medical waste? Yes [ ] No [ ]

19. If the answer to (18) is yes, what types of PPE do you use?

……

……

……

20. If the answer to (18) is no, give reason(s) for not using PPE

……

……

……

21. Do you think improper management of medical waste holds any risk for you, patients and the community? Yes [ ] No [ ]

22. If yes, what kinds of risks?

……

……

……

SECTION C (Challenges of medical waste management)

23. Is a guideline for management of medical waste available in your healthcare facility?: Yes [ ] No [ ]

24. If “yes”, how accessible is the guideline? It is in the office of the Head of the facility [ ] It is available in every ward [ ] Every staff has a personal copy [ ]

25. Have you received any training in clinical waste management? Yes [ ] No [ ]

26. Is there a schedule for regular training of staff about medical waste management in your healthcare facility? Yes [ ] No [ ]

27. Are there sufficient equipment for proper management of medical waste in your healthcare facility? Yes [ ] No [ ]

28. If the answer to (27) is “no”, which equipment is lacking or insufficient? Tick all the appropriate boxes

A. PPE: Gloves [ ] Overall clothing [ ] Boots [ ] Face masks [ ]

B. Segregation equipment: Color-coded bins [ ] puncture-proof container for sharps [ ]

C. Transportation equipment (onsite): Dedicated, wheeled trolleys [ ]

D. Temporary storage equipment: Secured dedicated room [ ]

E. Transportation equipment (offsite): Dedicated vehicles [ ]

29. If you have ticked any equipment in (28), why do you think the supply of the equipment is insufficient? Not supplied by the Department of Health [ ] Wastage/ Improper handling [ ] Frequent breakdown [ ] Non-replacement of old, re-usable equipment [ ]

30. Do you usually experience a delay in the transportation of waste offsite? Yes [ ] No [ ]

31. If “yes”, what factors do you think are responsible for the delay? Poor access to the healthcare facilities [ ] Poor communication with waste disposal agents [ ]

Do you think there is a need for improvement with medical waste management at your facility? Yes [ ] No [ ]

32. If yes, what types of improvement do you think are needed?

……

……

……

……

……

……

Thank you for your time.

Appendix 5: Observation Checklist

Identification code of healthcare facility ……

Day…….. Date ……..

Parameter	Site 1		Site 2		Site 3		Site 4		Comments	
	Yes	No	Yes	No	Yes	No	Yes	No		
Availability of separate bins for:										
i. General waste										
ii. Infectious waste										
iii. Sharps										
iv. Others										
Adequate segregation of waste at source										
Use of personal protective equipment										
i. Gloves										
ii. Overall clothing										
iii. Boot										
iv. Face mask										
Onsite transportation										
Dedicated wheeled trolley										
Trolley constructed according to standard										
Any available equipment										
Waste spilling										
Temporary onsite storage										
Available, dedicated site										
Secured storage room										
Inaccessible to unauthorized persons										
Presence of flies or rodents										
Waste securely contained in containers										
Treatment and disposal										
Onsite										
Open dumping										
Burning										
Incineration										
Offsite										
Rate of collection of waste offsite										
Regular										
Irregular										
Use of designated vehicles										
Any available vehicle										
Record of waste generation, treatment and disposal										
Certificate of destruction always received										
Other comments										

Appendix 6: Letter of approval of study from the University Higher Degrees' Committee

UNIVERSITY OF VENDA

OFFICE OF THE DEPUTY VICE-CHANCELLOR: ACADEMIC

TO : MR/MS F.C OLANIYI

SCHOOL OF HEALTH SCIENCES

FROM: SENIOR PROFESSOR L.B KHOZA

DEPUTY VICE-CHANCELLOR: ACADEMIC

DATE : 23 APRIL 2018

DECISIONS TAKEN BY UHDC OF 23RD APRIL 2018

Application for approval of Thesis research proposal in Health Sciences: **F.C Olaniyi (14014787)**

Topic: "Development of Interventions Strategies for the Management of Medical Waste in Vhembe District, South Africa."

Promoter	UNIVEN	Prof. J.S Ogola
Co-promoter	UNIVEN	Dr. T.G Tshitangano

UHDC approved Thesis proposal

Senior Professor L.B. Khoza
ACTING DEPUTY VICE-CHANCELLOR: ACADEMIC

Appendix 7: Ethical Clearance Certificate

RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:
Dr FC Olaniyi

Student No:
14014787

PROJECT TITLE: **Development of intervention strategies for management of medical waste in Vhembe District, South Africa.**

PROJECT NO: **SHS/18/PH/07/0405**

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Prof JS Ogola	University of Venda	Promoter
Dr TG Tshitangano	University of Venda	Co - Promoter
Dr FC Olaniyi	University of Venda	Investigator – Student

ISSUED BY:
UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE

Date Considered: May 2018
Decision by Ethical Clearance Committee Granted
Signature of Chairperson of the Committee: .....
Name of the Chairperson of the Committee: Senior Prof. G.E. Ekosse

UNIVERSITY OF VENDA
DIRECTOR
RESEARCH AND INNOVATION
2018 -05- 28
Private Bag X5050
Thohoyandou 0950

University of Venda
PRIVATE BAG X5050, THOHOYANDOU, 0950λ LIMPOPO PROVINCEλ SOUTH AFRICA
TELEPHONE (015) 962 8504/8313 **FAX** (015) 962 9060
"A quality driven financially sustainable, rural-based Comprehensive University"

Appendix 8: Letter of Approval from the Department of Health

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF HEALTH

Enquiries: Stander SS (015 293 6650)

Ref: LP_2018_

Olaniyi FC
University of Venda
Private bag X5050
Thohoyandou

Greetings,

RE: Development of intervention strategies for management of medical waste in Vhembe District, South Africa

The above matter refers.

1. Permission to conduct the above mentioned study is hereby granted.
2. Kindly be informed that:-
   - Research must be loaded on the NHRD site (http://nhrd.hst.org.za) by the researcher.
   - Further arrangement should be made with the targeted institutions, after consultation with the District Executive Manager.
   - In the course of your study there should be no action that disrupts the services, or incur any cost on the Department.
   - After completion of the study, it is mandatory that the findings should be submitted to the Department to serve as a resource.
   - The researcher should be prepared to assist in the interpretation and implementation of the study recommendation where possible.
   - The above approval is valid for a 3 year period.
   - If the proposal has been amended, a new approval should be sought from the Department of Health.
   - Kindly note, that the Department can withdraw the approval at any time.

Your cooperation will be highly appreciated.

Head of Department

Date 20/06/2018

Private Bag X9302 Polokwane
Fidel Castro Ruz House, 18 College Street. Polokwane 0700. Tel: 015 293 6000/12. Fax: 015 293 6211.
Website: http/www.limpopo.gov.za

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Appendix 9: Letter of Approval from Vhembe District Municipality

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF HEALTH
VHEMBE DISTRICT

Ref: S5/6
Enq: Muvari MME
Date: 18 July 2018

Dear Sir/Madam

PERMISSION TO CONDUCT RESEARCH ON "The Development of Intervention Strategies for the Management of Medical Waste in the Vhembe District, South Africa" Olaniyi F.C

1. The above matter refers.
2. Your letter received on the 18/07/2018 requesting for permission to do research in our facilities is hereby acknowledged.
1. The District has no objection to your request.
2. You are however advised to make the necessary arrangements with the facilities concerned.
3. Wishing you success in your endeavor.

..... 19/7/2018
CHIEF DIRECTOR DATE

Private Bag X5009 THOHOYANDOU 0950
OLD parliamentary Building Tel (015) 962 1000 (Health) (015) 962 4958 (Social Dev) Fax (015) 962 2274/4623
Old Parliamentary Building Tel: (015) 962 1848, (015) 962 1852, (015) 962 1754, (015) 962 1001/2/3/4/5/6 Fax (015) 962 2373, (015) 962 227

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Appendix 10: Letter of Permission to conduct the study at Tshilidzini Hospital

TSHILIDZINI HOSPITAL ETHICS COMMITTEE

Memorandum of understanding

Tshilidzini Hospital Ethics Committee with DLANIYI...F.C at their meeting resolved to sign a Memorandum of Understanding after the two parties have agreed on the following information:

1. Reasons for making a research at Tshilidzini hospital.
Tshilidzini hospital is the largest hospital in Vhembe District where I intend to conduct my research and it is a referral centre. I expect to find standard practice here.
2. What will be the benefit of the entire hospital community out of your findings?
My research is expected to generate intervention strategies for management of medical waste in Vhembe District. The strategies may be very useful for the hospital.
3. Who to meet in conducting your research
Heads of various departments who generate and handle medical waste (Doctors, nurses, cleaners, laboratory and pharmacy staffs) as well as waste generators and handlers.
4. What do you do with your findings?
My findings will be reported in my thesis, published in accredited journals and presented at various academic gatherings. It will also be reported to all participating health facilit
5. We will require the hard copy of your research
Yes, I agree.
6. We do not anticipate any information to be divulged to all types of media without the knowledge of the Ethics Committee and Hospital Board.
7. Memorandum of understanding should be signed by both parties.

Signed by: .....

31-08-2018
Date:

Researcher

Appendix 11: Letter of Permission to conduct the study at Elim Hospital

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF HEALTH
ELIM HOSPITAL

LIMPOPO PROVINCE
HUMAN RESOURCES MANAGEMENT & DEVELOPMENT
06 -11- 2018
P/BAG X312, ELIM HOSPITAL, 0960
DEPT. OF HEALTH & SOCIAL DEVELOPMENT

Ref: S5/3/2
Enq: Makondo A.T
Date: 2018.11.06

To: Dr. Foluke Comfort Olaniyi
University of Venda

CC: Acting Deputy Director: Risk Management Services:Mr Matsheka N.J

CC: Acting Assistant Director: Quality Assurance: Mr Siavhe N.Z

RE: APPLICATION FOR PERMISSION TO CONDUCT RESEARCH: DEVELOPMENT OF INTERVENTION STRATERGIES FOR THE MANAGEMENT OF MEDICAL WASTE: UNIVERSITY OF VENDA: DR FOLUKE COMFORT OLANIYI.

1. The above matter bears reference.
2. Receipt of your letter dated 11th of October 2018 together with the approval from the Provincial and District offices is hereby acknowledged with thanks.
3. You are hereby granted permission to access the hospital to conduct the research as requested.
4. When collecting the data, you are kindly advised to liaise with Mr Matsheka: Acting Deputy Director: Risk Management Services regarding issues of information security and the patient's rights.
5. Your urgent attention is always appreciated.

.....
CHIEF EXECUTIVE OFFICER

6. 11. 18
.....
DATE

P/Bag X312, Elim Hospital, 0960
Tel (015)556 3201/2/3/4/5, Fax (015)556 3160,
The heartland of Southern Africa - development is about people
RESTRICTED

Appendix 12: Letter of Permission to conduct the study at Malamulele Hospital

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF HEALTH
MALAMULELE HOSPITAL

REF : S 4/5
ENQ : Siwela T.S
DATE : 24/10/2018

TO WHOM IT MAY CONCERN

SUBJECT: PERMISSION TO CONDUCT A RESEARCH: DR OLANIYI F.C

1. This is to certify that the above mentioned has been granted permission to conduct a research at Malamulele hospital.
2. The research topic is on **" Development of Intervention Strategies for the Management of Medical Waste Vhembe district, South Africa"**
3. Attached hereto is the applicant's letter, research proposal, Training institution's Ethical clearance, participants' consent form, research questionnaire, Provincial and District offices approvals
4. Hopping for an effective cooperation between the participants of this research

Thank you

CHIEF EXECUTIVE OFFICER
MALAMULELE HOSPITAL

26/10/2018
DATE

DEPARTMENT OF HEALTH
MALAMULELE HOSPITAL. P/BAG X9245
MALAMULELE, 0982
30 OCT 2018
REGISTRY

CONFIDENTIAL

Malamulele Hospital Private Bag x9245 Malamulele 0982
Tel: (015) 851 0026/1020/1017/1019 Fax: (015) 851 0620

Appendix 13: Letter of Permission to conduct the study at Messina Hospital

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF HEALTH
MESSINA HOSPITAL

REF: S5/4/1/2
ENQ: Mulaudzi P
DATE: 05 October 2018

FROM: HUMAN RESOURCE DEVELOPMENT

TO: DR FC OLANIYI
UNIVERSITY OF VENDA
PRIVATE BAG X5050
THOHOYANDOU
0950

DEPARTMENT OF HEALTH
MESSINA HOSPITAL - H.R.M. OFFICE
05 NOV 2018
PRIVATE BAG X... MESSINA 0900
LIMPOPO PROVINCE

RE: DEVELOPMENT OF INTERVENTION STRATEGIES FOR MANAGEMENT OF MEDICAL WASTE IN VHEMBE DISTRICT,SOUTH AFRICA.

1. The above matter has reference.
2. This office wishes to inform you that your application has been approved as per conditions stipulated on the approval letter by Head of Department. You are requested to liaise with office of the Chief Executive Officer on your commencement date.
3. Your co-operation will be highly appreciated.

..... 2018.11.05
CHIEF EXECUTIVE OFFICER DATE

P.O. Box 60 Musina 0900
Tel: 015 534 0446 Fax 015 534 0819
The heartland of Southern Africa – development is about people!

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