CHARACTERISATION OF MEDICAL SOLID WASTE AND ASSESSMENT OF THE MANAGEMENT PRACTICES OF ITS INFECTIOUS COMPONENTS IN SELECTED GENERAL HOSPITALS IN LAGOS STATE

BY

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CERTIFICATION

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DEDICATION

This piece of work is dedicated to God almighty, the Alpha and the Omega, who has made this elusive stage of my life, a reality.

and

To the memory of my late mother, Mrs Felicia Amope Ekundayo, who couldn't wait to witness the completion of this programme.

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ABSTRACT

Infectious waste account for a fraction of the total solid waste generated in any city, but has a high potential for infection and injury than any other kind of waste. Mixed with the ordinary waste, infectious waste could make the entire municipal solid waste stream a public health hazard. In Nigeria, there is a gap in knowledge on the profile of medical waste composition and characteristics. This study was designed to characterise medical solid waste and assess the management practices of its infectious components in selected general hospitals in Lagos State.

A descriptive cross-sectional survey involving four hospitals selected from the twenty-three general hospitals using table of random numbers was carried out. Solid waste generated daily were weighed for one month, and physically characterised into paper/carton, kitchen waste/grasses/plant cuttings, cotton, plastics, metals and glass. Grab samples of organic fraction of waste was chemically analysed for pH, carbon, nitrogen, lead, cadmium and nickel using 1992 American Public Health Association(APHA) standard methods. Infectious waste samples were microbiologically assessed for predominant infectious bacterial and microbial load using APHA (1992) standard methods. Knowledge and practice of infectious waste management for 207 waste handlers and generators randomly selected from 415 hospital staff were assessed using a validated questionnaire with a 10-point knowledge scale. A knowledge score ≤ 5 points was considered as poor. A ten-item observational checklist was used to obtain information on infectious waste segregation practices, waste treatment and disposal methods and use of personal protective equipment. Descriptive statistics, Chi-square test and ANOVA were used for data analysis.

A total of 84.2±39.4 kg waste was generated daily in the selected hospitals. Daily output of infectious and non- infectious waste were 23.5±13.5 kg and 60.7± 26.0 kg respectively. Weight of characterised waste components were: 34.0±9.3 kg (paper), 20.6±7.5 kg (kitchen waste/grasses/plant cuttings), 15.5±6.9 kg (plastics), 2.7±1.3 kg (metal) and 1.6±0.5 kg (glass). Chemical characterisation of the waste showed the following components: pH-6.7, carbon-48.1%, nitrogen-1.6%, lead-11.9 mg/kg, cadmium-1.3 mg/kg and nickel-21.6 mg/kg. The predominant organisms isolated in infectious waste were *Klebsiella pneumoniae* (35.9%), *Staphylococcus aureus* (29.7%) and *Proteus mirabilis* (14.1%) with mean counts of 2.0×10^{12}

$\pm 7.0 \times 10^{1}$ cfu/100g, $17.0 \times 10^{12} \pm 2.1 \times 10^{1}$ cfu/100g, and $0.2 \times 10^{12} \pm 2.1 \times 10^{1}$ cfu/100g respectively. Among the respondents, 35.7% were waste handlers and 63.3% were waste generators. Knowledge score of respondents was 5.4 ± 1.5; knowledge score of waste handlers (5.9 ± 1.5) was significantly higher than that of waste generators (5.1 ± 1.4) ($p < 0.05$). Majority (60.4%) of the respondents had poor knowledge and 32.6% practised infectious waste segregation. In all the hospitals, infectious waste was not treated before disposal. Personal protective equipment (PPE) utilised by majority (87.4%) of the respondents was latex gloves and inappropriate use of PPE was common among waste handlers (85.6%).

Management of infectious waste was poor among health workers. Hospital management should engage in continuous training of its members of staff on proper handling of medical waste.

Keywords: Medical solid waste, Infectious waste management, Microbial load
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INTRODUCTION

1.1 Background Information

Healthcare services in rural or urban settings inevitably generate wastes that may be hazardous to health, or may have harmful environmental effects. Although, most waste generated in healthcare establishments can be managed as regular municipal solid waste, however, some of them such as sharps, cultures from medical laboratories or infected blood carry a higher potential for infection and injury than other types of waste, and so require special attention (Pruss *et al.*, 1999). Inadequate and inappropriate handling of healthcare waste may have serious public health consequences and a significant impact on the environment (Pruss *et al.*, 1999; Mathur *et al.*, 2010). Sound management of healthcare waste is thus a crucial component of environmental health protection.

Until recently, medical waste management was not generally considered an issue (Hedge *et al.*, 2007); concerns about Human Immunodeficiency Virus (HIV) and Hepatitis "B" virus (HBV) led to questions about potential risks inherent in medical waste. The washing up of medical waste in 1988 on USA beaches along the east coast from Maine to Florida, the west coast, the great lakes and the gulf coast also led to intense public pressure for the regulation of medical waste (Rutala and Mayhall, 1992). Medical waste is the second most hazardous waste after radioactive waste (Pruss *et al.*, 1999). The term "hazardous waste" means a solid waste or a combination of solid wastes, which because of its quantity, concentration, physical, chemical or infectious characteristics may cause, or significantly contribute to an increase mortality, or an increase in serious irreversible, or incapacitating irreversible illness; or pose a potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed (US-EPA, 1986).

Healthcare waste is defined as the total waste stream from health care establishments, research facilities, laboratories and emergency relief donations (Pruss *et al.*, 1999).

In the United States of America, the waste stream from medical facilities is differentiated into three categories. These are:

A. Hospital waste - All waste generated from a facility; biological and non-biological.

B. Medical waste - A subset of hospital waste generated as a result of patient diagnosis, treatment or immunisation of human beings or animals.

C. Potentially infectious waste - A subset of medical waste that has the potential to transmit an infectious disease (Hollie-Shanner and Glenn, 2006).

Medical waste management scheme must address the category "C" first; because potentially infectious wastes contain pathogens (or their toxins) with sufficient virulence and quantity, such that exposure to the waste by a susceptible host could result in an infectious disease (US-EPA, 1986; DHEC, 2000).

Healthcare waste generation has become a prime concern due to its multidimensional ramification as a risk factor to the health of patients, hospital staff; and even extending beyond the boundaries of the medical establishments to the general population (DHEC, 2000; Hedge *et al.*, 2007). Although very little disease transmission from medical waste has been documented; both the American Dental Association and the Centre for Disease Control recommended that medical waste disposal must be carried out in accordance with regulations (WHO, 2001; Hedge *et al., 2007*).

Infectious waste (also known as biomedical waste or regulated medical waste) include laboratory culture and stocks, pathologic waste, human blood, blood products, body fluids, contaminated and unused sharps, isolation waste and contaminated animal waste (Hagen *et al.*,2001). Hazardous waste, radioactive waste materials, infectious waste generated in a private residence, and etiological agent or specimens being transported to a laboratory for testing are excluded from the definition of infectious waste (DHEC, 2000).

Infectious waste represent a relatively small portion of the total solid waste stream, and are simple to identify, separate, and treat properly. The United States Environmental Protection Agency (1986) estimated that infectious waste constitutes between 10-15% of the medical waste stream. In Nigeria, however, all healthcare wastes fall under the category of infectious waste (FEPA, 1991). It was suggested at the Basel Declaration (2003) that if wastes are properly segregated, the infectious waste content can be reduced from 10% to between 1-5% of the waste generated in healthcare establishments. This fact is supported by the American Hospital Association which reported that on-site segregation can reduce infectious waste from 15% to 8% (DHEC, 2000).

All wastes generated at healthcare facilities in the past were regarded as hazardous and was incinerated before disposal. Today however, waste generated at health facilities is sorted and disposed off according to the risks it poses (Gabela, 2007). Segregation of infectious waste types is a key to achieving sound medical waste management. This can be considered a right step to health risk reduction (Longe and Williams, 2006). Segregation ensures that correct disposal routes are taken, personnel safety is maintained and environmental harm is minimised (Basel Declaration, 2003). Segregation practices within hospitals will result in a clean solid waste stream which can be easily, safely and cost-effectively managed through recycling, composting, and land filling (Longe and Williams, 2006). The most appropriate way of identifying the categories of biomedical waste is by sorting the waste into colour coded plastic bags or containers (Rao *et al*., 2004). Correct and efficient segregation will only be achieved through rigorous training and education of employees, supervisors and managers (Basel Declaration, 2003).

The management of infectious waste (and healthcare waste generally) requires increased attention and diligence to avoid the substantial disease burden associated with poor practices including exposure to infectious agents and toxic substances (WHO, 2008). Although, there have been tremendous advancements in the healthcare system, however, it is ironic that the healthcare settings, which restore and maintain community health are also threatening their well-being through poor waste management practices (Joseph and Ajithkrishnan, 2004). Adequate knowledge about the health hazard of hospital waste, proper technique and methods of handling the waste, and practice of safety measures can go a long way toward the safe disposal of hazardous hospital waste and protect the community from various adverse effects (Mathur *et al*., 2010). Thus, it is important that each hospital should develop an infectious waste management treatment plan; compliance with state and local regulations should be carefully considered in developing this plan (NIOSH, 1988).

1.2 Statement of the Problem

Waste management has become a critical issue as it poses potential health risks and damage to the environment. It is an issue that has taken central place in the national health policies of many countries. In developing countries, solid wastes have not received sufficient attention; very often, health issues compete with other sectors of the economy for the limited resources available (WHO, 2008). Thus, management of medical waste end up not getting the priority it deserves. However, health and environment are important issues throughout the world; therefore, the management of infectious waste (and healthcare waste generally) requires increased attention and diligence to avoid the substantial disease burden associated with poor practices including exposure to infectious agents and toxic substances (WHO, 2008).

Safe management of infectious waste is a key issue in the reduction and control of nosocomial infections inside a hospital, and also ensures that the environment outside is well protected (WHO, 2004). The mismanagement of HCW poses risks to people and the environment (Brayford, 2006), hence, it is essential that everyone concerned with healthcare waste should understand that HCW management is an integral part of healthcare, and that harm created through inadequate waste management reduces the overall benefits of healthcare services (Pruss *et al.*, 1999). The systematic monitoring and evaluation of HCW technology and good waste management are vital to improving public health initiatives (Tesfamicael, 2008), therefore, it is of utmost importance that medical waste be managed in an environmentally sound manner; and this involves proper understanding of risks associated with the handling of such waste (Johannessen *et al.*, 2000).

Mismanagement of hospital waste implies a combination of improper handling of waste during generation, collection, storage, transport and treatment. Improper handling comprises several unsafe actions, such as handling without personal protective equipment, poor storage (e.g. high temperature conditions combined with prolonged storage times before treatment), manual transport for longer distances, use of uncovered containers instead of closed plastic bags, etc (Manyele, 2004). Improper treatment or disposal of medical/ infectious waste, such as open dumping and uncontrolled burning increases the risk of spreading infections, and of exposure to toxic emissions from incomplete combustion. Incomplete combustion can constitute a significant source of pollution to the environment, due to the release of pollutants, such as dioxins, furan or mercury (WHO, 2004; Ram, 2006). Land filling of medical /infectious waste is a problem in many developing countries (Johannessen *et al.*, 2000); especially where scavenging of landfills is an organised activity among the poor, as observed in all the landfills located in Lagos. The practice of cleaning and re-selling syringes, needles, medicine vials and bottles, used latex gloves, or the use of cidex containers (a disinfectant regulated as a pesticide in the United States) to hold water for making tea, would make one to understand the risk associated with improper and unsecured medical waste disposal systems (Hollie-Shanner and Glenn, 2006; Ram, 2006). Under these adverse conditions, planning remains a key issue, and the identification of appropriate options in all health facilities is essential.

However, in most of the sub-Saharan countries of Africa, the healthcare waste management practices do not comply with international requirements, thus there is no guaranty of a safe and environmentally sound management (WHO, 2004). In many of these countries, the lack of resources (financial, human and material) in the health sector tends to affect negatively the way HCW is managed (WHO, 2004). The first step towards developing a comprehensive waste management strategy is to undertake a waste audit (Farmer *et al.*, 1997); because no rational decision on waste management is possible until the generation and composition of solid waste is known (Murthy *et al.*, 2010). A waste audit is the component within waste assessment that gives an insight into type, quantity and origin of waste produced. Waste audit promotes proper handling of waste, because it predicts the amount of waste to be generated beforehand. It also helps to assess the level of compliance with national law and international directives.

1.3 Rationale for the Study

Although medical wastes constitute a small fraction of municipal solid waste, the potential environmental and health hazards could be deleterious, if not properly handled, the worst scenarios could be in developing countries, (Pruss *et al.*, 1999). Efforts to manage medical waste have differed between countries, the worse scenario being in developing countries. In developed countries, legislation and good guidelines state the various ways for the collection, transport, storage, and disposal of infectious waste (Chandiraboss *et al.*, 2009). The result of a World Health Organisation assessment conducted in twenty-two developing countries showed that the proportion of health-care facilities that do not use proper waste disposal methods range from 18% to 64% (WHO, 2008).

Healthcare workers, hospital administrators, sanitarians, and other health-related professionals understand the necessity to protect themselves and the public from exposure to wastes that might be reservoirs of disease-transmitting organisms. Yet, safe waste management systems are lacking in many healthcare establishments; workers are often insufficiently protected and the implementation of safe systems is far from satisfactory in many countries (WHO, 2008). Improper use of personal protective equipment and improper segregation of waste is a common feature in most hospitals in Lagos. An assessment of the knowledge, attitude and practices of healthcare workers will provide information required for the training and retraining of healthcare workers on safe practices. This will ultimately promote proper segregation of infectious waste, thus reducing cost of disposal.

Due to the enormous population of Lagos state, its General Hospitals are largely populated, hence large amount of solid medical waste is generated daily. The current waste management practices in these hospitals could result in both environmental and public health problems. The rate of waste generation supersedes available material and manpower resources. Due to shortage of waste bags, especially the red and the yellow bags, improper use of colour coded bags is a regular feature. At times, waste bins get over filled and spill over littering the surroundings, attracting vectors and animals. Exposure of infectious waste to harsh weather conditions and delay in the collection of waste may lead to air pollution due to degradation of the organic component of the waste. Estimating the quantity of waste generated in these hospitals will provide a base-line data which can be used for budgeting and planning, thus addressing the problems of inadequate waste bags and over-filling of waste bins.

Infectious waste has not been reported to be a hazard in the environment, but with the increasing load of medical waste, due to increasing hospital beds, increased use of disposables, proliferation of blood borne diseases alongside improper on-site waste separation practices and improper/inadequate treatment methods; it is fast becoming a major source of the transmission of various diseases (Pruss *et al.*, 1999). This may predispose people handling the waste to various kinds of risk. Assessing infectious waste for its infectious potential will help reduce risk of disease spread in hospitals.

General Hospitals were selected for this study, because of their high patronage of patients and more wards/units, when compared with primary healthcare facilities and private hospitals. Thus data obtained from this study can be used as a framework for planning an efficient healthcare waste management system in the state.

1.4 Broad Objective

The broad objective of this study was to characterise hospital wastes and assess the infectious waste management practices in Lagos State Owned General Hospitals.

1.5 Specific Objectives

The specific objectives were to:

1. assess the knowledge, attitude and practice of health workers involved in infectious waste management.
2. determine the quantity of waste generated in these hospitals.
3. characterise waste generated in these hospitals into physical and chemical components.
4. assess the predominant species of infectious bacteria in hospital waste.
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CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of Infectious Waste

Infectious waste has been described by the public and all levels of government, with terms such as "hospital waste", medical waste" and "regulated medical waste/infectious waste" and yet it remains poorly defined (Utah, 2006). There is no standard universally acceptable definition for these terms, and there appears to be as many definitions in use as there are government agencies, and interest groups (Rutala and Mayhall, 1992). National circumstances, policies and regulations also affect interpretations of infectious waste (Basel Declaration, 2003). These differences are not surprising, given the diversity of interest and scientific credentials of persons, groups and agencies (e.g. physicians, environmentalists, trade unions etc) involved in the medical waste issue (Rutala and Mayhall, 1992). However, this has serious implications, because the definition adopted by a regulatory agency dictates, what waste requires special handling and treatment (Stewart *et al.*, 1989).

Medical waste is a subset of hospital waste; regulated medical waste which is synonymous with infectious waste from the regulatory perspective is a subset of medical waste (Rutala and Mayhall, 1992). Infectious waste refers to that portion of medical waste that could transmit an infectious disease (Rutala and Mayhall, 1992).The term "regulated medical waste" rather than "infectious waste" was used by the US congress and the US-EPA in the medical waste tracking act in deference to the remote possibility of disease transmission (Rutala *et al.*, 1989). Defining and assessing infectious waste has been a point of contention, wherever its separation is required (Molinari and Gleason, 1990). No consensus exist on the type of medical waste that should be designated as infectious or require special handling, although several categories are included in most lists, (U. S. congress, 1990). Infectious waste has been referred to as bio hazardous waste, medical waste, red bag waste, biomedical waste and regulated medical waste (Cocchiarella *et al.*, 2000).The definition of infectious waste, what constitutes infectious waste, and how it should be treated, has led to conflicting

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opinions from agencies; most definitions give undue emphasis to the presence of pathogens (Rutala, 1984; Rutala *et al.*, 1989). For instance, infectious waste is defined by the Utah statute as "a solid waste that contains or may reasonably be expected to contain pathogens of sufficient virulence and quantity, such that exposure to the waste by a susceptible host could result in an infectious disease (Utah, 2006). This definition is subjective, since there are no tests that allow infectious waste/virulence to be objectively identified (Rutala and Mayhall, 1992).

There is a need to have a common and internationally acceptable definition for the waste generated in healthcare facilities, so as to have a better understanding of the waste management practices of these facilities, (Basel Declaration, 2003).

2.2 Sources and Classification of Infectious Waste

Sources of infectious waste include not only large hospitals and laboratories, but also physicians' offices, dental offices, clinics, research facilities, surgery centres, veterinary offices, funeral homes, and a growing number of settings where home healthcare is delivered (Cocchiarella *et al.*, 2000). No consensus exist on the type of medical waste that should be designated as infectious, or require special handling, although several categories are included in most lists (U.S. Congress, 1990). US-EPA (1986) and NIOSH (1988) have listed seven types of medical waste to be referred to as "regulated medical waste". The categories of infectious waste are as follows:

Isolation wastes: These are generated by patients, who are isolated because of communicable disease.

Cultures and stocks of infectious agents and associated biologicals: these include specimen cultures from medical and pathological laboratories, culture and stocks of infectious agents from research and industrial laboratories, wastes from the production of biololgicals, discarded live and attenuated vaccines, culture dishes and devices used to transfer or inoculate and mix cultures.

Human blood and blood products: These include blood as well as serum, plasma, and other blood products.

Pathological wastes: These include tissues, organs, body parts and body fluids that are removed during surgery and autopsy.

Contaminated sharps: These are hypodermic needles, syringes, pasteur pipettes, broken glass, and scalpel blades. These items should be considered infectious wastes, because of the possibility of contamination with blood borne pathogens.

Contaminated carcasses, body parts and beddings: These emanate from animals intentionally exposed to pathogens during research, the production of biologicals, or the in-vivo testing of pharmaceuticals.

Miscellaneous waste: Miscellaneous wastes come from surgery and autopsies (e.g. soiled contaminated laboratory wastes (e.g. cover slips, slides, specimen containers etc.), dialysis unit waste and contaminated equipment.

Regulated medical waste varies considerably in composition and characteristics as shown in Table 2.1

Table 2.1: Typical Composition and Characteristics of Infectious Waste

Waste Characteristics	Percentage Composition
Celluloid Material (paper & Cloth)	50-70%
Plastics	20-60%
Glassware	10-20%
Fluids	1-10%
Typical Characteristics	
Moisture	8.5-17% by weight
Incombustibles	8% by weight
Heating Value	7,500 BTU/lb

Source: HCWH, 2001

2.3 Pathogens associated with Infectious Wastes

There is no epidemiological evidence that hospital waste disposal practices have caused diseases in the community (Rutala *et al.*, 1989); no medical or dental waste poses a threat to human health (Farmer *et al.*, 1997). More so, there is no evidence that a member of the public or a waste industry worker has ever acquired an infection from medical waste, although, injuries have been reported. (Rutala and Mayhall, 1992). The only medical waste that has been associated with infectious disease transmission is contaminated sharps (Rutala and Mayhall, 1992; Farmer *et al.*, 1997). The risk of infection with infectious waste is very low, because it is unlikely that the infectious agent will survive in refuse environments, and the probability of a portal of entry of infectious organisms into a susceptible host is low (Keene, 1991; Cocchiarella *et al.*, 2000). Pathogenic bacteria commonly isolated from infectious waste include: *Staphylococci, Escherichia coli, Salmonella, Klebsiella, Proteus, Pseudomonas, Enterobacter aerogenes* (Althus *et al.*, 1983; Akande, 1999; Sridhar and Ayeni, 2003). Early investigations on the solid wastes by Burchinal and Wallace (1971) and Wallace *et al* (1972) revealed that *Staphylococcus aureus* was by far the most predominant pathogen detected in waste; Spore forming organisms were not present in sufficient numbers to constitute a potential hazard, if accepted methods of sterilization are followed.

Although, pathogenic organisms can be present in hospital solid wastes in significantly high concentration and especially if an organic substrate is present (Wallace *et al.*, 1972). However, findings from multiple studies have shown that household waste contain more micro-organisms with pathogenic potential for humans on the average than infectious waste (Rutala and Mayhall, 1992). Kalnowski *et al* (1983) demonstrated that common nosochomial pathogens (i.e *Pseudodmonas aeruginosa, Klebsiella sp, Enterobacter sp, Proteus sp* and Group D streptococci) were detected more frequently in house hold waste. Jager *et al* (1989) also demonstrated that the bacterial concentration of hospital waste was less than or similar to that of house hold waste, however, the above fact is not well understood by the general public (Cocchiarella *et al.*, 2000).

2.4 Infectious Waste Management

Medical waste management is a process that helps ensure proper hygiene in the health institution, and safety of healthcare workers. Medical waste problems in the developing world are associated with poor funding and the lack of national regulations for the sanitary disposal of waste and/or lack of oversight (Spassov, 2005). Johannessen *et al* (2000) opined that proper management of medical waste can minimise the risk of infection and injury both within and outside healthcare facilities; therefore, each hospital waste management plan should provide the following:

- Designation of the waste that should be managed as infectious.
- Segregation of infectious waste from non-infectious waste.
- Packaging facilities
- Storage
- Treatment and disposal facilities
- Contingency measures for emergency situations and staff training.

A basic principle in all waste management schemes is to segregate wastes as early as possible in the waste stream; and find the simplest disposal solution for each type of waste (Spassov, 2005). Most estimates suggest that 10-15% of medical wastes generated by hospitals are infectious, although this figure can be as high as 80%, depending on the generator's definition (U.S Congress, 1990). Determining which portion of medical waste is infectious remains at the height of definitional issues (Rutala and Mayhall, 1992). The amount of infectious waste generated by medical facilities as a percentage of its total waste stream varies widely; this depends on the type of healthcare facility, the definition of infectious waste used, and the standard operating procedures specified for designating and separating waste types (NIOSH, 1988). How infectious waste is defined can greatly affect the cost of waste management and ultimately the choice of disposal options (U. S. Congress, 1990).

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2.4 Infectious Waste Management

Medical waste management is a process that helps ensure proper hygiene in the health institution, and safety of healthcare workers. Medical waste problems in the developing world are associated with poor funding and the lack of national regulations for the sanitary disposal of waste and/or lack of oversight (Spassov, 2005). Johannessen *et al* (2000) opined that proper management of medical waste can minimise the risk of infection and injury both within and outside healthcare facilities; therefore, each hospital waste management plan should provide the following:

- Designation of the waste that should be managed as infectious.
- Segregation of infectious waste from non-infectious waste.
- Packaging facilities
- Storage
- Treatment and disposal facilities
- Contingency measures for emergency situations and staff training.

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A significant reduction in the quantities of waste assessed as infectious could be achieved, if visible blood staining is used as the criterion for classification (Farmer *et al.*, 1997). Rinsing of gloves to remove visible stains, has been suggested by US- EPA (1986) as a valid strategy for infectious waste minimisation. Farmer *et al* (1997) also suggested that infectious waste generated from dental practice in Victoria, Australia could be readily reduced below 5 litres per week; if visible blood was used as the classification criterion and rinsing of gloves before disposal always took place.

Infectious waste must be segregated at the point of origin into orange or red containers, which has the universal "biohazard" symbol (NIOSH, 1988). WHO colour coding for infectious waste is yellow, but the use of other colour coding in a country is possible; the use of internationally recognized symbols and signs is of basic importance, and is essential for the safe handling and disposal of waste (Basel Declaration, 2003). The packaging used for infectious waste must be appropriate, leak-proof and tear-resistant; it must endure storage, transportation and treatment (NIOSH, 1988); these bags should be made of 150 microgram thick so as to be resistant to puncturing (Chandiraboss *et al.*, 2009). Waste bags should not be hand-carried for long distances, as this increases the risk of injury or spillage, and appropriate protective gears should be worn during handling (Tesfamicael, 2008).

Infectious waste should not be compacted before treatment, so as not to damage the packaging; the packaging should be secured, so as to ensure containment and prevent rodents and vermin penetration (NIOSH, 1988). Infectious waste should not be stored longer than seven days, and it must be stored below 5°C (Utah, 2006), because healthcare waste is a reservoir of potentially harmful micro-organisms which can infect hospital patients, healthcare workers and the general public. HCW can sometimes spread resistant micro-organisms from healthcare establishments into the environment; However, these risks have so far been poorly investigated (WHO, 2007). Thus, in warm climates, WHO has suggested the storage of infectious waste for a maximum of 48 hrs, during the cool season and maximum of 24 hrs during the hot season (Basel Declaration, 2003).

Healthcare waste generally should be effectively and actively managed so as to significantly reduce /eliminate risks of infection and as well protect the environment (Spassov, 2005). This is important considering sharps intrinsic capability to disrupt the skin's integrity and introduce infectious agents. The majority of sharp injuries do not result in infection, and occupationally acquired hepatitis and HIV infections due to sharp injuries is small (Basel Declaration, 2003). Yet, it is reported that worldwide, 8-16 million Hepatitis B infections, 2.3- 4.7 million Hepatitis C infections and 80,000 -160,000 HIV infections are estimated to occur yearly from re-use of syringe needles without sterilisation. Many of these infections could be avoided if syringes were disposed off safely (WHO, 2008).

Improper waste management will cause environmental pollution, unpleasant smell, growth and multiplication of insects, rodents and worms; this may lead to transmission of diseases like typhoid, cholera, and hepatitis through injuries from sharps contaminated with human blood. Yet, it has been observed that many countries do not have appropriate regulations, or do not enforce them, while in some, waste management is absent and there is a lack of awareness about the health hazards caused by HCW (WHO, 2008). It is essential that everyone concerned with healthcare should understand that healthcare waste management is an integral part of healthcare, and that creating harm through inadequate waste management reduces the overall benefits of healthcare (WHO, 2008). Thus all health facilities require a waste management policy and a comprehensive system of best practices and safety standards. A strong political and economic support with sufficient human and financial resources is required to create an efficient and effective waste management system (Tesfamicael, 2008).

According to Tesfamicael (2008), an effective waste management frame work can be best achieved through the following strategies:

- Effective co-ordination of the activities of healthcare professionals, municipalities and regional administrators, ministry of health, environmental agencies and other key partners.
- Waste management training and education for all healthcare professionals.
- Advocacy campaigns targeted at policy-makers, health organizations, the media and the public.
- Establishment of surveillance team on infection control and waste management practices.
- Identification and correction of poor waste management practices.

It should be noted that most hospitals, especially those in developing countries face a wide range of practical constraints in implementing an improved infectious waste management system. These constraints include one or more of the following:

- Low level of attention, and lack of clear understanding of requirements and options among hospital managers/administrators.
- Space constraints within treatment rooms and wards, thus preventing proper segregation.
- Lack of space for secured temporary storage of infectious waste.
- Shortage of appropriate bins and packaging.
- Constraints on purchase of high quality equipment due to public procurement procedures.
- Lack of adequate ventilation in storage areas (Spassov, 2005.)

2.5 Infectious Waste Treatment

Environmental regulations mandate the treatment of infectious medical waste on a daily basis, if it is to be stored at room temperature (Kaloch, 2007). A number of treatment methods are available, but there is no perfect "environment friendly strategy for eliminating HCW. When selecting HCW treatment technology; cost, risks, benefits and operating parameters, should be carefully weighed to ensure best practices and minimised risks to healthcare workers and the community (U.S. Congress, 1990; Tesfamicael, 2008). Physical characteristics such as heat value and moisture content. biological make up, chemical (elemental) composition of medical waste are important determinants of the most appropriate treatment technology (U. S. Congress, 1990). The efficacy of treatment method should be demonstrated by development of an appropriate biological testing programme (Turnberg, 1990).

A variety of waste treatment technologies are available and should be chosen to suit the needs of a healthcare facility and community (NIOSH, 1988). Infectious waste treatment methods include steam sterilisation, incineration, thermal inactivation, gas/vapour sterilization, chemical disinfection and sterilization by irradiation (NIOSH, 1988). Treatment of infectious waste could be off-site or on-site. Off-site disposal of regulated waste remain a viable option for smaller hospitals (less than 150 beds), however on-site processing such as compaction or hydro pulping may be necessary before sending the waste off-site (Cheremisinoff and Shah, 1990). On site disposal is a feasible alternative for hospitals generating 2 tons/day or more of solid waste (Cheremisinoff and Shah, 1990). After treatment, infectious waste or its ashes can be disposed off by discharge into sanitary sewer systems or buried in sanitary landfills (US-EPA, 1986).

2.5.1 On-Site Treatment of Infectious Waste

A number of treatment methods are available. These are incineration treatment and Non-incineration treatment which includes four basic processes: thermal, chemical, irradiative, and biological. The majority of non-incineration technologies employ the thermal and chemical processes (Katoch, 2007).

2.5.1.1 Incineration

Although, incineration converts combustible materials into non-combustible residue or ash (NIOSH, 1988), it is not the same as burning (Johannessen *et al.*, 2000). Incineration is a highly advanced technology that operates at sufficiently high temperature (1000-1200^{0}c) for a long enough time in a combustion chamber with sufficient turbulence and oxygen (Johannessen *et al.*, 2000). Properly controlled incineration is relatively expensive, but it achieves a relatively high level of organism destruction and reduces waste volume and weight by 95% (Cheremisinoff and Shah, 1990). Incineration is suitable for all infectious waste, but it is more useful for the treatment of pathological waste and sharps (Cheremisinoff and Shah, 1990). Incinerators provide an interim solution for developing countries, where options for waste disposal such as autoclave, shredder or microwave are limited (WHO, 2004).

Incinerators for medical and municipal waste have been linked to severe public health threats and pollution. The public has been particularly concerned over the citing of incinerators, because of problems associated with emissions, air toxins and the ultimate disposal of the ash at sanitary landfills (Cheremisinoff and Shah, 1990). Inadequate incineration or incineration of unsuitable materials can result in the release of pollutants into the air (WHO, 2008). The Environmental Protection Agency of the United States of America in 1994 found that emissions from incinerators in health care facilities were responsible for high levels of chemicals such as dioxin and furan in the atmosphere (Gabela, 2007). The U.S. EPA identifies medical waste incineration as the third largest known source of the highly toxic dioxin in the environment (US-EPA, 1986). Health facility waste contains a large proportion of polyvinyl chloride (PVC) plastics, dioxin is emitted into the atmosphere when PVC plastics are incinerated (Gabela, 2007). Dioxin is a carcinogen that has been linked to birth defects, immune system disorders and other harmful health effects. Other pollutants from incineration include furans, acids, mercury and other heavy metals and particulates (Ogbeide and Uyigue, 2003).

Environmental controls on incinerators in developed countries have been tightened in recent years, principally because of concerns over air emissions of pollutants (Johannessen *et al*., 2000). In Ireland, most hospital incinerators were closed down in the 1990's, because they could no longer meet the statutory environmental standards, and the cost of up grading them were considered uneconomical (Purcell, 2005). The technology of small capacity incinerators (for use by a single medical facility) is often rudimentary, WHO recommends the closing down of small incinerators that are not operating satisfactorily, because they may constitute serious air pollution hazard (Johannessen *et al*., 2000). Limited data indicated that small on-site incinerators can emit relatively high levels of some pollutants, because only few risks assessments have been performed on these incinerators. This has hindered the ability to definitively evaluate the relative degree of risks (U.S. Congress, 1988).

Most hospital incinerators have short stacks which may allow incinerator emissions to enter hospitals through air-conditioning ducts and windows (Lauber, 1988). Although the World Health Organisation (WHO) does not advocate incineration as a final solution, however, in resource poor settings, medical waste is burnt directly in an on-site incinerator, because adequate methods of disinfecting and pre-treating waste products may not be available (Tesfamicael, 2008). Incinerators are fast becoming an obsolete technology in many developed countries as they are moving towards safer and more economical alternative approaches to medical and municipal waste management. As a result, many incinerator companies target Asia, Africa, and Latin America to sell their technology; because these regions are yet to be aware of the serious health and environmental threats associated with incineration or the many advantages of alternatives (www.wwfpak.org/factsheethwf.php). It is estimated that there are more than one thousand incinerators in Africa, many of which have been reported to be inoperative or operating below standards (WHO, 2008). WHO aims to promote effective non-burn technologies for the final disposal of medical wastes to avoid both the disease burden from unsafe health-care waste management and potential risks from dioxins, furans and co-planar polychlorinated biphenyls (WHO, 2008).

2.5.1.2 Steam- sterilisation or Autoclaving

This involves heating of waste materials with steam in an enclosed container. At high pressure (100 Kpa), appropriate level of time (> 60 minutes) and temperature (> 121^{0}C), inactivation of all vegetative microorganisms and most bacteria spores can be achieved (Johannessen, *et al.*, 2000). It should be noted that improper time and temperature relationship may prevent proper sterilisation (Cheremisinoff and Shah, 1990). Segregation is an important factor in effective sterilisation (Johannessen *et al.*, 2000).

Steam sterilisation is time consuming when compared to incineration, and this makes it a less common waste treatment for most facilities (Doucet and Tiny, 1987). Several studies have indicated that the type of waste container, the addition of water, the volume and density of waste material have an important influence on the effectiveness of the autoclaving process (Lauber *et al.*, 1982; Sansbury, 1988). Each of these factors influences the penetration of steam to the entire load and consequently, the extent of pathogen destruction (U.S Congress, 1988).

Steam sterilisation allows for the treatment of only limited quantities of waste and is therefore commonly used only for highly infectious waste, such as microbial cultures or sharps (Katoch, 2007). Steam sterilisation is most effective with low-density waste, such as plastics, but not suitable for high density waste such as large body parts, because these requires longer sterilisation time, because they inhibit direct steam penetration (NIOSH, 1988). Incineration of blood bags is not recommended due to polyvinyl chloride (PVC) content of blood bags (Katosh, 2007). Autoclaving of PVC blood bags is a safer and reliable method compared to chemical disinfection (Chitnis *et al.*, 2003). Autoclaved infectious waste is known to add to land fill burden (NIOSH, 1988). When compared to incinerators, autoclaves are less costly to purchase and operate and require less space. However, cost advantage of autoclaves may be lessened if incineration is also required for same waste (U.S Congress, 1988).

2.5.1.3 Hydroclave Treatment

This is based on innovative equipment named Hydroclave, for steam sterilisation process (like autoclave) (Ram, 2006). Hydroclave is a double walled container in which the steam is injected into the outer jacket to heat the inner chamber containing the waste. Moisture contained in the waste evaporates as steam and builds up the requisite steam pressure (35-36 psi). Sturdy paddles slowly rotated by a strong shaft inside the chamber tumble the waste continuously against the hot wall thus mixing as well as fragmenting the same. In the absence of enough moisture, additional steam is injected. The system operates at 132^{0}C and 36 psi steam pressure for sterilisation time of 20 minutes. The total time for a cycle is about 50 minutes, which includes start-up, heat-up, sterilisation, venting and depressurisation and dehydration. The treated material can further be shredded before disposal. The expected volume and weight reductions are up to 85% and 70% respectively. The hydroclave can treat the same waste as the autoclave plus the waste sharps (also fragmented). This technology has certain benefits, such as, absence of harmful air emissions, absence of liquid discharges, non-requirement of chemicals, reduced volume and weight of waste etc (Ram, 2006).

2.5.1.4 Chemical Disinfection

Chemicals have an extensive and well documented history in the clinical setting in disinfecting environmental surfaces and medical devices (Brayford, 2006). Chemical is most suitable for treating liquid wastes, such as blood, urine, stools or hospital sewage. Chemicals commonly used are formaldehyde, sodium hypochlorite, chlorine dioxide, peracetic acid, glutaraldehyde and quaternary ammonium compounds. This method is not very suitable for solid infectious waste like microbiological culture or sharps, because they must undergo a relatively complex and expensive preparative process of segregation, shredding and milling prior to the application of chemical reagents (Johannessen *et al.*, 2000).

2.5.1.5 Microwave

The mechanism of microbial inactivation is thermal; the technique takes place in enclosed containers at atmospheric pressure and temperature below the normal water boiling point (Brayford,2006). Most microorganisms are destroyed by the action of microwave at a frequency of about 2450 MHz and a wavelength of 12.24 cm (Katoch, 2007). The microwaves rapidly heat the water contained within the waves and the infectious components are destroyed by heat conduction. In the USA, a routine bacteriological test using *Bacillus subtilis* is recommended to demonstrate a 99.99% reduction of viable spores (Pruss *et al.*, 1999). Microwave treatment of waste is similar to autoclaving technique, but the output from a microwave facility is considered non-hazardous, and can be land filled with municipal wastes (Johannessen *et al.*,2000). Microwaving is economically competitive and versatile; however, its disadvantages include high capital cost, great space requirement, highly trained personnel and potential work exposure (NIOSH, 1988).

2.5.1.6 Plasma Pyrolysis

Plasma pyrolysis is a state-of-the-art technology for safe disposal of medical waste. It is an environment-friendly technology that converts organic waste into commercially useful by-products. The intense heat generated by the plasma enables it to dispose all types of waste including municipal solid waste, biomedical waste and hazardous waste in a safe and reliable manner. Medical waste is pyrolysed into carbon monoxide, hydrogen gas, and hydrocarbons when it comes in contact with the plasma-arc. These gases are burned and produce a high temperature (around 1200°C). The plasma pyrolysis technology has been indigenously developed at the Facilitation Centre for Industrial Plasma Technologies, Institute for Plasma Research, Gandhiagar, India (Nema and Ganeshprasad, 2002).

Table 2.2: Advantages and disadvantages of common clinical waste treatment systems

Type	Advantages	Disadvantages
Incineration	Volume and weight reduction.	Public opposition.
	Unrecognisable waste.	High investment and operation cost
	Acceptable for all waste types	High maintenance cost
	Heat recovery potential	Future restrictive emissions laws
		Secondary hazardous waste
Steam autoclave	Low investment cost	Appearance and volume remain unchanged
	Low operating cost	Not suitable for all waste types
	Ease of biological test	Ergonomic concerns
	Low hazard residue	possible air emissions
Microwave	Unrecognisable waste	High investment cost
	Significant volume reduction	Not suitable for all waste types
	Absence of liquid discharge	Increased waste weight
		Possible air emissions
		Ergonomic concerns
Pyrolysis	Almost no waste remains	Novel technology
	Unrecognisable waste	Air emissions must treated
	Heat recovery potential	Skilled operator needed

Source: Salkin *et al.*, 2000.

Table 2.3: Recommended Treatment Techniques For Infectious Waste

Type of Infectious Waste	Recommended Treatment				
	Sterilisation	Incineration	Thermal activation	Chemical disinfection	Others
Isolation waste	x	x			
Culture and stocks, infectious agents and associate biological	x	x	x	x	
Human blood and blood products	x			x	x**
Pathological waste	x**	x			x§§
Contaminated sharps	x	x			
Contaminated animal waste	x++	x			
Bedding		x			

Source: New York State Energy and Research Development Authority, 1987.

++ For aesthetic reasons, steam sterilisation should be followed by incineration of the treated waste or by grinding with subsequent flushing to the sewing system in accordance with state and local regulations.

** Human blood and blood products should be discharged into sanitary sewer for treatment in the municipal sewage system (provided the secondary treatment is available).

§§ After treatment, waste should be handed by a mortician (for burial or cremation) or compaction may alleviate this concern.

It should be noted that the recommended treatment techniques are those that are most appropriate and are in common use; an alternative treatment may be used to treat infectious waste if it provides effective treatment (US-EPA, 1986). Whatever, the technology used, best practices must be promoted, so as to ensure optimal operation of the system (WHO, 2008).

2.5.2 Off- Site Treatment of Infectious Waste

Compaction of infectious waste reduce the total volume, and it often reduces transportation and disposal costs, but compaction does not change the hazardous characteristics of the waste. Waste containers could also burst during compaction, and release pathogens to the environment (Cheremisinoff and Shah, 1990). Grinding systems which first sterilises the waste before shredding are commercially available, and its use may alleviate the concern over burst containers during compaction (New York State Energy and Research Development Authority, 1987).

Hydro pulping, another off-site treatment method involves grinding the waste in the presence of an oxidizing fluid, for example, hypochlorite solution. Hydro pulping reduces the size of the waste and renders it innocuous. However, with this method, it is difficult to control fugitive emissions and it is difficult to conduct microbiological test which serves to determine, if pathogens and organic matters in the waste have been destroyed (Cheremisinoff and Shah, 1990).

2.6 Current Status of Available Literature

A general overview of the present literature reveals that although a lot of researches have been conducted on solid waste management in Nigeria, not much has been done on hospital waste management, especially with particular reference to infectious waste. There is need for more researches on infectious waste management, and physicochemical components of hospital waste so as to device appropriate treatment and disposal methods.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

Lagos State is the smallest, but the most densely populated state in Nigeria, and it is located on the South-Western Part of Nigeria, on the narrow coastal flood plain of the Bight of Benin. The State lies approximately on longitude 20 42°E and 3 22°E east respectively, and between latitude 600 22°N. Lagos State is bounded in the North and East by Ogun State; in the West by the Republic of Benin; and in the South by the Atlantic Ocean (LASG, 2008). Lagos state has five administrative divisions namely: Ikeja, Badagry, Ikorodu, Lagos Island and Epe. These divisions are further divided into twenty Local Government Areas and Thirty-seven Local Council Development Area. Territorially, Lagos State encompasses an area of 3,577 sq. km, which is just about 0.4% of the total land area of Nigeria.

Lagos State has two climatic seasons; Dry (November-March) and wet (April-October). The drainage system of the state is characterized by a maze of lagoons and waterways which constitute about 22% or 787 sq.km of the state total landmass (LASG, 2008). The dominant vegetation of the State is the tropical swamp forest. This consist of the fresh water and mangrove swamp forests both of which are influenced by the double rainfall pattern of the State, which makes the environment a wetland region.

The state has a population of 9,013, 534, the second largest in Nigeria (NPC, 2006). The state is highly congested with a population density of 4,193 per sq.km (LASG, 2008). While the State is essentially a Yoruba-speaking environment, it is a socio-cultural melting pot attracting both Nigerians and foreigners alike. Indigenous inhabitants include the Aworis and Eguns in Ikeja and Badagry Divisions respectively, with the Eguns being found mainly in Badagry. There is also an admixture of other pioneer settlers collectively known as the Ekos. The indigenes of Ikorodu and Epe Divisions are mainly the Ijebus with pockets of Eko-Awori settlers along the coastland and riverine areas.

3.2 Study Design

The study was a cross-sectional descriptive design conducted between January and June, 2010. The study had both laboratory and survey components. This study sets out to determine the quantity of infectious waste generated in relation to General/black bag waste. The knowledge, attitude and practice of hospital workers towards infectious waste management was also assessed. Physical and elemental composition of hospital waste was carried out. The infection potential of infectious waste was also assessed.

3.3 Study Population

Lagos State has 26 General Hospital Units which is jointly supervised by the Ministry of Health and the Health Service Commission (www.lagosstate.gov.ng/hsc). The study population which was selected from the randomly selected hospital units, included physicians, nurses, laboratory scientists/technicians, dental technician, etc.; these were classified as "infectious waste generators." Cleaners, nursing/ward assistants, environmental health officers and waste disposal officers, were classified as "infectious waste handlers".

3.4 Sample Size Determination

The sample size for this study was calculated, such that the results obtained would be within 95% confidence interval. Investigations carried out revealed that no previous study documented percentage responses on the knowledge, attitude and practices of infectious waste management practices among Lagos State owned General Hospitals, therefore 50% response rate was adopted for this study.

Sample size was calculated in line with the following conditions:

A) Proportion with good knowledge, attitude and practice of source segregation of waste = 50% (0.5)

B) Precision limit = 7% (0.07)

C.) 95% level of significance

$$n = \frac{Z^2pq}{d^2}$$

Where:

N	=	Sample size
Z	=	level of confidence corresponding to 5% = 1.96
p	=	anticipated population with good knowledge, attitude and practice of source segregation = 50%
q	=	1-p
d	=	precision limit = 0.07

Substituting in the formula

$$n = \frac{(1.96)^2 \times 0.5(1-0.5)}{(0.07)^2}$$

$$= \frac{3.84 \times 0.5 \times 0.5}{0.0049}$$

$$= 195.9$$

Therefore, sample size = 200.

10% of the calculated sample size was added to the sample size, this is to take care of attrition.

Thus sample size is 220.

3.5 Data Collection

3.5.1 Sampling Method

Two hundred and twenty respondents were randomly selected using the hospitals' nominal roll as sampling frame.

3.5.2 Questionnaire Administration

A 68 – item, semi-structured questionnaire was administered on participants to elicit information on their knowledge, attitude and practice towards infectious waste management. The questionnaire was self administered by the waste generators, while it was interviewer-administered for the waste-handlers. The questionnaire was divided into five sections for effective administration and subsequent analysis;

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Section A: Described the characteristics of the respondents in terms of age, sex, ethnicity, educational status, job designation and years of experience.

Section B: This section assessed the knowledge level of the respondents as regards methods of waste segregation, identification of biohazard symbols and importance of waste treatments.

Section C: Elicited information on the attitude of health workers towards best practice in infectious waste management.

Section D: This section documented infectious waste management practices in the selected hospitals. It covered issues such as: containment of spillage, management's attitude towards spillage, in-service training, use of personal protective equipments etc.

Section E: This focused on the health condition/impact of infectious waste handling. Issues in this section included perceived health conditions of the respondents, frequency of medical check-up, immunisation types, use of personal protective equipments, diseases/infections associated with infectious waste.

3.5.3 Onsite Observations

Observation checklist was used to validate the response given by the respondents. The areas observed included: waste bins for proper sorting, temporary storage site, use of personal protective equipment, method of waste treatment and disposal, methods and means of transportation and quality of waste bags used. Four wards/units were randomly chosen for observation of segregation practices, and observation was carried out four times a week for one month in each of the surveyed hospitals.

3.5.4 Standardisation of Instruments

Instruments used for the study such as the questionnaires and observation checklist were pre-tested at the Federal Medical Centre, Yaba, so as to ascertain its effectiveness. This hospital has similar characteristics as the general hospitals. Pre-test was carried out for a period of two weeks; after which necessary modifications were made on the instruments.

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Observation checklist was used to validate the response given by the respondents. The areas observed included: waste bins for proper sorting, temporary storage site, use of personal protective equipment, method of waste treatment and disposal, methods and means of transportation and quality of waste bags used. Four wards/units were randomly chosen for observation of segregation practices, and observation was carried out four times a week for one month in each of the surveyed hospitals.

3.5.4 Standardisation of Instruments

Instruments used for the study such as the questionnaires and observation checklist were pre-tested at the Federal Medical Centre, Yaba, so as to ascertain its effectiveness. This hospital has similar characteristics as the general hospitals. Pre-test was carried out for a period of two weeks; after which necessary modifications were made on the instruments.

3.6 Entry Procedure

Prior to the conduct of the study, approval was obtained from the Hospital Service Commission and the medical directors of the selected hospitals. Informed consent was obtained from respondents; confidentiality of information obtained was also maintained as access to information was restricted to the researcher.

3.7 Quantitative Estimation of Waste Generated

Quantitative estimation of Bio-medical waste was done by personal observations for 30 days in each hospital. The number of beds in different wards for each department, as well as the quantity of BMW generated each day was recorded. Daily weight of all solid wastes was taken using a pocket spring balance (calibrated at 0.5 kg). Daily weighing was done for 30 days so as to determine the weekly and monthly generation rate and average weight of the different waste. The pocket spring was checked for accuracy each morning before use by comparing standard known weights with the readings on the spring balance.

The waste generated rates per bed per day (Wo) were computed using the equation:

$$W_0 \text{ (kg per bed per day)} = \frac{\Sigma (W_1 - W_b)}{B}$$

(W_b) weight of empty bin

(W_1) gross weight of bin container and waste

(B) Average number of beds in the hospital at the time (t)

3.7.1 Waste Audit Procedure

A sorting table covered with plastic sheeting was used; the plastic sheet was disposed after each audit. All wastes were weighed and identified before sorting. Waste bags placed on the sorting table were cut open using a retractable knife. Contents of waste bags were sorted out into baskets of known weight. Tongs and poking rods were used for sorting, so as to minimise physical contact. After sorting, each basket was weighed and the weight of the basket subtracted from the total weight. This gives the actual weight of each waste component. After each day's work all materials used was disinfected in bleach solution. Different components of the waste were characterised as follows:

a. Plastics (included gloves, containers, tubes, bowls, bags, etc.)
b. Cotton (diapers, bandages, cotton balls, clothes, etc)
c. Paper (towel papers, newspapers, office papers, etc)
d. Metals (aluminium cans, metal cans, etc)
e. Glass (bottles, injection vials, etc)
f. Kitchen waste/organics (foods, fruits, cut flowers and grasses, etc).

3.8 Laboratory Methods/Procedures

This involved solid waste characterisation into physical and chemical components. The data was collected for one month in each location The quantity and composition of the wastes were determined at each hospital. Solid wastes weredaily sorted out into in to the following constituents: paper, food/organics, metals, glass, plastics and metals. The weight of each constituent was taken. Before segregation, the wastes were sprayed with disinfectant solution (0.5% sodium hypochlorite). Masks and large forceps were used to segregate waste into its constituent types. During segregation, each type of medical waste was discarded into bags.

3.8.1 Proximate Analysis

Proximate analysis was carried out to determine moisture content, ash content and carbon.

3.8.1.1 Moisture content

The moisture content of the Bio Medical Waste was calculated by "wet weight method". This was obtained by weighing the entire sample to obtain its wet weight (W_W), and then the sample was dried in an oven at 105^{0}C till its mass was constant. After drying, the dry weight (W_d) was measured.

$$\text{Moisture content (M)} = \frac{(W_w - W_d) \times 100}{W_W}$$

Where,

- M = Moisture content in %
- W_w = Initial weight of the sample, g
- W_d = Weight of sample after drying at 105^{0}C

3.8.1.2 Total Carbon Determination

A dry empty porcelain crucible was weighed (W_1). 10 g of well mixed oven dried organic waste sample of known moisture content was weighed in a dry porcelain crucible (W_2). The sample was heated slowly in a furnace raising the temperatures in steps from 100°C, to 200°C and finally to 550°C. The final temperature setting of 550°C was maintained for 8 hours. The crucible containing a greyish white ash was removed cooled in a desiccator and weighed (W_3).

Calculations:

The % Ash, % Organic matter and % Carbon were calculated as follows:

$$\% \text{ ash in sample} = \frac{(W_3 - W_1)}{(W_2 - W_1)} \times 100$$

Where:

W1 = Weight of the empty dry crucible

W2 = Weight of the dry crucible containing organic waste following sample

W3 = Weight of the dry crucible containing organic waste following ignition

% Organic Matter in sample = 100 - % ash

$$\% \text{ Carbon in sample} = \frac{\% \text{ Organic Matter in sample}}{1.729}$$

3.8.1.3 pH Determination

10 ml distilled water was added to 10 g of sample. The mixture was stirred and allowed to stand for 30 minutes; the mixture was stirred again for 2 minutes. The Dwyer Model WPH1 Water Proof pH Meter was calibrated with standard buffer 7.0 and 4.0. The pH of the waste suspension was then measured using the Electronic pH determination method (Bates, 1954).

3.8.2 Sample pre-treatment

The composite samples were dried in the oven at 75°C until a constant weight was achieved. The sample was then milled in a milling machine until its particle size was up to 2 mm. The samples were digested for the analysis of heavy metals

3.8.2.1 Sample Digestion for Heavy Metals Analysis

Determination of lead (Pb), Nickel (Ni), and Cadmium (Cd) in the raw organic sample was done by weighing 1 g of grounded sample into a conical flask. 5 ml of digestion reagent (2:1 concentrated HNO_3 and concentrated H_2SO_4) were added and heated until brown peroxide and white perchloric acid evaporated. The resulting residue was totally dried.

The procedure was repeated until a white precipitate remained in the flask. This was then filtered through a whatman filter paper (number 1) into a 100 ml volumetric flask. The filtrate was diluted with 0.1N HNO_3 to 100ml. The digested samples were then analysed for heavy metals with a Bulk Scientific 210/211 VGP Atomic Absorption Spectrophotometer using the American Public health Association standard methods (APHA, 1992).

3.8.2.2 Sample Pre-treatment for the Determination of Nitrogen, Potassium and Phosphorus

a. Reagents

Selenium powder (Se), Lithium Sulphate, ($Li_2SO_4.H_2O$), Hydrogen Peroxide (30% H_2O_2) and concentrated Sulphuric acid (H_2SO_4).

b. Digestion Mixture Preparation

About 0.42 g of selenium powder and 14 g lithium sulphate were added to 350 ml 30% hydrogen peroxide and mixed well. About 420 ml concentrated sulphuric acid was slowly added while cooling in an ice bath.

c. Sample Digestion

About 0.3 g of oven dried (65^{o}C) ground wastes sample was measured and placed in a labeled, dry and clean digestion tube. About 4.4 ml digestion mixture was added to each tube and also to 2 reagents blanks for each batch of samples. The solution was digested for 2 hours for 360^{o}C in a furnace until the solution became colourless. The contents were then allowed to cool. About 25 ml distilled water was added and mixed until no more sediment dissolved. The contents were then allowed to cool. The solution was then made up to 50 ml with water and mixed well. The solution was then allowed to settle so that a clear solution could be taken from the supernatant for analysis.

3.8.2.3 % Nitrogen Determination

a. Apparatus

- Macro- kejldahl digestion- distillation apparatus
- Macro- kjeldahl flask of 500 ml and 750 ml capacity.

b. Reagents

- Boric acid 4% solution (dissolve 40 g of boric acid crystal in 1 litre of distilled water)
- 40% hydroxide solution (dissolve 400 g of NaOH pellets in water, cool and make up to 1 litre with distilled water.)
- 0.2 N HCl (standardised)
- Sodium sulphate (anhydrous)
- Sulphuric acid (H_2SO_4)
- Mixed indicator: 0.099 g bromocresol green; 066 g methyl red; 0.011 g thymol blue.

The solution was dissolved in 100 ml ethanol.

Procedure

A Markham steam distillation apparatus was set up using NH_3 free distilled water. Steam was passed through the apparatus for 30 minutes, the steam bank was checked by collecting 50 ml distillate and titrating with N/70 HCl. 5 ml of digestion mixture was transferred to the reaction chamber and 10 ml of 40% NaOH was added. The solution was steamed distilled immediately into 5 ml of 1% boric acid containing 4 drops of the mixed indicator. This distillation was continued for 2 minutes from the time the indicator turned green. The distillate was removed and titrated with N/70 HCl until when the indicator turned from green to a definite pink. The volume of standard HCl required was recorded. A blank determination was run by digesting reagent blanks in place of sample and distilled as before and titrated with N/70 HCl. The ml of N/70 HCl required for the blank was subtracted from the micro-burette reading to give a corrected volume of N/70 HCl.

Calculation :

$$\% \text{ N in waste sample} = \frac{\text{corrected ml of N/70 HCl} \times 0.2}{\text{Weight of sample}}$$

3.8.2.4 Potassium Determination

Procedure

Two ml of the wet digested-sample solution was pipetted into a 50 ml volumetric flask. The solution was made to mark with distilled water and mixed well. Sample solutions starting with standard and blank solutions were sprayed directly into the flame of the Genway flame photometer Model PSP7 (wavelength at 7665A, slit 0.07 mm). The amount of potassium present in the solution (c) from the calibration curve was read by plotting absorbance readings against potassium concentrations.

Calculations:

For a 2.0 ml digest aliquot

$$\% \text{ K in sample} = \frac{\text{concentration} \times 0.125}{\text{Weight of Sample}}$$

3.8.2.5 Phosphorus Determination (Vanado-Molybdate Method)

Procedure:

10 ml of the wet-digested sample was pipetted into a 50 ml volumetric flask and about 0.2 ml of 0.5% Paranitrophenol indicator solution was added. Alkaline solution was made with 6 N NH_3 solutions by drop-wise addition with gentle shaking. About 1N dilute HNO_3 was added drop-wise with shaking until the solution became colourless. About 5 ml of Ammonium Molybdate/Ammonium Vandate mixed reagent was then added. The solution was made to 50 ml with distilled water stoppered and mixed well. The flask was kept for 30 minutes and the absorption of the solution was measured at 400 nm wavelength setting using a colorimeter. The phosphorus present in the solution was read off from a calibration curve prepared by pipetting 0,5,10,15,20 and 25 ml of the standard 10 ppm (mg/l) P solution into 50ml volumetric flasks, representing 0,1,2,3,4, the standard P solution by the addition of the p-nitrophenol indicator. NH_3 solution and HNO_3. The standards were prepared for each batch of samples.

Calculation:

A graph of absorbance was plotted against standard concentration. The solution concentrations for each unknown were determined for the 2 blanks. The mean blank value was subtracted from the unknowns to give a value for the corrected concentrations.

Taking a 10 ml digest aliquot

For a 50 ml final solution used for colour intensity (absorbance) measurement:

$$\% P \text{ in sample} = \frac{\text{concentration} \times 0.025}{\text{Weight of sample}}$$

3.9 Quality assurance and quality control

The following quality assurance and quality control were observed in order to ensure accurate, reproducible and reliable result during the course of the analysis.

3.9.1 Sample Preparation

This was done in a sterile environment in order to avoid sample contamination. Before grinding the sample, the grinder was opened up and thoroughly washed with deionised water and 5 percent nitric acid, and acetone and air dried for 1 day, to eliminate any form of memory effect from any previous milling operation.

After the processing of each component, the grinder was cleaned by passing dried wood chips through it and pressurised air blasted into it to ensure that it was completely free of sample particles or wood chips. This process was repeated after each sample processing.

A known amount of the samples was accurately weighed using a calibrated analytical balance. Representative samples were ensured in each determination and samples treated according to recommended procedure.

3.9.2 Glassware and Containers

All the glassware and containers used were first soaked and washed with detergent solution, rinsed copiously with tap water, soaked in 30% HNO_3 for 48 hours and finally rinsed with distilled-deionised water. The cleaning was repeated properly throughout the duration of the bench work. Adequate cleanliness was maintained during the bench work

3.10 Microbiological Analysis of Infectious Waste

Infectious waste samples were collected from each of the four hospitals, at different time intervals, for microbiological evaluation. Infectious wastes generated in each of these hospitals were weighed fresh. Microbiological analysis of infectious waste using APHA (1992) standard methods.

The wastes generated from each of the selected units for a whole day were divided into quarters; using sterile tongs,10 to 20 random 100 g sample was collected and placed in sterile labelled plastic bags; disposable gloves was used during sample collection to prevent contamination of the outside of the container. A total of 64 samples were collected. In the laboratory, each sample was poured into a clean plastic bowl that had been pre-sterilised with 70% alcohol, and 90ml of sterile normal saline was added to the sample. The suspension was left for one hour and shaken by mechanical means to release bound microorganisms from the wastes. The eluate was then poured into 10 ml universal bottle, from this solution; 1 ml was transferred into a dilution bottle containing 9ml of normal saline, and properly mixed (10^{-1} dilution). Serial dilution continued in a one-tenth stepwise to 10^{-6} dilution. 0.1 ml of the eluate was cultured on blood agar and MacConkey agar was used to identify the type of bacteria and also to quantify them. The inoculated plates were inverted and incubated at 37°C for 24 – 48 hrs, after which the plates were examined for growth. The discrete colonies which developed were counted and the average counts for duplicate cultures were recorded as total viable bacterial count. Isolated bacteria were sub cultured until pure cultures were obtained and identified based on their colonial and cellular morphology and biochemical characteristics.

3.10.1 Isolation, characterisation and identification of Bacteria

Pure culture of bacteria were obtained by aseptically streaking representative colonies of different morphological types which appeared on the cultured plates onto freshly prepared nutrient agar plates ,which were incubated at 28°C for 24 hrs. MacConkey agar was used for the isolation of coli-aerogenes-like enteric organisms. Discrete bacteria colonies which developed were sub-cultured on nutrient agar, and also incubated at 28°C for 24 hrs; these served as pure stock cultures for subsequent characterisation tests. The pure cultures were identified based on their cultural, morphological and physiological characteristics based on Bergey's manual. The characterisation test which was performed in duplicates included: Gram staining, catalase test, coagulase test sugar fermentation test, motility test, methyl red test, Voges –Proskauer test, Indole test and citrate utilisation test.

3.11 Data Management

Data was cleaned up and checked for consistency. A coding guide was developed to facilitate data entry by the investigator. Each questionnaire was coded manually after the completion of the survey before entry into the computer. All data collected were analysed using SPSS software package version 15.0. Descriptive statistics was used to summarise demographic data. Results were presented in tables, charts and figures. Chi-square (X^2) analysis was used to test for association between study variables of interest. Student t-test was used to compare means. The level of significance was set at 5%.

3.12 Limitations of the Study

The refusal of some members of staff to fill the questionnaire and the sudden transfer of some members of staff, who had collected questionnaires, reduced the sample size.

CHAPTER FOUR

RESULTS

4.1 Socio-Demographic Characteristics of Respondents

A total of 220 questionnaires were administered to staff of four randomly selected general hospitals (G.H) in Lagos state; of this number, 207 were retrieved, thus the response rate was 94.1%. 44 (21.3%) was retrieved from Surulere G.H; 38 (18.4%) from Isolo G.H; while 84 (40.6%) and 41 (19.8%) questionnaires were collected from Ikorodu G.H and Akodo G.H respectively. Based on job designation, the respondents were either waste handlers or waste generators. The population of waste handlers was 35.7% (this group included cleaners, waste collectors, nursing/ward attendants, environmental health officers and health assistants). Medical doctors, nurses, laboratory scientists/technicians, dental technicians and community health officers were grouped as waste generators; this group constituted 64.3% of the respondents' population.

The ages of the respondents ranged between 20 and 56 years with a mean age of 37.5 ± 8.2years. Among the participants, 137 (66.2%) were females while 70 (33.8%) were males. The marital status of the respondents were as follows: married (79.7%), single (17.4%), separated (0.5%), divorced (0.5%), and widowed (1.9%). Among the study participants, 131 (63.3%) were Christians, while 76 (36.7%) practiced Islam. Majority of the participants were Yoruba (88.4%), other ethnic groups that participated in the study included; Igbo (7.7%), Edo (3.4%), and Hausa (0.5%). 145 (70%) respondents had tertiary education, while 25 (12.1%) and 37 (17.9%) had primary and secondary education respectively. The work experience/service length of the respondents was between one and thirty-three years, the mean was10.8 ± 8.8years. Table 4.1 shows the demographic characteristics of the respondents.

Table 4.1a: Socio-Demographic Characteristics of Respondents

Demographic Characteristics	Frequency (N=207)	Percentage (%)
Age(Years)		
20 – 29	34	16.4
30 – 39	94	45.4
40 – 49	54	26.1
50 – 59	25	12.1
Total	**207**	**100**
Sex		
Male	70	33.8
Female	137	66.2
Total	**207**	**100**
Marital Status		
Married	165	79.7
Single	36	17.4
Separated	1	0.5
Divorced	1	0.5
Widowed	4	1.9
Total	**207**	**100**
Religion		
Christianity	131	63.3
Islam	76	36.7
Total	**207**	**100**

Table 4.1b: Socio-Demographic Characteristics of Respondents contd.

Demographic Characteristics	Frequency (N=207)	Percentage (%)
Ethnic Group		
Yoruba	183	88.4
Igbo	16	7.7
Hausa	1	0.5
Edo	7	3.4
Total	207	100
Highest Level of Education		
Primary	25	12.1
Secondary	37	17.9
Diploma in Nursing	49	23.7
OND	11	5.3
University degree/AIMLS	68	32.9
HND/NPHD	12	5.8
Post-Graduate	5	2.4
Total	207	100
Job Designation Category		
Waste handlers	74	35.7
Waste Generators	133	64.3
Total	207	100
Work Experience(Years)		
1-10	126	60.9
11-20	51	24.6
21-30	25	12.1
31-40	5	2.4

Table 4.1c: Socio-Demographic Characteristics of Respondents contd.

Demographic Characteristics	Frequency (N=207)	Percentage (%)
Department		
Nursing	48	23.2
Environmental/Domestic	73	35.3
Medical/GOPD	17	8.2
Community health	15	7.3
Medical Pathology	13	6.3
Paediatrics	10	4.8
Dental	16	7.7
Obstetrics and Gynaecology	12	5.8
Surgery	3	1.4
Total	207	100
Job Designation		
Cleaner	16	7.7
Waste collector	2	1.0
Nursing/ward attendant	37	17.8
Health assistant	11	5.3
Environmental health officer	8	3.9
Laboratory Scientist/technician	11	5.3
Dental technician	7	3.4
Nurse	61	29.5
Doctor	52	25.1
Community health officer	2	1.0
Total	207	100

4.2 Respondents' knowledge about Infectious Waste Management

The mean knowledge score was 5.4 ± 1.5, while the mode was 5; the minimum knowledge score was 2 and the maximum score was 9. Based on the 50th percentile cut–off, scores equal to or less than five was considered poor knowledge, while scores above 5 was rated good knowledge. One hundred and twenty five (60.4%) respondents had poor knowledge, while 82 (39.6%) had good knowledge. The mean knowledge score of environmental health officers (7.8 ± 1.5) was the highest, while the least mean score, 3.5 ± 0.7 was obtained by community health officers. Table 4.2 shows that environmental health officers, health assistants, cleaners and dental technicians had good knowledge of infectious waste management.

The mean knowledge score of waste handlers (5.9 ± 1.5) was significantly higher than that of waste generators (5.1 ± 1.4), (P<0.05; 0.000); however more waste generators (22.2%) had had good knowledge than waste handlers (17.4%), as shown by table 4.3. Table 4.4 shows the distribution of respondents' knowledge score according to educational level; the mean knowledge score of respondents with primary education was 5.8 ± 1.7, while respondents with secondary and tertiary education had mean scores of 5.5 ± 1.1 and 5.2 ± 1.6 respectively. The difference in knowledge scores across the educational levels was not statistically significant (P>0.05).

The relationship between work experience and knowledge score is shown in Table 4.5; the highest score of 5.6 ± 1.6 was in the class of 1 – 10 years, the 21 – 30 and 31-40 groups had mean scores of 5.3 ± 1.6 and 5.2 ± 1.8 respectively, the least score of 4.9 ± 1.2 was obtained by 11 – 20 years group.. Work experience had a significant effect on knowledge score (P< 0.05; 0.042). Attendance of training on proper waste management practices by respondents had a significant effect on knowledge score (P<0.05; 0.000); knowledge scores were significantly higher in respondents that were trained (5.6 ± 1.6) than those that were not trained (4.8 ± 1.2). Figure 4.1 shows the relationship between attendance of training and knowledge score; respondents that attended training had higher knowledge scores.

Table 4.2: Knowledge Scores of Respondents

Job Designation	Poor Knowledge Score(≤ 5)	Good Knowledge Score(>5)	Total	Mean Score (S.D)
Waste Handlers(N=74)				
Cleaners	7(3.4%)	9(4.3%)	16(7.7%)	6.2±1.7
Waste collector	0(0.0%)	2(1.0%)	2(1.0%)	4.5±0.7
Nursing/ward attendant	25(12.1%)	12(5.8%)	37(17.9%)	5.3±1.1
Environmental health officer	1(0.5%)	7(3.4%)	8(3.9%)	7.8±1.5
Health assistant	3(1.4%)	8(3.9%)	11(5.3%)	6.3±1.3
Waste Generators (N=133)				
Laboratory scientist/technician	8(3.9%)	3(1.4%)	11(5.3%)	4.8±1.0
Nurse	42(20.3%)	19(9.2%)	61(29.5%)	5.0±1.4
Doctors	32(15.5%)	20(9.7%)	52(25.1)	5.2±1.6
Community health officer	2(1.0%)	0(0%)	2(1.0%)	3.5±0.7
Dental technician	3(1.4%)	4(1.9%)	7(3.3%)	5.9±1.3

Table 4.3: Knowledge Score of Respondents According to Job Designation

Job Designation Category	Poor Knowledge Score(<5)	Good Knowledge Score(>5)	Mean (S.D)	P-value	T
Waste Handlers(N=74)	38(18.4%)	36(17.4%)	5.9±1.5	0.541	3.98
Waste Generators(N=133)	87(42.0%)	46(22.2%)	5.1±1.4	0.000	

Table 4.4: Distribution of Respondents According to Educational Level and Knowledge Score.

Educational Level	Poor Knowledge Score(≤ 5)	Good Knowledge Score(> 5)	Mean (S.D)	P.value	F
Primary	13(6.3%)	12(5.8%)	5.8±1.7	0.636	
Secondary	23(11.1%)	14(6.8%)	5.5±1.1	0.006	1.80
Tertiary	89(43.0%)	56(27.1%)	5.2±1.6	0.000	

Table 4.5: Knowledge Score of Respondents According to Work Experience

Work Experience	Poor Knowledge Score(≤ 5)	Good Knowledge Score(>5)	Mean(S.D)	P.value	F
1 – 10	68(32.9%)	58(28.0%)	5.6± 1.6	0.002	
11 – 20	37(17.9%)	14(6.8%)	4.9± 1.2	0.000	2.78
21 – 30	17(8.2%)	8(3.9%)	5.3± 1.6	0.039	
31 – 40	3(1.4%)	2(1.0%)	5.2± 1.8	0.374	

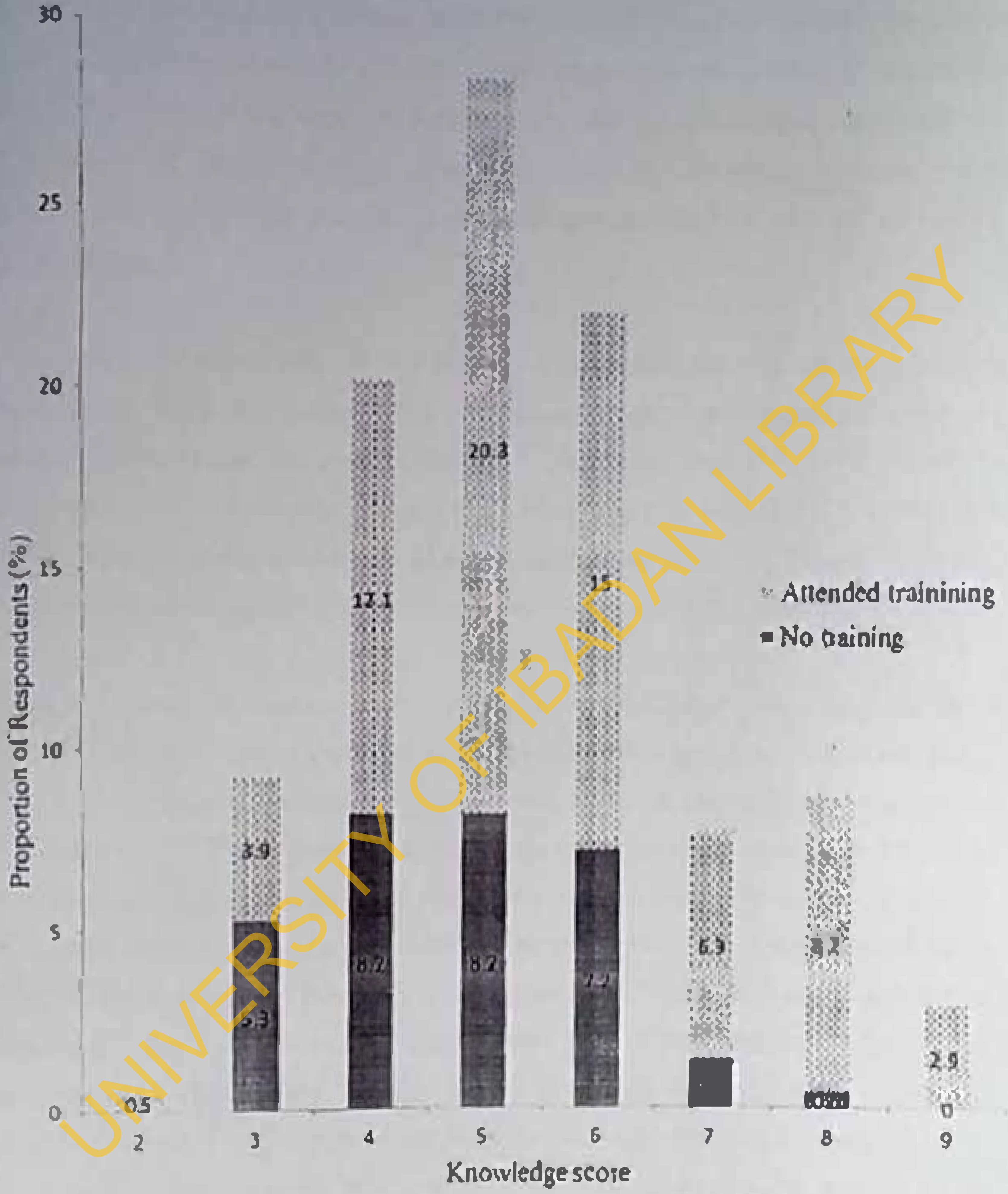


Figure 4.1: Effect of training on respondents' knowledge of infectious waste management

Almost all the respondents, (96.6%) reported that wastes were being segregated into different components in the surveyed hospitals, only 7 (3.4%) respondents stated otherwise. However, the number of components stated differed; 5 (2.4%) and 57 (27.5%) respondents stated that waste was segregated into one and two components respectively, 88 (42.5%) and 56 (27.1%) responded that waste was separated into three and four components respectively. The methods of identifying waste components stated by respondents included; use of colour-coded bags (73.4%),use of colour-coded dustbins (25.6%), and use of symbols (1.0%) (Figure 4.2).

A majority of the respondents (79.7%) correctly defined infectious waste as that which has the potential to spread disease. Other definitions include; waste generated within the hospital (6.3%), waste that contain blood and other body fluid (12.1%); 1.9% of the respondents could not define infectious waste. Among the respondents, 151 (73.7%) could classify waste bagged in red/orange bags as infectious waste, while 3 (1.5%) and 51 (24.8%) respondents referred to such waste as domestic and hazardous wastes respectively.

Table 4.6 shows the various reasons stated by respondents for separating infectious waste:131 (63.3%) respondents stated that waste segregation prevented disease spread,110 (53.1%) felt segregation promoted proper disposal of blood stained waste, easy disposal was stated by 9 (4.3%) respondents as the reason for segregation, while 10 (4.8%) stated that segregation promoted selection of useful materials from waste. The regular components of hospital waste as stated by respondents is shown in table 4.7; these included sharps (94.6%), blood and body fluid (61%),used gloves (33.7%),plaster, gauze and wound dressing (12.7%).Other components stated included paper (8.3%), canula/fluid line (2.0%), extracted tooth (7.3%), food particles (3.4%), drug pack (22.9%). Waste capable of producing infections as stated by respondents included used needle and syringe (54.7%), blood/bodyfluid/bloodbags (72.9%), tissue (45.3%), used gloves (26.6%), extracted tooth (5.9%), blood stained cotton wool/swabs (43.3%). Table 4.8 shows a list of hospital waste capable of producing infection/diseases as stated by respondents.

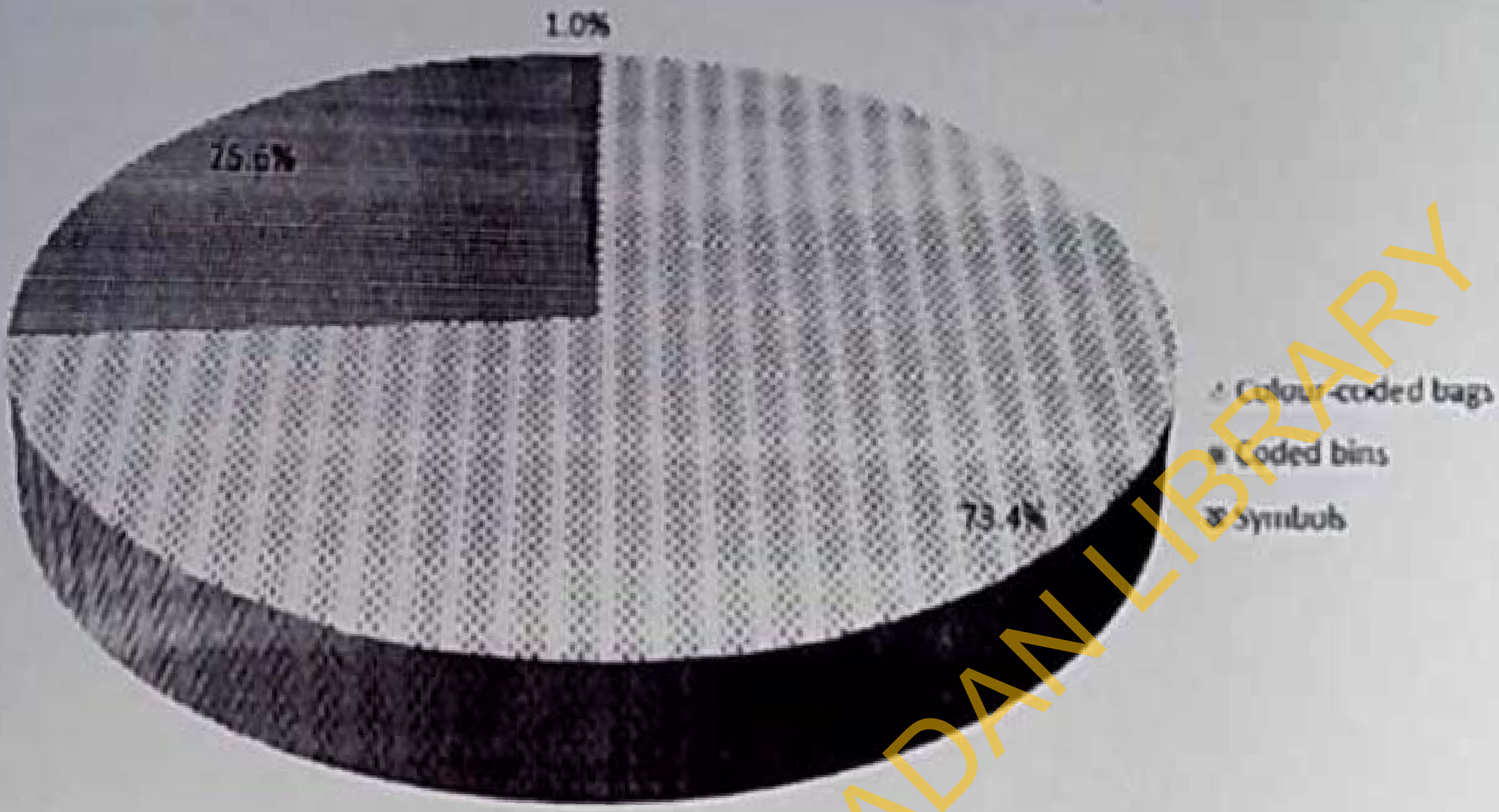


Figure 4.2: Methods of identifying of waste components

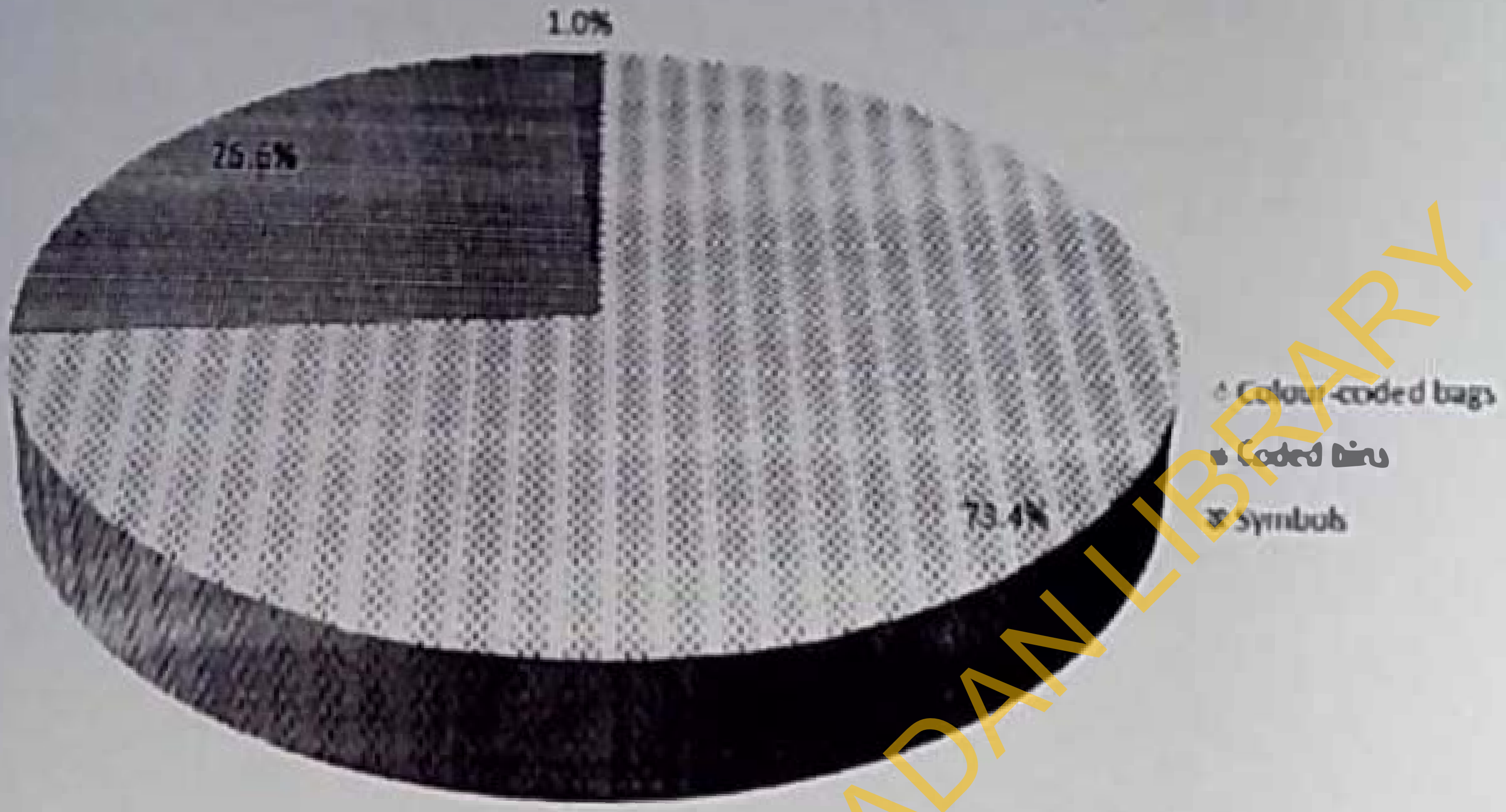


Figure 4.2: Methods of identifying of waste components

Table 4.6: Reasons stated for separating infectious waste

Reasons for segregating Waste	Frequency**
Easy disposal	9(4.3%)
Prevent disease spread	131(63.3%)
To be able to select useful materials	10(4.8%)
To be able to dispose waste with blood properly	110(53.1%)

**multiple responses allowed

Table 4.6: Reasons stated for separating infectious waste

Reasons for segregating Waste	Frequency**
Easy disposal	9(4.3%)
Prevent disease spread	131(63.3%)
To be able to select useful materials	10(4.8%)
To be able to dispose waste with blood properly	110(53.1%)

**multiple responses allowed

Table 4.6: Reasons stated for separating infectious waste

Reasons for segregating Waste	Frequency**
Easy disposal	9(4.3%)
Prevent disease spread	131(63.3%)
To be able to select useful materials	10(4.8%)
To be able to dispose waste with blood properly	110(53.1%)

**multiple responses allowed

Table 4.7: Regular components of waste generated in hospitals

Waste Types	Frequency**
Injection bottles	99(48.3%)
Sharps/needle and syringe	194(94.6%)
Drugs pack	47(22.9%)
Blood and body fluids	125(61.0%)
Stool/urine	32(15.6%)
Plaster/gauze/swab	26(12.7%)
Soiled dressing/bloodstained cotton wool	21(10.2%)
Food particles	7(3.4%)
Paper	17(8.3%)
Used gloves	69(33.7%)
Canula/fluid lines	4(2.0%)
Extracted tooth	15(7.3%)
Tissue	9(4.4%)

**multiple responses allowed

Table 4.8: Waste capable of producing infection/disease.

Infectious Waste Produced	Frequency**
Used needle and syringe	111(54.7%)
Blood/body fluid/blood bags	148(72.9%)
Plaster/gauze/soiled wound Dressing	30(14.8%)
Blood --stained cotton wool/swabs	88(43.3%)
Tissue	92(45.3%)
Used gloves/blood-stained gloves	54(26.6%)
Fluid line/canula	32(15.8%)
Placenta/blood-stained pad	11(5.4%)
Extracted tooth	12(5.9%)

** Multiple responses allowed.

Although, most of the respondents 174 (84.1%) claimed to be familiar with the biohazard logo, only 33 (15.9%) stated otherwise; however, only 74 (42.5%) respondents correctly stated the name of the logo as biohazard logo. Other names given were; recyclable material (5.2%), radioactive waste (2.3%), biological waste (3.4%), toxic/hazardous waste (3.4%), safety box (10.3%), danger (8.6%), while 13.8 % stated that the biohazard logo separates medical waste from domestic waste; 10.3% of the respondents did not know what the biohazard logo signifies (Table 4.9).

A majority of the respondents (60.7%) stated that waste should be treated before disposal, and 39.3% did not see any reason why waste should be treated. The methods of treating waste before disposal stated by respondents included: autoclaving 17 (12.1%), disinfections 68 (48.6%), dry heat 6 (4.3%), incineration 76 (54.3%) while burning was stated by 4 (2.8%) as method of treating waste in the hospitals studied. Among the 39 respondents that stated that waste should not be treated, 12 (5.8%) did not know why waste should be treated, 23 (11.1%) were of the opinion that treatment of waste before disposal is a waste of time and money; while 46 (22.2%) respondents felt waste to be disposed does not require any treatment.

4.3 Respondents' Attitude towards Infectious Waste Management

The mean attitude score was 46.5 ± 4.5; the mode was 47, while the minimum and maximum scores were 28 and 55 respectively. A score of 47 and above was considered to be good attitude, while scores less than 47 were classified as poor attitude. Participants' attitude towards infectious waste management is reported in Table 4.10. Table 4.11 shows that 120 (58.0%) respondents had good attitude, of these 37 (17.9%) were waste handlers, and 83 (40.1%) were waste generators; among the 87 (42.0%) respondents that had poor attitude, 37 (17.8%) were waste handlers and 50 (24.2%) were waste generators. The mean attitude score of waste generators (46.9 ± 4.9) was not significantly higher than the score of 45.9 ± 3.7 obtained by waste handlers ($P > 0.05$; 0.127).

Table 4.9: Identification of the biohazard logo

Identity	Frequency (%)
Biohazard	74(42.5)
Recyclable materials	9(5.2)
Radioactive waste	4(2.3)
Biological waste	6(3.4)
Toxic waste/hazardous waste	6(3.4)
Separates medical waste from Domestic waste	24(13.8)
Safety box	18(10.3)
Danger	15(8.6)
Don't know	18(10.3)

Table 4.10a: Respondents' attitude towards infectious waste management

Statement	Options	Waste handlers (N=74)	Waste generators (N=133)	Total
All waste generated in this hospital are properly packed and protected	Strongly disagree	49(22.7%)	46(22.2%)	93(44.9%)
	Disagree	19(9.2%)	64(30.9%)	83(40. 1%)
	Indifferent	1(0.5%)	6(2.9%)	7(3.4%)
	Strongly agree	3(1.4%)	12(5.8%)	15(7.2%)
	Agree	4(1.9%)	5(2.4%)	9(4.2%)
All waste produced in this hospital are the same and do not require separation into different waste bins or bags	Strongly disagree	3(1.4%)	2(1.0%)	5(2.4%)
	Disagree	1(0.5%)	3(1.4%)	4(1.9%)
	Indifferent	3(1.4%)	1(0.5%)	4(1.9%)
	Agree	28(13.5%)	36(17.4%)	64(30.9%)
	Strongly agree	39(18.8%)	91(44.0%)	130(62.8%)
Separation of waste into different bins is solely the job of a waste handler	Strongly disagree	12(5.8%)	6(2.9%)	18(8.7%)
	Disagree	29(14%)	12(5.8%)	41(19.8%)
	Indifferent	2(1.0%)	9(4.3%)	11(5.3%)
	Agree	16(7.7%)	41(19.8%)	57(27.5%)
	Strongly agree	15(7.2%)	65(31.4%)	80(38.6%)
Medical waste is more dangerous than household waste	Strongly disagree	1(0.5%)	3(1.4%)	4(1.9%)
	Disagree	0(0%)	3(1.4%0	3(1.4%)
	Indifferent	7(3.4%)	4(1.9%)	11(5.3%)
	Agree	15(7.2%)	42(20.3%)	57(27.5%)
	Strongly agree	51(24.6%)	81(39.1%)	132(63.8%)

Table 4.10b: Respondents' attitude towards infectious waste management contd.

Statement	Options	Waste handlers	Waste generators	Total
Dumping bio-medical waste with household waste cannot cause any health problem	Strongly disagree	3(1.4%)	5(2.4%)	8(3.9%)
	Disagree	1(0.5%)	1(0.5%)	2(1.0%)
	Indifferent	2(1.0%)	4(1.9%)	6(2.9%)
	Agree	37(17.9%)	43(20.8%)	80(38.6%)
	Strongly agree	31(15.0%)	80(38.6%)	111(53.6%)
The use of protective equipments such as gloves, apron, masks etc by waste handlers is not necessary	Strongly disagree	2(1.0%)	1(0.5%)	3(1.4%)
	Disagree	0(0%)	1(0.5%)	1(0.5%)
	Indifferent	0(0%)	1(0.5%)	1(0.5%)
	Agree	6(2.9%)	16(7.7%)	22(10.6%)
	Strongly agree	66(31.9%)	114(55.1%)	180(87.0%)
Infectious waste do not require special treatment before disposal	Strongly disagree	5(2.4%)	5(2.4%)	10(4.8%)
	Disagree	4(1.9%)	6(2.9%)	10(4.8%)
	Indifferent	1(0.5%)	5(2.4%)	6(2.9%)
	Agree	16(7.7%)	29(14.0%)	45(21.7%)
	Strongly agree	48(23.2%)	88(42.5%)	136(65.7%)
Separation of infectious waste will help protect the health of hospital staff, especially waste handlers	Strongly disagree	0(0%)	1(0.5%)	1(0.5%)
	Disagree	1(0.5%)	1(0.5%)	2(1.0%)
	Indifferent	0(0%)	1(0.5%)	1(0.5%)
	Agree	12(5.8%)	28(13.5%)	40(19.3%)
	Strongly agree	61(29.5%)	102(49.3%)	163(78.7%)
Hospital staff do not require any special training on good waste management practices	Strongly disagree	2(1.0%)	(0%)	2(1.0%)
	Disagree	1(0.5%)	1(0.5%)	2(1.0%)
	Indifferent	0(0%)	2(1.0%)	2(1.0%)
	Agree	14(6.8%)	46(22.2%)	60(29.0%)
	Strongly agree	57(27.5%)	84(40.6%)	141(68.1%)

Table 4.11: Distribution of Respondents' attitude according to job designation

Job Designation	Poor Attitude(≤46)	Good Attitude(>46)	Mean (S.D)	P-value	Chi-Square
Waste Handlers	37(17.8%)	37(17.9%)	45.9 ± 3.7	0.802	3.0
Waste Generators	50(24.2%)	83(40.1%)	46.9 ± 4.9	0.037	

The cross tabulation between job designation and attitude of respondents towards infectious waste management revealed that a higher percentage of doctors (19.3%) and nurses (17.4%) had good attitude. The highest proportion of bad attitude was also exhibited by nurses (12.1%). Chi- square annlysis revealed that job designation did not have any significant effect on attitude towards infectious waste management (P> 0.05). The highest mean attitude score was obtained by laborutory scientists/technicians (48.8 ± 2.9) while the lowest score was obtained by health assistant (45.3 ± 2.4) ;(table 4.12).

Respondents that had worked for 31 – 40 years had the lowest mean attitude score (42.6 ± 7.6); other scores according to work experience are as follows; 46.9 ± 4.0 (11 – 20years), 46.7 ± 4.5 (1 – 10 years) and 45.9 ± 4.7 (21 – 30). The differences in attitude scores according to work experience was not statistically significant ($p > 0.05$). The mean attitude scores of respondents with primary and secondary education were 45.8 ± 2.7 and 46.0 ± 3.4 respectively, while 46.8 ± 4.9 was obtained by respondents with tertiary education; the observed differences were not significant ($p > 0.05$; 0.431).

A majority of the respondents (97.0%) agreed that undergoing training on effective waste management practices is necessary; this was confirmed as attendance of training had a significant effect on the attitude of respondents($P<0.05$; 0.005). The mean attitude score of 47.1 ± 4.1 obtained by respondents that had recorded being trained was significantly higher than the 45.2 ± 5.1 scored by respondents that were not trained. Of 143 (69.1%) respondents that attended training, 87 (42.0%) had good attitude, while 56 (27.1%) had poor attitude. Among the 64 (30.9%) respondents that were not trained, 33 (15.9%) had good attitude and 31 (15%) had poor attitude.

The knowledge of respondents about infectious waste management had no significant effect on their attitude ($P>0.05$; 0.63); Table 4.13 shows the relationship between knowledge score and attitude. Out of the 207 respondents, 125 (60.4%) had poor knowledge, of these 66 (31.9%) had good attitude, while 59 (28.5%) had poor attitude Among 82 (39.6%) respondents that had good knowledge, 28 (13.5%) and 54 (26.1%) respondents had poor and good attitude respectively.

Table 4.12: Attitude Score according to Job Designation

Job Designation	Poor Attitude (< 46)	Good Attitude (≥ 46)	Mean Attitude Score± S.D	P- value
Cleaner	8(3.9%)	8(3.9%)	45.8 ± 2.4	0.762
Waste collector	0(0%)	2(1.0%)	47.5 ± 0.7	0.205
Laboratory scientist/technician	2(1.0%)	9 (4.3%)	48.8 ± 2.9	0.010
Nursing/ward attendant	17(8.2%)	20(9.7%)	45.9 ± 3.5	0.888
Nurse	29 (14.0%)	32 (15.5%)	45.8 ± 5.5	0.816
Doctor	16 (7.7%)	36 (17.4%)	47.8 ± 4.3	0.005
Environmental health officer	4 (1.9%)	4 (1.9%)	46.4 ± 7.5	0.892
Community health officers	0(0%)	2 (1.0%)	48.5 ± 2.1	0.344
Dental technician	3 (1.4%)	4(1.9%)	46.0 ± 4.7	1.000
Health assistant	8 (3.9%)	3 (1.4%)	45.3 ± 2.4	0.341

Table 4.13: Knowledge score in relation to attitude score

Knowledge Score	Good Attitude(>46)	Poor Attitude(≤46)	Total	P-value
Good knowledge(>5)	54(26.1%)	28(13.5%)	82(39.6%)	
poor knowledge(≤5)	66(31.9%)	59(28.5%)	125(60.4%)	0.63

One hundred and seventy three (85.0%) respondents stated that medical waste was not properly packed and protected in the hospitals studied; although 24 (11.5%) thought otherwise, while 7 (3.4%) felt indifferent. Almost all the respondents (93.7%) did not see any reason, why hospital waste should be segregated, because the waste is similar.

Most of the respondents (92.2%) were of the opinion that the dumping of biomedical waste with household waste cannot cause any health problem, while 10 (4.9%) felt otherwise, but 6 (2.9%) respondents were indifferent. Sorting or separation of hospital waste as stated by 137 (66.1%) respondents is solely the job of a waste handler; only 59 (28.5%) felt sorting was everybody's job, while 11 (5.3%) respondents were indifferent. Based on job designation, majority of the waste generators 106 (51.2%) were of the opinion that segregation of waste was solely the job of a waste handler, only 18 (8.7%) waste generators disagreed, while 9 (4.3%) were indifferent. Among the seventy-four waste handlers that participated in the study, 31 (14.9%) agreed that sorting of waste was solely their job, however, 41 (19.8%) disagreed with this statement, while 2 (1.0%) waste handlers were indifferent. Figure 4.3 shows respondents' attitude towards waste segregation according job designation. Classification of responses based on educational qualification of respondents also showed a similar trend; of the 145 respondents with tertiary education, 111 (53.6%) believe segregation of waste is the job of a waste handler, only 23 (11.1%) respondents felt otherwise, while 11 (5.3%) were indifferent.

4.4 Infectious Waste Management Practices

One hundred and forty three (69.1%) respondents had received training on proper infectious waste management, while 64 (30.9%) did not receive any training. Among the trained respondents, there were 84 (40.6%) waste generators and 59 (28.5%) waste handlers. The respondents were trained at different times in their career, 15.3% were trained before employment, 79.9% received in-service training, 1.4% was trained as undergraduates and 3.5% were trained immediately they were employed. Table 4.14 shows attendance of training based on job designation; attendance of training was highest among nurses (22.2%).

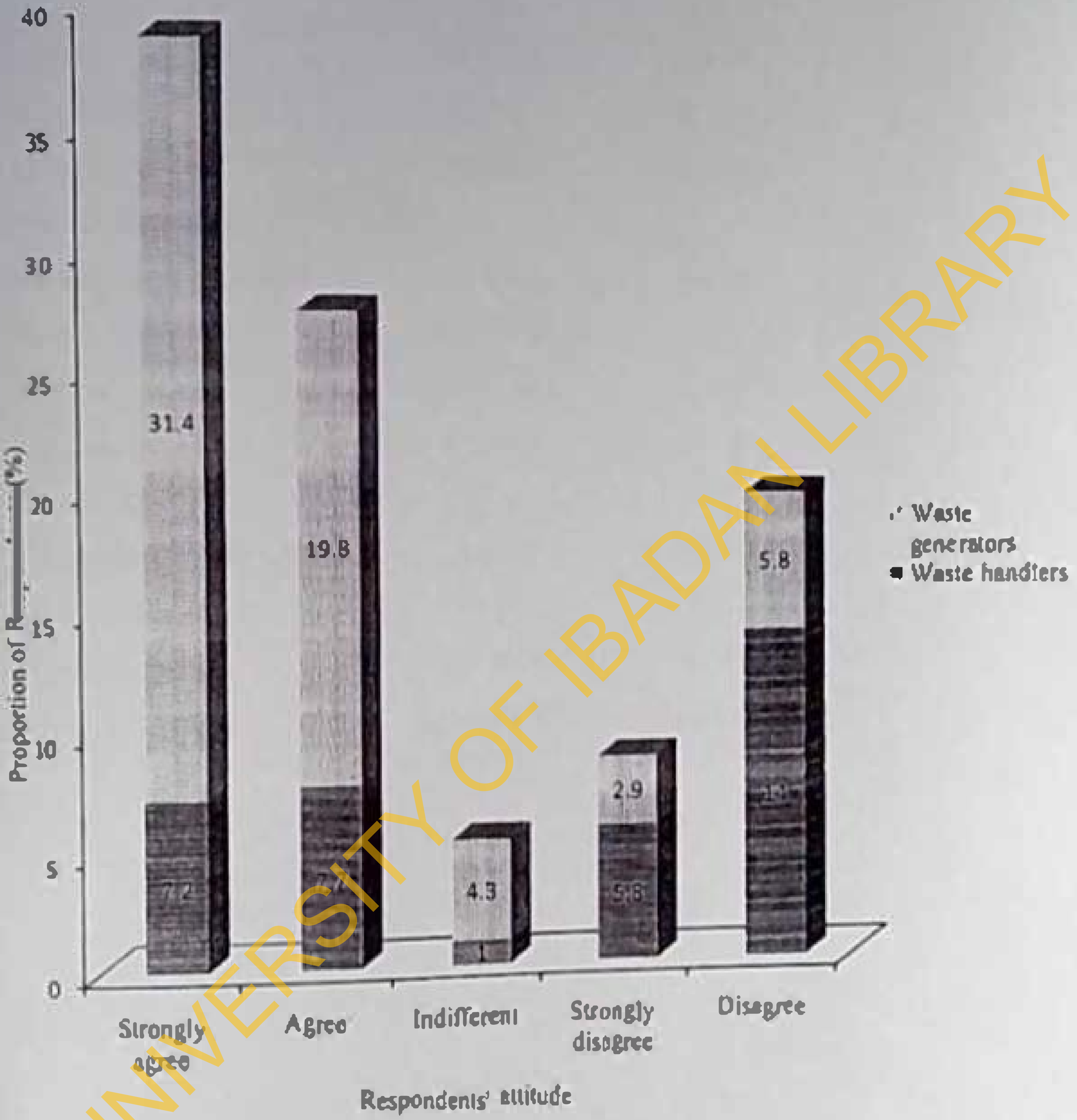


Figure 4.3: Respondents' attitude towards waste segregation according to job designation

Table 4.14: Attendance of training according to job designation

Job designation	Attendance of training	
	Yes	No
Cleaner	15(7.2%)	1(0.5%)
Waste collector	0(0%)	2(1.0%)
Laboratory scientist/technician	6(2.9%)	5(2.4%)
Nursing/ward attendant	28(13.5%)	9(4.3%)
Nurse	46(22.2%)	15(7.2%)
Doctors	27(13.0%)	25(12.1%)
Environmental health officer	6(2.9%)	2(1.0%)
Community health officer	1(0.5%)	1(0.5%)
Health assistant	10(4.8%)	1(0.5%)
Dental technician	4(1.9%)	3(1.4%)
TOTAL	143(69.1%)	64(30.9%)

Majority of the respondents, 196 (94.7%) reported that source separation of sharps was being carried out at all times, but 5 (2.4%) respondents stated that source separation of sharps was not done all the time, while 6 (2.9%) reported that sharps were not separated at all. Respondents stated that sharps were collected into different containers made from cardboard (84.5%), plastic (13.5%), safety box (1.4%) and polythene (0.5%), (Figure 4.4). The responses on the kind of containers used for waste collection were as follows; containers with cover (33.2%), containers without cover (13.1%), containers lined with leak proof bags (37.7%), colourcoded bags/dustbins (43.2%), and safety boxes (14.1%). Plates 4.1, 4.2 and Figure 4.5 show the kind of containers used for waste collection in the surveyed hospitals.

The respondents reported that flies and other insects (27.1%), stench/bad odour (91.8%) and rats (22.7%) were common features at temporary waste collection point. After each day's work, respondents do one or more of the following to protect themselves from infections: Wash hands with soap and water (37.2%), wash hands with soap, water and disinfectant (55.6%), take bath with soap water and disinfectant (34.3%), wash hands with water only (18.8%). Lagos Waste Management Authority(LAWMA) was stated by 144 (69.6%) respondents to be responsible for carting away infectious waste produced in the hospitals studied (Plate 4.3); 32 (15.5%) stated that infectious waste were incinerated, while 8 (3.9%) and 9 (4.3%) respondents reported that infectious wastes were burnt off in the open and disposed at dumpsite respectively; other responses were that infectious waste was buried within the hospital premises 4 (1.9%), and 10 (4.8%) respondents don't know what become of infectious waste.

Spillage as stated by 81 (39.1%) respondents is prevented by proper packaging of waste; while proper storage and early disposal of waste was stated by 41 (19.8%) and 30 (14.2%) respondents respectively as methods of preventing spillage. However, 38 (18.4%) stated that all the three aforementioned methods were utilised to prevent spills, while 17 (8.2%) respondents do not know how to prevent spills.

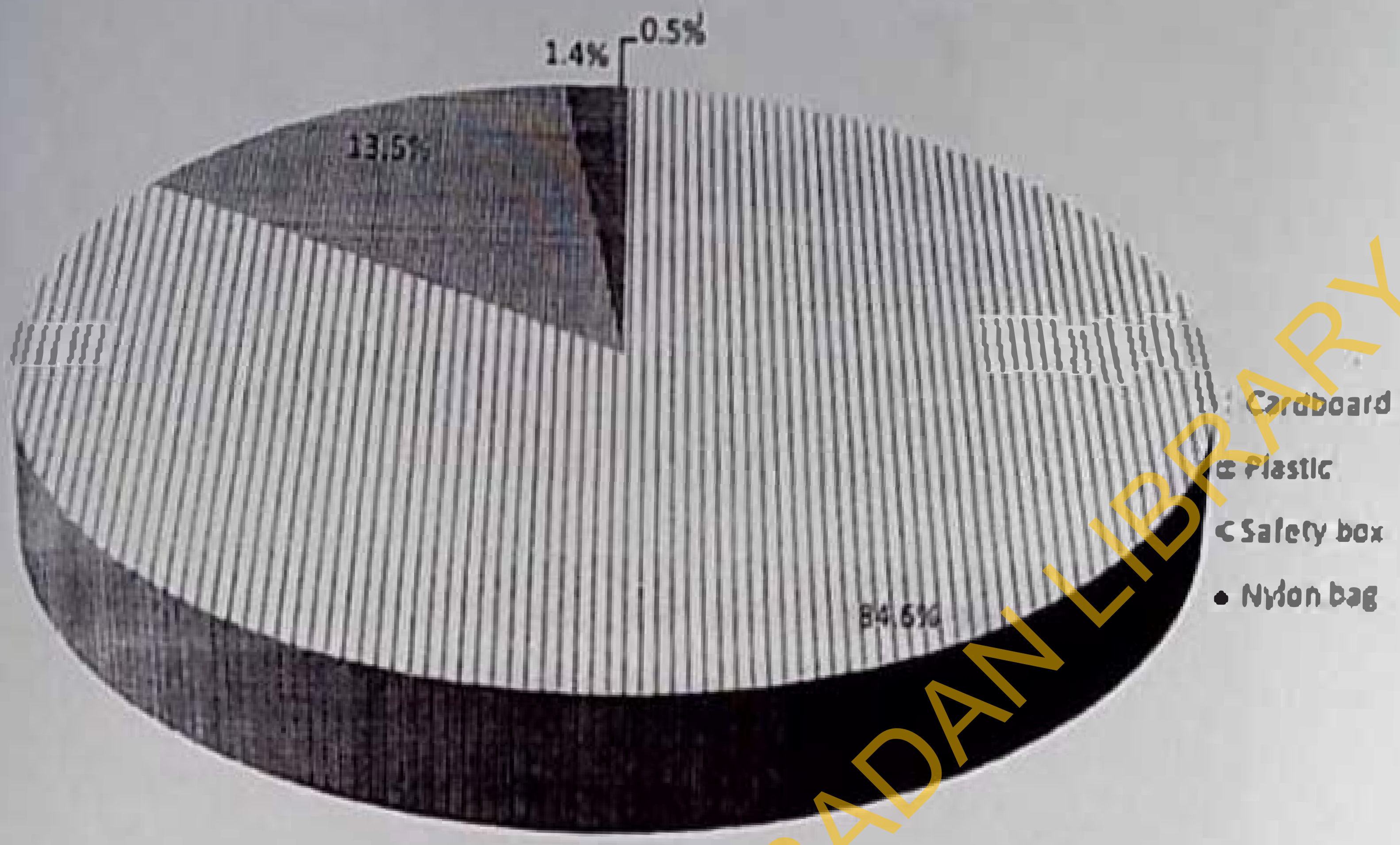
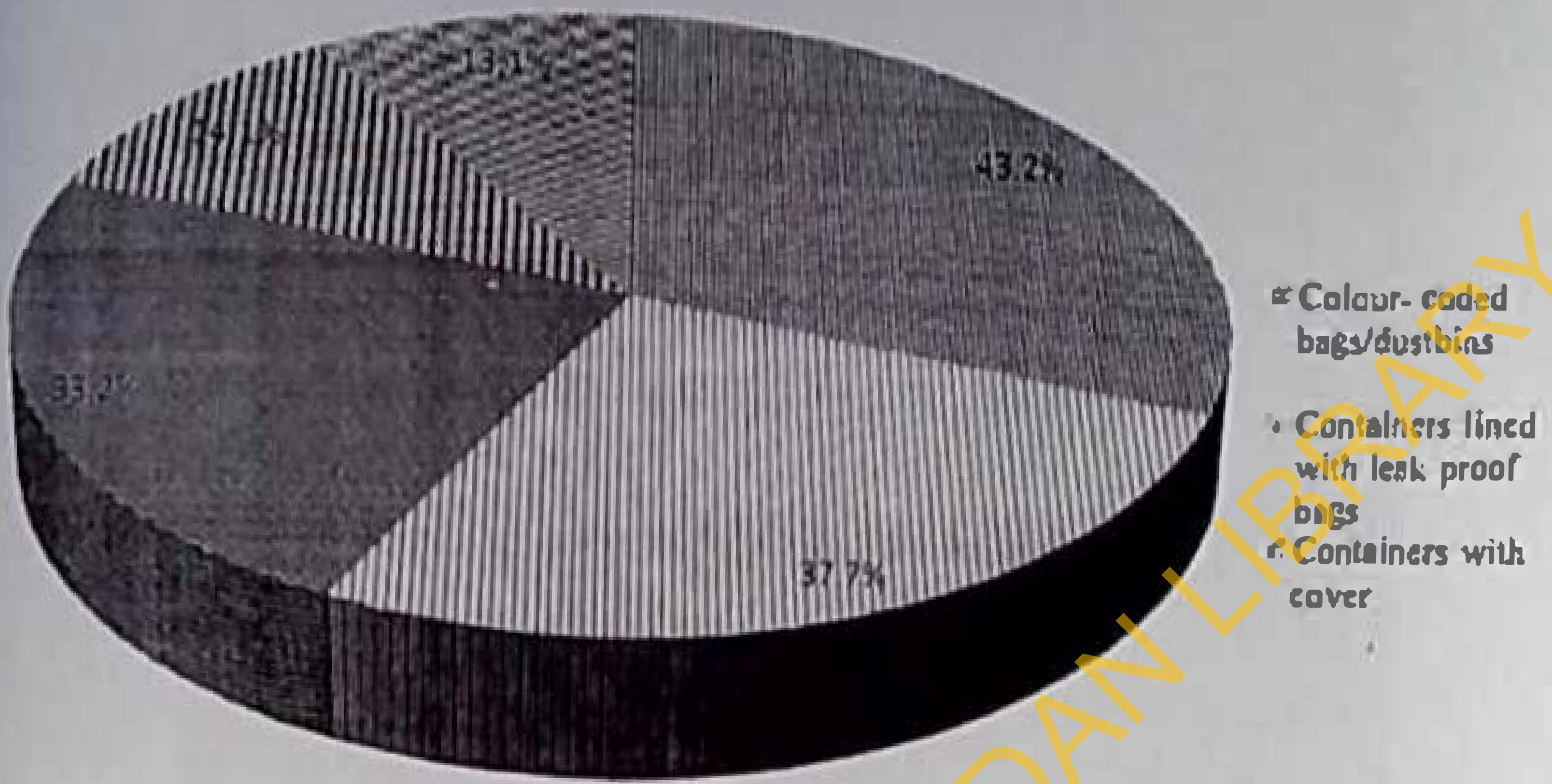


Figure 4.4: Materials used as sharp containers

Plate 4.1: Safety boxes made from carton used for sharp collection

Plate 4.2: Containers used for waste collection in the hospitals surveyed.



**multiple response allowed

Figure 4.5: Containers used for waste collection

Plate 4.3: Van used by LAWMA for the transportation of infectious waste

Actions taken by individual respondents during spillage occurrence include the following: pack the waste and disinfect the place (68.1%), pack the waste (15.9%), notify the waste management team (4.8%); while 23 (11.1%) respondents do not know what action to take. There were no records of spillage occurrence in the four hospitals, yet 107 (52.2%) respondents claimed to report incidents of spills to the management; however 66 (31.9%) respondents foiled to report incidence of spills to management, while 32 (15.6%) just called cleaners to clean spill sites, but do not make any report. Hospital management takes a variety of action during spillage as shown in Table 4.15.

Seventy-seven (37.4%) respondents in the surveyed hospitals were satisfied with infectious waste handling/disposal practices, while 129 (62.6%) were not satisfied. The reasons stated for their dissatisfaction as shown Table 4.16 include; prevalent nosocomial infection (7.4%), improper separation of waste (45.2%) (Plates 4.4a & b), inadequate training (40.7%), absence of incinerators (9.6%), improper treatment of waste (1.5%), over filled waste bins, due to long distance to dump site (16.3%). Adequate provision of personol protective equipment and insistence on use (33.7%), enforcement of strict rules regulation (41.7%), continuous training of health workers (26.6%) are some of the suggestions proffered by respondents to ensure proper management of infectious waste in hospitals (Table 4.17).

4.5 Health Information and Conditions.

Majority of the respondents (98.5%) were aware that improper waste management practices can promote disease/infection spread, only 1.5% reasoned otherwise. Table 4.18 shows diseases/infections that can be coused/transmitted by improper infectious waste management practices as stated by respondents. These include hepatitis B virus (61.6%), human immunodeficiency virus (72.9%), wound infections (14.8%), tetanus (12.3%), gastroenteritis (30.5%), malaria/typhoid fever/yellow fever (9.4%). Only 10 (4.9%) respondents reported that they have been diagnosed for one or more of the diseases mentioned above; majority of them 196 (95.1%) claimed never to have been diagnosed of any of these diseases.

Table 4.15: Actions taken by management during spillage of infectious waste

Actions taken	Response frequency**
Prompt and appropriate action	47(36.7%)
Pack the waste and disinfect the place	62(48.4%)
Pack and dispose waste and update staff knowledge	32(25%)
Immediate disposal by *LAWMA	21(16.4%)
Proper disposal	11(8.6%)

*Lagos state waste management Authority

**multiple response allowed

Table 4.16: Problems associated with infectious waste management

Problems stated	Response frequency**
Nosocomial infection is prevalent	10(7.4%)
Improper separation of waste	61(45.2%)
Inadequate training and inadequate provision of materials	55(40.7%)
Waste handlers do not understand the importance of waste management	32(23.7%)
Delay/lateness in the disposal of waste	46(34.1%)
Waste are overfilled and over flowing due to long distance to dump site	22(16.3%)
There are no incinerators in hospitals	13(9.6%)
Improper treatment of laboratory waste	2(1.5%)

**multiple response allowed

Plate 4.4a: Over filled and improperly used waste bag

Plate 4.4b: Improper separation of waste (domestic waste mixed with infectious waste) within hospital wards

Plate 4.4a: Over filled and improperly used waste bag

Plate 4.4b: Improper separation of waste (domestic waste mixed with infectious waste) within hospital wards

Table 4.17: Suggestions proffered by respondents for proper management of infectious waste

Suggestions proffered	Response frequency**
Current method requires continuous improvement and maintenance	13(6.5%)
Prompt disposal of waste by LAWMA	30(15.1%)
Continuous provision of sanitary working implements	34(17.1%)
Continuous training and enlightenment on proper waste handling and management	53(26.6%)
LAWMA should promptly supply more colour-coded bags	52(26.1%)
Strict rules and regulations should be enforced	83(41.7%)
Adequate provision of safety equipments and insistence on use	67(33.7%)
Incinerators should be provided for hospitals	19(9.5%)

**multiple response allowed

Table 4.18: Infections/diseases that can be transmitted through improper waste management practices

Diseases/Infections	Response Frequency**
Tuberculosis/respiratory infections	58(28.6%)
Hepatitis B virus	125(61.6%)
Human immunodeficiency virus	148(72.9%)
Skin disease	29(14.3%)
Wound infections	30(14.8%)
Tetanus	25(12.3%)
Cough/catarrh	10(4.9%)
Sepsis	8(3.9%)
Gastroenteritis/diarrhoea/cholera	62(30.5%)
Malaria/typhoid fever/yellow fever	19(9.4%)

**multiple response allowed

The personal protective equipment (PPE) used by the respondents included gloves (87.4%), nose/face masks (37.4%), boots (8.2%), goggles (3.9%), aprons/coats (14.6%), while 11.1% claimed to use all the aforementioned protective equipment. Figure 4.6 shows the use of protective equipment according to job designation; of the 87.4% respondents that utilised latex gloves, 55.8% were waste generators. More waste generators (25.7%) than waste handlers (11.7%) utilised nose/face masks as PPE. Table 4.19 shows the frequency of use; 79% and 33.7% respondents always utilised gloves and nose/face masks respectively, while on duty. Plates 4.5a and b show improper use of PPE, while Plate 4.6 shows properly dressed waste handlers.

Among the 207 respondents, only 71 (34.3%) respondents went for medical check-up/periodic medical examination. Of these, 51 (24.6%) have tertiary education, 8 (3.9%) and 12 (5.8%) have secondary and primary education respectively (Table 4.20). The frequencies of going for check-up are as follows: every year (37%), every six months (19.2%), every three months (27.4%), whenever necessary (16.4%). A majority of the respondents, 136 (65.7%) do not go for medical check-up, and various reasons were given for this. These include: I do not think it is necessary, since I am not sick (17.9%), it is a waste of time and money (6.8%), I cannot afford it (15.0%), my employers did not make provisions for it (22.7%), always busy (3.4%).

Majority of the respondents, 171 (82.6%) stated that no immunisation was made compulsory for them; whereas 36 (17.4%) reported that immunisation was compulsory. Only 35 (16.9%) respondents stated that they have been immunised for various diseases. Of these number, only 4 (11.4%) were waste handlers. Twenty six (74.3%) and 4 (11.4%) respondents were immunised for hepatitis and cholera respectively. Respondents immunised against typhoid fever and tetanus were 7 (20.0%) and 10 (28.6%) respectively; other immunisations were yellow fever 7 (20.0%) and tuberculosis 6 (17.1%). Figure 4.7 Shows diseases respondents have been immunised against according to job designation.

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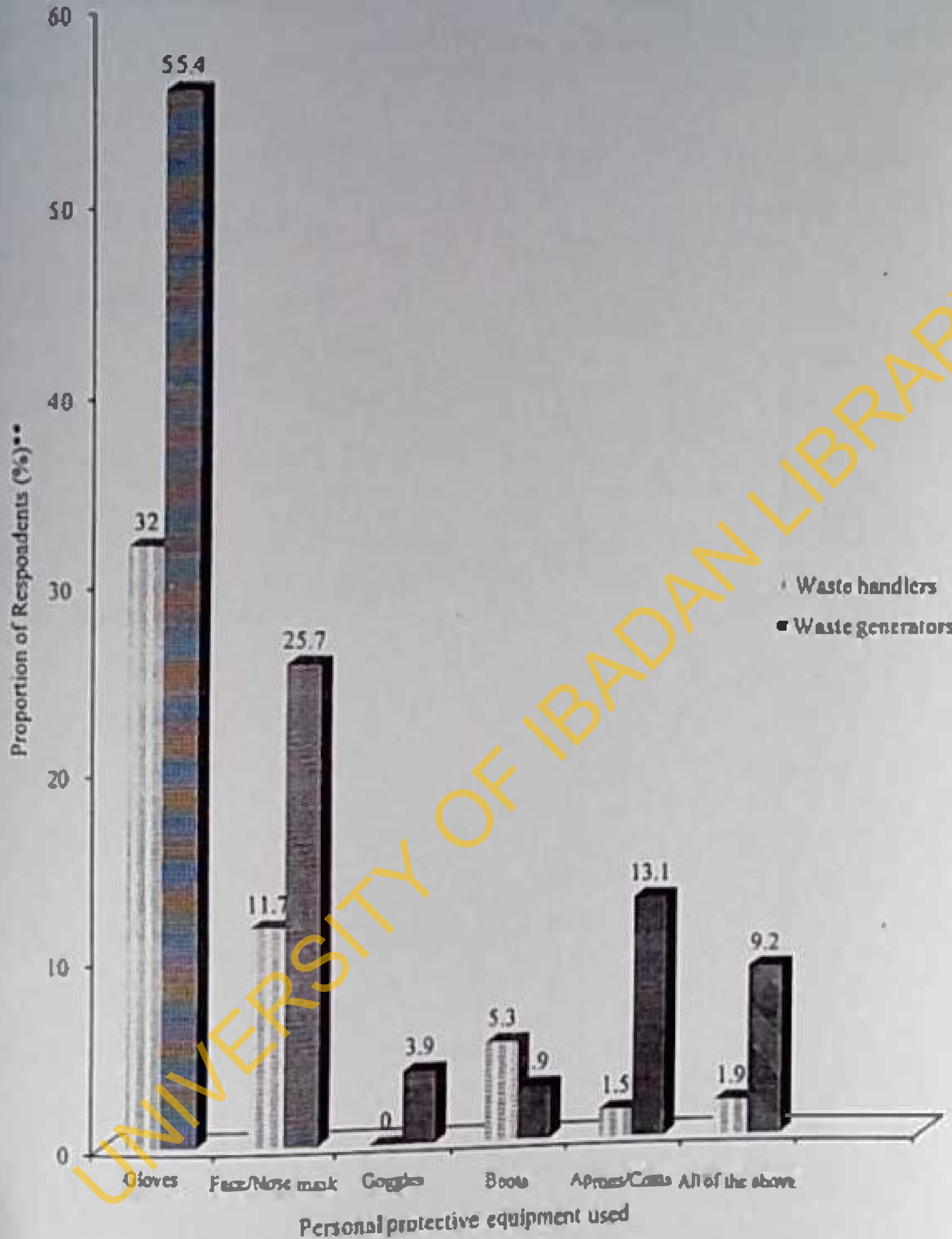

Figure 4.6: Use of protective equipment according to job designation

**multiple response allowed

Table 4.19: Frequency of use of personal protective equipment

Protective Equipment	Frequency of Use**		
	Always	Sometimes	Whenever it is Provided
Gloves	162 (79%)	9 (4.4%)	8 (3.9%)
Nose/Face masks	69 (33.7%)	1 (0.5%)	7 (3.4%)
Boots	14 (6.8%)	1 (0.5%)	2 (1.0%)
Goggles	0 (0%)	7 (3.4%)	1 (0.5%)
Aprons/Coats	25 (12.2%)	2 (1.0%)	3 (1.5%)
All of the above	16 (7.8%)	0 (0%)	7 (3.4%)

**multiple response allowed

Plate 4.5a: Collection of safety boxes without adequate personal protective equipment (Waste handlers are without heavy duty gloves, safety boots. A situation that promotes sharp injury and infection)

Plate 4.5b: Collection of hospital general waste without the use of personal protective equipment by waste handlers

Plate 4.5a: Collection of safety boxes without adequate personal protective equipment (Waste handlers are without heavy duty gloves, safety boots. A situation that promotes sharp injury and infection)

Plate 4.5b: Collection of hospital general waste without the use of personal protective equipment by waste handlers

Plate 4.6: A waste collector with all the required personal protective equipment

Table 4.20: Distribution of respondents according to hospital attendance for medical check- up

Education level	Do you go for medical check-up	
	Yes	No
Primary	12(5.8%)	13(6.3%)
Secondary	8(3.9%)	29(14.0%)
Tertiary	51(24.6%)	94(45.4%)
	71(34.3%)	136(65.7%)

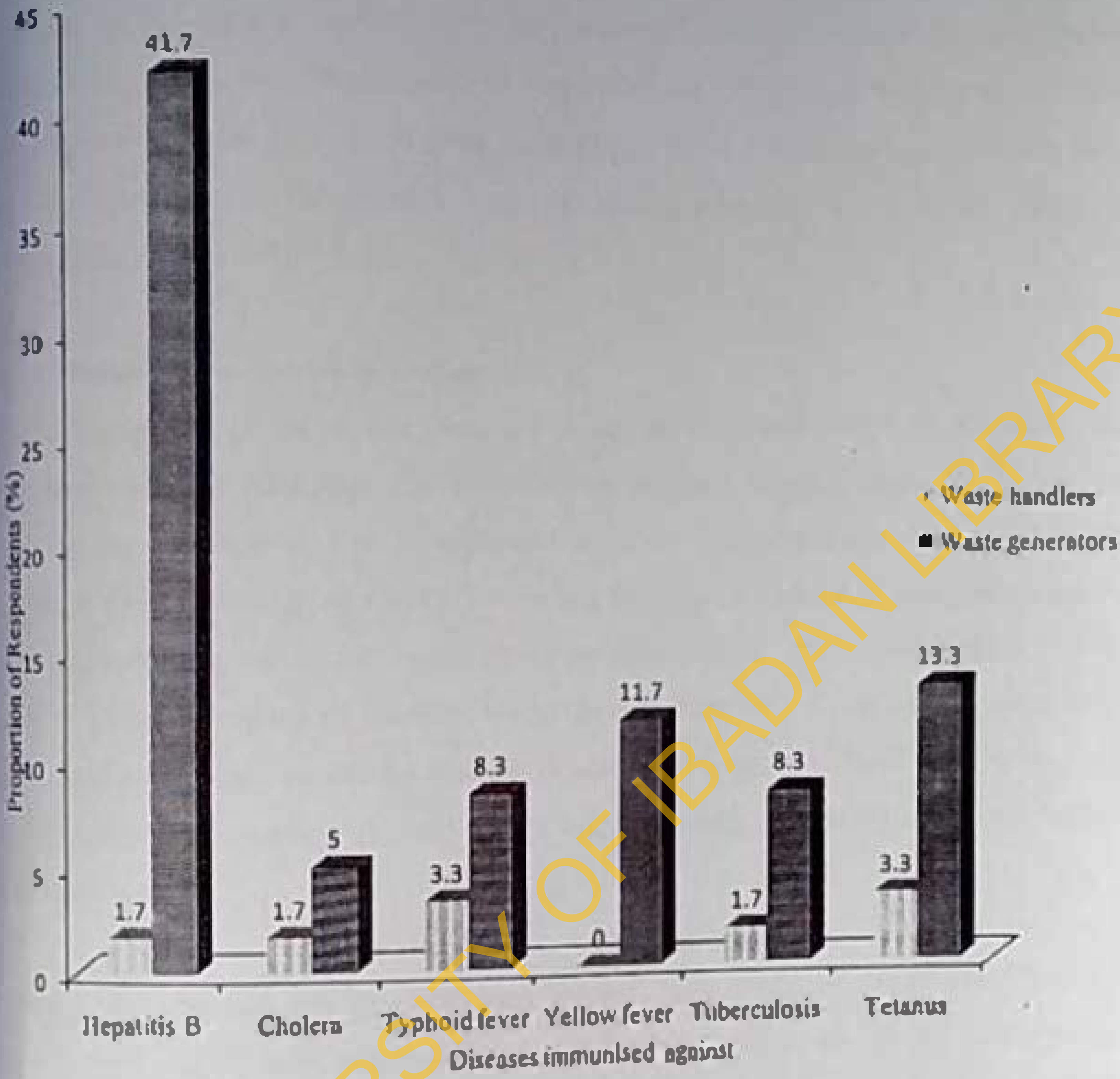

Figure 4.7: Immunisation of Respondents according to job designation

None of the respondents with primary and secondary education had been immunised for hepatitis, cholera, yellow fever; only one respondent with secondary education had been vaccinated against tuberculosis, while two respondents with primary education had each been immunised against typhoid fever and tetanus.74.3% of respondents with tertiary education had received vaccinations for hepatitis, 8 (22.9%) and 7 (20.0%) had been immunised for tetanus and yellow fever respectively. Table 4.21 shows immunisation based on educational level. Educational level of respondents had a significant effect on immunisation (P< 0.005).

4.5. Outcome of On-site Observations

Partial segregation of waste was observed in all the hospitals; 67.2% of the waste bins examined had both infectious and domestic waste mixed together (Table 4.22). In each ward, waste was supposed to be separated into four components; black bag (domestic waste), red bag (pathological waste), yellow bag (infectious waste) and safety box (sharps), but the rule of three waste bins was observed not to be obeyed all the time (Plate 4.7a & b); some of the wards had only a domestic waste bin and safety box. There was also shortage of red/yellow waste bags, sometimes black bags were used in place of these bags, without any special label or information; red and yellow bags were interchangeably used for infectious waste (Plate 4.8a).

Safety boxes were leak and puncture proof, but they were overfilled most times (Plate 4.8b &b); in most wards, only one safety box was available and it was placed at the nurses' station or close to the entrance. The rule of segregation was not adhered to strictly, especially segregation of sharps; of the 193 personnel observed 130 (67.4%), were observed to mix infectious waste with domestic waste, including sharps; among these were 72 (37.3%) nurses, 48 (24.9%) doctors and 10 (5.2%) laboratory personnel. Waste bags were thin, transparent and not puncture resistant; yet sharps such as scalpel blades, lancets, razors, broken injection vials etc. were dropped into these bags.

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Table 4.21: Immunisation according to educational level

Immunisation Type	Educational level**			P-value
	Primary	Secondary	Tertiary	
Hepatitis	0(0%)	0(0%)	26(74.3%)	
Cholera	0(0%)	0(0%)	4(11.4%)	
Typhoid fever	1(2.9%)	0(0%)	6(17.1%)	0.000
Yellow fever	0(0%)	0(0%)	7(20.0%)	
Tuberculosis	0(0%)	1(2.9%)	5(14.3%)	
Tetanus	1(2.9%)	1(2.9%)	8(22.9%)	

**multiple responses allowed

Table 4.22: Onsite Observation of Waste Segregation

Waste segregation indicators present	G.H. Surulere	G.H. Isolo	G.H. Ikorodu	G.H. Akodo
Black waste bags, yellow waste bags, red waste bags and safety box	+	+	+	+
Black waste bags, red or yellow waste bags and safety box	+++	++	++	+
Black waste bags and safety box	++	+++	+++	+++
Waste bin type				
Colour-coded with cover	++	+	+	+
Colour-coded without cover	+	+	+	+
No colour coding, no cover	++	++	+++	+++
No colour coding, but covered	++	+	++	+

G.H. =General Hospital

Key:

1 - < 4 Present = +

4 - 6 Present = ++

> 6 Present = +++

Plate 4.7a: Containers used for waste collection according to colour coding (the ideal situation). The wheeled bin is for temporary storage of infectious waste

Plate 4.7b: Containers used for waste collection as observed in the hospitals

Plate 4.8a: Improper use of colour coded waste bags (These bins are without cover and not correctly colour coded.

Plate 4.8b: Overfilled safety boxes (To prevent injuries, WHO guidelines requires that safety boxes should be ¾ filled)

At the temporary waste storage site, it was difficult to ascertain contents of waste bags, point and date of collection, because no waste bag was labelled (Plate 4.9). Most times, depending on the ward, the distance between waste generation point and central collection point was between fifty and five hundred meters, yet on-site transportation of waste was done by pulling the waste bags/safety boxes by hand (plates 4.10a and 4.10b). Although these hospitals had wheeled trolleys, they were not utilised most of the time for waste movement. It was also observed that wheeled bins were used for temporary storage of waste and so was never moved at all.

Most of the waste bins (87.2%) in the wards were not colour coded and were uncovered, but they were lined with waste bags. It was observed that waste bins were reused, most of the time without being washed; waste bins were washed once in week. There was no outlined procedure for waste bins decontamination; waste bins were washed mostly with water containing disinfectant using broom, soap was rarely used for cleaning bins in all the surveyed hospitals. There was no pre-treatment of waste at source. It was also observed that in all the hospitals, there was no laid down procedure for handling and cleaning of infectious waste spills; record of spills was also not kept at all. There was no proper record of waste generation rate in all the hospitals. all they had was LAWMA bill which contained the quantity of waste carted away weekly. None of these hospitals, had a written waste management policy, but they had LAWMA hand book on proper segregation and handling of hospital waste.

The primary waste storage facility for infectious waste were mostly plastic bins, 72.5% of which were not colour-coded (Plate 4.11), it was observed that not all the plastic bins had covers. In all the hospitals, domestic waste was stored separately, except for Akodo G.H, where all waste were dumped together, and dump site was very close to the female ward. Most of the time (76.6%), bins at collection points were overflowing with infectious waste. Only General Hospital Ikorodu had a building, with unlocked door for temporary storage of waste, other hospitals stored their waste in the open, exposed to sunlight. In all the hospitals, the content of the waste bins were moist/wet before disposal, waste was kept for more than forty eight hours before disposal. Stench flies and other insects were observed at the temporary waste storage site.

Plate 4.9: Properly bagged waste ready to be carted away for disposal

(None of these bags have labels)

Plate 4.10a: Improper method of on-site transportation of infectious waste

Plate 4.10b: The use of patients' stretcher for onsite transportation of safety boxes.

(The arrangement of the boxes could promote accident)

Plate 4.11a: Infectious waste bins exposed to harsh weather conditions

Plate 4.11b: Unprotected waste bins used for temporary storage of infectious waste (waste bins are not colour coded; the black waste bags contain infectious waste)

There was no infectious waste treatment facility in all the four hospitals studied. Open burning of domestic waste mixed with infectious waste (mainly used needles and syringes, and blood-stained cotton wool) was observed in Isolo G.H; open burning and open dumping of waste was also observed in Akodo G. H which is located in a rural area. Untreated infectious waste was collected once a week by LAWMA from hospitals located in urban areas for disposal at an unprotected non-sanitary landfill. Before the completion of this study, LAWMA had acquired a hydroclave for treatment of medical waste, before disposal. It was observed that LAWMA was not regular in the rural hospitals; only sharps were collected, while, other waste were either collected as regular municipal waste or burnt when overflowing.

Latex gloves was the most commonly used personal protective equipment among all categories of health workers (87.4%). Majority of the nurses (91.2%) wore their aprons, but only a few doctors were seen with their clinic coats; clinic coats were not used at nights and weekends. The use of nose/mouth masks was rare among all categories of workers (5.2%), except for personnel within the theatre, and waste handlers who dealt with waste that produced stench. All the laboratory staff wore protective clothing, but nose/mouth mask and goggles were rarely used, even when it was required. Majority of the waste handlers (85.6%) used the wrong gloves, latex gloves was used instead of heavy duty gloves for waste handling; most of them (67.5%) wore open sandals, while conveying waste.

4.6. Physico-chemical Characteristics of Hospital Solid Waste

The total quantity of solid waste generated daily in the surveyed hospitals was 336.8 kg; the quantity of general waste produced was 242.6 kg (72.1%), while infectious waste was 93.9 kg (27.9%), 3.3% (3.5 kg) of infectious waste were sharps. The quantity of waste generated each day was between 58.2 kg and 140.4 kg. The mean waste generated per day was 84.2 ± 39.4 kg, thus waste generated per month was 10104 kg and the estimated waste generated per year would be 121.25 tons. Table 4.22 shows the total solid waste generated daily in Surulere and Isolo general hospitals as 58.2 kg and 82.7 kg respectively, while 140.4 kg and 55.2 kg was generated in Ikorodu and Akodo general hospitals.

Table 4.23: Quantity of Waste Generated Per Day

General Hospital	General Waste(Kg/day)	Infectious Waste(Kg/day)	Total(kg/day)
Surulere	42.9	15.3	58.2
Isolo	59.8	22.9	82.7
Ikorodu	97.7	42.7	140.4
Akodo	42.2	13.0	55.2
Total	242.6	93.9	336.5
Mean	60.7 ± 26.0	23.5 ± 13.5	84.2 ± 39.4

The quantity of waste generated daily in the wards/clinics as shown in table 4.23 was between 1.8kg and 54.8kg. Surgical wards (33.9 kg), maternity/labour ward (54.8kg), paediatric ward (35.2 kg) and operation theatre (42.3 kg) produced large quantities of waste. Dental clinic (6.3 kg), eye clinic (1.8 kg), family planning clinic (3.2 kg) and HIV clinic (5.4 kg) produced small quantity of wastes daily. The smallest quantity of waste was generated in the eye clinic (1.8 kg), while the highest quantity was generated in the maternity/labour ward (54.8 kg). The waste generation rate per bed per day was between 0.2 and 1.2 kg/bed/day with an average of 1.0 ± 0.1 kg/bed/day. The average generation rate for general waste and infectious waste was 0.7 ± 0.1 kg/bed/day, and 0.3 ± 0.1 kg/bed/day respectively. There were a total of 320 beds in the surveyed hospitals, and the bed/ day occupancy rate was between 85% and 100%. Table 4.24 shows waste generation rate per bed per day in the surveyed hospitals; 0.9 kg and 1.2 kg of waste was generated per bed per day in Akodo and Ikorodu general hospitals respectively; while Surulere and Isolo general hospitals, each generated 1.0 kg of waste was per bed per day.

The mean daily generation of paper, plastic, metal in the surveyed hospitals were as follows: 34.0± 9.3, 15.5 ± 6.9, 2.7 ± 1.3 respectively; while the mean daily generation rate of glass, cotton and food waste/organics was 1.6 ± 0.5, 8.8 ± 3.4, 20.6 ± 7.5 respectively. Paper (40.8%) and food waste/organics (24.7%) constituted the highest proportion of waste generated, and glass was the least (1.9%) as shown in figure 4.8. The generation rate of paper, plastic, glass, cotton and food waste/organics was significantly different across the four hospitals ($p<0.05$); however, there was no significant differences in the generation of metals among the surveyed hospitals. Table 4.25 shows the characteristics and quantification of waste in the surveyed hospitals; the highest quantity of paper (47.2 kg) was generated in Ikorodu, while the lowest was generated in Surulere. Glass was the least generated, with the highest weekly generation of 2.8 kg. The moisture content of the waste generated in Surulere, Isolo, Ikorodu, and Akodo general hospitals were 38.4%, 37.3%, 37.1% and 40.3% respectively. The pH of the waste samples were as follows: 6.7 for general hospital (G.H.) Surulere, 6.3 for Isolo G.H.; while that of Ikorodu G.H was 6.5 and a pH of 6.9 was recorded for Akodo G.H.

Table 4.24: Waste Produced in the Different Wards/Clinics in the Surveyed Hospitals

Ward/unit	General Hospitals(kg/day)				Total (kg/day)
	Surulere	Isolo	Ikorodu	Akodo	
Casualty/out-patient	5.3	5.0	8.4	3.9	22.6
Surgical	5.7	9.1	13.5	5.6	33.9
Medical	3.4	6.3	10.4	4.2	24.3
Laboratory	6.7	6.8	11.3	4.8	29.6
Maternity/labour	7.8	11.5	23.4	12.1	54.8
Operation theatre/surgical	8.4	9.3	17.5	7.1	42.3
Paediatrics	4.4	11.7	15.1	4.2	35.4
Dental	2.8	1.2	2.3	-	6.3
Administrative block	1.8	1.6	2.1	1.1	6.6
Pharmacy	4.2	4.4	8.3	3.6	20.5
Eye	-	0.8	1.0	-	1.8
Family planning	0.7	0.6	1.3	0.6	3.2
Heart-Heart centre (HIV clinic)	0.7	0.8	2.9	1.0	5.4
Mortuary	-	5.3	7.3	-	12.6
Ante-natal/Post-natal	1.9	2.0	4.3	1.5	9.7
Kitchen	4.4	6.3	11.3	5.5	27.5
Total	58.2	82.7	140.4	55.2	336.5

Table 4.25: Quantity of waste generated per bed per day

General Hospital	No. of beds	General waste (kg/bed/day)	Infectious waste (kg/bed/day)	Total (kg/bed/day)
Surulere	60	0.7	0.3	1.0
Isolo	80	0.7	0.3	1.0
Ikorodu	120	0.8	0.4	1.2
Akodo	60	0.7	0.2	0.9
Total	320	2.9	1.2	4.1
Mean		0.7 ± 0.1	0.4 ± 0.1	1.0 ± 0.1

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General Hospital	No. of beds	General waste (kg/bed/day)	Infectious waste (kg/bed/day)	Total (kg/bed/day)
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Isolo	80	0.7	0.3	1.0
Ikorodu	120	0.8	0.4	1.2
Akodo	60	0.7	0.2	0.9
Total	320	2.9	1.2	4.1
Mean		0.7 ± 0.1	0.4 ± 0.1	1.0 ± 0.1

Table 4.26: Characterisation and Quantification of Hospital waste

Waste Type	*G.H. Surulere	Mean Weight (kg) ±S.D G.H. Isolo	G.H. Ikorodu	G.H. Akodo	P-value
Paper/carton	26.1 ± 1.5	33.2 ± 3.2	47.2 ± 2.6	29.4 ± 1.3	0.005
Plastic	10.0 ± 0.5	14.4 ± 0.8	25.6 ± 2.4	12.1 ± 1.5	0.021
Metal	1.2 ± 0.8	2.6 ± 1.3	5.3 ± 1.4	1.8 ± 0.4	0.057
Glass	0.9 ± 0.3	1.3 ± 0.7	2.8 ± 0.8	1.2 ± 0.5	0.036
Cotton	5.3 ± 1.7	9.3 ± 2.6	13.3 ± 4.3	7.4 ± 1.2	0.014
Food/organic waste	15.1 ± 2.7	20.4 ± 2.6	31.2 ± 2.5	15.7 ± 0.7	0.012

*General Hospital

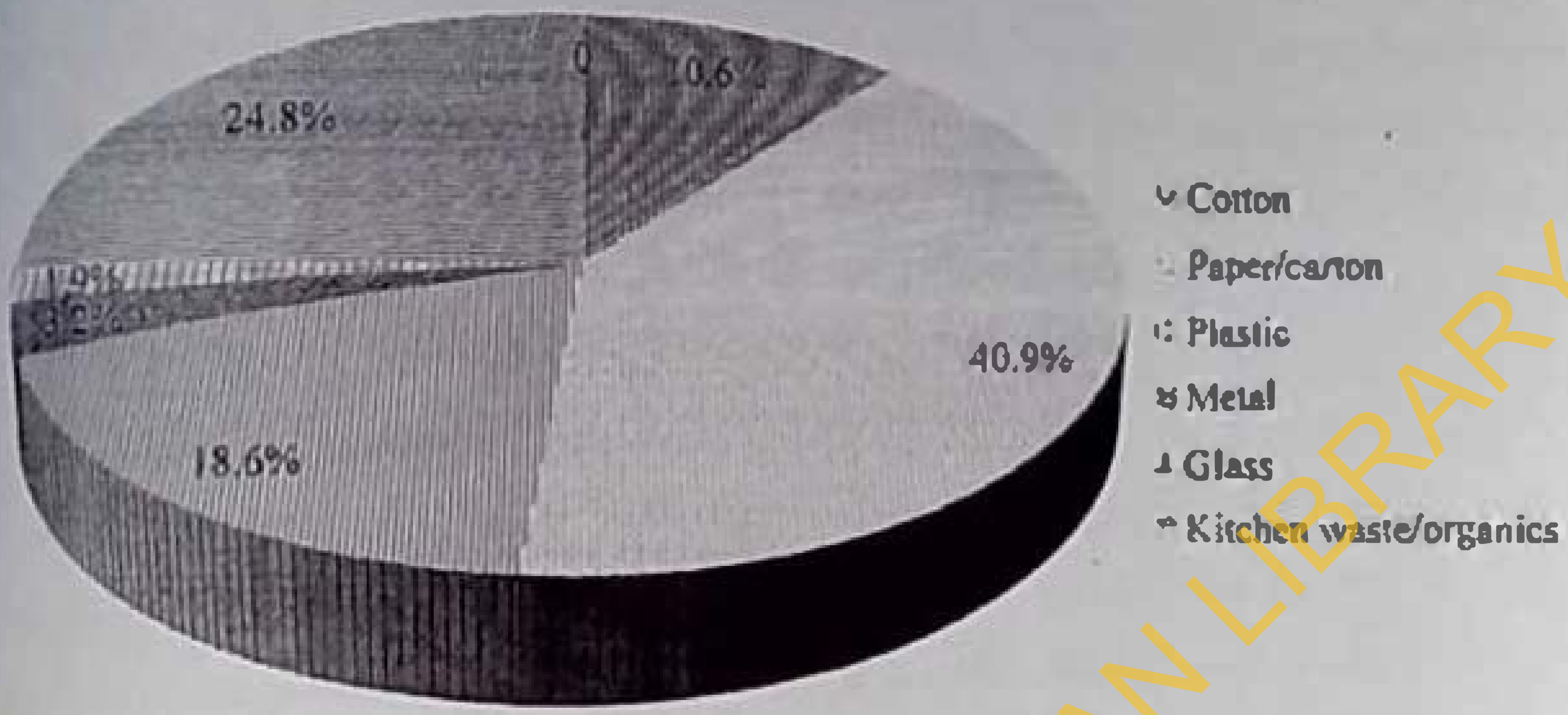

Figure 4.8: Characteristics of weekly waste components (%)

Elemental analysis revealed that carbon was the dominant element; values recorded were 44.8 %, 47.9 %, 50.6 % and 49.3 % for Surulere, Isolo, Ikorodu and Akodo G.H respectively. The values for nitrogen content were 1.5 % for Surulere G.H, 1.6 % for Isolo G.H, 1.7 % each for Ikorodu and Akodo G.H. Lead composition in the analysed waste was 12.2 mg/kg, 11.7 mg/kg in Surulere and Isolo G.H respectively; 12.5mg/kg was recorded for Ikorodu G.H, while that of Akodo G.H was 12.6 mg/kg. Nickel was also present in the analysed waste; the values were 18.9 mg/kg for Surulere G.H, 22.3 mg/kg for Isolo G.H, 23.4 mg/kg for Ikorodu G.H and 25.6 mg/kg for Akodo G.H. Table 4.26 show the elemental composition of the analysed waste.

4.7 Microbiology of solid infectious waste

The bacteria isolated with their frequency of isolation from infectious waste were: *Klebsiella pneumoniae* (35.9%), *Staphylococcus aureus* (29.7%), *Escherichia coli* (12.5%), *Streptococcus pyogenes* (12.5%), *Proteus mirabilis* (14.1%), *Staphylococcus* albus (10.9%) and *Pseudomonas aeruginosa* (9.4%). Table 4.27 shows the frequency of bacteria isolation in the surveyed hospitals; *Staphylococcus albus* and *Pseudomonas aeruginosa* had the least frequency of isolation across the four hospitals. *Proteus mirabilis* was not isolated in general hospital, Akodo, while *Staphylococcus albus* was not isolated in general hospital, Isolo. Table 4.28 shows the mean bacterial counts in the infectious waste of surveyed hospitals ; the mean bacterial load in the infectious waste samples ranged between 1.21 × 10^{11} cfu /100 g and 5.01 × 10^{13} cfu /100 g. Statistical analysis revealed that there was no significant difference in the mean microbial counts across the four hospitals ($p>0.05$).

The lowest geometric mean counts of 1.83 × 10^{11} cfu / g and 2.81 x 10^{11} cfu /100 g were observed in *Proteus mirabilis* and *Streptococcus pyogenes* respectively; while the highest count of 1.70 × 10^{13} cfu /100 g and 2.0 × 10^{12} cfu /100 g were recorded for *Staphylococcus aureus* and *Klebsiella pneumoniae* (Table 4.29).

Elemental analysis revealed that carbon was the dominant element; values recorded were 44.8 %, 47.9 %, 50.6 % and 49.3 % for Surulere, Isolo, Ikorodu and Akodo G.H respectively. The values for nitrogen content were 1.5 % for Surulere G.H, 1.6 % for Isolo G.H, 1.7 % each for Ikorodu and Akodo G.H. Lead composition in the analysed waste was 12.2 mg/kg, 11.7 mg/kg in Surulere and Isolo G.H respectively; 12.5mg/kg was recorded for Ikorodu G.H, while that of Akodo G.H was 12.6 mg/kg. Nickel was also present in the analysed waste; the values were 18.9 mg/kg for Surulere G.H, 22.3 mg/kg for Isolo G.H, 28.4 mg/kg for Ikorodu G.H and 25.6 mg/kg for Akodo G.H. Table 4.26 show the elemental composition of the analysed waste.

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Table 4.27: Elemental Composition of Hospital Waste

Parameter	General Hospital	Mean ± SD
Carbon (%)	Surulere	44.7 ± 3.6
	Isolo	47.9 ± 1.4
	Ikorodu	50.6 ± 0.5
	Akodo	49.3 ± 1.1
Phosphorus (%)	Surulere	0.8 ± 0.2
	Isolo	1.2± 0.2
	Ikorodu	1.2 ± 0.2
	Akodo	1.0± 0.3
Nitrogen (%)	Surulere	1.5 ± 0.7
	Isolo	1.6 ± 0.1
	Ikorodu	1.7 ± 0.1
	Akodo	1.7 ± 0.05
Potassium (%)	Surulere	0.6 ± 0.01
	Isolo	0.7± 0.02
	Ikorodu	0.6 ± 0.02
	Akodo	0.5 ± 0.05
Lead (mg/kg)	Surulere	12.2 ± 0.8
	Isolo	11.7± 1.3
	Ikorodu	12.5 ± 1.7
	Akodo	12.6 ± 1.4
Cadmium (mg/kg)	Surulere	1.3 ± 0.3
	Isolo	1.4 ± 0.1
	Ikorodu	1.5 ± 0.5
	Akodo	1.2 ± 0.1
Nickel(mg/kg)	Surulere	23.4 ± 0.9
	Isolo	21.7 ± 3.1
	Ikorodu	20.9 ± 1.7
	Akodo	20.4 ± 2.5

Table 4.28: Frequency distribution of isolated bacteria from infectious waste

Bacteria strains	G. H**. Akodo(%)	G. H. Surulere(%)	G. H. Ikorodu(%)	G. H. Isolo(%)	Total(%)
Klebsiella pneumoniae	4(6.3)	6(9.4)	8(12.5)	5(7.8)	23 (35.9%)
Staphylococcus aureus	7(10.9)	5(7.8)	4(6.3)	3(4.7)	19(29.7%)
Escherichia coli	2(3.1)	3(4.7)	2(3.1)	1(1.6)	8(12.5%)
Streptococcus pyogenes	4(6.3)	2(3.1)	1(1.6)	1(1.6)	8(12.5%)
Proteus mirabilis	NG*	1(1.6)	5(7.8)	3(4.7)	9(14.1%)
Staphylococcus albus	1(1.6)	4(6.3)	2(3.1)	NG	7(10.9%)
Pseudomonas aeruginosa	1(1.6)	3(4.7)	1(1.6)	1(1.6)	6(9.4%)

*NG = No growth

**G.H. = General hospital

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Staphylococcus aureus	7(10.9)	5(7.8)	4(6.3)	3(4.7)	19(29.7%)
Escherichia coli	2(3.1)	3(4.7)	2(3.1)	1(1.6)	8(12.5%)
Streptococcus pyogenes	4(6.3)	2(3.1)	1(1.6)	1(1.6)	8(12.5%)
Proteus mirabilis	NG*	1(1.6)	5(7.8)	3(4.7)	9(14.1%)
Staphylococcus albus	1(1.6)	4(6.3)	2(3.1)	NG	7(10.9%)
Pseudomonas aeruginosa	1(1.6)	3(4.7)	1(1.6)	1(1.6)	6(9.4%)

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Staphylococcus aureus	7(10.9)	5(7.8)	4(6.3)	3(4.7)	19(29.7%)
Escherichia coli	2(3.1)	3(4.7)	2(3.1)	1(1.6)	8(12.5%)
Streptococcus pyogenes	4(6.3)	2(3.1)	1(1.6)	1(1.6)	8(12.5%)
Proteus mirabilis	NG*	1(1.6)	5(7.8)	3(4.7)	9(14.1%)
Staphylococcus albus	1(1.6)	4(6.3)	2(3.1)	NG	7(10.9%)
Pseudomonas aeruginosa	1(1.6)	3(4.7)	1(1.6)	1(1.6)	6(9.4%)

*NG = No growth

**G.H. = General hospital

Table 4.29: The mean bacterial counts in the infectious waste of surveyed hospitals

Isolates	Mean microbial counts (cfu/100g)				p.value
	G.H**. Akodo	G.H. Surulere	G.H. Ikorodu	G.H. Isolo	
Klebsiella pneumoniae	2.45×10^{10}	7.89×10^{12}	1.46×10^{13}	2.24×10^{12}	0.488
Escherichia coli	1.21×10^{10}	2.31×10^{12}	9.52×10^{11}	9.39×10^{11}	0.688
Streptococcus pyogenes	1.37×10^{11}	4.72×10^{11}	6.47×10^{10}	6.25×10^{12}	0.765
Staphylococcus aureus	5.01×10^{13}	2.10×10^{13}	1.23×10^{13}	3.41×10^{12}	0.520
Proteus mirabilis	N.G*	2.12×10^{11}	1.13×10^{11}	1.50×10^{12}	0.828
Staphylococcus albus	3.20×10^{13}	1.99×10^{11}	1.06×10^{13}	N.G	0.355
Pseudomonas aeruginosa	3.20×10^{10}	1.05×10^{12}	4.20×10^{12}	2.30×10^{10}	0.916

*NG = No growth

**GH = General hospital

Table 4.30: Frequency of bacterial isolates and their geometric mean count

Isolates	Frequency of occurrence	Geometric mean count (cfu/100g)
Klebsiella pneumoniae	23(35.9%)	$2.00 \times 10^{12} \pm 6.98 \times 10^{1}$
Staphylococcus aureus	19(29.7%)	$1.70 \times 10^{13} \pm 2.14 \times 10^{1}$
Escherichia coli	8(12.5%)	$5.59 \times 10^{11} \pm 2.56 \times 10^{1}$
Streptococcus pyogenes	8(12.5%)	$2.81 \times 10^{11} \pm 1.85 \times 10^{1}$
Proteus mirabilis	9(.14.1%)	$1.83 \times 10^{11} \pm 2.08 \times 10^{1}$
Staphylococcus albus	7(10.9%)	$1.28 \times 10^{12} \pm 4.29 \times 10^{1}$
Pseudomonas aeruginosa	6(9.4%)	$3.91 \times 10^{11} \pm 2.23 \times 10^{1}$

CHAPTER FIVE

DISCUSSION

5.1. Socio-Demographic Characteristics

More females than males participated in this study; this is similar to the study of Shafee *et al* (2010) in which more females than males participated. Majority of the participants were Yoruba, this is expected, because the study area is located in the south-western region of Nigeria, where the Yorubas are predominant.

The population of waste handlers in this study was less than that of waste generators; Akter and Trankler (2003) in Bangladesh also used more waste generators in their study. Majority of the study participants had tertiary education; this compares with the report of Joseph and Ajithkrishnan (2004) in Pondicherry, India in which 61.9% of the study participants had tertiary education. The higher population of participants with tertiary education could also be due to the fact that the delivery of health care services required skillful professionals on a large scale.

Among the respondents, the population of the age group 30- 39 was highest; this is not in agreement with the reports of Joseph and Ajithkrishnan (2004) in which the >25 years age group was highest among the study participants. The mean age of the respondents was 37.5 years and the work experience/service length was 10.8years.

5.2. Knowledge about Infectious Waste Management

Although, mean knowledge score was high, a majority of the respondents had poor score, thus this study revealed that Knowledge about Infectious Waste Management was poor. Waste handlers had better knowledge than waste generators; this is contrary to the reports of Saini *et al* (2005) and Mathur *et al* (2010) in which paramedical staff/ sanitary staff had poorer knowledge. The low knowledge score obtained by waste generators might be attributed to apathy towards the operational aspects of the biomedical waste management

system, and the tubular vision of the professionals that is mainly focused on the curative aspects of patient care services. Work experience had a significant effect on the knowledge of respondents; these might be due to inadequate supervision and poor enforcement of rules and regulations.

Majority of the respondents stated that waste segregation is been practiced in the surveyed hospitals; this was observed to be true; however, minute quantities of infectious waste were mixed with general waste in all the hospitals studied. Similarly, Longe and Williams (2006) reported that three of the four hospitals surveyed in Lagos practiced waste segregation. On the contrary, Bassey *et al* (2006) in Abuja and Mokuolu (2009) in Ilorin reported that waste segregation was not practiced in the hospitals surveyed.

The infectious waste generated in the surveyed hospitals included used needle and syringe, blood/body fluid/blood bags, plaster/gauze/soiled wound dressing, blood –stained cotton wool/swabs, tissue, used gloves/blood-stained gloves, fluid line/canula, placenta/blood-stained pad and extracted tooth. This is consistent with the report of Jim *et al* (2009) which stated that infectious waste can include used gauze/dressing, blood/intravenous lines, gloves, anatomical waste, and body fluids from patients with highly infectious diseases.

At each point where hazardous waste, most likely infectious waste, is generated, there should be a minimum of two bins (Jim *et al.*, 2009). In this study, it was observed that almost every unit that produced infectious waste had two waste bins and a safety box. The bin liners were colour –coded, but the waste bins were not. Joseph and Ajithkrishnan (2004) also observed that 74% of the hospitals in their study did not colour code their wastes.

According to Yadav (2001) the container in which infectious wastes are stored shall display promptly the International Biohazard symbol label in red colour; the waste bins present in all the hospitals surveyed had no biohazard logo, although some waste bin liners had this logo, but it was concealed by the waste bin; biohazard logo was present on safety boxes. This is similar to the report of Joseph and Ajithkrishnan (2004), in which only 15% of the health facilities sampled used the biohazard symbol for labelling of waste bags/bins.

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It was observed in this study that most of the respondents could not identify the biohazard logo correctly; the inadequate use of the biohazard logo may be responsible, since the respondents are not familiar with the logo; more so, there were no posters/educational materials to show proper waste disposal practices. Generally in developing countries, only few individual staffers of health care facility are familiar with the procedures for an effective and efficient waste management program (Diaz and Savage, 2003). This is confirmed in this study, considering the low population of respondents who could identify the biohazard logo and the low knowledge scores obtained by the respondents.

5.3. Attitude towards Infectious Waste Management

Safe management of health care waste has been recognised as being more of a problem of attitude rather than just providing technology or facilities (Joseph and Ajithkrishnan, 2004). This statement was confirmed by the low mean attitude score recorded in this study. Low attitude score may also be due to lack of commitment, poor managerial skills on the part of management. More waste generators than waste handlers had a better attitude towards infectious waste management; this is not out of place since a large proportion of hospital staffs are well educated.

A large proportion of the respondents believed that medical waste segregation will help protect their health, because medical waste is more dangerous than domestic waste; yet, they were of the opinion that waste segregation is an exclusive function of waste handlers. This attitude/misconception might be due to inadequate training/education and/or lack of interest and commitment. It is a universally accepted fact that segregation of infectious waste should be the responsibility of the generator of the waste (Yadav, 2001). This statement is at variance with the findings in this study in which more waste generators than handlers were of the opinion that waste segregation was strictly the job of waste handlers. However, the findings in this study is in agreement with the findings of Joseph and Ajithkrishnan(2004), in which only a very small percentage (5.29%) of the respondents were of the view that doctors have a role in waste segregation. Thus it can be said that 'sensitising' the generators of waste to properly segregate the waste at the source of generation is 'key' to the successful implementation of infectious waste management (Yadav, 2001). This is so considering the fact that a majority of respondents in this study believed that hospital waste is similar, and does not require segregation.

5.4. Infectious Waste Management Practices

Majority of the respondents had received training on proper waste management practices. This is similar to the reports of Patil and Pokhrel (2005) and Gabela (2007). In spite of the large population that had been trained, it was observed that hospital staff did not pay attention to proper waste segregation and handling; there was incorrect use of waste bags and excessive filling of safety boxes. This poor practice might be due to a combination of insufficient knowledge and their lack of interest in infectious waste management; considering the poor knowledge score obtained by most of the respondents. Similarly, in India, both Gupta and Boojh (2006), and Chandiraboss *et al* (2009) reported that hospitals do not manage their medical waste properly and that coloured bags were indiscriminately used without any organized segregation or treatment.

Blenkharn (2006) and Ngwuluka *et al* (2009) in their separate studies reported that most of the hospitals in Nigeria have refuse collection points within the hospital premises, where all categories of wastes were left in no specific containers. In most cases, the storage area was unsecured and unfenced; sometimes these wastes were left for days and weeks and were subjected to the direct effects of weather. This observation was confirmed in this study; none of the hospitals had a secured waste collection point. The storage areas however were found to be freely accessible to visitors and other unauthorised persons. Flies, cockroaches, and rodents were a common feature of waste collection points. Ngwuluka *et al* (2009) and Neupane (2010) recorded similar observations in their separate studies. Neupane (2010) opined that scattered medical wastes are responsible for the spread of communicable diseases.

Prior to disposal, infectious waste should be stored for a maximum of 48 hours at the central storage area (Jim *et al*., 2009). Observations at the study sites were contrary; waste was collected once a week for disposal by LAWMA and was therefore stored for more than 48 hours. Removal of waste from hospitals once a week is not in agreement with WHO (2005) recommendations. Bins should be made of a non-corrosive material (e.g., plastic) and have a lid that fits tightly and easily opened and closed. They should be leak-proof and washable, and must have handles that enable waste handlers to safely transport them. (Jim *et al.*, 2009).The waste bins in all the hospitals were in conformity; they were washable, leak-proof plastics with handles, but most of them had no tight fitting lids. This is unlike the report of Pruthvish *et al* (1999). in which only 35% of the healthcare facilities studied used covered waste bins.

WHO (2005) also recommended regular daily removal of HCW from the point of generation; all the hospitals acted in conformity, waste were removed twice daily from points of generation. In hospitals or larger facilities, HCW is usually transported on a trolley or similar device to a temporary storage area (Jim *et al.*, 2009), transmission routes should be minimised and waste containers covered (Rushbrook and Zghondi, 2005). In this study, uncovered waste bins were transported, most of the time to temporary storage site by hand pulling of waste bags/safety boxes, across long distances. This method of transportation could promote spillage occurrences, which could lead to injuries and spread of infectious diseases. Temporary storage containers and trolleys for on-site transport should have the same colour coding (Rushbrook and Zghondi, 2005). In this study, no trolley was colour coded, and most of the temporary storage containers were not colour coded as well.

A noticeable problem was the multiple uses of black plastic bags for storage of both infectious waste and domestic waste without appropriate labelling; this could be a reason for improper segregation of waste observed in all the hospitals, because segregation and colour coding work hand in hand. Longe and Williams (2006) and Asim *et al* (2009) in similar studies also reported similar observation. The multiple uses were attributed to the inadequate supply of red and yellow waste bags by LAWMA, and inadequate funding by hospital management for procurement. Unlike, Patil and Pokhrel (2005) in India that reported that color-coded, high-density polyethylene bags were used for waste collection; waste bags placed in bins in the surveyed hospitals were too thin to resist puncture. However, sharps, mostly needle and syringes were collected into rigid, puncture proof containers with the international hazardous waste logo, but were overfilled. The overfilled safety boxes could lead to occupational injury among waste handlers.

Land filling and uncontrolled land disposal are still the most commonly used methods for waste disposal worldwide (Run-dung *et al.*, 2006). Land filling, open burning and open dumping were some of the methods of disposing waste. Similar observations were recorded by Bassey *et al* (2006) in Abuja and Ngwuluka *et al* (2009) in Jos. Burning and incineration of medical waste have been linked to severe public health threat and pollution resulting in the release of toxic substances (Bassey *et al.*, 2006). Putrefaction occurs in portions of refuse, which have not been fully burnt and add to air pollution through foul smells (Bassey *et al.*, 2006). Apart from the 'partial' waste segregation observed in the surveyed hospitals, no form of waste treatment was carried out before disposal. However, the recent acquisition of hydroclave by LAWMA will solve the problem of improper waste treatment.

The documentation of all activities involved in the management of hazardous wastes is a regulatory requirement (FEPA, 1991). The bags or containers should carry a label, which should indicate the point of production, ward/department in hospital, date of collection, contents and waste (Ngwuluka *et al.*, 2009). No form of waste bags documentation was done in all the hospitals, and there was no proper documentation of volume and composition of waste generated; and of spill occurrence. Joseph and Ajithkrishnan (2004) and Longe and Williams (2006) also recorded similar observations. Improper documentation might lead to inadequate budgeting, and this might be a reason for shortage of appropriate waste bags.

5.5. Health Risks and Conditions.

According to Yadav (2001), indiscriminate management of infectious waste could cause nosocomial infections, AIDS, and Hepatitis B and C; the most important are biological agents, which pollute water and food and cause alimentary infections like cholera, typhoid, dysentery, infective hepatitis, polio, ascariasis, hook worm diseases etc (Ekugo,1998; Neupane, 2010). In this study, a similar response was obtained from an overwhelming majority of the respondents. Pruthvish *et al* (1999) observed in their study that only 10% of the facilities studied conducted periodic medical examination for personnel; similar

observations was made in this study, none of the hospitals studied conducted periodic medical examination.

All waste handlers must be protected front injury and exposure to diseases or contaminants associated with infectious waste (Yadav, 2001; Jim *et al.*, 2009). In this study, waste handlers were not properly protected, Inappropriate and incomplete use of PPE was a common feature; on the contrary, Dehghani *et al* (2008) observed that waste handlers in his study sites used complete PPE, while Agbola *et al* (2009) reported that most of the health facilities in Ibadan provided only disposable gloves or apron as PPE. The inappropriate and incomplete use of PPE observed in this study might be due to inadequate funding, poor monitoring and enforcement by management, and non cholant attitude on the part of waste handlers. Immunisation against infectious disease was low. Salkin (2004) opined that the consequences of the hazards posed by medical waste in low-income countries may be more significant due to limited availability of immunisation against infectious diseases

5.6. Physicochemical Characteristics of Infectious Solid Waste

In developing countries, the total amount of hospital waste generated in health care facilities varied from 0.54 to 1.39 kg/bed/day (Diaz and Savage, 2003); the waste generation rate io the surveyed hospitals was within this range. The waste generation rate reported in this study is within LAWMA's estimated range of 0.8–1.75 kg/bed/day (LAWMA, 2005), but it is slightly higher than the generation rate of 0.43 -0.67 kg/bed/day reported in a similar study in Lagos by Longe and Williams (2006). The slight increase might be due to population increase, as a result of the regular influx of people into the mega city, and the increased use of disposables. The higher waste generation rate observed in Ikorodu and Isolo general hospitals was due to their bigger size and wider range of medical services rendered.

The percentage composition of domestic waste recorded in this study is similar to the reports of Bossey *et al* (2006) in Abuja and Gabela (2007) in South Africa, but less than the 54% recorded by Longe and Williams (2006). According to FEPA (1991), infectious waste constitutes between 19% and 37% of the entire medical waste stream; the infectious waste generated in the surveyed hospitals was within this range, and similar findings were

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The solid waste generation rate per day was lowest at the eye clinic of the surveyed Hospitals and highest at the maternity/labour ward. Ahmed (1997) similarly reported that the dominant trend is that large quantity of waste is produced in surgical, gynaecology, orthopaedic and medical sections. The considerable smaller quantities of solid wastes generated at the eye clinic is not surprising, the kind of therapy usually prescribed does not lead to generation of much wastes. The variation in the waste generation rate from one ward or unit to another within each health institution obtained is as expected, since this depended on the nature of activities in a specific ward or unit; and the number of patients at the time of measurement. Majority of the patients attended to at the eye and dental clinics were out patients, generating typically light weight wastes such as cotton wool, needles, syringes; whereas relatively heavy and moisturized wastes such as soaked swabs, gauze, pads, disposable napkins were generated by the largely in-patients at the maternity/labour ward, paediatric ward and operation theatre (Bassey *et al.*,2006).

The characteristics of waste from hospitals are almost similar in all countries except for amounts generated due to standard procedures observed in the medical field (Ahmed, 1997). Waste characterisation showed that a greater percentage of wastes produced is combustible; elemental analysis also revealed that carbon was the most dominant. Li and Jeng (1993) also reported that the combustible waste in their study was 99 % and carbon was the dominant element. Nickel was also found to be dominant; the presence of a fairly large percentage of food/organic waste and plastics could be a contributing factor, nickel is used in some industries for plastic production, and it is a constituent of kitchen waste. The moisture content of the waste in all the hospitals was high. Li and Jeng (1993) also reported high moisture content (39%) in their study; the high moisture content might be from extraneous reported by Bassey *et al* (2006) as well as Longe and Williams (2006). However, this value is still higher than the 10-15% range specified by US-EPA (1986), and the higher percentage might be due to improper on-site separation of waste observed in the surveyed hospitals. Similarly, Gabela (2007) reported that the amount of HCW generated in Ilembe, South Africa differed from WHO guidelines and attributed this to improper segregation of waste categories. This implies that proper segregation of waste at source could reduce the percentage composition of infectious waste.

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The percentage composition of waste in the studied hospitals was similar to the results obtained by Dehghani *et al* (2008) in Iran; except for the percentage composition of plastics which was thrice as much as the percentage reported in Iran. The observed difference might be due to the recycling practices in Iran hospitals. Glass and metals were the least generated in the hospital studied; similar results were reported by Li and Jeng (1993); Patil and Shekdar (2001) in their different studies.

5.7 Microbial content of solid infectious waste

The bacteria isolated from this study agrees with the findings of Mizra (1996), Akande (1999) and Omojasola *et al* (2009) who also isolated *Staphylococci sp, Escherichia coli, Klebsiella sp, Proteus sp, and Pseudomonas sp* and reported them as pathogenic bacteria commonly isolated from hospital waste . However, Althus *et al* (1983), Kalnowski *et al* (1983) and Sridhar and Ayeni (2003) have reported in their separate studies that these microbes can also be isolated from household waste. This is suggestive of their abundance in the environment (Sridhar and Ayeni, 2003), but their presence portends potential health hazards, because they have been reparted as potential pathogens (Akter, 2000)

Both Sridhar and Ayeni (2003) and Oyeleke *et al* (2008) reported that *Klebsiella pneumoniae* and *Staphylococcus aureus* are the most prevalent aerobic bacteria present in medical wastes; others include *Staphylococcus albus, Proteus mirabilis,* and *Pseudomonas aeruginosa*. Similar observation was made in this study. The mean microbial count recorded in this study was similar to the counts reported by Sridhar and Ayeni (2003), but higher than that reported by Omojasola *et al* (2009). The similarities in environmental conditions and methods of handling waste could be the reasons for the insignificant differences observed in the mean microbial count across the four hospitals.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study characterised hospital solid waste, and also assessed infectious waste management practices in selected general hospitals in Lagos state. The findings in this study show that knowledge about infectious waste management was good, but attitude and practices were poor. On-site segregation of infectious waste was partially done and most of the waste bins were not colour coded. Elemental analysis revealed that carbon was the dominant element, while characterisation showed that paper/carton was the most generated waste.

Although, the mean knowledge score was good, more than half of the respondents had poor knowledge of infectious waste management. The knowledge score of waste handlers was higher than that of waste generators. Respondents' attitude towards infectious waste management was poor; job designation, work experience and level of education did not have any effect on attitude. Waste generators were of the opinion that waste segregation is strictly the job of waste handlers. The knowledge of respondents did not have any effect on their attitude. Attendance of training on proper infectious waste management practices had a positive effect on both knowledge and attitude of respondents.

The outcome of this study indicated the nature and quantity of solid waste generated in these hospitals; the waste recorded heavy moisture content, with carbon as the dominant element. The characteristics of the waste showed that a large percentage of the waste is recyclable, if segregation of the infectious component of the waste is properly carried out.

Though, there were some exceptions, waste segregation was being practiced as confirmed by the use of colour coded waste bags but the two –bin system as against the three-bin system was a regular feature in all the hospitals surveyed. Record keeping of spillage

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This study characterised hospital solid waste, and also assessed infectious waste management practices in selected general hospitals in Lagos state. The findings in this study show that knowledge about infectious waste management was good, but attitude and practices were poor. On-site segregation of infectious waste was partially done and most of the waste bins were not colour coded. Elemental analysis revealed that carbon was the dominant element, while characterisation showed that paper/carton was the most generated waste.

Although, the mean knowledge score was good, more than half of the respondents had poor knowledge of infectious waste management. The knowledge score of waste handlers was higher than that of waste generators. Respondents' attitude towards infectious waste management was poor; job designation, work experience and level of education did not have any effect on attitude. Waste generators were of the opinion that waste segregation is strictly the job of waste handlers. The knowledge of respondents did not have any effect on their attitude. Attendance of training on proper infectious waste management practices had a positive effect on both knowledge and attitude of respondents.

The outcome of this study indicated the nature and quantity of solid waste generated in these hospitals; the waste recorded heavy moisture content, with carbon as the dominant element. The characteristics of the waste showed that a large percentage of the waste is recyclable, if segregation of the infectious component of the waste is properly carried out.

Though, there were some exceptions, waste segregation was being practiced as confirmed by the use of colour coded waste bags but the two –bin system as against the three-bin system was a regular feature in all the hospitals surveyed. Record keeping of spillage occurrence, waste quantity and composition was poor. Waste management plan was not available in all the hospitals, training manuals and LAWMA operational handbook were being used as guide. The temporary storage site for waste was in the open; this increased the moisture content of waste. Inappropriate and inadequate use of personal protective equipment (PPE) was a regular feature among waste handlers. Most of the respondents were not immunised against common pathogens associated infectious waste, and they hardly go for medical check up to ascertain their health status.

6.2 Recommendations

Effective management of infectious waste will prevent spread of infections and accidental injuries to healthcare workers especially waste handlers. However, field observations have shown that these have not been met in many hospitals. Based on the findings in this study, the following recommendations are proffered:

1. There should be proper in-house management of medical solid waste. Written procedures and checklists for proper waste segregation, handling, treatment, and disposal should be formulated.
2. Appropriate policy and laws should be enforced and effective monitoring system should be in place. Baseline inventory to be used to set goals and evaluate progress should be defined. There should be effective and strict implementation of rules by surprise visits and inspection by appropriate authorities; the accountability of each and every person involved in management of bio-medical waste should be fixed.
3. Data on waste generation rates, characterisation on types, sources and composition of medical waste has to be improved, because planning for sustainable waste management requires good and reliable national data on generation levels and composition.
4. Provision of adequate and correct personal protective equipment (PPE). Individualised training should be provided on the correct use and removal of PPE. There should be insistence on use; defaulters should be sanctioned.
5. There should be mandatory education and continuous training of all cadres of healthcare workers on good waste management practices. Trainings should be directed at waste minimisation, appropriate segregation, handling and disposal practices. Intensive training programmes should be conducted at regular time interval for all the staff with special

importance to the new comers. Training curriculum should be specifically designed to suit the different professional cadre in the healthcare system.

6. Environmental service managers and supervisors must receive training and be certified. Orientation programs should be organised for newcomers to enable them understand the hospital operation.

7. There should be a system in place for the prevention of sharps injuries; and the management of sharps injuries when they occur.

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APPENDIX I

QUESTIONNAIRE

INFECTIOUS WASTE MANAGEMENT PRACTICES IN SELECTED LAGOS STATE OWNED GENERAL HOSPITALS

Dear Respondent,

I am a Postgraduate Student majoring in Environmental Health in the University of Ibadan, Ibadan. I am carrying out a study on "Infectious Waste Management Practices in Selected Lagos State – owned General Hospitals". This research is purely for academic purpose; the findings will be of immense benefit in the area of bio-medical waste management. Kindly feel free to express your opinion; I assure you that your comments will be kept confidential. Your honest response to the following questions will be highly appreciated.

Thank you for taking your time to fill this questionnaire.

Yusuff, M.C.

Location.. Serial No.........................

Instruction: Please tick or provide the correct responses accordingly:

SECTION A: SOCIO –DEMOGRAPHIC CHARACTERISTICS

1. Age (last birthday)...
2. Sex: 1. Male [ ] 2. Female [ ]
3. Highest level of education: 1. No formal education [ ] 2. Primary education [ ]
   3. Secondary education [ ] 4. Others (please write the highest degree/certificate)...
4. Marital status: 1. Single [ ] 2. Married [ ] 3. Separated [ ] 4. Divorced [ ]
   5. Widowed [ ]
5. Religion: 1. Christianity [ ] 2. Islam [ ] 3. Traditional [ ]
   4. Others please specify..
6. Ethnic group 1. Yoruba [ ] 2. Igbo [ ] 3. Hausa [ ]
   4. Others specify ....
7. Department ....

APPENDIX 1

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Location………………………………… Serial No……………………

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SECTION A: SOCIO –DEMOGRAPHIC CHARACTERISTICS

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2. Sex: 1. Male [ ] 2. Female [ ]
3. Highest level of education: 1. No formal education [ ] 2. Primary education [ ]
   3. Secondary education [ ] 4. Others (please write the highest degree/certificate)………………………………………………………
4. Marital status: 1. Single [ ] 2. Married [ ] 3. Separated [ ] 4. Divorced [ ]
   5. Widowed [ ]
5. Religion: 1. Christianity [ ] 2. Islam [ ] 3. Traditional [ ]
4. Others please specify……………………………………………………………
6. Ethnic group: 1. Yoruba [ ] 2. Igbo [ ] 3. Hausa [ ]
   4. Others specify ……………………………………………………………
7. Department ……………………………………………………………………

8. Job designation: 1. Cleaner [ ] 2. Waste collector/transporter/disposal personnel [ ]
3. Laboratory scientist/technician [ ] 4. Ward attendant/Nursing assistant [ ] 5. Nurse [ ]
6. Doctor [ ] 7. Others specify...

9. Work experience (Years): ....

SECTION B: KNOWLEDGE ABOUT INFECTIOUS WASTE MANAGEMENT

10. Are wastes separated into different components in your department?
1. Yes [ ] 2. No [ ]

11. If Yes to Question 10 please state the number of components, the wastes are separated into: 1. one [ ] 2. Two [ ] 3. Three [ ] 4. Four [ ]
5. Others specify ....

12. How do you or waste handlers identify these components? 1. Use of colour-coded wastes bags? [ ] 2. Use of colour coded dustbins [ ] 3. Use of symbols [ ]
4. Others specify...

13. Have you seen this logo before 1. Yes [ ] 2. No [ ]

14. If the answer to Question 13 is yes, what does it signify ....

15. What is the reason for separating medical waste into different components?
1. For easy disposal because each component will not be heavy [ ]
2. to prevent spread of disease [ ] 3. To be able to select the useful ones [ ]
4. To be able to dispose waste with blood and other body fluids properly [ ]
5. Others specify ....

16. What do you understand by the term infectious waste? 1. waste that has the potential to spread disease [ ] 2. Waste generated within the hospital [ ]
3. Waste that contain blood and other body fluid [ ] 4. Don't know [ ]
5. Others specify ....

17. What are the infectious wastes generated in your department?

18. Wastes packed in yellow 1. Domestic waste [ ] 2. Hazardous waste [ ]
3. Don't know [ ] 4. Others specify ....

19. Is it necessary to treat infectious wastes before disposal? 1. Yes [ ] 2. No [ ]

20. If Yes to Question 19 what are the methods used

1. Autoclaving [ ] 2. Disinfections [ ] 3. Dry heat [ ] 4. Incineration [ ]

5. Others specify ....

21. If No to Question 19, why is treatment of infectious waste not necessary?

1. Waste to be disposed do not require any treatment [ ] 2. Treatment before disposal is a waste of money and time [ ] 3. I don't know why waste should be treated

4. Others specify..

SECTION C: ATTITUDE OF HOSPITAL STAFF TOWARDS INFECTIOUS WASTE MANAGEMENT PRACTICES

Instruction: Please tick the word that best fits your opinion for each statement. SA – Strongly Agree, I- Indifferent, A- Agree, D- Disagree, SD- Strongly Disagree

Attitude statements	SA	A	I	D	SD
22. All wastes generated in this hospital are properly packed and protected					
23. All wastes produced in this hospital are the same and do not require separation into different waste bins or bags					
24. Separation or sorting of wastes into different bins is solely the job of a waste handler					
25. Medical waste is more dangerous than household waste					
26. Dumping bio-medical waste with household wastes cannot cause any health problem					
27. Failure to wash one's hand does not pose any health risk to one's self and others					
28. The use of protective equipment such as gloves, apron, masks etc. by waste handlers is not necessary.					
29. Infectious waste does not require any special treatment before disposal.					
30. Separation of infectious waste will help protect the health of hospital staff especially waste handlers?					
31. Hospital staffs do not require any special training on good wastes management practices.					
32. Infectious waste should be dumped within the hospital and burnt in the open.					

SECTION C: INFECTIOUS WASTE MANAGEMENT PRACTICES IN HOSPITALS

33. Did you undergo any training on how to handle infectious waste? 1. Yes [ ] 2. No [ ]

34. If yes to question 33, when were you trained? 1. Before employment [ ]
    2. In-service training [ ] 3. Immediately I was employed [ ]
    4. Others please specify...

35. Are sharps separated from other infectious waste? 1. Yes [] 2. No [ ]

36. If yes to question 35, what kind of container is used for collection? 1. Plastic [ ]
    2. Cardboard/carton [ ] 3.Nylonbag [ ] 4. Other
    specify...

37. What kind of dust bin is used for waste collection? 1. Containers with cover [ ]
    2. Containers without cover [ ] 3. Containers lined with leak proofbags [ ]
    4. Colour coded bags or dustbins [ ] 5. Others
    specify...

38. What happens to the infectious wastes produced/collected in your Department?
    1. Open burning [ ] 2. Incineration [ ] 3. Burying within the hospital premises [ ]
    4. LAWMA collects for landfill disposal [ ] 5. Disposed at dumpsite [ ]
    6. Others specify...

39. Do you observe one or more of the following at the point, where wastes are gathered?
    1. Flies [ ] 2. Bad odour/stench [ ] 3. Rats [ ] 4. Dogs [ ]
    5. Others specify...

40. Do you handle waste as part of your duties? 1. Yes [ ] 2. No [ ]

41. If no to question 40, do you separate your wastes as they are being generated
    1. Yes [ ] 2. No [ ]

If yes to question 40. Answer questions 42 - 47

42. How do you convey the waste container?
    1. By carrying on the head [ ] 2 push carts [ ] 3. Trolley [ ]
    4. Others specify...

43. Where do you take these wastes to after collection? 1. Incinerator [ ]
    2. Dumpsite [ ] 3. Closed storage area [ ] 4. Others
    specify...

44. Is waste container re-used after waste disposal? 1. Yes [ ] 2. No [ ]

45. If 44 is Yes, how is the container decontaminated? 1. Washing with soap and water using broom or brush [ ] 2. Washing with water only [ ] 3. Washing with soap, water and disinfectant [ ] 4. We don't wash the containers, we just empty it [ ]
5. Others specify..

46. Do you or any of your members re-use any material from the waste collected?
1. Yes [ ] 2. No [ ]

47 If 46 is Yes, list the materials that can be re-used ....
....

48. After each day's work, do you do one or more of the following?
1. wash hands with soap and water [ ] 2. Wash hands with soap, water and disinfectant [ ] 3. Take my bath with soap, water and disinfectant [ ] 4. Wash hands with water containing disinfectant [ ] 5. Wash hands with water only [ ]
6. Others specify.....................................

49. How do you prevent spillage? 1. Proper packaging of the waste. 2. Proper storage so that animals will not spill it [ ] 3. Early disposal [ ] 4. All of the above [ ]
5. Don't know [ ] 6. Others specify...

50. Whenever infectious waste is spilled, what actions do you take? 1. Pack the waste [ ]
2. Pack the waste and disinfect the place. 3. Don't know [ ]
4. Others specify ....

51. Do you report incidence of spill to the management? 1. Yes [ ] 2. No [ ]

52. If yes to 51, what action does the management take?
....

53. Are you satisfied with the current method of infectious waste handling/disposal in your hospital? 1. Yes [ ] 2. No [ ]

54. If no to question 53, what are your reasons/observations
....

55. What are your suggestions for proper handling of infectious wastes?
....

44. Is waste container re-used after waste disposal? 1. Yes [ ] 2. No [ ]

45. If 44 is Yes, how is the container decontaminated? 1. Washing with soap and water using broom or brush [ ] 2. Washing with water only [ ] 3. Washing with soap, water and disinfectant [ ] 4. We don't wash the containers, we just empty it [ ] 5. Others specify...

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....

55. What are your suggestions for proper handling of infectious wastes?
....

SECTION D: HEALTH INFORMATION AND CONDITION

56. List the regular components of the wastes produced in your Department

....

57. Which of these wastes listed above can cause disease/infection?

....

58. Can improper waste disposal practices cause any disease? 1. Yes [ ] 2. No [ ]

59. List four disease/infections that can be contracted from improper waste management practices...

60. Have you ever been diagnosed for any of the diseases mentioned in 59 above?

1. Yes [ ] 2. No [ ]

61. If yes to question 60, when was that? ....

62. How do you protect yourself from injury or infection, while handling infectious waste?

1. Use of gloves [ ] 2. Use of nose masks/goggles [ ]

3. Use of boots [ ] 4. Use of aprons [ ] 5. I do not use anything [ ] 6. All of the above [ ] 7 others specify...

63. How often do you protect yourself with protective equipment? 1. Always [ ]

2. Sometimes [ ] 3. Never [ ] 4. Whenever it is provided [ ]

5. others specify ....

64. Do you go for medical checkup? 1. Yes [ ] 2. No [ ]

65. If yes to question 61. how often do you go for this checkup 1. Every year

2. Every six months 3. Every three months 4. Others specify.............................

66. If no to question 61 why? 1. I don't feel it is necessary since I am not sick [ ]

2. it is a waste of time and money [ ] 3. I cannot afford it [ ]

4. my employer did not make provision for it [ ]

5. Others specify..............................

67. Does your employer make any immunization compulsory? 1. Yes [ ] 2. No [ ]

68. If Yes to question 67, list the infections/diseases you have been immunised for...

....

APPENDIX II

OBSERVATION CHECKLIST ON THE ASSESSMENT OF INFECTIOUS WASTE MANAGEMENT PRACTICES IN SOME SELECTED LAGOS STATE-OWNED GENERAL HOSPITALS.

NAME OF HOSPITAL...

LOCATION...

NO OF STAFF..

A: SEGREGATION OF INFECTIOUS WASTE

Colour of container used	Infectious waste only	All types of waste	Non-hazardous waste	Remarks
Black				
Orange/red				
Other colours				

B: SHARP CONTAINMENT

Sharp containment	yes	no	Remarks
Separate container used			
Container is leak and puncture proof			
Container is tightly lidded			

C: DOCUMENTATION OF WASTE CONTAINER

Documenta Tion	Available	Not available	Adequate	Inadequate
Label				
Date of collection				
Ward				
Content				
Destination				

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OBSERVATION CHECKLIST ON THE ASSESSMENT OF INFECTIOUS WASTE MANAGEMENT PRACTICES IN SOME SELECTED LAGOS STATE-OWNED GENERAL HOSPITALS.

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LOCATION...

NO OF STAFF...

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Orange/red				
Other colours				

B: SHARP CONTAINMENT

Sharp containment	yes	no	Remarks
Separate container used			
Container is leak and puncture proof			
Container is tightly lidded			

C: DOCUMENTATION OF WASTE CONTAINER

Documenta Tion	Available	Not available	Adequate	Inadequate
Label				
Date of collection				
Ward				
Content				
Destination				

D: CONTAINER DECONTAMINATION

	Available	Not available	Sufficient	Insufficient
Outlined procedure				
Water				
Soap				
Disinfectant				
Brush				

E: SANITARY AND HYGENIC CONDITION OF WASTE CONTAINER

Sanitary and hygienic condition of waste container	Yes	No	Remarks
Covered			
Exposed			
Wet			
Smelling			
Flies and other vectors present			
Overflowing			

F: ONSITE TRANSPORTATION OF WASTE

	Absent	Available and functional	Available but non functional	Remarks
Wheeled trolley				
Wheeled bins				
Carts				

G: PRIMARY/INTERIM WASTE STORAGE FACILITY

Primary waste storage facility	Absent	Present and functional	Present but non functional	Remarks
Drums without lid				
Drums with lid				
Plastic bins without lid				
Plastic bins with lids				
Cement dump				
Open dump				

H: WASTE TREATMENT FACILITY

Infectious waste treatment facility	Absent	Present and functional	Present and non-functional	Remarks
Open burning				
Incineration				
Pit dumping				
Composting				
Landfill				

I: WASTE TREAMENT METHODS

Treatment methods	Absent	Available functional adequate	Available functional inadequate	Available non functional
Incineration				
Autoclave				
Microwave				
Plasma pyrolysis				
Chemical disinfection				

J: PROTECTIVE EQUIPMENT USED

Protective equipment used	Available functional adequate	Available functional inadequate	Available non functional	Remarks
Apron/coats				
Mouth/nose mask				
Gloves				
Boots				
Eye protector/goggle				

K: SPILL MANAGEMENT

	Available	Not available	Remarks
Procedures for handling and cleaning of infectious spill			
Record of spill			

L: SPILL EQUIPMENTS PROVIDED

Spill equipment provided	Available functional adequate	Available functional inadequate	Available non functional	Remarks
Absorbent material				
Disinfectant				
Red/orange bags				
Protective eye wear				
Broom/brush				
Nose/mouth mask				

J: PROTECTIVE EQUIPMENT USED

Protective equipment used	Available functional adequate	Available functional inadequate	Available non functional	Remarks
Apron/coats				
Mouth/nose mask				
Gloves				
Boots				
Eye protector/goggle				

K: SPILL MANAGEMENT

	Available	Not available	Remarks
Procedures for handling and cleaning of infectious spill			
Record of spill			

L: SPILL EQUIPMENTS PROVIDED

Spill equipment provided	Available functional adequate	Available functional inadequate	Available non functional	Remarks
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Disinfectant				
Red/orange bags				
Protective eye wear				
Broom/brush				
Nose/mouth mask				

J: PROTECTIVE EQUIPMENT USED

Protective equipment used	Available functional adequate	Available functional inadequate	Available non functional	Remarks
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Gloves				
Boots				
Eye protector/goggle				

K: SPILL MANAGEMENT

	Available	Not available	Remarks
Procedures for handling and cleaning of infectious spill			
Record of spill			

L: SPILL EQUIPMENTS PROVIDED

Spill equipment provided	Available functional adequate	Available functional inadequate	Available non functional	Remarks
Absorbent material				
Disinfectant				
Red/orange bags				
Protective eye wear				
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Nose/mouth mask				