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An assessment of awareness of medical waste management amongst primary health care workers in Kano State

Hamza Yahaya [1,*] and Faiza Isah Sheshe [2]

[1] *National Hydroelectric Power Producing Areas Development Commission (NHYPPADEC), Minna. Nigeria.*
[2] *Faculty of Environmental Science, Department of Environmental Management, Bayero University Kano (BUK), Nigeria.*

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Abstract

The outcome of healthcare services is aimed at preventing potential human health risks and environmental hazards as well as improving wellbeing. In the process, however, wastes that are potentially harmful are generated and poor management of these primary healthcare wastes (HCW) exposes the health workers, patients, patient's visitors, waste handlers and the general public to health risks. The objective of this study is to assess the waste management practices of health workers in Kano Municipal Local Government Area, Kano state. A descriptive cross-sectional design was employed to collect data from four selected healthcare facilities. A total of 303 health workers randomly selected served as respondents. A structured questionnaire was administered to health workers to determine their knowledge and practice on healthcare waste management. Whereas non-participatory observation checklist was used to collect data on their current practices as regards to healthcare waste management. Data were analyzed, and presented as descriptive statistics using Statistical Package for Social Sciences (SPSS) version 20.0 and hypothesis was tested using Pearson product-moment correlation coefficient. In conclusion, management of healthcare wastes (HCW) has become one of the critical concerns in developing countries especially Nigeria. Healthcare waste is dangerous, if handled, treated or disposed of incorrectly can spread diseases, and poison people, livestock, wild animals, plants and ecosystems. Healthcare institutions must utilize the most practical options to achieve acceptable standards and practices for healthcare waste management using available technologies. Measures to improve the Primary Healthcare waste management practices in healthcare facilities in Kano Municipal Local Government and the country at large is to enhance training of all health workers on healthcare waste management. It is recommended that colour coded bag be made available for segregation of clinical waste in all primary healthcare facilities.

Keywords: Healthcare; SPSS; Data; Kano; Environmental Hazards; Waste Management

1. Introduction

Hospital is one of the complex institutions, which is visited by people from every walk of life in the culture without any difference between age, gender, race and religion [1]. And, hospitals and other healthcare facilities in the cause of providing services to communities inevitably create waste which is hazardous to health and carries a higher potential for infection and injury than any other type of waste. But resulting medical waste from healthcare settings in many countries have raised several concerns owing to the fact that there are inappropriate techniques for the management of these wastes [2]. Biomedical waste which is used interchangeably with words like clinical waste, hospital waste and medical waste has been given a range of definitions by various scholars and organizations. The nuances in the terminology used by various researchers to designate waste generated on daily basis from healthcare facilities and activities is a testimony to their bewildering diversity in terms of sources, types, nature and treatment options; as well as the type of waste stream of interest to a researcher [3].

* Corresponding author: Hamza Yahaya

The term medical waste refers to all medical, liquid or gaseous wastes which are generated from healthcare facilities, medical laboratories, research centers, pharmaceutical and veterinary factories, veterinary clinics, and home nursing institutions; human and animal remnants, body fluids; blood and derivatives, human excreta, contaminated clothings, wipes, injectors, contaminated sharp tools, expired medicines and chemicals.

WHO [3] states healthcare waste (HCW) to include all the wastes generated by healthcare establishment, research facilities and laboratories including waste generated from minor or scattered sources such as those produces in the course of healthcare undertaken in the home such as dialysis, insulin and injection and medical waste according to [4] is a subset of wastes generated at health care facilities, such as hospitals, physicians' offices, dental practices, blood banks, and veterinary hospitals/clinics, as well as medical research facilities and laboratories.

Medical waste can also be said to be healthcare waste that that may be contaminated by blood, body fluids or other potentially infectious materials and is often referred to as regulated medical waste. It further states that medical waste is any kind of waste that contains infectious material (or material that's potentially infectious). This definition includes waste generated by healthcare facilities like physician's offices, hospitals, dental practices, laboratories, medical research facilities, and veterinary clinics [5].

According to some other scholars, medical waste is used to describe any waste which is generated in the treatment or immunization of human beings or animals, in research pertaining there to, or in the production and testing of biological. They went further to describe biomedical waste as "any solid, fluid or liquid waste, including its container and any intermediate product, which is generated during the diagnosis, treatment or immunization of human beings or animals pertaining there in to research activities or in the production or testing of biological and the animal waste from slaughter houses and any other such establishment" [6].

From the definitions of bio-medical waste above, one can say bio-medical wastes are waste generated from medical procedures within healthcare facilities (HCF) that could be highly infectious, hazardous and delicate to handle in order to prevent harm to human health and the ecosystem. Thus, the need for bio-medical wastes to be managed in a scientific and discriminate manner and this could be achieved through the efficient and effective practice of health care waste management (HCWM).

Health care waste management (HCWM) is a process that helps to ensure proper hospital hygiene and safety of health care workers and communities. Health care waste management (HCWM) deals with planning and procurement, staff training and behavior, proper use of tools, machines and pharmaceuticals, proper methods applied for segregation, reduction in volume, treatment and disposal of biomedical waste [7].

[4] defines medical waste as a subset of wastes generated at health care facilities, such as hospitals, physicians' offices, dental practices, blood banks, and veterinary hospitals/clinics, as well as medical research facilities and laboratories. Generally, medical waste is healthcare waste that that may be contaminated by blood, body fluids or other potentially infectious materials and is often referred to as regulated medical waste. Medical waste is any kind of waste that contains infectious material (or material that's potentially infectious). This definition includes waste generated by healthcare facilities like physician's offices, hospitals, dental practices, laboratories, medical research facilities, and veterinary clinics [5].

Medical or healthcare wastes are in the form of solid and liquid wastes generated in the diagnosis, treatment or immunization of human beings or animals; in medical research; or in production of vaccines or other substances produced from living organisms. They are commonly generated by hospitals, medical or research laboratories, clinics, offices of physicians and dentists, veterinarians, long term-care facilities (for example, nursing homes) and funeral homes. Hospital wastes include sharps (for example hypodermic syringes, glass slide, needles, razor and scalpels), human or animal tissue or excretion, medical products (including swabs and dressings).

According to the 1988 Medical Waste Tracking Act (MWTA), medical waste is "any solid waste that is generated in the diagnosis, treatment, or immunization of human beings or animals, in research, or in the production or testing of biologicals" [5]. The term "medical waste" covers all wastes produced in health-care or diagnostic activities (ICRC, n.d.).

1.1. Classification of Medical Wastes

The term "medical waste" can cover a wide variety of different byproducts of the healthcare industry. Highlighted below are most common medical waste categories as identified by various bodies and persons.

According to the Medical Waste Tracking Act of 1988, medical waste can be identified by one of four different categories: infectious, hazardous, radioactive, and general.

Infectious waste describes waste that has the possibility of causing infections to humans. It can include human or animal tissue (blood or other body parts), blood-soaked bandages, discarded surgical gloves, cultures, stocks, or swabs to inoculate cultures. Much of this category, including human or animal tissue, can also be labeled as pathological waste, which requires specific treatment methods. Pathological waste is either known or suspected to contain pathogens.

Hazardous waste describes waste that has the possibility to affect humans in non-infectious ways, but which meets federal guidelines for hazardous waste under the Resource Conservation and Recovery Act. Some medical waste is hazardous waste. This includes sharps, which are generally defined as objects that can puncture or lacerate the skin, but can include needles and syringes, discarded surgical instruments such as scalpels and lancets, culture dishes and other glassware. Hazardous waste can also include chemicals, both medical and industrial. Some hazardous waste can also be considered infectious waste, depending on its usage and exposure to human or animal tissue prior to discard. Old drugs, including chemotherapy agents, are sometimes hazardous.

Radioactive waste can be generated from nuclear medicine treatments, cancer therapies and medical equipment that use radioactive isotopes. Pathological waste that is contaminated with radioactive material is treated as radioactive waste rather than infectious waste.

General waste makes up at least 85% of all waste generated at medical facilities, and is no different from general household or office waste, and includes paper, plastics, liquids and any other materials that do not fit into the previous three categories [8].

[3] classified medical waste into:

- **Non-hazardous medical waste:** These are wastes that do not pose any particular biological, chemical, radioactive or physical hazard and of the total amount of waste generated by health-care activities, about 85% is general, non-hazardous waste comparable to domestic waste.
- **Hazardous medical waste:** A fraction of 15% of medical waste is considered hazardous material that may be infectious, toxic or radioactive. Hazardous waste is sub-divided into several categories and these include:
    - **Infectious waste:** Infectious waste is suspected to contain pathogens (bacteria, viruses, parasites, or fungi) in sufficient concentration or quantity to cause disease in susceptible hosts. This category includes cultures and stocks of infectious agents from laboratory work, waste from surgery and autopsies on patients with infectious diseases (e.g. tissues, and materials or equipment that have been in contact with blood or other body fluids), waste from infected patients in isolation wards (e.g. excreta, dressings from infected or surgical wounds, clothes heavily soiled with human blood or other body fluids), waste that has been in contact with infected patients undergoing haemodialysis (e.g. dialysis equipment such as tubing and filters, disposable towels, gowns, aprons, gloves, and laboratory coats) or any other instruments or materials that have been in contact with infected persons or animals [3]. On the other hand, [9] describes infectious wastes as waste materials suspected to contain pathogens in sufficient quantities to cause diseases to humans. It includes discarded materials used for the diagnosis, treatment and prevention of disease as dressings, swabs, etc. This group also includes liquid waste such as urine, blood and sputum or lung secretions.
    - **Pathological wastes:** Pathological waste consists of tissues, organs, body parts, human fetuses and animal carcasses, blood, and body fluids. Within this category, recognizable human or animal body parts are also called anatomical waste [3]. It may also include healthy body parts that are removed during a medical procedure or produced during medical research [10].
    - **Sharps:** Sharps are items that could cause cuts or wounds, including needles, scalpels and other blades, knives, saws and broken glass. These items are usually considered highly hazardous [11]. According to [3], sharps are items that could cause cuts or puncture wounds, including needles, hypodermic needles, scalpel and other blades, knives, infusion sets, saws, broken glass, and nails. Whether or not they are infected, such items are usually considered as highly hazardous health-care waste.
    - **Pharmaceutical waste:** Pharmaceutical waste includes expired, unused, spilt, and contaminated pharmaceutical products, drugs, and vaccines, and sera that are no longer required and need to be disposed of appropriately. The category also includes discarded items used in the handling of pharmaceuticals, such as bottles or boxes with residues, gloves, masks, connecting tubing, and drug vials [3].

- **Genotoxic waste:** Genotoxic waste is derived from drugs used in oncology or radiotherapy units that have a high hazardous mutagenic or cytotoxic effect, vomit or urine from patients treated with cytotoxic drugs or chemicals should be considered as genotoxic. [3] states that genotoxic waste is highly hazardous and may have mutagenic, teratogenic, or carcinogenic properties. It raises serious safety problems, both inside hospitals and after disposal, and should be given special attention.
- **Chemical waste:** Chemical waste includes discarded chemicals that are generated during disinfecting procedures [9]. Chemical waste includes discarded solid, liquid, and gaseous chemicals that are generated during diagnostic and experimental work and from cleaning, housekeeping, and disinfecting procedures. Chemical waste from health care may be hazardous or nonhazardous; in the context of protecting health, it is considered to be hazardous if it is toxic, corrosive (e.g. acids of pH < 2 and bases of pH > 12), flammable, reactive (explosive, water-reactive, shock-sensitive), genotoxic (e.g. cytostatic drugs) while nonhazardous chemical waste consists of chemicals with none of the above properties. Non-hazardous chemical wastes include sugars, amino acids, and certain organic and inorganic salts [3].
- **Wastes with high content of heavy metals:** Wastes with a high heavy-metal content represent a subcategory of hazardous chemical waste, and are usually highly toxic. Examples include mercury wastes which are typically generated by spillage from broken clinical equipment such as thermometers and manometers. Residues from dentistry have high mercury content. Another example of wastes with a high content of heavy metals is cadmium waste that is mainly sourced from discarded batteries. Also certain "reinforced wood panels" containing lead which are used in radiation proofing of X-ray and diagnostic departments are an example of this subset of hazardous medical wastes [3].
- **Radioactive waste:** Radioactive waste includes gas, liquids and solids contaminated with radio-nuclides whose ionizing radiations have genotoxic effects. [12].

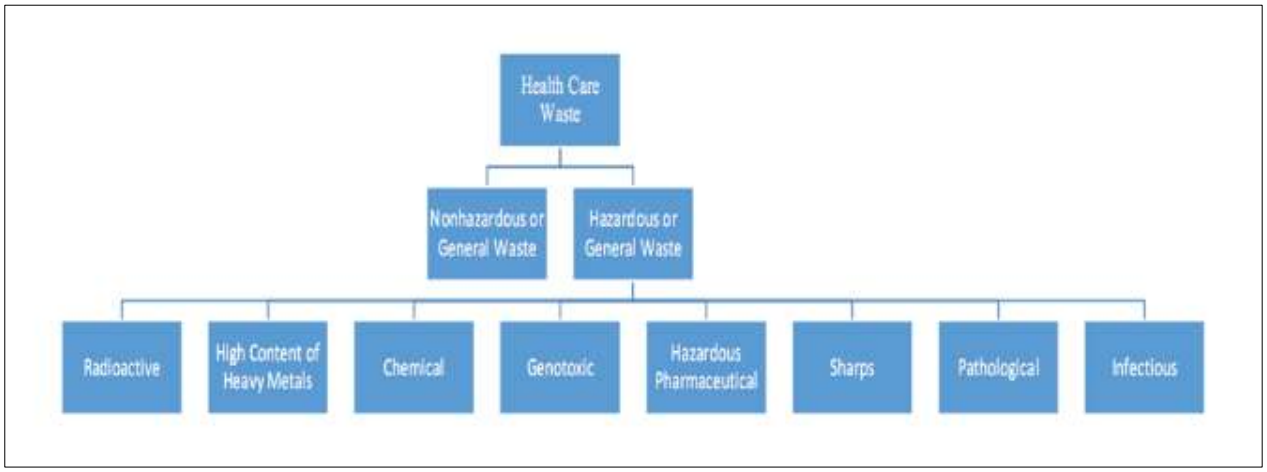

Figure 1 Classification of health care waste

1.2. Sources of Medical Wastes

The sources of health-care waste can be classed as major or minor according to the quantities produced. The major and minor sources of medical waste are listed in Table 1.

Table 1 Source of Medical Wastes

Sources	Description
Major sources	Hospitals, Emergency medical care services, Health care centres and dispensaries, obstetric and maternity clinics, outpatient clinics, Dialysis centres, Transfusion centres, Military medical services, Medical and biomedical laboratories, Medical research centres, Mortuary and autopsy centres, Animal research and testing, Blood banks and blood collection services, Biotechnology laboratories and institutions, Nursing homes for the elderly.
Minor sources	Physicians' offices, Dental clinics, Acupuncturists, Non-health activities involving intravenous or subcutaneous interventions (e.g. Cosmetic ear-piercing and tattoo parlours, Illicit drug users).

Source: [3] WHO, 1999.

1.3. Primary Health Care Facilities

The availability and reliability of data on expenditure related to all three components of PHC are generally poor, both as a result of underinvestment in resource tracking systems and because of the complexity of defining and tracking expenditure on PHC, partly because of its multisectoral nature. This dearth of reliable and consistent measurement has hindered accountability for PHC financing and implementation. The available data point to significant under-financing as a result of insufficient fiscal space for health, and allocation schemes that favour curative, subspecialist and hospital care. For example, only eight of the 30 countries for which data are available spend at least US$40 per capita on PHC per year [13]. With regard to health services specifically, prevention and promotion activities are generally underfunded. Subspecialist care and hospitals receive a larger share of both public and private spending than health centres and primary care providers [14]. In many countries there is a need to increase allocation of public funds to health, prioritizing new resources to PHC, thus ensuring the availability of core services and access for marginalized communities and people in vulnerable situations. In the African Region, access to health facilities remains limited, with 85% of countries having fewer than 10 health centres per 100 000 population, and 82% fewer than one district hospital per 100 000 population [15].

Human resources are at the heart of delivering effective PHC. The number, distribution and competencies of the PHC workforce will need to be addressed in many countries. In some settings, this will entail a focus on the recruitment, training and retention of adequate numbers of health workers, while in others emphasis will need to be given to ensuring competence and quality through approaches such as accreditation, supportive supervision, clinical mentoring, and in-service training. Elsewhere, the major issue will be ensuring an appropriate distribution of the workforce, so that all communities have access to health professionals. This may require strategies such as recruitment of students from underserved areas who then return to work in their communities, incentive schemes to encourage workers to relocate to underserved areas and programmes that proactively balance workforce distribution. These efforts should apply to the different cadres of health professionals, as there is considerable evidence of the benefits of multidisciplinary primary care teams that include both facility- and community-based members. Family practice teams, in particular, offer an approach to primary care that has shown clear benefits in a wide range of settings [16].

Adequate resourcing of an appropriate physical infrastructure is important to ensuring quality PHC and is a particularly crucial investment in the early stages of its development and implementation. A successful shift of services and health workers from hospital-based care to community settings will require adequate investments. Such investments – and the resulting facilities equipped with appropriate diagnostic and therapeutic products and technologies – will also be important to overcome any negative perceptions about the quality of care provided in these settings [3]. Primary care and public health should employ appropriate new health technologies to increase the effectiveness and efficiency of services, for example point-of-care diagnostics [3].

Similarly, the availability of affordable, quality-assured medicines is critical to PHC. This often requires coordinated action across different parts of government and a strong management system.

New technologies are critical for both demand- and supply-side efforts to improve health and well-being through stronger PHC. The rapid pace of change in information and communication technologies has opened up exciting possibilities for self-care and for the engagement of people and communities, developing resources that people can draw on as part of their self-care efforts. A number of efforts are under way to develop mHealth and eHealth platforms that expand the reach of health services and support self-care (e.g. by making information available when needed or by providing reminders for appointments or medications).

Information and communications technologies are also powerful tools for improving the functioning of health systems, such as by strengthening health management information systems. Advances in information systems should be fully leveraged to support and optimize the functionality of shared electronic health records, linking them to other health facilities and services and supporting two-way referrals along clinical pathways. Use of remote consultation services or telemedicine can be used to improve information flows between patients and health workers as well as better integrate primary care with referral care. Other technologies, such as artificial intelligence and drones, are also being actively explored and may offer new avenues to improve the quality and accessibility of services. As the field is developing, ongoing research together with proper regulation and legislation, as required, is needed to manage its potential harmful effects and potential for worsening inequities. For example, the increase in mental illness in children, and suicide, associated with the digital revolution is a negative impact that needs to be managed in a PHC approach [17].

1.4. Health Hazards of Sharps and Infectious Wastes

Sharps are items that could cause cuts or wounds, including syringes, needles, scalpels, blades, knives, broken glass and others [18].

Worldwide, an estimated 16 billion injections are administered every year. Not all needles and syringes are disposed of safely, creating a risk of injury and infection and opportunities for reuse [19] and according to [18], a person who experiences one needle stick injury from a needle used on an infected source patient has risks of 30%, 1.8%, and 0.3% respectively of becoming infected with HBV, HCV and HIV and in 2010, unsafe injections were responsible for as many as 33 800 new HIV infections, 1.7 million hepatitis B infections and 315 000 hepatitis C infections.

World Health Organization also opined that globally injections with contaminated syringes caused 21 million hepatitis B infections (32% of all new infections), 2 million hepatitis C infections (40% of all new infections) and 260,000 HIV infections (5% of all new infections) [20]. Furthermore, [21] documented that, in India, 2 million, new Hepatitis B, 400,000 Hepatitis C and 30,000 HIV positive cases occur in a year due to needle prick injuries.

Infectious waste on the other hand includes waste that is contaminated with blood and other bodily fluids (e.g. from discarded diagnostic samples), cultures and stocks of infectious agents from laboratory work (e.g. waste from autopsies and infected animals from laboratories), or waste from patients in isolation wards and equipment (e.g. swabs, bandages and disposable medical devices) [22]. Infectious waste may contain any of a great variety of pathogenic organisms and these pathogens present in infectious waste, may enter the human body by a number of routes such as:

- Through a puncture, abrasion, or cut in the skin;
- Through the mucuous membrane;
- By inhalation; and
- By ingestion [3].

Infections, which can be caused by exposure to infectious biomedical waste include, but are not limited to:

- Gastro enteric infections,
- Respiratory infections,
- Ocular infection, Genital infections,
- Skin infections,
- Meningitis,
- Acquired immunodeficiency syndrome (AIDS),
- Haemorrhagic fevers, Septicaemia, Bacteraemia, Candidaemia,
- Viral hepatitis A, B and C. (WHO, n.d)

1.5. Hazards from Chemical and Pharmaceutical Wastes

Chemical wastes consist of solvents used for laboratory preparations, disinfectants, and heavy metals contained in medical devices (e.g. mercury in broken thermometers) and batteries while pharmaceuticals wastes are made up of expired, unused and contaminated drugs and vaccines [23].

Chemical and pharmaceutical wastes are hazardous because most are toxic, corrosive, inflammable, reactive, and explosive. Though found in small quantities in biomedical waste, they may cause intoxication, injuries, and burns when they come in contact with the skin or are inhaled. Intoxication can result from absorption of a chemical or pharmaceutical substance through the skin or the mucous membranes, or from inhalation or ingestion. Injuries to the skin, the eyes, or the mucous membranes of the airways can be caused by contact with flammable, corrosive, or reactive chemicals (e.g. formaldehyde and other volatile substances) (Manual on Health care waste management).

1.6. Health Hazards from Genotoxic Wastes

Inhalation of dust or aerosols, absorption through the skin, ingestion of food or substances accidentally contaminated with cyctotoxic drugs or waste are the main pathways of exposure to genotoxic waste. The severity of the health hazards related to the exposure of genotoxic waste depends on the mode of exposure to the waste. Another form of exposure to genotoxic waste is during the preparation of treatment with particular drugs or chemicals or through contact with body fluids and secretions of patients undergoing.

1.7. Health Hazards from Radioactive Wastes

Radioactive waste includes gas, liquids and solids contaminated with radio-nuclides whose ionizing radiations have genotoxic effects [12].

Health effects caused by exposure to radioactive substances or materials contaminated with radioactivity can range from reddening of skin, headaches, and dizziness, nausea to more serious problems such as cancer induction and genetic consequences to succeeding generations of the exposed individual [24].

1.8. Health Hazards Associated with Treatment and Disposal of Medical Wastes

Although treatment and disposal of health-care wastes aim at reducing risks, indirect health risks may occur through the release of toxic pollutants into the environment through treatment or disposal.

1.9. Health Hazards Associated with Incineration of Medical Wastes

Medical waste incineration involves the burning of wastes produced by hospitals, veterinary facilities, and medical research facilities. These wastes include both infectious medical wastes as well as non-infectious, general housekeeping wastes.

Medical waste incinerators can emit significant quantities of pollutants to the atmosphere. These pollutants include particulate matter (PM), metals, acid gases, oxides of nitrogen (NOx), carbon monoxide (CO), organics, and various other materials present in medical wastes, such as dioxins and furans.

- **Dioxins and Furans:** Dioxins have been called the most dangerous chemical known to man and are known to cause serious health hazards. Furans, are similar to dioxins, and cause cancer in animals, and are suspected to cause cancer in people. These chemicals form when temperatures are not consistent, when waste is not completely incinerated, and during by-pass events when air pollution control equipment fails. Items common to medical waste that may contain dioxins and furans are blood bags and fluid bags. Smaller amounts of dioxins are present in bleached paper products including facial tissue, toilet tissue, paper towels, and disposable diapers. Dioxins formed during incineration are released into the air and travel long distances via air currents, contaminating fields and crops. When cattle and other livestock eat soil contaminated with dioxin, the dioxin enters their tissues, and then people eat the contaminated meat and dairy products. Once dioxins enter the human body they are absorbed by fat tissue where they stay for years. Long-term, low-level exposure of humans to dioxins and furans can lead to the impairment of the immune system, cancer, impairment of the development of the nervous system and endocrine system, birth defects, altered liver functions, breast cancer, and reproductive functions. Dioxins have also been linked with lowered sperm counts, behavioral problems and increased incidence of diabetes. A systematic review of epidemiologic studies has found an association between dioxin exposure and heart disease. Short-term, high-level exposure may result in skin ulcers called chloracne.
- **Mercury:** Mercury is found in dental wastes which are burned by medical waste incinerators. Mercury is suspected to cause cancer. At high levels it may cause damage to the brain, kidneys, and developing foetus. It may also result in irritability, shyness, tremors, changes in vision or hearing, and memory problems.
- **Hydrogen Chloride:** Hydrogen chloride is irritating and corrosive to any tissue it contacts. Brief exposure to low levels causes throat irritation; exposure to higher levels can result in rapid breathing, narrowing of the bronchioles, blue coloring of the skin, accumulation of fluid in the lungs, and even death. Some people may develop an inflammatory reaction to hydrogen chloride, called reactive airways dysfunction syndrome (RADS), a type of asthma caused by irritating or corrosive substances.
- **Nitrogen Oxide:** Low levels of nitrogen oxides in the air can irritate your eyes, nose, throat, and lungs, possibly causing coughs and shortness of breath, tiredness, and nausea. Breathing high levels of nitrogen oxides can cause rapid burning, spasms, and swelling of tissues in the throat and upper respiratory tract, a build-up of fluid in your lungs, and death. Exposure of pregnant animals to nitrogen oxides has resulted in toxic effects in developing fetuses. Nitrogen oxides have also caused changes in the genetic material of animal cells.
- **Lead:** Lead is one out of four metals that have the most damaging effects on human health. Lead is highly toxic and can enter the human body through uptake of contaminated food, water and air. Health effects include anemia, elevated blood pressure, kidney damage, miscarriages and subtle abortions, disruption of nervous systems, brain damage, and declined fertility of men through sperm damage. Lead is particularly harmful to children, and exposure can result in diminished learning abilities, and behavioral disruptions, such as aggression, impulsive behavior and hyperactivity.
- **Cadmium:** Cadmium is an extremely toxic metal and causes cancer. Acute exposure may result in flu-like symptoms of weakness, fever, headache, chills, sweating and muscular pain. Chronic or long-term exposure is

lung and/or prostate cancer, and kidney damage. Cadmium also is believed to cause pulmonary emphysema and bone disease. Cadmium may also cause anemia, teeth discoloration and loss of smell.

- **Sulphur dioxide:** Short-term exposure to sulphur dioxide has been linked to wheezing, chest tightness and shortness of breath. Other effects associated with longer-term exposure include respiratory illness, alterations in the lungs' defenses and aggravation of existing cardiovascular disease.
- **Carbon monoxide:** Carbon monoxide is an odorless, colorless, toxic gas and results from incomplete combustion. At lower levels of exposure, carbon monoxide causes mild effects that are often mistaken for the flu. These symptoms include headaches, dizziness, nausea and fatigue.
    - **Particulate matter:** Particle pollution, especially fine particles, contains microscopic solids or liquid droplets so small that they can get deep into the lungs and cause serious health problems. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing, decreased lung function, aggravated asthma, development of chronic bronchitis, irregular heartbeat, nonfatal heart attacks and premature death in people with heart or lung disease. People with heart or lung diseases, children and older adults are the most likely to be affected by particle pollution exposure. However, even if you are healthy, temporary symptoms may result from exposure to elevated levels of particle pollution (Blue Ridge Environmental Defense League, n.d.).

In developing countries, additional hazards occur from scavenging at waste disposal sites and the manual sorting of hazardous waste from health-care establishments [25].

1.10. Persons at Potential Risk from Associating with Medical Wastes.

- Medical doctors, nurses, health-care auxiliaries, and hospital maintenance personnel;
- Patients in health-care establishments or receiving home care;
- Visitors to health-care establishments;
- Workers in support services allied to health-care establishments, such as laundries, waste handling, and transportation;
- Workers in waste disposal facilities (such as landfills or incinerators), including scavengers [3].

1.11. Environmental Hazards of Medical Wastes

Apart from the associated risks of the improper handling, disposal and treatment of medical wastes to human health, consideration must also be given to the impact of medical wastes to the environment, in particular is the possible pollution to the air, water, soil or land including aesthetics.

- **Air pollution:** Air pollution may be by means of biological, chemical and radioactive emissions. Biological air emissions occur from inside and outside the hospital premises [26]. Untreated and openly dumped biomedical wastes causes air pollution from outside the hospital premises. Chemical induced air pollution is caused by open burning and incinerators. Radioactive emissions also produce air pollution by small quantity of radioactive gases generated during research and treatment [27]. Indoor air pollution or pollution caused within the hospital premises is as a result of pathogens present in biomedical waste that can enter and remain in the air for a long period in the form of spores or as pathogens [28].
- Finally, some the pollutants from medical waste may become airborne if the waste is not incinerated at the proper temperature. If these pollutants are carrying airborne diseases, anyone who breathes the pollution could be affected [29].
- **Land pollution:** Land pollution from biomedical waste is caused due to infectious waste, discarded medicines, chemicals used in treatment, etc. heavy metals such as cadmium, lead, mercury etc., which are present in the waste, will get absorbed by plants and can then enter the food chain. Nitrates and phosphates present in leachates from landfills are also pollutants [28].
- To note as well is that landfills which are made to keep all waste in a controlled area could become easily damaged due to the improper disposal of biomedical wastes. This is because some may have liners to keep the waste from seeping into the environment and throwing sharps away could puncture these liners, which then allow liquids from improperly processed biomedical waste to seep into the soil and groundwater [29].
- **Water pollution:** The presence of biological, chemicals and radioactive substances in improperly disposed biomedical wastes leads to the emissions of pathogens and heavy metals that can reach out and contaminate ground or surface water. This process can alter water parameters such as pH and biological oxygen demand (BOD) [27]. In addition, pharmaceuticals and other chemicals dumped in landfills may leach into water bodies. Furthermore, people who take pharmaceuticals excrete small amounts of those drugs in urine and sometimes

may pour unused drugs down the drain. Genotoxic materials are included in the wastewater of some hospital oncology (cancer treating) units [30].

- **Environmental Hazards due to the Incineration of Biomedical Wastes:** Incinerators release pollutants into the air, water, soil, and foliage. Harmful contaminants are released when plastics that contain polyvinyl chloride (PVC) are incinerated, or when the incinerator is not hot enough. When plastics containing PVC are incinerated, they produce dioxin. Dioxins and other pollutants from incinerators are water soluble, meaning they are dissolved in bodies of water near the incinerator. Once in water, these pollutants can become part of drinking water and become integrated into the food humans eat. Dioxins are harmful to humans, potentially impairing the immune system, disrupting hormones and reproductive functions. Also, incinerators produce ash as a byproduct; if not properly disposed, toxins in the ash may leech into waterways. Most conventional sewage plants do not remove all these residues; therefore, trace amounts of the drugs and toxins join the water that supports ecosystems and may eventually pollute drinking water. This phenomenon is widespread across the United States [30].

1.12. Medical Waste Management

Medical waste management is a process that help ensures proper hygiene in the health institution and safety of healthcare workers and communities [31]. [32] opine that proper management of medical waste can minimize the risk both within and outside healthcare facilities. The first priority is to segregate wastes, preferable at the point of generation into reusable and non-reusable, hazardous and non-hazardous components. They identified other important steps as, the institution of a sharps management system, waste reduction, avoidance of hazardous substances wherever possible, ensuring worker safety, providing secure methods of waste collection and transportation, and installing safe treatment and disposal mechanisms. According to [32], there are generally four key steps to medical waste management:

- Segregation into various components, including reusable and safe storage in appropriate containers;
- Transportation to waste treatment and disposal sites,
- Treatment and final disposal.

Acharya and Singh [33] also identified the medical waste management process to include, handling, segregation, mutilation, disinfection, storage, transportation and final disposal. He suggests that these are vital steps for safe and scientific management of medical waste in any establishment. Also according to [34], the key to minimization and effective management of medical waste is segregation (separation) and identification of the waste. They recommend that the most appropriate way of identifying the categories of medical waste is by sorting the waste into colour coded plastic bags or containers. Medical waste should be segregated into containers/bags at the point of generation. The WHO suggests that hospitals should provide plastic bags and strong plastic containers for infectious waste such as empty containers of antiseptics used in the hospital [3].

The safe management of hospital waste involves, as a first step, a correct identification and segregation of hazardous waste from non-hazardous waste to avoid risks to staff, patients and the environment. It is essential not to mix general waste with risk-waste, to avoid incurring extra costs of treatment and special disposal unnecessary [35]. Additionally, HCWM comprises seven key stages: segregation, collection, storage, handling, transportation, treatment and disposal. It is important that hospitals segregate HCW into designated categories, with storage in appropriate containers [36].

1.13. Stages in Medical Waste Management

The stages involved in medical waste management as indicated in the last paragraph above include segregation, collection, storage, handling, transportation, treatment and disposal. These stages are discussed in detailed below.

1.13.1. Segregation

According to [37], segregation refers to separation of waste into designated categories. In other words, segregation can simply be said to be the basic separation of different categories of waste generated at source. Various scholars note segregation to be the most crucial step in medical waste management. This is so because segregation of medical waste helps to prevent the mixture of medical waste like sharps with the general municipal waste and it also help reduce the amount of waste that needs special handling and treatment.

The simplest way to segregate the different categories of medical waste is to provide hospitals or other medical related facilities with plastic bags or separate containers that are colour coded and labelled. These vessels should be placed as

close to the point of generation as possible. Failure to separate the various medical waste according to the risk they pose, results in complex stream of waste [38].

1.13.2. Collection

Nursing and other clinical staff should ensure that waste bags are tightly closed or sealed when they are about three-quarters full. Light-gauge bags can be closed by tying the neck, but heavier-gauge bags probably require a plastic sealing tag of the self-locking type. Wastes should not be allowed to accumulate at the point of production. A routine programme for their collection should be established as part of the health-care waste management plan [3]. Certain recommendations should be followed by the ancillary workers in charge of waste collection:

- Waste should be collected daily (or as frequently as required) and immediately transported to the designated central storage site [3].
- No bags should be removed unless they are labelled with their point of production (hospital and ward or department) and contents [3].
- The bags or containers should be replaced immediately with new ones of the same type [3].
- A supply of fresh collection bags or containers should be readily available at all locations where waste is produced [3].
- When collecting medical waste, sharps must always be kept in puncture-proof containers to avoid injuries and infection to the workers handling them. Cytotoxic wastes are to be collected in leak proof containers, clearly labeled as cytotoxic waste [33].

1.13.3. Handling of Bags Containing Medical Wastes

Bags and containers containing medical waste must be closed whenever they are two-thirds full and when the wastes are to be disposed, the bags or containers are to grasped or held from the top (never hold them against the body) and wear gloves.

1.13.4. Storage

A storage location for health-care waste should be designated inside the health-care establishment or research facility. The waste, in bags or containers, should be stored in a separate area, room, or building of a size appropriate to the quantities of waste produced and the frequency of collection. In a situation where a refrigerated storage room is available, storage times for health-care waste (i.e. the delay between production and treatment) should not exceed the following limits:

- Temperate climate: 72 hours in winter and 48 hours in summer
- Warm climate: 48 hours during the cool season and 24 hours during the hot season [3].
- Also, in accordance to [3], storage facilities for health-care wastes are expected to meet some certain recommendations which include:
- The storage area should have an impermeable, hard-standing floor with good drainage; it should be easy to clean and disinfect.
- There should be a water supply for cleaning purposes.
- The storage area should afford easy access for staff in charge of handling the waste.
- It should be possible to lock the store to prevent access by unauthorized persons.
- Easy access for waste-collection vehicles is essential.
- There should be protection from the sun.
- The storage area should be inaccessible for animals, insects, and birds.
- There should be good lighting and at least passive ventilation.
    - The storage area should not be situated in the proximity of fresh food stores or food preparation areas.
    - A supply of cleaning equipment, protective clothing, and waste bags or containers should be located conveniently close to the storage area.

1.13.5. Transportation

Transportation of medical waste takes places in two ways: the first is from the source of generation to an on-site treatment or disposal facility, while the second involves taking away from a source of generation to an on-site temporary storage facility [39].

Transportation to the central store is usually performed by using a wheelie bin or trolley. Wheelie bins or trolley should be easy to load and unload, have no sharp edges that could damage waste bags or containers and they should be easy to clean. Ideally, they should be marked with the corresponding coding color [40]. The vehicle and means of conveyance have to be cleaned daily. The transportation should be always properly documented and all vehicles should carry a consignment note from the point of collection to the treatment facility [41].

1.13.6. Treatment and Disposal

The choice of treatment and disposal techniques depends on a number of parameters: the quantity and type of wastes produced, whether or not there is a waste treatment site near the hospital, the cultural acceptance of treatment methods, the availability of reliable means of transport, whether there is enough space around the hospital, the availability of financial, material and human resources, the availability of a regular supply of electricity, whether or not there is national legislation on the subject, the climate, groundwater level, etc [42].

The method must be selected with a view to minimizing negative impacts on health and the environment. There is no universal solution for waste treatment. The option chosen can only be a compromise that depends on local circumstances [42].

The variety of treatment and disposal techniques that may be employed in the treatment and final disposal include disinfection, autoclaving, irradiation, incineration, shredding, encapsulation, sanitary landfills, trenches, pits.

1.13.7. Chemical Disinfection

Chemical disinfection, which is commonly used in health facilities to kill micro-organisms on medical equipment, has been extended to the treatment of health-care wastes. Chemicals are added to the wastes to kill or inhibit pathogens and reduce the toxicity of medical wastes. This method involves the use of chemical disinfectants like sodium hypochlorite, acetic acid or chlorine dioxide. This type of treatment is suitable mainly for treating liquid infectious wastes such as blood, urine, faeces or hospital sewage. For this method to be employed in the treatment of solid medical wastes, the solid waste has to be shredded first. The advantage of chemical disinfection is that the chemicals to be used for disinfection are readily available. However, these chemicals that are used themselves entail a health risk for the people who handle them and a risk of environmental pollution. They could cause skin irritation, and harm the eyes and respiratory system. Thus, they must be handled with caution and personal protective equipment must be used before handling the chemicals. Apart from the harmful nature of the chemical disinfectants, another setback of this treatment method is that disinfection cannot be used to treat some hazardous wastes, pharmaceuticals and cytotoxic waste [3].

1.13.8. Autoclaving

Autoclaving is a thermal process at low temperatures where waste is subjected to pressurized saturated steam for a sufficient length of time to be disinfected. Autoclaving is environmentally safe but, in most cases, it requires electricity, which is why in some regions it is not always suitable for treating wastes. Once wastes have been processed in an autoclave, they are no longer infectious materials: they can be land filled with municipal refuse [3].

1.13.9. Incineration

It is a controlled combustion process where waste is completely oxidized and harmful microorganisms present in it are destroyed under high temperature. The process removes hazardous materials, reduces the mass and volume of the waste and converts it into ash that is harmless. Incineration is suitable for wastes that are 60% combustible. Incineration is suitable for pathological and infectious waste or sharp wastes. Incinerators exist in several different types; each type has a specific function. A mobile incinerator called “drug terminator” is used for disposal of pharmaceuticals. A diesel fired medical waste incinerator called “MediBurn” treats pathological and infectious waste in small medical facilities, and laboratories. This unit is portable and easy to operate and it can incinerate everything from laboratory waste to animal remains. The advantage of incineration process is that the volume of the waste that will remain for disposal will be reduced by 50 - 400 times. Incineration has a significant advantage of decreasing the volume of the wastes; however, its disadvantages include high costs, smoke generation and pollution risks due to the emission of furans and dioxins [43].

1.13.10. Encapsulation

Encapsulation (or solidification) consists of containing a small number of hazardous items or materials in a mass of inert material. The purpose of the treatment is to prevent humans and the environment from any risk of contact. Encapsulation involves filling containers with waste, adding an immobilizing material, and sealing the containers. The

process uses either cubic boxes made of high-density polyethylene or metallic drums, which are three-quarters filled with sharps, chemical or pharmaceutical residues, or incinerator ash. The containers or boxes are then filled up with a medium such as plastic foam, bituminous sand, lime, cement mortar, or clay. Once the medium has dried, the containers are sealed and disposed of in a sanitary landfill or waste burial pit. The following proportions are recommended, for example: 65% pharmaceutical waste, 15% lime, 15% cement and 5% water.

The main advantage of the process is that it is very effective in reducing the risk of scavengers gaining access to the hazardous waste. Encapsulation of sharps is generally not considered to be a long-term solution. Encapsulation of sharps or unwanted vaccines could, however, be envisaged in temporary settings, such as camps or vaccination campaigns. However, a major setback of encapsulation is that it is to be regarded as a temporary solution [44].

1.13.11. Disposal of Medical Waste

There are two distinct types of waste disposal to land. They are open dumps and sanitary landfills. Open dumps are characterized by the uncontrolled and scattered deposit of wastes at a site; this leads to acute pollution problems, fires, higher risks of disease transmission, and open access to scavengers and animals. Thus, the disposal of medical waste in an uncontrolled dump is not recommended and must only be used as a last resort prior after the application of proper treatment [3].

Sanitary landfills are designed to have at least four advantages over open dumps: geological isolation of wastes from the environment, appropriate engineering preparations before the site is ready to accept wastes, staff present on site to control operations, and organized deposit and daily coverage of waste. The following are the essential factors that must be taken into consideration in the design and use of a sanitary landfill:

- access must be restricted and controlled;
- competent staff must be available;
- the discarding areas must be planned;
- the bottom of the landfill must be waterproofed;
- the water table must be more than 2 metres below the bottom of the landfill;
- there must be no drinking water sources or wells in the vicinity of the site;
- chemicals must not be disposed of on these sites;
- the waste must be covered daily and vectors (insects, rodents, etc.) must be controlled;
    - the landfill must be equipped with a final cover to prevent rainwater infiltration;
    - leachates must be collected and treated [3].

1.14. Regulations, Policies, Agreements, Principles and Guidelines on Medical Waste Management in Nigeria

The management of healthcare waste (HCW) requires special attention due to the risk posed by the presence of hazardous waste. The first step towards this is the issuance of national legislation complemented by policy documents, regulations and technical guidelines. In Nigeria there is no specific legislation for healthcare waste management (HCWM). However, like most countries in the world, Nigeria has ratified most international agreements aimed at protecting human populations and the environment to regulate hazardous wastes. Therefore, a thorough understanding of medical waste management system in Nigeria should look into international conventions and national laws and regulations.

1.14.1. Duty of Care Principle

This principle stipulates that any organization that generates waste has a duty to dispose of the waste safely. Therefore, it is the healthcare facility (HCF) that has ultimate responsibility for how waste is containerized, handled on-site and off-site and finally disposed of [41; 3] notes the "duty of care" principle to stipulate that any person handling or managing hazardous substances or related equipment is ethically responsible for using the utmost care in that task.

Basically, the duty of care can be said to be a legal obligation imposed on the waste generator to use the utmost of skill and care in the management of healthcare waste, such that no harm or less harm befalls on others and the environment. In the case where the healthcare waste generator fails to apply the duty of care principle in healthcare waste management, then a claim in negligence could then follow.

In other words, the duty of care requires you to "look before you leap." and a person who violates the duty of care by acting negligently, wantonly, or recklessly is liable for any harm another person suffers as a result of the first person's failure to be reasonably careful [45].

1.14.2. Polluter Pays Principle

The "polluter pays principle" implies that all producers of waste are legally and financially responsible for the safe and environmentally sound disposal of the waste they produce. This principle also attempts to assign liability to the party that causes damage [3].

For instance, in the case of an accidental pollution, the organization is liable for the costs of cleaning it up. If pollution results from poor management of health-care waste then the healthcare facility (HCF) is responsible. However, if the pollution results because of poor standards at the treatment facility then the healthcare facility (HCF) is likely to be held jointly accountable for the pollution with the treatment facility [41].

1.14.3. Precautionary Principle

The Precautionary Principle is one of the key elements for policy decisions concerning environmental protection and management. It is applied in the circumstances where there are reasonable grounds for concern that an activity is, or could, cause harm but where there is uncertainty about the probability of the risk and the degree of harm. The Precautionary Principle has been endorsed internationally on many occasions majorly at the Earth Summit meeting at Rio in 1992, where world leaders agreed on Agenda 21, which advocated the widespread application of the Precautionary Principle in the following terms:

"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." (The Precautionary Principle and Approach, n.d).

According to [46], the goal of the precautionary principle is to protect humans and the environment against uncertain risks of human action by means of pre-damage control (anticipatory measures). The precautionary principle provides a rational approach to the satisfactory and ethically justified management of uncertain risks to public health, society or environment and calls for measures that either are likely to prevent the possible harm from occurring or are likely to contain or reduce the possible harm should it occur.

The precautionary principle states that, in cases of serious or irreversible threats to the health of humans or ecosystems, acknowledged scientific uncertainty should not be used as a reason to postpone preventive measures [20].

Following this principle, one must always assume that waste is hazardous until shown to be safe. This means that where it is unknown what the hazard may be, it is important to take all the necessary precautions [41]. In other words, "prevention is better than cure."

1.14.4. Proximity Principle

This principle recommends that treatment and disposal of hazardous waste take place at the closest possible location to its source in order to minimize the risks involved in its transport [3].

Webteam [47] submitted that Proximity Principle is said to highlight a need to treat and/or dispose of wastes in reasonable proximity to their point of generation. The principle works to minimize the environmental impact and cost of waste transport. Thus, in accordance with this principle, most waste should be treated and managed within the region in which it is generated provided there are no unacceptable adverse effects - on people, the environment or transportation systems.

1.15. National Policies, Laws and Regulations with Respect to Medical Waste Management

In Nigeria, there is no specific healthcare waste management legislation. However, there are policies, regulations, bye-laws and legislations with provisions that may offer a legal frame for the management of healthcare waste. These include:

1.15.1. 1999 Constitution of the Federal Republic of Nigeria

The basis of environmental policy in Nigeria is contained in the 1999 Constitution of the Federal Republic of Nigeria. This is so because in Chapter II, Section 20 of the 1999 Nigerian Constitution, it is stipulated there that "the state shall protect and improve the environment and safeguard the water, air and land, forest and wildlife of Nigeria".

Pursuant to section 20 of the Constitution, the State is empowered to protect and improve the environment and safeguard the water, air and land, forest and wildlife of Nigeria [48].

1.15.2. Nigerian Criminal Code Act, CAP. 77, LFN, 2004

The relevant provisions of the Criminal Code Act affecting public health and environmental standards enforcement are under Sections 245-248 of the Act [48].

Any person who corrupts or fouls the water of any spring stream, well, tank, reservoir, or place, so as to render it less fit for the purpose for which it is ordinarily used, is guilty of a misdemeanor, and is liable to imprisonment for six months.

Any person who:

- vitiates the atmosphere in any place so as to make it noxious to the health of persons in general dwelling or carrying on business in the neighborhood, or passing along a public way; or
- does any act which is, and which he knows or has reason to believe to be, likely to spread the infection of any disease dangerous to life, whether human or animal; is guilty of a misdemeanor, and is liable to imprisonment for six months [48].

1.15.3. Environmental Impact Assessment Act of 1992 (EIA Act)

The EIA Act was promulgated principally to enable the prior consideration of environmental impact assessment of public or private projects. Environmental Impact Assessment Act 1992 is an act to set out the general principles, procedure and methods to enable the prior consideration of environmental impact assessment on certain public or private projects. It was adopted on the 10th December, 1992 [48]. The Act is basically divided into three parts namely:

Part I: General principles of environmental impact assessment.

Here, the broad objectives of an environmental impact assessment and other important provisions are stated and these include:

- **Section 1a:** to establish, before a decision is taken by any person, authority, corporate body or unincorporated body, including the Government of the Federation, State or local government intending to undertake or authorize the undertaking of any activity, those matters that may likely or to a significant extent affect the environment or have an environmental effect on those activities and which shall first be take into account;
- **Section 1b:** to promote the implementation of appropriate policy in all Federal Lands (however acquired) States and local government areas, consistent with all laws and decision- making processes through which the goal and objective in section (1a) may be realized;
- **Section 1c:** to encourage the development of procedures for information exchange, notification and consultation between organs and persons when proposed activities are likely to have significant environmental effects on boundary or trans-State or on the environment of bordering town and villages.
- **Section 2** where is it recommended that before the public or private sector of the economy embarks on any project, an environmental impact assessment must be carried out and authorized to note the likely environmental consequences or impacts of the proposed project.
- **Section 3(1)** prescribes in identifying the environmental impact assessment process under this Act, the relevant significant environmental issues shall be identified and studied before commencing or embarking on any project or activity convened by the provisions of this Act or covered by the Agency or likely to have serious environmental impact on the Nigerian environment while Section 3(2) states that where appropriate, all efforts shall be made to identify all environmental issues at an early stage in the process.
- **Section 4** specifies the minimum content of environmental impact assessment and that is a description of the proposed activities, a description of the potential affected environment, including specific information necessary to identify and assess the environmental effect of the proposed activities; a description of the practical activities, as appropriate; an assessment of the likely or potential environmental impacts of the proposed activity and the alternatives, including the direct or indirect cumulative, short-term and long-term effects; an identification and description of measures available to mitigate adverse environmental impacts of proposed activity and assessment of those measures; an indication of gaps in knowledge and uncertainty which may be encountered in computing the required information; an indication of whether the environment of any other State or local government area or areas outside Nigeria is likely to be affected by the proposed activity or its alternatives.

- **Section 6** states that the information provided as part of an environmental impact assessment shall be examined impartially by the Agency prior to any decision to be made thereto (whether in favour or adverse thereto) while Section 7 gives opportunity for certain groups like government agencies, members of the public, experts in any relevant discipline and interested groups to make comment on the environmental impact assessment of the activity before the Agency gives a decision on an activity to which an environmental assessment has been produced.
- **Sections 9 and 10** states that after a decision has been made by the Agency prior to the steps taken in Sections 6 and 7, the Agency's decision on any proposed activity subject to environmental impact assessment shall be in writing and supported by reasons and details such as conditions for project executions, to any directive for mitigating and appropriate supervision while Section 11(1) covers the notification and timely consultations to potentially affected States or local government area, persons, etc. This section under sub-section 2 also proscribes that it is the duty of the Agency to see that the provisions of subsection (1) of this section are complied with and the Agency may cause the consultations provided pursuant to subsection (1) of this section to take place in order to investigate any environmental derogation or hazard that may occur during the construction or process of the activity concerned (ENVIRONMENTAL IMPACT ASSESSMENT ACT. (n.d.).

Part II: Environmental assessment of projects

This part in sections 13 and 14 basically covers cases where environmental assessment is required and projects for which an environmental assessment could be excluded. Embedded in this part also is the environmental assessment process from sections 15 to 57 and summarily, these include:

- A screening or mandatory study and the preparation of a screening report;
- A mandatory study or assessment by a review panel as provided in section 35 of the Act and the preparation of a report;
- The design and implementation of a follow-up program.
- Decision of the Agency including implementation of mitigation measure, follow up programmes and certification.
- Council's decision
- Mediations and constitutions and assessment of review panel (ENVIRONMENTAL IMPACT ASSESSMENT ACT. (n.d.).

Part III: Miscellaneous

Part III of the EIA Act of 1992 covers the agency's power to issue guidelines, codes of practice and facilitating regulations, offence and penalty and interpretation. For instance, under Section 58, the Agency in order to facilitate the environmental impact assessment may:

- Issue guidelines and codes of practice to assist m conducting assessment of the environmental effects of projects;
- Establish research and advisory bodies;
- Enter into agreements or arrangements with States for the purposes of co-ordination, consultation, and exchange of information in relation to the assessment of the environmental effects of projects of common interest;
- Establish criteria for the appointment of mediators and members of review panels (ENVIRONMENTAL IMPACT ASSESSMENT ACT. (n.d.).
- While in Section 60 under Offence and penalty, it is noted that any person who fails to comply with the provisions of this Act shall be guilty of an offence under this Act and liable on conviction in the case of an individual to N100, 000 fine or to five years' imprisonment and in the case of a firm or corporation to a fine of not less than N50, 000 and not more than N100, 000 [48].

Follow up to the EIA Act of 1992, there has been calls for reviews to make the Act more effective and efficient. In line with this, the EIA Act of 1992 was reviewed and this led to the birth of the EIA Act of 2004 which is a bill that seeks to amend the Environment Impact Assessment Act, Cap. E12 laws of the Federation to make it responsive by ensuring that project developers, approving authority and persons whose livelihood will be affected by the proposed project are involved in the decision making to safeguard the environment and ensure adequate re-mediation of the environment.

1.15.4. National Environmental Health Practice Regulations 2007

This Health Practice Regulations came into force in May, 2007 and the purpose of the Regulations as provided under Section 1 inter alia includes;

- To provide a guideline for the enforcement of the regulatory powers in the Act to prevent and abate nuisance and to protect, preserve, and promote the physical, mental, spiritual and social well-being of the public.
- To prevent and control the incidence of communicable diseases through environmental health intervention [48].

1.15.5. National Environmental Standards and Regulations Enforcement Agency (NESREA) Act, 2007

On 17th May, 2007 and 30th May, 2007, the Nigerian Senate and the House of Representatives, respectively, passed the National Environmental Standards and Regulations Enforcement Agency (Establishment) Bill, 2007. On 30th July, 2007, the then Nigerian President, Late Umaru Musa Yaradua, assented to the Bill, thus heralding the new law on environmental protection, hereinafter called the NESREA Act, 20071. It is worthy of note that the NESREA Act repealed the Nigerian flagship law on the environment i.e the Federal Environmental Protection Agency Act (FEPA Act). Consequently, the NESREA Act has become the primary law on environmental protection while the new Agency has replaced the old Agency (NATIONAL ENVIRONMENTAL STANDARDS AND REGULATIONS EN FORCEMENT AGENCY (NESREA) ACT - A REVIEW∗, n.d.).

Part I of the NESREA Act covers the establishment of the national environmental standards and regulations enforcement agency (NESREA). This Agency shall be the enforcement Agency for environmental standards, regulations, rules, laws, policies and guidelines; shall be a body corporate with perpetual succession and a common seal; and may sue and be sued in its corporate name. The Agency, shall, subject to the provisions of this Act, have responsibility for the protection and development of the environment, biodiversity conservation and sustainable development of Nigeria's natural resources in general and environmental technology, including coordination and liaison with relevant stakeholders within and outside Nigeria on matters of enforcement of environmental standards, regulations, rules, laws, policies and guidelines (NATIONAL ENVIRONMENTAL STANDARDS AND REGULATIONS ENFORCEMENT AGENCY (ESTABLISHMENT) ACT, 2007, n.d.).

Part II of the NESREA Act contains the functions and powers of the Agency. The Agency is authorized to enforce compliance with laws, guidelines, policies and standards on environmental matters; coordinate and liaise with stakeholders, within and outside Nigeria, on matters of environmental standards, regulations and enforcement; enforce compliance with the provisions of international agreements, protocols, conventions and treaties on the environment, including climate change, biodiversity, conservation, desertification, forestry, oil and gas, chemicals, hazardous wastes, ozone depletion, marine and wild life, pollution, sanitation and such other environmental agreements as may from time to time come into force; enforce compliance with policies, standards, legislation and guidelines on water quality, environmental health and sanitation, including pollution abatement; amongst others (NATIONAL ENVIRONMENTAL STANDARDS AND REGULATIONS ENFORCEMENT AGENCY (ESTABLISHMENT) ACT, 2007, n.d.).

The Agency is armed with a wide range of powers with a view to making its operations more effective. In the sphere of environmental protection, the Agency can:

- Prohibit processes and use of equipment or technology that undermine environmental quality;
- Conduct field follow-up compliance with set standards and take procedures prescribed by law against any violator;
- Enter into agreement and contracts with public or private organizations and individuals to develop, utilize, coordinate and share environmental monitoring programmes, research effects, and basic data on chemical, physical and biological effects of various activities on the environment and other environmental related activities other than in the oil and gas sector;
- Establish mobile courts to expeditiously dispense cases of environmental infringements. However, this has to be done with the 'relevant judicial authorities' as well as in consonance with the Nigerian Constitution;
- Conduct public investigations on pollution and the degradation of natural resources, except investigations on oil spillage conduct public investigations and
- Submit for the approval of the Minister, proposals for the evolution and review of existing guidelines, regulations and standards on environment other than in the oil and gas sector (NATIONAL ENVIRONMENTAL STANDARDS AND REGULATIONS ENFORCEMENT AGENCY (ESTABLISHMENT) ACT, 2007, n.d.).

Under section 20 (1) of the NESREA Act 2007, the Agency may make regulations setting specifications and standards to protect and enhance the quality of Nigeria's air resources, so as to promote the public health or welfare and the natural development and productive capacity of the nation's human, animal, marine or plant life. Prior to this, the Agency may establish monitoring stations or network to locate sources of atmospheric pollution and determine their actual or potential danger. Any person who violates the regulations made to protect and enhance the quality of Nigeria's air resources commits an offence and shall on conviction, be liable to a fine not exceeding N200, 000 or to imprisonment for a term not exceeding one year or to both such fine and imprisonment and an additional fine of N20,000 for every day the offence subsists. In a situation where the offence is committed by a body corporate, it shall conviction be liable to a fine not exceeding N2,000,000 and an additional fine of N50, 000 for every day the offence subsists.

Section 23 enables the Agency to collaborate with other relevant agencies to make regulations that would enhance the quality of water and protect public health or welfare. Anyone who is found violating the regulations of this section, commits an offence and shall on conviction, be liable to a fine not exceeding N50, 000 or to imprisonment for a term not exceeding one year or to both such fine and imprisonment and an additional fine of N5, 000 for every day the offence subsists (NATIONAL ENVIRONMENTAL STANDARDS AND REGULATIONS ENFORCEMENT AGENCY (ESTABLISHMENT) ACT, 2007, n.d.).

Another very important stipulation of the NESREA Act 2007 is the information contained in Section 25 which states that the Agency may make regulations for the purpose of protecting public health and promotion of sound environmental sanitation and any person who violates these regulations shall be guilty of an offence and punished under the penalties imposed in the regulations made pursuant thereto.

Section 26 gives power to the Agency to make regulations, guidelines and standards for the protection and enhancement of the quality of land resources, natural watershed, coastal zone, dams and reservoirs including prevention of flood and erosion and a person who violates the Provisions of the regulations made pursuant to this section, commits an offence and shall on conviction, be liable to a fine not exceeding N200, 000 or to imprisonment for a term not exceeding one year or to both such fine and imprisonment and an additional fine of N10,000 for every day the offence subsists. Where an offence under subsection (1) of this section is committed by a body corporate, it shall on conviction, be liable to a fine not exceeding N1,000,000 and an additional fine of N50,000 for every day the offence subsists.

Section 27 of the Act prohibits without lawful authority the discharge in such harmful quantities of any hazardous substance into the air or upon the land and the waters of Nigeria or at any adjoining shorelines. This offence is punishable under this section with a fine not exceeding N1,000,000 or to imprisonment for a term not exceeding 5 years. In the case of where the offence is committed by a corporate body, every person who was in charge of the corporate body at the time the offence was committed shall be deemed to be guilty of such offence and shall be liable to be proceeded against and punished accordingly (NATIONAL ENVIRONMENTAL STANDARDS AND REGULATIONS ENFORCEMENT AGENCY (ESTABLISHMENT) ACT, 2007, n.d.).

1.15.6. National Policy on Injection Safety and Healthcare Waste Management 2007

- The National Policy on Injection Safety and Health Care waste Management sets out to ensure that patients, health workers, communities and the environment are protected from risks associated with unnecessary and unsafe injections, as well as improper treatment and disposal of injection materials and other health care waste. The policy document will achieve this objective by providing guiding principles for safe injection practices and proper management of all health care waste [49; 50].
- Noted in the policy also are its mission statement and overall goal which is to protect and or minimize the risks due to unsafe injection and health care waste management practices to the patients, health workers, consumers and the environment from hazardous healthcare waste disposal practices and ensuring safe injection practices and proper management of health care waste. The goal will be achieved through the following guiding principles that include:
- Behavioral change of the patients, health workers and the community to significantly affect injection and waste management practices.
- Appropriate procurement, distribution and monitoring of injection equipment and related supplies such as safety boxes, auto disable syringes and needle cutters.
- Capacity building for safe use of injection materials and appropriate healthcare waste management as well as supervision and monitoring of health facilities at all levels of implementation to ensure behavioral change.
- Improve injection and health care waste management practices and increased awareness [49].

The policy highlights the re-use and sharing of disposable injection materials, which leads to a significant amount of risk of blood borne disease transmission such as Hepatitis B, Hepatitis C and HIV as a challenge. Furthermore, it states the indiscriminate dumping and disposal of health care waste in health institutions, municipalities and communities as well as inadequate health care waste management system for health care facilities and the communities as another challenge [49]. In view of the challenges highlighted above, the policy aims to:

- Eliminate the practice of re-using disposable needles and syringes, including sharing among family members;
- Provide guideline for health workers in both public and private sectors and communities for proper health care waste management disposal practice;
- Implement effective behavioral change approaches to injection safety, targeting both health workers and communities through effective advocacy, community mobilization, communication, and creating an enabling environment;
- Train health care workers in injection safety issues and appropriate waste disposal practices;
- Support supervision of health care workers involved in administration of injections and the process of disposal and destruction of health care waste;
- Provide guidelines for injection and other health care waste management practices to all health facilities;
- Ensure that all health facilities have easy access to appropriate disposal facilities for used injections and other health care waste;
- Establish and ensure that proper injection and other health care waste management practice are observed at all health facilities and in the community and to
    - Mobilize the community on appropriate health care waste management [49].

To ensure the implementation of this policy, the Federal Ministry of Health shall in collaboration with other line Ministries:

- Formulate, review and produce the National Policy on injection safety and Healthcare Waste Management;
- Enact, review and harmonize existing Legislation on injection safety and healthcare waste management;
- Develop and ensure the implementation of the National Action Plan on injection safety and healthcare waste management;
- Collaborate with the Academic, Research Institutions, other relevant Ministries, Agencies, External Support Agencies (ESAs), Non-Governmental Organizations (NGOs) and the private sector on injection safety and healthcare waste management;
- Embark on capacity building and human resource development for managing injection safety and healthcare waste management;
- Mobilize resources both internally and externally for healthcare waste management [49].

Health care facilities, also in a bid to ensure the successful implementation of the policy shall;

- Ensure segregation of wastes at every point of generation within the healthcare facility using the appropriate primary collection equipment with appropriate color coding.
- Provide facilities for the safe disposal of all hazardous healthcare waste produced from such facilities.
- With higher installed capacity for onside disposal of healthcare waste than they presently required, shall provide such excess capacity to other healthcare facilities in the area for the disposal of their own wastes at the reasonable cost [49].

While Civil Society Organizations (NGOs/ CBOs) and Professional Regulatory Bodies and Academia also in a bid to achieve the policy's objectives shall:

- Mobilize communities through awareness campaigns about National Policy on Injection Safety and Healthcare Waste management;
- Develop community programmes that will support implementation ofϖ National Policy on Injection and Healthcare Waste Management;
- Educate communities on the National Policy on Injection Safety and Healthcare Waste Management;
- Revise training curricula to reflect training gap on injection safety and healthcare waste management issues;
- Conduct training and manpower development of their members on injection safety and healthcare waste management and
- Collaborate with Federal Ministry of Health in propagating information on injection safety and healthcare waste management research findings amongst their professional [49].

Still on National Policies, Laws and Regulations related to medical waste management, NESREA as part of its responsibility to produce and enforce environmental standards, regulations, rules, laws, policies and guidelines and owing to the need to handle waste from the health sector in a safe manner and in accordance with internationally accepted standards drafted the National Environmental (Healthcare Waste Control) Regulations, 2017, in consultation with relevant stakeholders. The thrust of this new regulation which shall cover healthcare generators, handlers and treatment facilities is to prevent and minimize waste emanating from activities of healthcare facilities with a view to safeguarding human health and the Nigerian environment by ensuring the collection, transportation, treatment and final disposal of wastes within the specified standards and guidelines [51]. Amongst other things, it will protect healthcare workers and improve public safety; hold practitioners to account; ensure safe handling of healthcare wastes and their sustainable disposal; and make our environment safer and healthier [52].

1.16. Statement of the Research Problem

Indiscriminate dumping of untreated health care waste in Municipal bins increases the chances of survival and mutation of pathogenic microorganism population in the municipal waste, which can lead to disease epidemics and increased incidence of communicable disease in the community. The prevalence of infectious disease like Hepatitis B, C, Measles, acquired immunodeficiency syndrome, Tuberculosis, Chickenpox, Cholera and others has also been traced to the inappropriate segregation and disposal of hospital waste. In Kano State, the researcher observed that the primary healthcare facilities neglected healthcare waste management in the area of segregation and disposal. Materials required for segregation and disposal of these hospital wastes are not provided by the constituted authority, thus these pose a serious threat to the health workers, patients, environments and the community at large [43]. The indiscriminate dumping of primary healthcare waste among domestic waste makes the community members easily access it. A tour of these primary healthcare facilities shows the absence of some waste management facilities such as incinerators, autoclave, and microwave.

1.17. Significance of the Study

In many countries, medical wastes containing hazardous and infectious wastes are still handled and disposed together with municipal wastes, posing a great health risk to municipal workers, generality of the public and the environment. In other words, improper management of bio-medical wastes is of significant concern because of its health and environmental risks.

Keeping this in view and to provide a solution to the problem noted in the paragraph above, it has been noted that the adequate awareness among the hospital's healthcare personnel concerning good practices in medical waste management is crucial to prevent these hazards. In fact, it could be said to be the first step towards the proper management of biomedical waste. Hence, this study that is focused on the assessment of the awareness and practice of medical waste management among healthcare personnel in the study area. Kano Municipal healthcare centers was selected to conduct this study because no such study has been conducted about medical waste management in the hospital and since no study has been conducted at study area of this nature, the study will provide baseline data for further research.

1.18. Scope of the Study

The study focused on some selected healthcare services (Sharada, Yan`awaki, Gandu and U/Gini Primary healthcare services) in Kano Municipal LGA of Kano state. It mainly covered the healthcare wastes generated at the hospital and the management practices implored at the facility, assessing its compliance with international standards and regulations such as that of World Health Organization (WHO).

Aim and Objectives

The aim of the study is to assess the awareness and practice of biomedical waste management among primary health care workers in the Kano Municipal with the specific objectives to; identify the components of biomedical waste generated, determine the current practices on biomedical waste management at Kano Municipal Healthcare centers, compare the current practice of biomedical waste management in the primary health care centers with the standards.

1.19. Study Area

1.19.1. Location and Size

Kano Municipal is a Local Government Area within the Kano Urban Area in Kano State, also known as capital of kano state, Nigeria. Its headquarters is at Kofar Kudu (western entrance of emir's palace), in the south of the city of Kano. It has an area of 17 km^2 and 13 wards with population of 365,525 at the 2006 census and a postal code of 700.

1.19.2. Topography

The area forms an extensive flat plain which lies in the central parts of the Kano plain and is termed a drift plain. The slopes are very long and gentle, less than 2^0 descending into the shallow reaches of river Kano that spans over the area. There are very few shallow streams, full of the fine sandy materials and are seasonal. Also, due to the high porosity of the soil water flow in these streams is evident only during the high peak period of the rainy season (July and August), when most of the rain seeps to the ground water table. Therefore, there is a limited possibility of sheet erosion [53].

1.19.3. Climate

A tropical wet and dry climate prevails over the state and it has two distinct seasons; the wet and dry seasons. The wet season lasts between May and early October while the dry season lasts between November and April. The southern part of the state lies in the northern Guinea savannah agro-ecological zone while the northern part covers the sudan savannah. Annual rainfall varies from 600 – 1200mm in the Guinea savannah to 300 – 600mm in the Sudan savannah. The mean annual temperature is about 26^0c in the coolest months (December/January) and 31^0c in the hottest months (April/May).

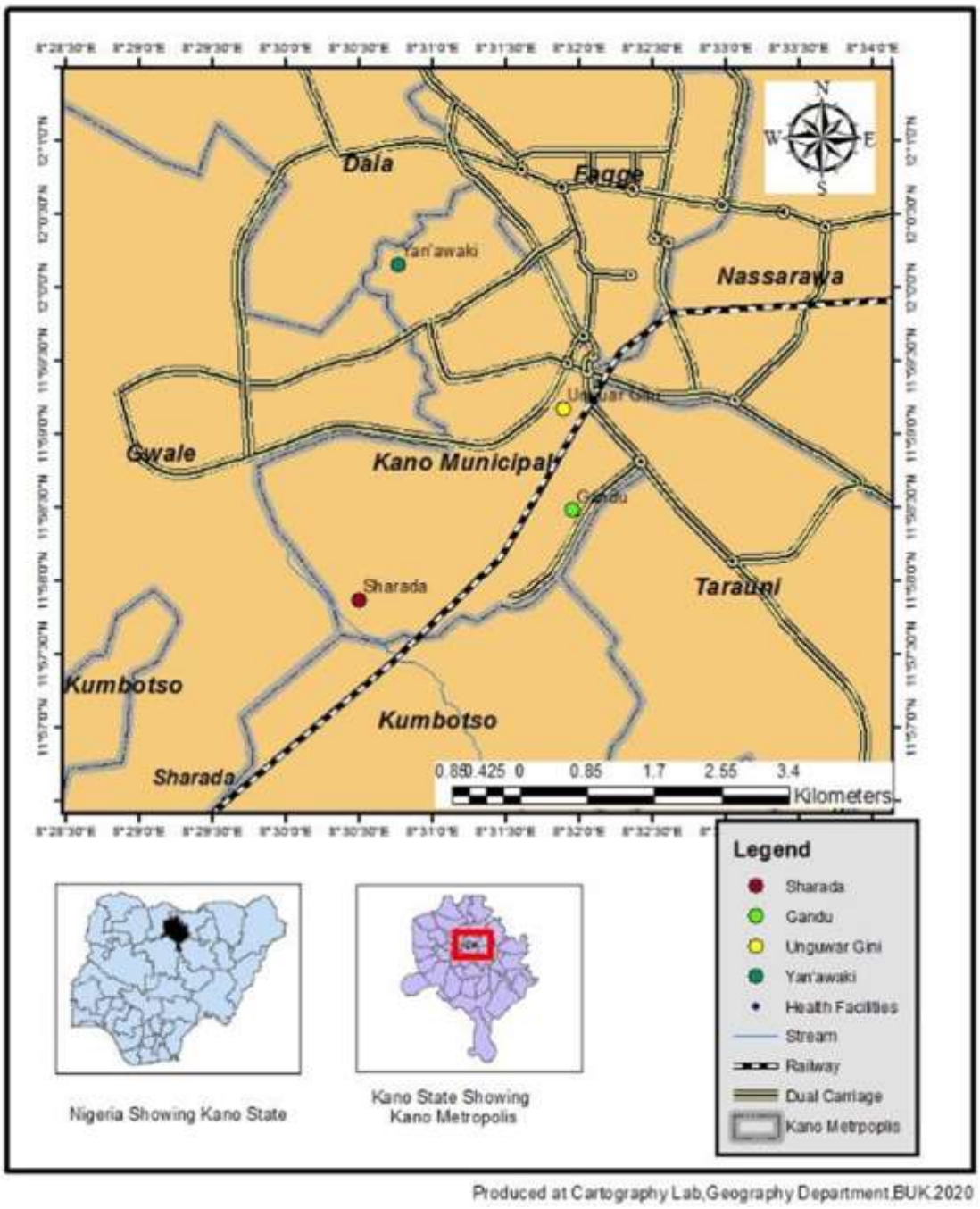

Figure 2 Study Area

2. Materials and method

The methodology adopted for this study is the use of questionnaire, focused group discussion, description of research design and description of the population and sampling procedure.

2.1. Research Design

This research was descriptive cross-sectional in design.

2.2. Study Population

The study participants were health workers in the selected primary healthcare facilities in Kano Municipal Area of Kano State. These include nurses, laboratory scientist, pharmacists and waste handlers. The overall populations of health workers that were sampled in Kano Municipal Area of Kano State are One hundred and sixty (160) health workers.

Table 2 Numbers of Healthcare Facilities in the Study Area

S/N	Names of health facilities in KMC	Total No of healthcare workers
1.	Yan Awaki PHC	28
2.	Sharada PHC	35
3.	Ungwan Gini PHC	37
4.	Gandu PHC	30
5	Cleaners	30
	Total	160

2.3. Sampling Technique

The study made use of purposive sampling technique to select respondents among the selected four health facilities in Kano municipal namely Sharada, Gandu, Ungwan Gini and Yan Awaki health facilities.

2.4. Research Instruments

Questionnaires were used to obtain data from respondents on their current practices of health care waste management of the respective health care facilities. The researcher ensured that the same research procedures were carried out in all selected primary healthcare facilities.

2.5. Questionnaire

The questionnaire was used to collect data from respondents about their awareness and knowledge on biomedical waste management.

The close and open-ended Questionnaire were administered to different categories of health workers, nurses, laboratory scientist, pharmacists and waste handlers. These healthcare professionals are the generators of healthcare waste (HCW). They spend most of their time with patients in healthcare facilities thus increasing their risk of exposure to infections and injuries that are in Primary Healthcare center environment. The purpose of this research was explained to the health workers. Respondent participated voluntarily.

2.6. Method of Data Analysis

Data was analyzed and summarized using descriptive statistics such as frequency and percentage, and inferential statistics.

3. Results and Discussions

These present results obtained from fieldwork which include results and discussion from completed questionnaires. The results are presented in tables and charts. The discussion of the results is also presented below;

3.1. Socio-Demographic Characteristics of the Respondents

Table 3 Gender

SEX	FREQUENCY	PERCENTAGE
Male	60	37.5%
Female	100	62.5%
Total	160	100%

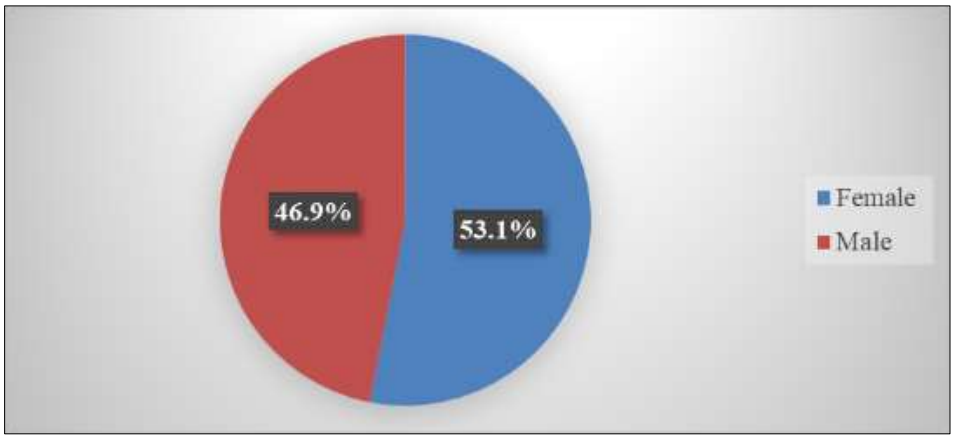

Figure 3 Distribution of the respondents by Gender

From Figure 3, female respondents constitute 53.1%, while the males 46.9% of the respondents. In African society, information that has to do with domestic matters are better sourced from women.

3.2. Age

Table 4 Distribution of the study population based on age range

Age Range	Frequency	Percentage (%)
20-25 years	3	1.9%
26-30 years	50	31.3%
31-35 years	40	25.0%
36-40 years	30	18.8%
41-45 years	20	12.5%
46-50 years	7	4.4%
Above 50 years	10	6.1%
Total	160	100%

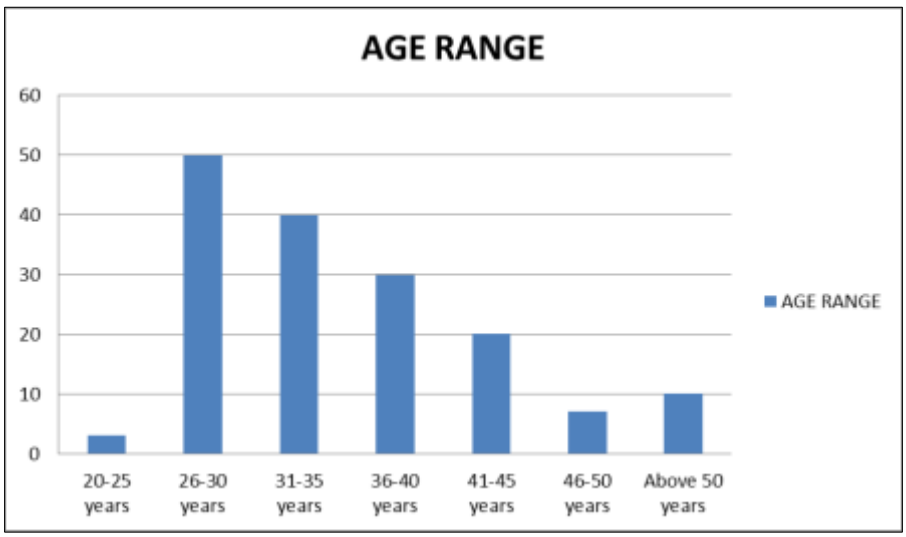

Figure 4 Distribution of the respondents by Gender

Table 4 above show the categories of the study participants based on age bracket showed that 1.9% of respondents are between 20-25 years, 31.3% of them are between 26-30 years which is the highest, 25.0% fell under the age bracket of 31-35 years, 18.8% between 36-40 years. Furthermore, 12.5% of the total number of respondents fell under the age bracket of 41-45 years, 4.4% between 46-50 and those aged 50 years and above had a percentage of 6.1%. These results indicates that there is a significant number of young people working at the health care facility.

Table 5 Educational Qualification

Alternatives	Frequency	Percentage %
WASSCE/SSCE	20	40
ND/NCE	25	50
B.Sc./HDN	05	10
MASTERS and OTHERS	00	00
Total	50	100

Educational Qualification of Respondentsshows that, the majority (50%) of the respondents have ND/NCE as a higher educational qualification. It can be inferred that, people within this majority of qualification are at average as represented in figure 4

3.3. Profession

Table 6 Distribution of Respondents by Profession

	Visiting Doctors	Nurses	Laboratory Technicians	Pharmacists	Sanitary Staff	Total
Frequency	33	43	37	20	27	160
Percentage (%)	20.6%	26.9%	23.1%	12.5%	16.9%	100%

Table 6 shows that, 20.6% were doctors, 12.5% were pharmacists, 26.9% were nurses while 23.1% of the study populations were laboratory technicians and the remaining percentage of 16.9% were sanitary staff or cleaners.

In an interview, the resource persons submitted that in Nigeria, most of the hospitals are short of trained sanitary staff, whose work is to clear the environment of filth and wastes. The implication is that, in an attempt to take care of patients in our hospitals, we might up cross breeding diseases through wastes produced. This is reminiscence of the state of affairs in environmental cleanliness of Nigeria.

3.4. Departments

Table 7 Distribution of Respondents Based on the Departments Operated in the PHC

Department	Frequency	Percentage (%)
LEVEL 5: Medical officer of health (MOH) is a who supervises group of primary health care (PHC) centres in each Local Government	47	23.1%
LEVEL 4: A nurse/midwife heads a PHC centre and consults with the supervisory MOH in difficult cases. In local Governments where there are no medical officers, the most senior nurse deputizes as supervisor.	34	15.0%
LEVEL 3: Community health officers (CHOs) are next in rank to the nurses, and they head the PHC centres in the absence of a nurse. CHOs initially train as community health extension workers (CHEWs), but have received and additional year of training in a teaching Hospital.	12	4.4%

LEVEL 2: Community health extension workers (CHEWs)receive their training from schools of health technology for 3 years and qualify with a diploma in community health care.	18	5.7%
LEVEL 1: Volunteer Health Workers (VHWs) and traditional Birth attendants (TBAS) are informally trained ad-hoc staff to help the PHC centres with cases finding and community engagement	29	12.5%
Pharmacy: Technicians support the work of pharmacists and other health professionals by performing a variety of pharmacy related functions, including dispensing prescription drugs and other medical devices to patients and instructing on their use.	30	13.1%
Total	160	100%

Various departments of the facility were covered including the general medical officer of health (MOH). With regards to the department in which the respondents operated within the PHC, theresultsrevealedthat15.0% worked within the general out-patient department (GOPD) with a composition of 23.1% visiting doctors and 15%nurses respectively; the: Community health officers (CHOs) 4.4 %. Also, Community health extension workers (CHEWs) 5.7 %. Similarly, 23.1% of the healthcare personnel worked in the PHC and 13.1% worked in the pharmacy. It is also good to note that the sanitary staff who comprised a fraction of 16.9% in the total number of the study population didn't have specific working departments because of the transient nature of their job. This means that they could be deployed to work in any department within the PHC premises at any given point in time.

3.5. Appropriate Bio-Medical Waste Management Process

3.5.1. Components of biomedical waste

Table 8 illustrates that 88.7% of the total number of respondents stated biomedical waste to be composed of sharps, while 79.3%noted blood and body fluids as constituents biomedical waste, whereas 68.8% noted chemical wastes to be what biomedical waste constitutes of. However, the further breakdown of the study population's knowledge as to the constituents of biomedical waste showed that a total of 48.8% respondents were of the opinion that biomedical waste composed of blood and body fluids, sharps, pharmaceutical wastes, radioactive waste, chemical waste, anatomical waste (human tissues, body parts, amongst others) and pathological wastes. This fraction of respondents consisted 6.3%, 19.4%, 10.3%, 8.8% and 4.4% of doctors, laboratory technicians, pharmacists, nurses and cleaners respectively.

Table 8 Respondents Knowledge on the Components of Biomedical Waste

Composition of Biomedical Waste	Doctors	Laboratory Technicians	Pharmacists	Nurses	Sanitary Staff
A+B+C+D+E+F+G+H	6.3%	19.4%	10.6%	8.8%	4.4%
A+B+C+D+E	-	-	-	1.9%	-
A+B+C+D+E+G	1.9%	-	-	1.9%	-
A+B+C+D+E+F	1.9%	-	-	-	-
A+B+D+E+F+G	-	-	-	10.6%	1.9%
A+B+D+E+G	1.3%	1.9%	-	-	-
A+C+E+F	1.9%	-	-	-	-
A+B	-	-	-	-	1.9%
A+E	-	-	-	1.9%	-
B+G	1.9%	-	-	-	-
A	1.9%	-	-	1.9%	4.4%
B	3.2%	1.9%	1.9%	-	4.4%
Total	20.3%	23.2%	12.5%	27%	17%

Where

- **A =** Blood and body fluids,
- **B =** Sharps,
- **C =** Pharmaceutical wastes,
- **D =** Radioactive waste,
- **E =** Chemical waste,
- **F =** Anatomical waste (human tissues, body parts, amongst others) and,
- **G =** Pathological waste.

3.2% of doctors, 1.9% of laboratory technicians, 1.9% of pharmacists and 4.4% of cleaners noted biomedical waste to compose of sharps only while 1.9% of the sanitary staff/cleaners indicated biomedical waste to be made up of blood and body fluids as well as sharps.

From the results obtained from questionnaire administration as it pertains to respondents' knowledge on the components of biomedical wastes, it's seen that a higher number of laboratory technicians rightly classified items that classified biomedical wastes. The justification for this observation was witnessed during the in-depth interview carried out where the laboratory technicians displayed a higher knowledge of the components of biomedical wastes. This may be said to be due to the fact that a higher percentage of the laboratory technicians had attended trainings on biomedical waste management.

Though, a general view of these results, the respondents could be said to have adequate knowledge on the components of biomedical waste and this understanding was vital towards aiding the practice of proper segregation and other steps in the set standards for management of biomedical waste.

3.5.2. Segregation of biomedical wastes

Table 9 noted that 12.5% of the sanitary staff stated that biomedical waste is appropriately separated in each department; while 4.4% noted that non-existence of segregation for biomedical waste at their departments and hospital in general. Also, the table makes it known that 78.7% of the medical practitioners reported that biomedical waste was segregated at their respective departments and medical institution in general.

Table 9 Biomedical waste segregation practice at hospital for sanitary staff and medical personnel

Are biomedical wastes segregated in the hospital?		**Sanitary Staff**	**Medical Personnel**
	Yes	12.5%	78.7%
	No	4.4%	4.4%
	Total	16.9%	83.1%

Source: Author's Field survey, 2018

The knowledge of majority of the respondents about the proper segregation of biomedical waste at the point of source is important to achieving a sound biomedical waste management as stated in [54; 3].

3.5.3. Biomedical Wastes Categorization

Table 10 shows that 46.9% of the respondents reported that the available containers and bags are align with the WHO colour code standards which identifies black bin bags for general wastes, red for pathological wastes, yellow for infectious wastes while 14.4% said no and the remaining 38.7% did not know. Out of the 46.9% that affirmed that biomedical waste collection bags and containers conformed to the WHO standards, 43.1%were medical staff and the remaining 3.8% were cleaners. The composition of the 43.1% of medical staff that stated biomedical wastes collection bags and containers conformed to the WHO standards include 15.6%, 5%, 13.1% and 9.4% of doctors, pharmacists, nurses and laboratory technicians respectively. These results tallied with what was obtained in a hospital in Nairobi,, [55] in which it was observed that just 44% of the entire study population was aware of the correct colour coding scheme to use in disposing the different types of medical wastes. The low percentage of respondents used in this research as regards the used of WHO colour code for segregation of biomedical wastes indicates the poor level of understanding its essence in biomedical waste management.

However, with what the researcher noticed during site visitations, it was concluded upon that although there were coloured containers according to the WHO standards used for the collection of biomedical wastes in most departments of the hospital, wastes were most times indiscriminately dumped without regards to adhere to the WHO colour coding scheme.

Table 10 Respondents' knowledge on WHO colour coding scheme

Question	Distribution of respondents' according to profession	Reply			Total
		Yes	No	Not sure	
Containers and bags available conformto colourcode	Doctors	15.6%	1.9%	3.1%	20.6%
	Nurses	13.1%	5%	8.8%	26.9%
	Pharmacists	5%	2.5%	5%	12.5%
	Laboratory Technicians	9.4%	3.1%	10.6%	23.1%
	Sanitary staff/cleaners	3.8%	1.9%	11.4%	16.9%
Total		46.9%	14.4%	38.7%	100

3.6. Knowledge on biomedical Waste Transportation and temporary Storage

Table 11 show that 62.5% of respondents identified that carts are used for inside transportation and from the hospital building to the temporary storage facility while 16.2%of the respondents observed that the sanitary staff carry the bin bags of biomedical waste with their hands when transporting it to the hospital's temporary storage facility. Additionally, while 9.4% indicated that they were not certain as to how containers of biomedical waste were transported within and outside the hospital and a total number of 11.9% observed that it has been seen on several occasions how the sanitary staff makes use of both their hands and carts to transports bags containing biomedical wastes. As to whether the carts used to transport biomedical wastes collection bags are washed and disinfected daily, 70.6% of the total study population were uncertain if the carts were cleaned and disinfected daily, while 20.6% of the said yes and 8.8% said no.

Table 11 Means of transportation of biomedical wastes

How is medical waste transported within the hospital building?				
By the use of Hand	**By the use of Cart**	**By the use of Hand and Cart**	**Not sure**	**Total No. of Respondents**
16.3%	62.5%	11.9%	9.3%	100%
Are transportation carts/trolleys/vehicles washed and disinfected daily?				
Yes	No	Not sure	Total No. of Respondents	
33(20.63%)	14(8.75%)	113(70.62%)	147(100%)	

In relation to a temporary storage area, that is, the place where the biomedical waste is kept before transporting to the final disposal site, results gathered displayed that about 95.6%ofrespondents say that the hospital does have a temporary storage facility while4.4%were unsure. Concerning the suitability of the temporary storage area in terms of ventilation and lighting, 83.0% said the temporary storage area inside the hospital was suitable 11.8% said no, and 5.2% did not know. However, an assessment of the condition of the temporary storage facility during one of the researcher's site visits to the hospital indicated that the temporary storage area in the hospital was situated in an open space, clean and spacious, but it was quite close to the hospital's cafeteria and was not restricted. This should not be so as unauthorized persons should not be granted access to such an area and easy access.

3.7. Occupational Health and safety of respondents' when dealing with biomedical waste

As evident from 5, out of a total number of 83.1% medical staff, 64.4% noted that they wore hand gloves when dealing and disposing of biomedical wastes while a fraction of 18.7% said sometimes. It was also observed that 6.3% of the sanitary staff sometimes wore protective garments when dealing with biomedical wastes while 10.6% stated that they did wear their protective garments at any point they were dealing with biomedical waste.

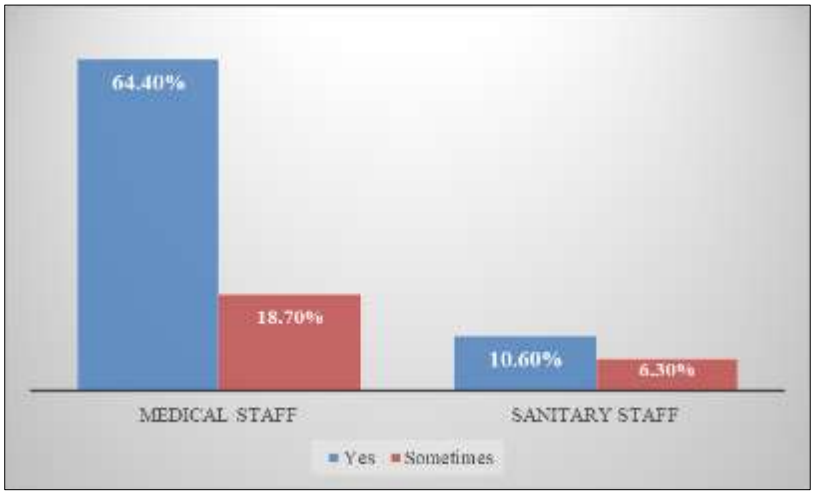

Figure 5 Graphical illustration for the occupational health and safetyfor both the medical and cleaner/sanitary staff of the hospital

To collaborate more on the results gotten as it relates to occupational health and safety of medical personnel and sanitary staff, site visitations conducted during the course of carrying out the research let the researcher in on the fact that a majority of the sanitary staff who were largely responsible for the transportation and disposal of biomedical wastes to the temporary storage area made use of heavy-duty gloves, boots and apron. This was in line with WHO standards that required the use of heavy-duty gloves, boots and apron [3]. This is similar to a cross-sectional study conducted in a Kenyan hospital where the staff employed for handling waste in the hospital use complete personal protective equipment, including overall gown and protective boots and gloves, [55].

3.8. Assessment on awareness by the study population on treatment and disposal methods of biomedical wastes in the hospital

Table 12 Methods used for medical waste treatment and their frequencies according to the respondents

Profession	Treatment Methods								
	A	B	C	D	E	F	G	Not sure	Total
Nurses	22.5%	0.6%			1.9%			1.9%	26.9%
Doctors	10.0%			2.5%		1.9%		6.2%	20.6%
Pharmacists	10.6%			1.9%					12.5%
Laboratory Technicians	19.4%							3.7%	23.1%
Cleaners	15.0%			1.9%					16.9%
Total	77.5%	0.6%	0.0%	6.3%	1.9%	1.9%	0.0%	11.8%	100%

Where

- **A =** Incineration,
- **B =** Autoclaving,
- **C =** Microwaving,
- **D =** Chemical Disinfection,
- **E =** Encapsulation,

- **F =** Open dumps and,
- **G =** Landfilling.

Table 12 depicts incineration to be the most common method used for treating biomedical wastes within the facility. This is so because 22.5% of nurses, 10.0% of doctors, 10.6% of pharmacists, 19.3% of laboratory technicians and 15.0% of cleaners stated incineration to be the treatment method used for biomedical wastes. Similarly, 1.9% of pharmacists, 2.5% of doctors and 1.9% of sanitary staff choose chemical disinfection as a way in which biomedical waste was treated in the hospital. However, 1.9% of nurses, 6.2% of doctors and 3.7% of laboratory technicians were not sure as to the type of treatment method(s) carried out in the management of biomedical wastes in the hospital.

Results gotten from questionnaire administration conformed to what was noted during interviews conducted. During an interview with the head of unit of waste management and control at the facility, it was noted that incineration was a major waste treatment method undergone at Kano Municipal Health Services. Autoclaving, chemical disinfection and encapsulation are also used for treating biomedical wastes in the hospital. Kano Municipal Health Services has a working in cinerator that is in good condition and controlled to prevent emissions of dangerous gases. The incinerator is always in a good state. The methods used to treat and dispose biomedical wastes in the hospital align with WHO set standards for biomedical wastes treatment and disposal, [3].

3.9. Assessment on training received by the study population on biomedical waste management

From the data illustrated in figure 6, all those who were nurses comprising a total of 26.9% had received training as it relates to biomedical waste management. Also, a total of 19.3% out of 23.1% of laboratory technicians had received training too. A fraction of 10.6% of the sanitary staff/cleaner had also undergo training on biomedical waste management. However, it is pertinent to note that while only a very small fraction of 1.9% of doctors had received training on biomedical waste management, no pharmacist out of the 12.5% that comprised part of the study population had ever trained on biomedical waste management. The observation that no pharmacist in the study population had ever received any form of biomedical management was what was also noticed in [56] where pharmacists and dieticians seldom go for training.

However, from the results obtained through the administration of questionnaires, a total of 10.6% of sanitary workers and 58.7% of health care practitioners had at one point or the other received training on biomedical waste management.

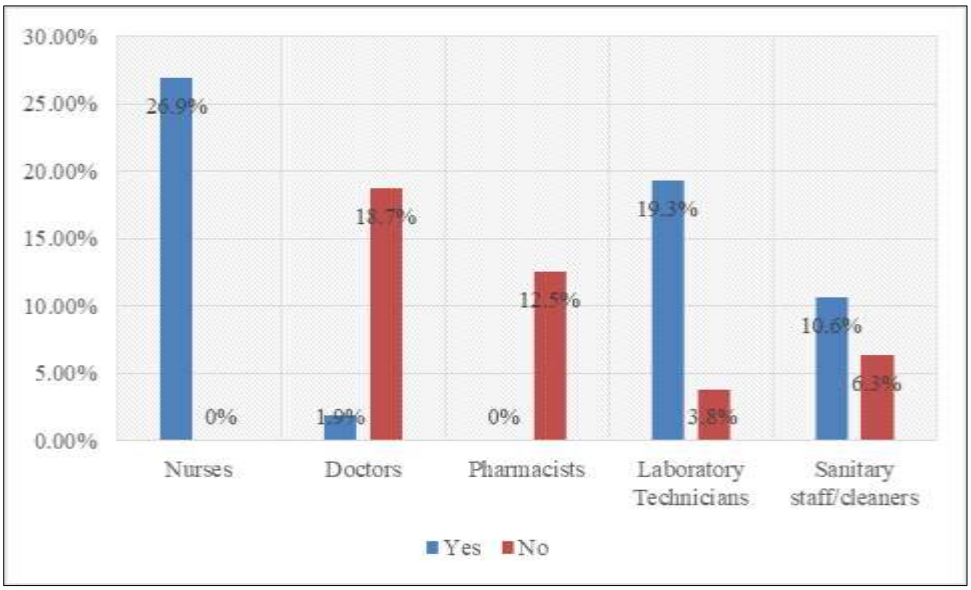

Figure 6 Biomedical waste training for healthcare practitioners and sanitary staff

4. Conclusion

Based on the results of this study the following deductions were made; the healthcare personnel in Kano Municipal had a beyond average awareness on the proper biomedical waste management practices. However, awareness of biomedical waste management in this institution can be improved, especially in the areas of waste segregation, i.e., separation of biomedical waste. Also, pharmacists and more doctors needed to be included in the training of staff on biomedical waste

management. This is not so said, more training can't be done for other healthcare personnel and the sanitary staff in the hospital. They need to be informed about current available technology to deal with medical wastes. Sound knowledge and safe practices among them, are to be strengthened. The methods used for treatment, disposal and collection are the recommended methods hence the hospital has taken the right steps in that regard. Adherence to WHO colour code in terms of containers used to collect wastes should be emphasized.

Recommendations

- Regular specialized training sessions and seminars on medical waste management for the healthcare personnel should be carried out more frequently.
- Adequate biomedical waste management budget should be allocated within the primary health care budget.
- The temporary storage place for biomedical wastes in the primary health care should be restricted to authorized users only and if possible moved to another location that is farther away from the hospital's cafeteria.
- Advocacy on hazards associated with mismanagement of biomedical waste to the community and general public should be done and promoted. This will to enhance the cooperation of those who visit the healthcare facility for their services to stick to the colour coding system of WHO when disposing wastes.
- Materials like helmets, eye protectors and of course, more heavy-duty gloves, boots and aprons or overalls be made available in the facility.
- More comprehensive policies and laws on biomedical waste management be drafted, implemented and enforced.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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