THE PRACTICE AND CHALLENGES OF BIOMEDICAL WASTE MANAGEMENT: A STUDY OF SELECTED MEDICAL FACILITIES IN ILE-IFE, OSUN STATE

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Abstract

In pursuing their aims of providing treatment and safeguarding the health of the people against illnesses, health-care services inevitably create waste that is hazardous to health and whose management has remained a great challenge due to its highly toxic contents. This paper examines the practice of biomedical waste management in some medical facilities in Ile-Ife with a view to determining the risks associated with the practice. Four medical facilities with some level of sophistication in waste management were purposively selected for study. The type of waste generated was determined by sorting of waste while hand-held scale was used to determine the volume of waste generated. Questionnaire was used to obtain information from the waste management and medical staff of the selected medical facilities. Descriptive (frequencies and percentages) and inferential statistics (Multinomial logistic regression) were used in analysing the data. The study established that the daily per capita waste generation in the medical facilities was 0.51kg. Scrap (Syringes and absorbent paper) (96.7%), infectious (Excreta and dressing swabs) (72.9%) and pathological wastes (Human tissue and body fluid) (57.0%)were the most generated waste while open dumping and pit burial of waste were widely practiced among the medical facilities. Exposure to harmful chemical and radioactive waste (68.8%)and injuries from sharps (52.3%)pose serious health risks not only to the waste managers but health care workers. The paper holds that solutions to the challenges of biomedical waste management practices lie in strict adherence to the global best practices as recommended by the World Health Organisation.

Keywords: Biomedical Waste; Medical Facilities; Incineration; Radioactive Waste; Infections[33]

1.0 INTRODUCTION

The term biomedical waste includes any waste which consists wholly or partly of human or animal tissue, blood or other body fluids, excretions, drugs, or other pharmaceutical products, swabs or dressings or syringes, needles or other sharp instruments being waste which unless rendered safe may prove to be hazardous to any persons coming into contact with it (WHO, 2015). Also, any other waste arising from medical, nursing, dental and veterinary, pharmaceutical or similar practice, investigation, treatment, care, teaching or research, or blood from transfusion, being waste which may cause infection to any persons coming into contact with it may be seen as biomedical waste (Anjali et. al., 2014). In recent times, serious concerns

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have been expressed on proper handling of biomedical waste globally but most especially in developing countries. The concerns are unconnected with the quantity of the biomedical waste being generated but rather its hazardous nature which calls for extra care in handling. WHO (2005) estimates that each year there are about 8 to 16 million new cases of Hepatitis B virus (HBV), 2.3–4.7 million cases of Hepatitis C virus (HCV) and 80,000–160,000 cases of Human Immunodeficiency Virus (HIV) due to unsafe injections disposal and mostly due to very poor waste management systems. It has been reported that in UK in the period of 1996 to 2004, 2,140 people got occupational exposures to blood borne viruses with 21% of the injuries occurred during the disposal process (Banu and Shetty, 2010). A study in Mexico City revealed that out of 69 interviewed waste handlers 34% reported 22 needle stick injuries during the first 12 months and 96% had seen needles and syringes in waste (Johnson, Gonzalez, Duenas, Gamero, Relyea and Luque, 2013). In Pakistan Waste Pickers who were going through medical waste, for collection and resale, experienced on average, three to five needle stick injuries a day (Ramesh,Babar, Shaikh, and Robert, 2015). In India more than 30% of the injections administered each year were carried out using re-used or inadequately sterilized medical equipment and that nationally, 10% of health care facilities sold used syringes to waste pickers (Manasi, 2017). Research suggests that population living within 3 km of old incinerators saw an increase of 3.5% in the risk of contracting cancer (Kumar, Khan, Ahmed, Khan, Magan and Nousheen, 2010).

Biomedical waste management in Nigeria have been observed to fall short of international best practices or even meeting a minimum standard required for it to pose less threats to public health and the environment (Ibijoke, Babajide and Rafid, 2013). As observed by Sawyerr, Adeolu, Salami, and Adejoh, (2016), medical waste in Nigerian urban centres was generally managed as any other waste which exposes the scavengers, children and the local people to hazards. For instance, contaminated injection equipment was found to be scavenged from waste areas and dump sites in Kano either to be reused or sold to be used again (Oke, I. A. (2008). Anozie, Lawani, Eze, Mamah, Onoh, Ogah, Umezurike and Anozie, (2017) also reported that some members of local communities in Ebonyi salvaged and used some of the waste receptacles such as sharps, containers to store food commodities while healthcare workers used red waste bags for other purposes other than storage of infectious waste. Despite the deadly nature of biomedical waste, WHO (2005) has revealed in a study that two thirds of hospitals in 22 countries, mostly developing countries including Nigeria were not following the proper infectious waste management practices. The inference from this study is that about one third of the health facilities were properly managing their biomedical waste. Unfortunately, research efforts aimed at explaining the biomedical waste management practices in Nigeria are few and limited in scope (Abah, and Ohimain, 2011; Ogbonna, Chindah and Ubani, 2012; Ibijoke, Babajide, and Rafid, 2013). Few researchers have also been preoccupied with empirical studies undertaken to identify the public health implications of poor handling of biomedical waste (Coker and Sridhar, 2010) while the effects of the poor handling on the healthcare workers

themselves have received less research attention. This study seeks to fill this gap in knowledge by examining the effects of biomedical waste management practices on the healthcare workers using Ile-Ife, Osun State as example. Another merit of this study is that both public and private hospitals of different hierarchy of healthcare facilities were included in the study. This is not the case in most of the previous studies which focused more on teaching hospitals (Sawyerr, Adeolu, Salami and Adejoh, 2016; Toyobo, Baba, and Oyeniyi, 2012).

ISSUES IN BIOMEDICAL WASTE MANAGEMENT

WHO (2012) has categorised biomedical waste as follows: Infectious waste (Anything that may be infectious or that is infectious goes into this category. This may include excreta, swabs, equipment, tissues and lab cultures); Sharps (This type of medical waste includes scalpels, needles, broken glass, lancets, staples, razors, trocars, wires or anything else that can pierce the skin); Pathological (Any human tissue, fluids, body parts, blood, bodily fluids and contaminated animal carcasses); Radioactive (Unused radiotherapy liquid, lab research liquid, glassware and other supplies and equipment that may be contaminated with lab research liquid or radiotherapy liquid); Pharmaceuticals (This includes any expired, unused and contaminated drugs and vaccines. Injectables, antibiotics and pills also fall into this category); Chemical (Solvents, disinfectants, batteries and any heavy metals that are found in medical equipment such as mercury from thermometers); Genotoxic waste (This medical waste is highly hazardous and is mutagenic, carcinogenic or teratogenic. Cytotoxic drugs that are used in cancer treatment also fall into this category).It has been roughly estimated that about 1 to 1.5 kg/day/bed of biomedical waste is produced by hospitals in developing countries while waste produced in developed countries' hospitals has been quoted up to 5.24 kg (WHO, 2015).

It has been established that, the hazards of exposure to biomedical waste can range from gastro-enteric, respiratory, and skin infections to more deadly diseases such as HIV/AIDS, and Hepatitis (Rao, 2008). For instance, WHO (2012) reported 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). As documented by (Rao, 2008), 2 million new Hepatitis B, 400,000 Hepatitis C and 30,000 HIV positive cases occur in a year due to needle prick injuries in India. Van Schalkwyk (2013) further asserts that the risk of being infected by HBV, HCV and HIV for a person who experiences one needle stick injury from an infected needle is 30%, 1.8% and 0.3% respectively.

According to WHO (2013), biomedical waste management involves waste generation, sorting (separation), collection, treatment, storage, transportation and disposal. The management of biomedical waste varies between the developed and less developed countries owing to their level of economic prosperity, technological advancement and availability of adequate regulations (Diaz and Savage, 2003; Abah, and Ohimain, 2011; Babanyara, 2012). Considering

the global impact of poor biomedical waste management and the need to ensure safety in these practices, standard measures for managing biomedical waste have been established by international organizations, countries' agencies and known scholars in the field of health care waste management. These standard practices are reviewed and used to assess the level of compliance by the sampled health care facilities in Ile-Ife in this paper.

WHO (2014) has outlined several safe methods of biomedical waste treatment which include: incineration (controlled combustion process where waste is completely oxidized and harmful microorganisms present in it are destroyed under high temperature); Autoclaving (low-heat thermal process where steam is brought into direct contact with waste in a controlled manner and for sufficient duration to disinfect the wastes);Microwaving (Microbial inactivation through inter-molecular heating process which occurs inside the waste material in the presence of steam); Hydroclaving (indirect heating of waste by applying steam in the outer jacket. The waste is continuously tumbled in the chamber during the process); Shredding (a process by which waste are cut into smaller pieces so as to make the wastes unrecognizable. It helps in prevention of reuse of bio-medical waste and also acts as identifier that the wastes have been disinfected and are safe to dispose of).

Waste sorting should be carried out immediately the wastes are generated to separate all hazardous biomedical waste from the non-hazardous general waste. For safety of staff and patients, the hazardous waste portion should be separated into two parts: used sharps and potentially infectious items such as bandages, disposable medical items, swabs and tissues (Hotel Services Manager,2005). Consequently, the segregation of non-hazardous waste, potentially infectious waste and used sharps into separate containers is often referred to as the "three-bin system" (WHO, 2013). To make it easier for medical staff and hospital workers to put waste items into the correct container, and to maintain segregation of the wastes during transport, storage, treatment and disposal as well as providing a visual indication of the potential risk posed by the waste in that container, colour coding should be introduced. WHO (2014) has recommended the following colour coding: Yellow, marked "HIGHLY INFECTIOUS" with biohazard symbol for highly infectious waste, Yellow, marked "SHARPS", with biohazard symbol for sharps and black for non-hazardous waste. Infectious wastes are to be stored in strong, leak-proof plastic bag, or container capable of being autoclaved, sharps are to be stored in puncture-proof container while non-infectious waste are to be stored in plastic bag. The waste central storage area(s) within a medical facility should be fenced, lockable and isolated from patients and the public (Kharat, 2016). The maximum storage times before treatment or disposal of infectious waste are not longer than 72 hours in winter and 48 hours in summer in temperate climate while in tropical climate, the storage times should not be more than 48 hours during the wet season and 24 hours during the dry season.

Transportation of biomedical waste has two phases. The first phase is waste movement from the points of generation to storage site within a medical facility otherwise known as on-site transportation while the second phase is the waste movement from the medical facility to disposal sites outside the facility otherwise known as off-site transportation (Palanisamy, Sivaraman, Babu and Athimoolam, 2011). For on-site transportation, hazardous and non-hazardous waste should always be transported separately in order to prevent possible spread of infectious agents. Waste trolleys painted in black and labeled "Non-hazardous waste" should be used in transporting non-hazardous waste while infectious waste should be transported with trolleys coloured in the appropriate colour code for infectious waste (yellow) and labelled with an "Infectious waste" sign (WHO, 2014). For off-site transportation, the most important requirement is for the vehicle transporting hazardous waste to be roadworthy and labelled to indicate its load, and its payload to be secured to minimize the risk of accidents and spillages (WHO, 2015). Any vehicle used to transport health-care waste should fulfill several design criteria: Vehicles or containers used for transporting health-care waste should not be used for transporting any other material. Vehicles should be kept locked at all times, except when loading and unloading, and kept properly maintained.

There are several ways of disposing biomedical waste but the most hygienic option is sanitary landfill. A sanitary landfill is designed to minimize contamination of soil, surface water and groundwater; limit atmospheric releases and odours; block access to waste by pests and vectors; and prevent contact with the public. Where sanitary landfills are not available, as in many Nigerian small and medium sized cities, safe burial of biomedical waste on hospital premises have been advocated (Visvanathan, (2006). (Oli, Ekejindu, Adje, Ezeobi, Ejiofor, Ibeh and Ubajaka, 2016) have however, maintained that to adopt this option the following safety measures must be established: access to the disposal site should be restricted to authorized personnel only; the burial site should be lined with a material of low permeability, such as clay, dung and river silt, if available, to prevent pollution of shallow groundwater and nearby wells; new water wells should not be dug near the disposal pit; only infectious health-care waste should be buried because if non-infectious waste were also buried on the premises, available space would be quickly filled.

An important aspect of biomedical waste management is the use of personal protective equipment (PPE) and other safety practices in handling the waste. Before handling biomedical waste, waste workers must be fully kitted with necessary PPE such as boots, gloves, safety glasses, hard hats, dust masks and impervious clothing (Ozder, Teker, Eker, Altındis, Kocaakman and Karabay, 2013). Boots should have steel toes and puncture-resistant soles and 6 inch lace-up cover to provide added protection for the ankles. Gloves should be worn whenever the hands may come in contact with the waste. Safety glasses and hard hats may also provide protection to the head and face from splashes. Other skin surfaces should be covered with impervious clothing whenever the skin might be exposed to infectious agents. Special

equipment, such as respirators, face shields and boot covers may be necessary if splashing or splattering is expected, or if another unusual hazard arises (Manyele, 2014).

3.0 STUDY AREA AND METHODOLOGY

3.1 Study Area

Ile-Ife is an ancient Yoruba city in south-western Nigeria. It is located in present day Osun State. The city is about 218 kilometers northeast of Lagos and 75 kilometers east of the city of Ibadan and connected to it through the Ife-Ibadan highway; Ife is also 40 km from Osogbo and has road networks to other cities such as Ede, Ondo and Ilesha.The main city of Ife is divided into two local government areas: Ife East, headquartered at Oke-ogbo and Ife central at Ajebandele area of the city. Both local governments are composed of a total of 21 political wards. The city has an estimated population of 355,813 people (Yoade, 2015). It is located between latitudes 7°28′N and 7°45′N and longitudes 4°30′E and 4°34′E. Ile-Ife has an undulating terrain underlain by metamorphic rocks and characterized by two types of soils, deep clay soils on the upper slopes and sandy soils on the lower parts (Yoade, 2015). It has average rainfall of 1,000–1,250 mm usually from March to October and a mean relative humidity of 75% to 100% (Ajala and Olayiwola, 2013). Ile-Ife has about 35 health facilities with a teaching hospital, one general hospital, one specialist hospital, one comprehensive health centre and thirty-one primary health centres. Wastes generated from these facilities are often mixed with municipal waste and are deposited in the two dumpsites provided by the municipal authorities in the city (Nwosu and Pepple, 2016).

3.2 Methodology

This study used the data that were collected from selected health care facilities in Ile-Ife, Osun State in Nigeria. The data were collected between April and June, 2016 with well structured questionnaire comprising of four distinct modules. The first module contained information on selected healthcare facilities, the second contained information on the facilities waste management practices, the third was on staff involvement in waste management, and the fourth contained information on the occupation health risks associated with the facilities' waste management practices. Out of the 35 health care facilities in Ile-Ife, one is a teaching hospital, one is a general hospital, one is a specialist hospital, one is a comprehensive health centre while the remaining 31 are primary health centres. From preliminary investigations, it was observed that the four higher order health care facilities had some level of sophistication in their biomedical waste management practices while there were no organised waste management practices in any of the primary health centres. Consequently, the 31 primary health centres were excluded from the study. Two waste workers in each sampled facility were selected for survey. In order to determine the level of staff involvement in waste management and the health risks associated with the waste management practices of the sampled health care facilities, two staff (one Doctor and one Nurse) in each department and unit of the facilities were randomly selected

for survey. Thus, the Teaching Hospital with 15 departments had 30 respondents, General Hospital with 8 departments had 16 respondents, the Comprehensive Health Centres with 3 departments had 6 respondents, the specialist hospital with 4 departments had 8 respondents. Hence, 60 questionnaires were administered in the sampled health facilities. To determine the volume of the waste collected, hand-held scale was used to measure the biomedical waste after they had been segregated from the general waste. Descriptive statistics (frequency and percentages) and inferentialstatistics (multinomial logistic regression) were used in analyzing the data collected.

4.0 RESEARCH RESULTS

The findings of the study are presented under the various sub-headings below. Unless otherwise stated, all the tables in this section emanated from the survey carried out by the authors in 2016.

4.1 Types and Volume of Waste Generated

Sharps, infectious and pathological waste constituted the major waste being generated in the sampled establishments.There was a preponderant of sharps (used cannulas, needles, surgical blades, vial injections, syringes) constituting the major component of the waste generated in the sampled healthcare facilities (96.7%). Others are dressing swarbs (39.1%), human tissue (32.3%), excreta (33.8%), blood or other body fluids (24.7%). A total of 642.3 kg of these wastes were generated daily in these facilities. The bulk of the waste was generated by the teaching hospital (395.4 kg), while the general hospital, comprehensive health centre and specialist hospital generated about 154.3 kg, 62.5 kg and 48.4 kg respectively. The per capita waste for the teaching hospital was computed to be 0.75 kg while the per capita waste for the general hospital, comprehensive health centre and the specialist hospital were 0.47 kg, 0.34 kg and 0.29 kg respectively. Thus, the average per capita waste was 0.51 kg.

4.2 Waste Sorting

Waste sorting is an important and recommended practice in biomedical waste management. It ensures appropriate handling, treatment and disposal of waste by types thereby reducing the costs of biomedical waste management and protecting the public health. Findings from the sampled facilities indicated that none of the sampled healthcare facilities sorted its wastes before other subsequent phases of waste management are carried out. The non-sorting of waste was due to less time dedicated to waste management because of the need to carry out other engagements in the establishment (Comprehensive health centre and general hospital) as well as inadequacy of personal protective equipment to carry out the sorting (Teaching hospital, specialist hospital and comprehensive health centre).

4.3 Waste Collection and Storage

With the exception of the teaching hospital, other healthcare facilities did not collect waste on daily basis. The frequency of waste collection from the waste bins at the general hospital and comprehensive health centre was two days while waste collection at the specialist hospital took three days. None of the sampled healthcare facilities used labeled bags with appropriate colour codes indicating the waste content of the bags and points of production (wards, laboratories etc) to collect the biomedical waste as recommended by WHO (2014). Instead, polythene bags and metal bins were used in the teaching and general hospital while plastic waste bin was used in the comprehensive health centre and the specialist hospital. Furthermore, contrary to the WHO (2014) recommendations for ideal storage facilities for biomedical waste, the storage area of all the sampled facilities were not shielded from the sun, accessible for animals, insects and birds and did not have hard-standing floor with good drainage. However, the storage areas offered easy access for staff in charge of waste handling and waste collection vehicles as recommended by WHO (2014). Moreover, the waste storage time (i.e. the delay between production and treatment) in all the sampled healthcare facilities did not follow the global best practice. While WHO (2014) recommended maximum of 48 hours (2 days) during wet season and 24 hours (One day) during dry season for waste storage in the tropical region such as Nigeria, the earliest period for waste storage in all the sampled facilities was three days. It took about three days for waste to be stored in the teaching hospital, five days in the general hospital and comprehensive health centre and 6 days in the specialist hospital.

4.4 Waste Treatment

The key motive for biomedical waste treatment is to reduce the potential hazard posed by the waste to humans, animals and the environment to the barest minimum. Basically, there are about seven different techniques of waste treatment (WHO, 2014). These include: incineration, sterilization, disinfection, shredding of wastes, autoclaving, microwaving and encapsulation. Findings from the sampled health facilities indicated that only the teaching and general hospitals used incineration and disinfection as waste treatment techniques regularly, the comprehensive health centre employed sterilization and disinfection periodically but regularly employed open burning while the specialist hospital relied on disinfection and open burning.

4.5 Waste Transportation

On-site transportation of waste was done through push carts in the teaching hospital and general hospital while in the comprehensive health centre and the specialist hospital, the practice was to carry the waste containers to the on-site storage facilities. For off-site transportation of the waste, only the teaching hospital and the general hospital used waste trucks to transport their waste directly to the public disposal site while the comprehensive health centre and specialist hospital relied on public waste trucks to transport their waste to the disposal sites.

4.6 Waste Disposal

Ile-Ife had no sanitary landfill site, therefore, all the sampled healthcare facilities disposed their biomedical wastes in the two dumpsites provided by the municipal authorities in the city. It should be noted that these dumpsites were opened and serious control of dumping was not ensured. With the exception of the teaching hospital and general hospital that transport their waste directly to these dumpsites, other sampled facilities disposed their waste in the municipal stationary waste containers for transportation to the dumpsites by the municipal authorities. In addition, three of these establishments engaged in pit burial of the waste.

4.7 Use of personal Protective Equipment

Personal protective equipments being used in all the sampled healthcare facilities were boots, gloves, and dust masks. While waste management workers in the teaching hospital and general hospital used all the three equipments, the workers in the comprehensive health centre used only gloves and dust masks.

5.0 STAFF INVOLVEMENT IN BIOMEDICAL WASTE MANAGEMENT

5.1 Year of Service

Analysis of the data revealed that 64.5% of the sampled staff had worked in their respective establishments for between 7 and 9 years. Some 14.2% had worked for 4 to 6 years, 8.4% had worked for between 1 and 3 years, 7.8% had worked for more than 10 years while 5.1% had worked for less than a year. The result implies that majority of the respondents were sufficiently knowledgeable to assess the waste management practice of their respective establishments.

5.2 Method of Waste Collection

Plastic and metal bins were mostly used in all the sampled establishments for waste collection as stated by 78.2% of the respondents. A further disaggregation of the data revealed that metal bin was mostly used in the teaching hospital and the general hospital as indicated by 82.4% and 71.6% of the respondents working in the establishments respectively. Plastic bin was mostly used in the comprehensive health centre as stated by 88.2% of the respondents working in the establishment while 74.3% of the specialist hospital staff indicated polythene as the main means of collecting waste in their establishment.

5.3 Waste Sorting

Majority of the staff of the teaching hospital (76.2%) stated that the wastes from their units were normally sorted before collection. However, fewer percentages of the respondents from the general hospital (37.6%), comprehensive health centre (31.0%) and specialist hospital (14.5%) stated that they did sort their wastes before disposal. This result corroborates the finding from the waste management staff (See section 4.2).

5.4 Rating of Waste Management Practices

The respondents were asked to rate the biomedical waste management practices of their establishments. This expectedly generated diverse responses. Some 40.2% stated that the waste management practice in their establishment was good, 38.6% indicated fairly okay while 21.2% considered the waste management practice in their establishments poor. A further disaggregation of the data revealed that 50.1%, 32.5%, 14.4% and 8.2% of the respondents in teaching hospital, general hospital, comprehensive health centre and specialist hospital respectively stated that their the waste management practice of their establishment was good. Also, 31.2%, 20.4%, 10.5% and 10.2% of the respondents in teaching hospital, general hospital, comprehensive health centre and specialist hospital respectively stated that the waste management practice of their establishment was fairly okay while those that considered the waste management practices of their establishments poor accounted for 11.1% in the teaching hospital, 18.6% in the general hospital, 28.8% in the comprehensive health centre and 41.5% in the specialist hospital.

6.0 CHALLENGES OF BIOMEDICAL WASTE MANAGEMENT

A number of challenges associated with biomedical waste management were identified by the respondents. This includes physical injuries and infections.

6.1 Injuries from Contact with Sharps

About 52.3% of the respondents had incurred injuries from waste handling or accidental contact with waste (21.8%) especially sharps. Larger percentage (31.6%) was from the comprehensive health centre, followed by the general hospital (20.4%), teaching hospital (12.8%) and specialist hospital (8.5%).

6.2 Infections from Contact with Waste

A number of respondents have had infections as a result of either exposure to harmful chemical and radioactive waste (42.3%) or deliberate contact with biomedical wastes (such as in the process of waste sorting or disposal) (26.5%). The general hospital recorded the highest rate of infection (62.3%), followed by comprehensive health centre (51.5%), specialist hospital (42.2%) and teaching hospital (21.8%).

6.3 Types and Frequency of Infection

Tetanus (40.1%) and hepatitis B (37.2%) were the most frequent infections resulting from contact with biomedical waste. Other infections as indicated by the respondents were dysentery (13.4%), pneumonia (6.2%) and malaria (3.6%). The general hospital recorded more tetanus (42.6%) than the teaching hospital (30.5%), comprehensive health centre (26.2%) and specialist hospital (21.4%). More staff of the teaching hospital (61.2%) has had tetanus than the general hospital (50.6%), specialist hospital (43.4%) and comprehensive health centre

(39.1%). Moreover, 16.5%, 11.3% and 9.4% of the respondents in the comprehensive health centre, teaching hospital and general hospital respectively have had hepatitis B while none of the respondents in specialist hospital reported this.Majority (60.8%) of the respondents did experience waste-related infections twice in a year, 20.5% experienced it once in a year, 8.4% experienced it four times in a year while 11.2% experienced waste-related infections occasionally.

6.4 Cost Bearer of Injuries and Infections Treatment

As stated by all (100%) the respondents from teaching hospital and general hospital, the cost of treatment of injuries and infections associated with biomedical waste management was bored by the management of the two establishments while all (100%) respondents from the comprehensive health centre and specialist hospital reported that treatment cost is shared by the management and the affected staff. Cost sharing takes place when medical services (consultation) are provided free to affected staff while the staff bears the cost of drugs.

A question deserves an answer in this analysis. Can it be said that the biomedical waste management of the sampled medical establishments influenced the rate and type of infections afflicting their staff. This question prompted the formulation of a hypothesis as follows: infections are not a function of biomedical waste management practices. The hypothesis was analysed using multinomial logistic regression. Infection of staff was regressed against biomedical waste management variables. They are: waste collection, waste sorting, waste treatment, waste storage, waste transport and disposal. The result of the analysis is presented in Table. The multinomial regression model derived from the analysis is given as: $Y = 53.064 + 36.325x_1 + 74.613x_2 + 41.251x_3 + 20.592x_4 + 21.642x_5 + 16.764x_6$.

The 2-log likelihood of the model which is 53.064 indicates a direct positive relationship between the independent and predictor variables. The Nagelkerke pseudo r2 of 0.791 shows that, the six independent variables accounted for 79% of the variation in the rate and types of infections. All the predictors in the model exert positive influence on the frequency and types of infections. Waste sorting with 74.613 influences infections most. This is followed by waste treatment with 41.251, while waste collection, waste treatment, waste storage and waste disposal with 36.325, 21.642, 20.592 and 16.764 respectively exert moderate positive influence on the rate and types of infections suffered by the staff of the sampled healthcare establishments. Thus, given the present biomedical waste management practices among the healthcare facilities, a unit increase in any of the independent variables will lead to increase in infections and vice versa.

7.0 DISCUSSION

There is a preponderance of sharps (or radioactive waste) in the biomedical waste stream of the sampled healthcare facilities. This finding conforms with WHO's (2014) assertion that sharps usually constitute the larger component of biomedical waste in developing countries. It should, however, be noted that the high sharps component of the biomedical waste constitutes a potential danger to the healthcare facilities waste handlers especially where there is inadequate personal protective equipment such as hand gloves, boots, safety glasses and hard hats to effectively shield the handlers from injuries from the sharps which might open the door for other deadly infections. Studies have shown the likely consequences of human contact with sharps (Rao, 2008; WHO, 2012). The per capita waste generation from the sampled health facilities (0.51kg) is a slight departure from the WHO's (2014) report that 0.54 to 1.39 kg/bed-day of biomedical waste is generated in health care facilities in developing countries. There was partial compliance with the World Health Organisation's recommended biomedical waste management practice including collection, sorting, treatment, storage, transportation and disposal. For instance, metal and plastic collection bins were used by the sampled healthcare facilities for biomedical waste collection. This to some extent is hygienic and close to the recommended bins by WHO (2014). However, none of the sampled healthcare facilities used labeled bags with appropriate colour code indicating the waste content of the bags and points of production as recommended by WHO (2014) to pack their wastes. Contrary to the recommended global best practice of biomedical waste storage time not exceeding between one and two days in the tropical region (Nigeria is in tropical region), biomedical waste storage in the sampled facilities took an average of five days before they are transported to disposal sites. Three-quarter of the sampled healthcare facilities did not sort waste before disposal. Three-quarter of the sampled facilities did not treat the biomedical waste before storage, despite WHO (2014) recommendation that biomedical waste should be treated either by incineration, autoclaving, microwaving, hydroclaving or shredding before storage. Considering the harmful nature of biomedical waste, non-treatment of the waste before storage, makes the waste management staff in particular and other staff and even patients highly susceptible to deadly infections if contact is made with the waste. Biomedical wastes have been found to contain highly communicable pathogens such as staphylococcus (Sridhar and Ayeni, 2003). This explains why majority of the sampled staff of the healthcare facilities have had infections as a result of contact with biomedical wastes in their respective establishments.

Half of the sampled facilities disposed their biomedical waste in public stationary waste containers while all the sampled healthcare facilities disposed their biomedical waste in the public uncontrolled dumpsites in the city. Similar findings were made in an earlier study by Agbola et al. (2009) in Ibadan where biomedical waste were dumped either in public stationary containers, designated communal dumpsites or open dumpsites. Thus, not only the staff and patients of the healthcare facilities are exposed to dangers through the biomedical waste management practices of these facilities, but the public especially the waste scavengers and

young ones are rendered vulnerable to deadly infections. This results from the usual search for the disposed wastes for recyclable/reusable items and materials to play with respectively.
Injuries and infections were the major health challenges experienced by the employees of the healthcare establishments as a result of improper biomedical waste management. Thus, tetanus, hepatitis B, dysentery, pneumonia and malaria were frequently reported by the sampled employees. This agrees with similar study conducted in UK by Banu and Shetty (2010) where it was reported that in the period of 1996 to 2004, 2,140 people got occupational exposures to blood borne viruses with 21% of the injuries occurred during the disposal process. A similar study in Mexico City by Johnson, Gonzalez, Duenas, Gamero, Relyea and Luque (2013) revealed that out of 69 interviewed waste handlers 34% reported 22 needle stick injuries during the first 12 months of operation. This finding is reinforced by the result of the hypothesis which indicates that waste collection, waste sorting, waste treatment, waste storage, waste transport and disposal exert positive influence on the rate and types of infections suffered by the staff of the sampled healthcare facilities.

CONCLUSION

As noted earlier, researchers have been preoccupied with investigating the public health implications of poor handling of biomedical waste while the effects of the poor handling on the healthcare workers themselves have received less research attention. Thus, this study has filled an important gap in knowledge by establishing that poor management of biomedical waste by healthcare facilities makes the healthcare workers themselves more susceptible to deadly diseases or infections. Understanding the effect of poor biomedical waste management on the healthcare workers is required for evolving or adoption of a better management practices for safe, healthy and effective biomedical waste management in the healthcare centres. It is however, pertinent to note that this study relied essentially on questionnaire administration to determine the type and frequency of infections the healthcare workers had experienced, efforts are needed to clinically determine the magnitude of susceptibility to infections and the linkage of the identified infections to poor biomedical waste management in the sampled healthcare facilities. Furthermore, the findings of this study indicate that healthcare workers in Nigeria and other developing countries are faced with the challenges of accidental contraction of infections due to improper management of biomedical waste in their respective healthcare facilities. This also applies to waste management sector generally, where non application of appropriate technology for managing wastes by waste management agencies is capable of exposing the waste handlers to serious diseases.

The above observations suggest that a better approach to biomedical waste management practice is imperative. The paper therefore, holds that solutions to the challenges of biomedical waste management practices lie in strict adherence to the global best practices as recommended by the World Health Organisation. In addition, the State and Local Governments should ensure the establishment of a sanitary landfill in the city for general and biomedical waste disposal.

Dumpsite is being phased out globally due to its numerous threats to public health such as: pollution of groundwater, highly toxic smoke from continuously smoldering fires, foul odour from decomposing refuse, health hazards to waste pickers and spread of infectious diseases (*Powell, Townsend, Zimmerman, 2015)*. In order to avert possible threat to public health, there is also the need to raise awareness among residents especially those living close to dumpsites and the waste pickers on the dangers of carelessly searching through disposed waste without using protective equipment such as boot, gloves, nose cover and eye glasses. The awareness can be accomplished through close collaboration among the waste management agency, state ministry of environment, local government's departments of environmental health services and community development as well as the community development associations in each neighbourhood.

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