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A Study to Assess the Status and Challenges of Medical Waste Management Practices in a University Health Institution, Southern Nigeria

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ABSTRACT

Introduction: Medical waste includes all types of waste with potential characteristics to spread diseases, generated from healthcare institutions. Objective: The study was carried out to assess the status and challenges of medical waste management practices in Delta State University Teaching Health Institution. Methodology: A cross-sectional survey was carried out between March and August 2019. Multistage sampling approach comprising of purposive sampling and case study approach was employed for the study. The approach involved estimating the quantity of medical waste generated and the evaluation of waste management strategy used by the healthcare institution. A total of 240 respondents were sampled. Collected data were subjected to statistical analysis using SPSS version 21. Result and discussion: Average total weight of waste generated from the departments was estimated to be 948.366 kg/day. Medical waste generation rate was 13.598 kg/patient/day with an average bed per day generation rate of 1.133 kg/bed/day. Kitchen department had the highest generation rate of (254.448 kg/day) whereas the least generation rate was from NET (9.11 kg/day). It was observed that segregation of waste at source exist but poorly implemented and monitored as medical waste was still being mixed and dumped with general wastes that were collected, transported and disposed. Segregation was not carried out in line with NHCWMP standards. Waste generated were collected on a daily base and transported to a designated place for temporary storage. Lidded plastic container, storage house, hand cart, waste skip and wheeled trolley were mainly used to store and transport waste. The institution lack sufficient waste containers to handle volumes of medical waste. The result revealed that higher percentage of waste handlers were poorly educated and irrespective of the availability of PPE; they were observed to be wrongly used by waste handlers. Land fill was revealed to be the most preferred final disposal option but occasionally incineration and open pit burning were also adopted. Conclusion: This study has helped to establish a baseline data on medical waste management strategy in Delta State University Teaching Health Institution.

INTRODUCTION

The challenges of medical waste management and its final disposal practices including other toxic hazardous wastes has become a rapidly growing global concern recently dived into my researchers in order to proffer solution to the potential risks posed to the general public. Advancement in health programs has increased the challenges of medical waste management globally, particularly in the developing countries (DaSilva *et al.,* 2005; Al Emad 2011). Generally, waste from the medical sector has been defined by several scholars to include materials that are generated in the course of health protection, medical diagnosis, treatment and scientific research, immunization of humans and testing of biological specimen (Ramokate and Basu, 2009; Mbu, 2015). Medical wastes are classified as a potential reservoir of pathogenic organisms that requires reliable, safe and appropriate handling techniques (Abor and Anton, 2008). It is an environmental and public health issue that requires immediate attention in both industrialized and developing countries.

Poor management of medical wastes result in adverse impacts on the health of the public as well as deteriorating the quality of the environment with the most common reoccurring issues on its management to include the occupational safety of the workers handling the waste and safe disposal of the materials generated (Ananth *et al*., 2010). Persons most exposed to the potential risk from the improper handling and management of medical wastes include professional and non-professional staff of the medical centres, waste handlers, hospital patients and their visitors (Arab *et al.*, 2008). A reasonable number of researchers have reported that the inappropriate handling and disposal of medical waste poses potential risks to health workers who may be directly exposed to the health facilities as well as people who reside close to the facilities, especially children and scavengers who may become severely exposed to infectious waste materials and life threatening diseases such as HIV/AIDs, hepatitis B and C (WHO, 2002, 1999; Oke, 2008; Coker *et al*., 2009; Path, 2009; Adegbita *et al*., 2010). In addition to health risk from medical wastes, threat to the environment equally needs to be considered; this includes contamination of soil, water sources and poisonous emissions from improper burning. In the long run, waste from medical facilities does not only impair the quality of life but as well affect the welfare of the entire people where the facilities are sited (Bathma *et al.,* 2012; Nwachukwu *et al.,* 2013).

The disposal of medical waste in uncontrolled sites has been reported by scholars from other countries to have a direct environmental impact by contaminating the soil and ground waters (Ananth *et al*., 2010). Chemical residues discharged from medical establishments into sewerage system have been reported to adversely affect the operations of biological sewage treatment plants as well as the natural ecosystem of the receiving water bodies (Omofunmi *et al.,* 2016). Similar challenges have equally been acknowledged from pharmaceutical residues like antibiotics and other drugs, phenol and derivatives, disinfectants and antiseptics. Chemical materials stored in torn bags and containers, directly impact negatively on the health of workers whom comes in direct contact with them (Mbu, 2015).

Improper management of medical waste can create serious health threatening challenges especially threats to the health and safety of the workers and the environment where the facilities are sited (Ali and Kuroiwan, 2009). In countries like Nigeria, where many health concerns are competing for limited resources, it is not surprising that medical waste management has received less attention and priority it deserves from stakeholders and government (Abah and Ohimain, 2011). Although, reliable quantitative data on the nature and quantity of waste from medical facilities and the appropriate management techniques to adequately dispose of these wastes has remain a challenge in many developing countries around the world. It is believed that several hundreds of tons of waste from the health sector are deposited openly in waste dumps and surrounding environments, often alongside with other solid waste materials (Alagoz and Kocasay, 2007; Abah and Ohimain, 2010). In Nigeria, there is neither available database nor records on the quantity and nature of waste generated from the health sector. Waste from this sector which poses serious life threatening potential risk on environmental health has been reported to be at the ground floor on issues with priority from the government. Available evidence revealed that medical waste are handled and managed in line with other solid wastes that are generated on a daily base (Edmund, 2012). Several hospitals are seemed to dispose their waste in dustbins, drains and canals as well as dumping on the outskirts of the towns. Such disregard to protecting the general health of the public occurs as a result to lack of awareness, low waste management skill, lack of waste treatment facilities and systems, nonchalant attitude of the coordinating ministries and agencies; bribery and corruption among health inspectors. The challenge is getting worse on a daily base with rapid spread in numbers of health centres, government owned general hospitals, private clinics and diagnostic laboratories across the country (Mokuolu, 2009).

The rapid increase of healthcare institutions in Delta State exerts a tremendous impact on human health ecology. Estimate suggests that there are more than 625 healthcare centres existing in the state (Ibekwe, 2015). These facilities generate hazardous and toxic wastes in hundreds of tons on daily operations. Only a few have the necessary requisite and facilities to safely manage the wastes. The current strategy reportedly used in handling these wastes in Delta state is a player to positively contributing to the spread of infectious diseases. The generated liquid and solid wastes contain toxic and infectious materials that are simply disposed into the nearest drain and garbage heap respectively; thereby posing risk to waste pickers and scavengers that picks up scrap from these garbage dumps. Very few studies have been carried out on medical waste in Nigeria particularly in

Delta State and presently, considerable gap exist in literature with regards to the assessment of medical waste management practices in the state; hence the need for this study. The main objective of this study is to assess the status and challenges of medical waste management practices in Delta State using the State University Teaching Health Institution as case study.

RESEARCH DESIGN AND METHODOLOGY

Study Area

Delta State University Teaching Hospital, Oghara with the acronym DELSUTH is a health institution visited by people of different race, age group, gender and religion when medically unfit. The health institution is located at Oghara main town in Ethiope West Local Government Area of Delta State. It lies at latitude 5°35'11.99" N and longitude 6°06'0.60" E (see Figure 1). The health institution is 17 m above sea level and sited in a town covering an area of 1,175 km^2 within the tropical rain forest belt of Nigeria (Ibekwe, 2015). The health institution is a renowned and National University Commission (NUC) accredited University Teaching Hospital owned by Delta State Government. It was built as an initial 180-bed capacity ultra-modern specialist hospital and upgraded to 250-bed capacity. Other important close landmarks include: Nigerian Naval Logistics Headquarters, Mopol 51 Base of the Nigeria Police Force, Local Government Council headquarter, Pan Ocean Flow Station and Gas Plant, Delta Polytechnic, Otefe and Western Delta University. The health institution renders services to an estimated adult population of 288,070 (Ibekwe, 2015) with over 2,064 staff strength comprising of 230 medical doctors and 572 nurses (see Table 1).

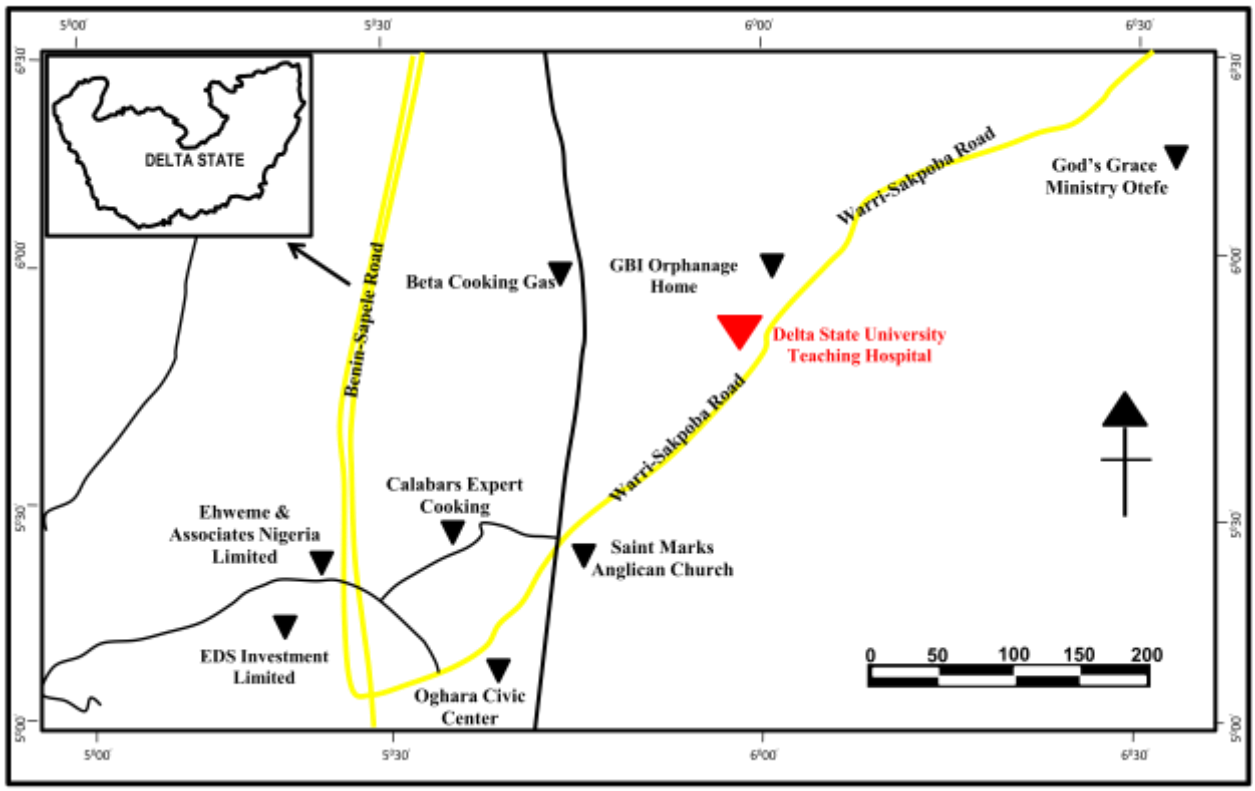

Fig. 1: Map of Oghara showing the Health Institution

Table 1: Characteristics of the health institution

Characteristic	Strength
Number of beds	250
Approximate number of health care workers (post registration)	532
Consultant Clinicians	94
Doctors	230
Nurses	572
Pharmacists	23
Out-patient attendance in the previous year (2018)	28,416

Source: Fieldwork, 2019

Research Design

The study adopted a cross sectional survey to assess the status and challenges of medical waste management practices in Delta State University Teaching Health Institution, Oghara from March to August 2019. It made use of a multistage sampling approach. Firstly, a purposive sampling approach was employed in selecting the respondents. Out of 240 respondents selected for the study, 50% were health workers in different areas of specialty like doctor, nurse; laboratory technologist and pathologist who are the primary generators of these wastes during the course of carrying out their professional duties (see Table 2). The balance 50% of respondents are waste handlers, out-patients and residents in the community. Solid waste sampling was performed once per day from each department within the health institution; weighed daily for 60 days and quantity recorded according to its classification (see Table 3) over a period of 6-months to determine the generation rates. The methodology applied also consisted of questionnaire survey and in-depth interview with the sampled respondents. The information was collected using forms specifically developed for this purpose. Site visits was conducted to support and supplement information gathered in the survey. Interviews and site visits was helpful in obtaining information about common practices in the management of wastes. Questionnaires were developed from studying previous research on this area, so that they would cover all basic requirements needed for the study. Self administered questionnaire was adapted from WHO recommendation assessment tool. Pre-testing of questionnaire was made to assess the validity of the questions out of the study area. Spot-checks and review of the completed questionnaires were made daily by the researchers to ensure completeness and consistency of the information collected. Collected data were then subjected to further statistical analysis.

Table 2: Breakdown of respondents for the study

S/N	Profession	No of questionnaire administered	Percentage
1	Doctor	30	12.5
2	Nurse	30	12.5
3	Laboratory Technologist	30	12.5
4	Pathologist	30	12.5
5	Waste Handler	40	16.7
6	Out Patients	40	16.7
7	Residents	40	16.7
	Total	**240**	**100**

Source: Fieldwork, 2019

Ethical approval

Ethical approval was obtained from the ethical approval committee of the Delta State University, Abraka. A formal letter of introduction collected from the Department of Industrial Safety and Environmental Management, School of Marine Technology, Burutu, Delta State was given to the University and permission secured. To clear any misconceptions about the intention of the study, participants were informed on the purpose of the study, benefits and harms of participation. After verbal consent was obtained from each participant, questionnaires were distributed to participants and filled in the presence of the data collectors. Codes were given to participants instead of names to keep their responses confidential.

Statistical Analysis

The questionnaires were cleaned, coded and data were entered into Statistical Package for the Social Sciences (SPSS) version 21 software and analyzed. Frequency count and percentage table was used in analyzing the demographic and socioeconomic characteristics of the respondents.

RESULTS AND DISCUSSION

This study was designed to assess the status and challenges of medical waste management practices in Delta State University Teaching Hospital in order to ascertain if the waste management procedure applied meets WHO standard for healthcare waste management. To achieve these set out objectives; respondents of varying categories were engaged with typeset questionnaires and personal interview. Data collected were subjected to descriptive and statistical analysis. Presented in Table 3 is the categories of medical waste as outlined by WHO (2004). Table 4 contains summary details of generated waste in the study area from March to August 2019. The demographic and socio-economic representation of the sampled respondents are presented in Table 5, whereas Figure 2 displays working experience between health workers and waste handlers. Perceived facilities for the collection and segregation of medical waste are shown in Table 6. Table 7 displays facilities for storage and transportation of medical waste; so also is Table 8 which revealed with details on the perceived facilities for the treatment and disposal of waste. Table 9 revealed the conditions of facilities for waste handler and Table 10 deals with details on the condition of waste storage facilities. Respondents perceived categories of medical waste

generated in the study area are displayed in Table 11; and Table 12 shows the perceived impact of medical waste on the respondents. Analysis on respondents' perceived preventive measures for medical waste management and health workers satisfaction are shown in Tables 13 and 14.

Table 3: Categories of medical waste

Waste category	Examples
Infectious waste	Waste that may contain pathogens. This includes used dressings, swabs and other materials or equipment that has been in contact with infected patients or excreta. It also includes liquid waste such as blood specimen, faeces, urine and other body secretions.
Pathological waste	Waste from human tissues like placentas, blood, body parts and fetuses. Anatomical waste is a sub-group of pathological waste and consists of recognizable body parts.
Waste Sharps	Needles, scalpels, infusion sets, blades and broken glass
Pharmaceutical waste	This includes expired pharmaceuticals and items contaminated by pharmaceuticals (bottles, boxes) which are no longer needed.
Genotoxic waste	Include substances with genotoxic properties that has the capacity to cause genetic damage such as certain drugs and genotoxic chemicals.
Chemical waste	Waste containing chemical substances like film developer, laboratory reagents, solvents and disinfectants that have expired and no longer needed.
Waste with high content of heavy metals	This category of waste includes broken thermometers, gauges, batteries and blood-pressure.
Pressurized containers	This includes gas cartridges, cylinders and aerosol cans.
Radioactive waste	Waste containing radioactive substances from radiotherapy and laboratory research.
General waste	Papers, packaging materials, kitchen-waste, cardboard, debris, x-rays sheets, garden waste, tins, food-leftovers, and plastic bags

Source: WHO (2004)

A. Generation of medical waste per department for the period

The assessment of medical waste is very important because it helps in organizing the flow chart of waste, stage by stage; all through from the point of generation to collection, treatment and final disposal (Uddin *et al*., 2014). The quantity of waste generated by any health institution can only be established through an assessment process carried out specifically for that particular healthcare organization. This is because the quantity of waste generated during a particular timeframe depends on several factors and can as well help to provide detailed holistic

management plan. It is therefore imperative to measure medical waste in order to identify the categories, nature and types of waste generated as well as to map out effective management plan to combat the likely negative impacts on human health and the general environment (Kelly, 2012).

Average total weight generated medical waste per kg/day in the departments studied was 948.366 kg/day. This consisted of infectious and non-infectious waste. Within the study period, the health institution with a 250-bed capacity recorded an average number of 174 patients. Medical waste generation rate was 13.598 kg/patient/day with an average bed per day generation rate of 1.133 kg/bed/day. Kitchen department had the highest generation rate of 254.448 kg/day followed by internal department (151.31 kg/day), emergency (133.65 kg/day); outpatient clinics (131.37 kg/day); general surgery (94.22 kg/day) and least generation coming from NET (9.11 kg/day). The recorded average generation rate for kitchen department could probably be due to the number of patients' visitors patronizing the kitchen and staff whose shifts necessitate that they stay late at the hospital. The overall waste generated at the internal department (151.31 kg/day) was slightly higher than the generation rate from emergency unit (133.65 kg/day) even with the emergency ward recording higher average number of patients. Laboratory department had a generation rate (18.508 kg/day) close to the rate from X-ray department (19.25 kg/day). On the spot observation, revealed that majority of the waste generated from the laboratory and X-ray departments are infectious and of high risk; therefore requiring all necessary measures to keep infectious waste from non-infectious wastes. This finding agrees with the assertion made by Yashpal and Poonam (2000), that there is an urgent need to ensure that infectious waste are separated from non-infectious waste. Reason is because infectious waste, which constitutes about 10-15% when mixed with non-infectious waste, can render the entire waste infectious. Also, the observed quantity of generated wastes at the laboratory unit depended on two major factors: number of tests per day and nature of these tests. It was established in this study that the quantity of generated wastes is proportional to the number of tests per day. This finding conform the assertion by Bdour *et al*. (2007). The total average weight generated waste per kg/day in the departments studied were lower than the rate reported by Farzadika *et al*. (2009) in Iran University of Medical Sciences teaching hospital; Tesfahun *et al*. (2014) in some selected Ethiopian public and private hospitals but higher than the rate reported by Madhukumar and Ramesh (2012) in medical college hospital, Bangalore.

Table 4: Summary of generated waste at DELSUTH (March – August 2019)

Department	Average total weight generated (kg/d)	Average number of patients	Generation rate (kg/patient/day)	Percentage by total weight
General surgery	94.22	62	1.519	9.93
Emergency	133.65	375	0.356	14.093
Internal department	151.31	58	2.608	15.955
Neurology	13.42	9	1.491	1.41
Orthopedic	18.64	17	1.096	1.96
NET	9.11	11	0.828	0.961
Outpatient clinics	131.37	826	0.159	13.852
Operating theatre	78.01	23	3.391	8.23
X-ray unit	19.25	367	0.052	2.03
Pharmacy and Disinfection	11.09	-	-	1.17
Laboratory	18.508	139[a]	0.133[b]	0.019
Blood bank	15.34	31	0.494	1.62
Kitchen	254.448	173	1.471	26.830
Total	**948.366**	**174**	**13.598**	**100**

Total average weight generated = 948.366 kg/day; average number of patients = 174; total number of beds = 250 beds; generation rate = 13.598 kg/patient/day; generation rate 1.133 kg/bed/day.
[a] Number of tests per day
[b] Kg/test/day

B. Demographic and socio-economic representation of respondents

A total of 240 respondents participated in the study. Half of these respondents (50%) were health workers in this order: medical doctors (12.5%), nurses (12.5%), pathologists (12.5%) and laboratory technologists (12.5%). This was followed by waste handlers (16.7%), out patients (16.7%) and residents (16.7%) (see Table 2). Further analysis revealed that 50% were female respondents whereas the other 50% were their male counterparts. However, majority of these female respondents were from the health workers and waste handler cadre. Also, the analysis

for the male respondents revealed that male from health workers and out patients constituted over 75% of the total male respondents. Out of the 240 respondents, the result revealed that a higher percentage is within the age range of 31-40 years; followed by age range of 41-50 years and below 30 years. Those above 61 years of age constituted only 3.3% from the total respondents. Uniquely revealed from the study is that 42.5% from the 120 health workers' respondents sampled were predominantly within the age range of 41-50 years; followed by age range of 31-40 years which constituted 31.7% and age range of 51-60 years with a percentage ratio of 22.5%.

Table 5: Demographic and socio-economic characteristics of the respondents

	Categories of Respondents									
Variables	**Health workers**		**Waste handlers**		**Out patients**		**Residents**		**Total**	
Gender	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
Male	72	60	13	32.5	18	45	17	42.5	120	50
Female	48	20	27	67.5	22	55	23	57.5	120	50
Sub-Total	120	100	40	100	40	100	40	100	240	100
Age group	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
below 30 yrs	4	3.3	10	25	3	7.5	7	17.5	24	10
31 - 40 yrs	38	31.7	21	52.5	9	22.5	14	35	82	34.2
41 - 50 yrs	51	42.5	7	17.5	11	27.5	12	30	81	33.7
51 - 60 yrs	27	22.5	2	5	11	27.5	5	12.5	45	18.8
61 & above	0	0	0	0	6	15	2	5		3.3
Sub-Total	120	100	40	100	40	100	40	100	240	100
Level of education	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
No formal education	0	0	0	0	2	5	0	0	2	0.8
Primary school	0	0	7	17.5	8	20	10	25	25	10.4
Secondary school	0	0	29	72.5	17	42.5	14	35	60	25
Tertiary institution	120	100	4	10	13	32.5	16	40	153	63.8
Sub-Total	120	100	40	100	40	100	40	100	240	100
Level of income	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
below 25,000	0	0	0	0	5	12.5	8	20	13	32.5
26,000 - 55,000	0	0	36	90	15	37.5	12	30	63	26.3
56,000 - 105,000	56	46.7	4	10	14	35	16	40	90	37.5
105,000 & above	64	53.3	0	0	6	15	4	10	74	30.8
Sub-Total	120	100	40	100	40	100	40	100	240	100

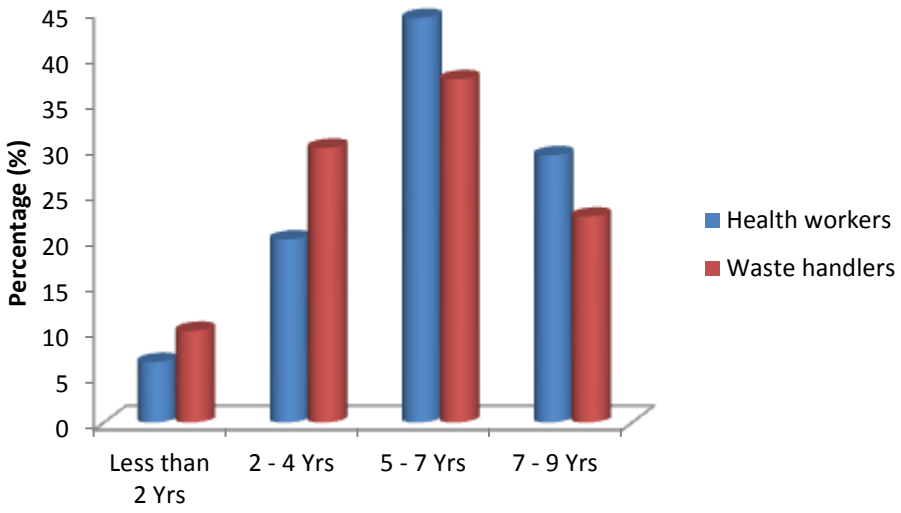

Figure 2: Chart showing working experience between health workers and waste handlers

Information as regard the level of education attained by the respondents revealed that 0.8% had no formal education; 10.4% had primary school certificates, 25% were secondary school certificate holders and 63.8% had one form of degree or the other from a tertiary institution. Overall average, revealed that majority of the respondents are educated. This finding corroborated the submissions by Mokuolu (2009); Olubukola (2009) and Awodele (2016). Further finding revealed that 100% of the 120 respondents of health workers sampled had one university degree or the other conforming that a university degree is the minimum educational prerequisite to practice any major medical profession in Nigeria. This results also supported the earlier assertion made by Adegbita (2010) and Oli *et al.* (2016) in their research work were they observed that health workers are among the most educated workforce in developing countries. Outpatients with secondary school certificate outnumbered other outpatient respondents with a percentage ratio of 42.5%; followed by those who attended tertiary institutions (32.5%) and primary school certificate holders (25%). Investigation on income of respondents revealed that respondents with an income range of 56,000 – 105,000 had the highest percentage; followed by those in the range of above 105,000 and below 25,000. Specifically, it was revealed that a larger percentage of health workers constituted income wage of 56,000 – 105,000 and above 105,000. This was so because Nigeria is a country where the level of education determines the monthly income of government workers. Also revealed in the study was that all the respondents earned a monthly income above the National Minimum wage which was pegged at 18,000 during this study.

Figure 2 revealed details on working experience between health workers and waste handlers since they are full time workers with the healthcare institution. 37.5% of the sampled waste handlers have worked for 5-7 years, followed by 30% who have worked for 2-4 years; 22.5% have worked for 7-9 years, whereas only 10% have worked for less than 2 years. Among health workers, 44.2% were recorded for those who have worked for 5-7 years; 29.2% for those with 7-9 years; 20% for 2-4 years and only 6.6% have worked for less than 2 years. Respondents in the category of outpatients were asked the number of days stayed in the hospital whereas respondents that were residents were asked to state the number of years they have lived in the community where the healthcare institution operates. All these criteria were read out to the respondents in order to ascertain how knowledgeable the respondents were about the issue under study. Residents that have lived between 1-2years and more than 2years recorded percentage ratio of 14.2% and 15.4% respectively. Among those that have resided in the study area for a period of 1-10 years has a percentage score of 42.3%, whereas those that have resided more than 10 years had 18.5% and less than a year had 9.6%. Among the respondents that were outpatient, those that have been visiting the healthcare institution for one medical challenge or another for the past one year had a higher percentage of 48.1%.

B. Inventory of Medical Waste Management Facilities

Handling and storage of special medical waste consist of strategies for packaging at source and packaging for transportation. For packaging at source, all categories of medical waste are placed in leak-proof and disposable containers. Furthermore, Bdour *et al.* (2007) noted in their study that the containers designed for sharp wastes should be puncture proof. Glass containers generally are unsuitable based on specific environmental protection reasons. Also, WHO (2004) recommended that containers for pathological waste should be colour-coded to indicate the level of risk. To ascertain and authenticate inventory of the facilities used by the healthcare institution studied to segregate and collect waste; the view of waste handlers and health workers were used as their perception will provide a better reliable data to guide

the researchers rather than the perception of patients and residents, because they are more familiar as well as major users of these facilities. Critical analysis as shown in Table 6, detailing the perception of waste handlers and health workers revealed punctured proof containers to have the highest Waste Collection Index of 3.54 with a deviation of 0.28 from the mean. This was followed by colour waste container having a WCI of 3.43 and deviation of 0.17 from the mean. It was also revealed that plastic bag and colour coded bins had WCI that were slightly below the mean with deviation of -0.03 and -0.04 respectively. Conveyor had Waste Collection Index value of 2.87 which was far below the mean and a deviation of -0.39.

Table 6: Facilities for the collection and segregation of medical waste

Facilities	Rating					F	SWV	WCI	$\bar{x}$	(x-$\bar{x}$)	(x-$\bar{x}$)^2
	5	4	3	2	1						
Puncture proof containers	315	221	26	4	0	160	566	3.54		0.28	0.0784
Colour waste container	340	125	53	31	0	160	549	3.43		0.17	0.0289
Plastic bag	200	229	77	4	6	160	516	3.23	3.26	-0.03	0.0009
Colour coded bins	240	157	95	23	0	160	515	3.22		-0.04	0.0016
Conveyor	145	137	155	4	18	160	459	2.87		-0.39	0.1521
Total								**16.29**			**0.2619**

Lack of specific and affordable transportation facilities in the management of healthcare institution's waste as well as lack of monitoring capacities have been reported by several scholars in other parts of the world to hamper smooth medical waste treatment and disposal options (Abor and Anton, 2008; Ali and Kuroiwa, 2009; Path, 2009). Oke (2008) asserted that to avoid waste accumulation, collection must be on a regular basis. Alagoz and Kocasoy (2007) noted in their study that medical waste must be transported to a central storage area within the healthcare institution before being treated and removed. According to Yawson (2014), medical waste collection must follow specific routes through the healthcare facilities to reduce the passage of loaded carts from the wards and other clean areas. The carts should be easy to load and unload as well have no sharp edges that can damage waste bags or containers. Ananth *et al.* (2010) reported that transportation of medical waste has not been given the attention needed. Results in Table 7 shows the analysed rating difference on waste storage and transportation facilities; which are mandatory for the smooth movement of medical waste from on-site to off-site. The result revealed that lidded container has the highest Waste Storing Index of 3.61 with deviation of 1.18 from the mean; followed by storage house (WSI 3.41, deviation 0.98); hand cart (SWI 3.14, deviation 0.71) and waste skip (SWI 2.99, deviation 0.56). It was also observed that the mean was higher than the values of other facilities in descending order: wheeled trolley (SWI 2.16, deviation -0.27); wheeled bin (SWI 1.84, deviation -0.59); bin lorry (SWI 1.28, deviation -1.15) and wheelbarrow (SWI 1.01, deviation -1.42). This has also been reported by Ramokate and Basu (2009); Adegbita *et al.* (2010) and Ananth *et al.* (2010), where in their various studies they observed lidded containers, storage house and hand cart to be among the majority of facilities needed for the storage and transportation of special healthcare waste.

Table 7: Facilities for storage and transportation of medical waste

Reasons	Rating					F	SWV	WSI	$\bar{x}$	(x-$\bar{x}$)	(x-$\bar{x}$)^2
	5	4	3	2	1						
Lidded plastic container	350	189	29	10	0	160	578	3.61		1.18	1.3924
Storage house	290	165	83	3	5	160	546	3.41		0.98	0.9604
Hand cart	300	45	104	53	0	160	502	3.14		0.71	0.5041
Waste skip	215	145	98	0	21	160	479	2.99	2.43	0.56	0.3136
Wheeled trolley	0	165	113	51	16	160	345	2.16		-0.27	0.0729
Wheeled bin	0	85	122	51	36	160	294	1.84		-0.59	0.3481
Bin lorry	0	0	77	89	39	160	205	1.28		-1.15	1.3225
Wheelbarrow	45	0	0	31	86	160	162	1.01		-1.42	2.0164
Total								**19.44**			**6.9304**

Proper selection of disposal sites is a prerequisite for efficient and effective disposal of waste Bathma *et al.* (2012). Sites for treatment technology options must be located far away from built environment and the disposal technology designed in such a way that it meets standard to safeguard the environment. Results of facilities for the treatment and disposal of medical waste as presented in Table 8 revealed landfill and incineration to have the highest values of WTI (waste treatment index) of 3.63 and 3.61 respectively with 1.18 and 1.16 deviations from the mean. Open pit dumping and composting also had positive WTI of 3.58 and 3.14. Other facilities according to the table hierarchy had values that were less than the mean. The fact as represented in Table 8 revealed that landfill and incineration are the most widely used means of disposing the generated waste from the healthcare institution studied. This however disagree with Madhukumar and Ramesh (2012), who reported burial pit and landfill as the most commonly used measures to dispose medical waste in medical college hospital, Bangalore.

Table 8: Facilities for the treatment and disposal of medical waste

Reasons	Rating					F	SWV	WTI	$\bar{x}$	(x-$\bar{x}$)	(x-$\bar{x}$)^2
	5	4	3	2	1						
Land fill	239	165	120	53	4	160	581	3.63		1.18	1.3924
Incineration	265	145	105	63	0	160	578	3.61		1.16	1.3456
Open pit burning	231	167	125	51	0	160	574	3.58		1.13	1.2769
Composting	190	143	105	62	3	160	503	3.14		0.69	0.4761
Steam sterilization	45	122	68	53	24	160	312	1.95	2.45	-0.50	0.2500
Gas disinfection	0	88	90	83	50	160	311	1.94		-0.51	0.2601
High-level disinfection	0	0	113	79	56	160	248	1.55		-0.90	0.8100
Burial pits	0	0	0	145	73	160	218	1.36		-1.09	1.1881
Recycling	60	42	0	0	98	160	200	1.25		-1.20	1.4400
Total								**22.01**			**8.4392**

Considering the type of waste segregation in view with the responses of waste handlers and health workers sampled which accounted for 66.7% out of 240 respondents; 91.2% of them revealed that there exist devisable means of segregating waste at source from the point of generation in the study area; 48.6% of the respondents consented that leak proof container is the major segregation facilities mainly used. The observed finding in this study was consistent with the report by Mokuolu (2009) in another study in Nigeria. Furthermore, 27.4% of the sampled respondents affirmed coloured coded bins as the facility used for segregating medical waste; whereas 9.6% attested to coloured waste container as the major segregation facilities used in the study area. Moreover, respondents who affirmed plastic bag as the segregation devise accounted for 15.9%. Further findings revealed that respondents who consented that waste handlers went through the routine of waste management training in order to equip them with detail background knowledge on risk associated with improper medical waste handling were 75.2%.

Table 9: Conditions of facilities for waste handler

Facilities for Handler	Rating					F	SWV	FCI	$\bar{x}$	(x-$\bar{x}$)	(x-$\bar{x}$)^2
	5	4	3	2	1						
Heavy duty gloves	390	129	102	23	0	160	644	4.03		1.64	2.6896
Protective clothes	227	163	154	24	2	160	570	3.56		1.17	1.3689
Safety shoes	215	165	120	16	0	160	516	3.23		0.84	0.7056
Goggles	128	65	115	35	0	160	343	2.14	2.39	-0.25	0.0625
Apron	48	72	66	29	13	160	228	1.43		-0.96	0.9216
Mask	55	0	135	11	7	160	208	1.30		-1.09	1.1881
Head cap	0	0	98	45	22	160	165	1.03		-1.36	1.8496
Total								**16.72**			**8.7859**

Table 9 shows the result on the assessment of health workers' perceived condition of equipment used by waste handlers in the study area for protection against possible health risk associated with medical waste management. Result from the calculated facility condition index (FCI) revealed heavy duty gloves which have the highest value (FCI 4.03; deviation 1.64) top the equipment used by waste handlers. This was followed by protective clothing (FCI 3.56; deviation 1.17) and safety shoes (FCI 3.23; deviation 0.84). Other equipment in descending order goggle (2.14); apron (1.43); mask (1.30) and head cap (1.03) were observed to have recorded values that was below the mean with deviations indicating negative sign.

Table 10: Condition of waste storage facilities

Criteria for waste storage plant	Rating					F	SWV	SFI	$\bar{x}$	(x-$\bar{x}$)	(x-$\bar{x}$)^2
	5	4	3	2	1						
Good accessibility	375	229	57	16	0	160	667	4.17		1.04	1.0816
Far from the hospital room	320	286	0	41	5	160	652	4.08		0.95	0.9025
Hygiene and sanitation	240	130	180	43	0	160	593	3.71	3.13	0.58	0.3364
Exclusively sited	82	282	81	25	0	160	470	2.94		-0.19	0.0361
Adequate security	115	77	125	88	13	160	418	2.61		-0.52	0.2704
Close to site door	0	0	77	70	58	160	205	1.28		-1.85	3.4225
Total								**18.79**			**6.0495**

The condition of waste storage facilities were analysed in the study, employing National Healthcare Waste Management standard guidelines for citing waste storage plants. The opinion of respondents were sought in order to ascertain if the criteria as stipulated in the National Healthcare Waste Management Policy and National Healthcare Waste Management Plan (NHCWMP) were met in citing the storage plants. From the results, good accessibility of storage plant recorded the highest Storage Factor Index value (SFI) of 4.17. Next indicator with a higher SFI value above the mean was far from the hospital room (4.08); followed by hygiene and sanitation (3.71). Indicators like exclusively sited (SFI 2.94), adequate security (SFI 2.61) and close to site door (SFI 1.28) had SFI values that were below the mean. Also observed from Table 10 is that indicators in descending order from exclusively sited had negative deviations (-0.19, -0.52 and -1.85) from the mean.

C. Respondents' Perceived Medical Waste Generated

To determine the appropriate waste disposal technology for medical waste, it is necessary to estimate the quantities and compositions of waste generated per annual and classify the waste based on their characteristics (Longe, 2012). Only after then can the different appropriate technologies be selected, adopted and applied at different stages of medical waste management. To ascertain the perceived view of respondents on the quantity of waste generated in the study, the perception of all the entire categories of respondents used were analysed in this section. Waste generated from the study was categorized into eleven different types. This categorization was in accordance with medical waste classification by WHO (2014) and NHCWMP (2018). From the perceived view of respondents sampled during the study period from March to August 2019; infectious waste was recorded as the most generated waste in the study; having the highest Medical Waste Index (MWI) value of 4.55 with deviation of 1.76 from the mean. Isolation waste was observed to have the second highest MWI value of 4.53 and deviation of 1.74 (see Table 11). Other types of medical waste with recorded positive values from the mean were waste sharps (3.58); pathological waste (3.30); chemotherapeutic waste (3.18) and radioactive waste (2.94) respectively. Medical wastes like general and pharmaceutical wastes; pressurized containers, chemical and genotoxic wastes had MWI values that were below the mean. This lower MWI values recorded for these categories of medical waste reflects low generation rate in the study.

Table 11: Respondents perceived categories of medical waste generated

Categories of medical waste	MWI for the study area			MWI	MWI - *MWI	(MWI - *MWI)^2
	Health worker	Patients	Residents			
Infectious waste	4.54	4.68	4.43	4.55	1.76	3.09
Isolation waste	4.57	4.34	4.69	4.53	1.74	3.03
Waste sharps	3.91	3.72	3.11	3.58	0.79	0.62
Pathological waste	3.30	3.49	3.12	3.30	0.51	0.26
Chemotherapeutic waste	3.28	3.22	3.05	3.18	0.39	0.15
Radioactive waste	3.14	3.01	2.68	2.94	0.15	0.02
General waste	2.62	2.36	2.27	2.42	-0.37	0.14
Pharmaceutical waste	2.03	2.45	2.00	2.16	-0.63	0.39
Pressurized container	1.18	1.62	1.84	1.55	-1.24	1.54
Chemical waste	1.06	1.37	1.16	1.19	-1.60	2.56
Genotoxic waste	1.01	1.22	1.58	1.27	-1.52	2.31
Total	**30.64**	**31.48**	**29.93**	**30.67**		
***MWI**	**2.78**	**2.86**	**2.72**	**2.79**		

D. Effect of Medical Waste to the Environment

Respondents' perceived impact of medical waste on the environment was analysed and represented in Table 12. It is a known fact that the effects of medical waste on human population and the environment varies in general. The major impact of waste generated from the healthcare institution studied on the environment was categorized and respondents' opinion sought to ascertain the most prevalent effect in the study area. The result revealed a recorded mean Waste Effect Index (WEI) value of 3.49 in the study. Furthermore, it was revealed that major effects such as offensive odour had the highest WEI value of 4.72 and deviation of 1.23 from the mean. This was followed by other effects like exposure to fugal and bacterial infection (4.28) and airborne diseases (3.72) respectively. Two other effects (contaminated groundwater -2.99 and radioactive diseases -1.76) had values that were lesser than the mean in the study.

Table 12: Perceived impact of medical waste on the respondents

Effects	WEI for the study area			WEI	WEI - *WEI	(WEI - *WEI)^2
	Health worker	Patients	Residents			
Offensive odour	4.97	4.52	4.69	4.72	1.23	1.51
Exposure to fugal, bacterial and viral infection	4.43	4.06	4.36	4.28	0.79	0.62
Airborne diseases	3.85	3.53	3.78	3.72	0.23	0.05
Contaminated groundwater	3.32	2.66	3.01	2.99	-0.5	0.25
Radioactive disease	1.87	1.89	1.52	1.76	-1.73	2.99
Total	**18.44**	**16.66**	**17.36**	**17.47**		
***WEI**	**3.69**	**3.33**	**3.47**	**3.49**		

E. Preventive Measure for Proper Medical Waste Management

Revealed in table 13 are respondents' perceived preventive measures for medical waste management in the study area. From the analysis, it was revealed that enforcement of regulation had the highest Waste Preventive Index (WPI) value of 4.84 and deviation of 1.15 from the mean. Respondents' opinion as revealed in the result further affirmed the finding that enforcing rules and regulations serve as check and balance to stakeholders for strict adherence to standards in properly managing medical waste. Other preventive measures as perceived by the respondents are environmental management system (4.48); proper transportation from on-site to off-site (3.94) and

identification of each hazardous waste (3.32) respectively with deviations of 0.79; 0.25 and -0.37. Counting of total weight of hazardous materials and recycling had the least WPI values of 3.15 and 2.39 respectively. This reveled that respondents do not consider these measures as the best preventive measures from the effects of medical waste.

Table 13: Respondents' perceived preventive measures for medical waste management

Preventive Measures	WPI for the study area			WPI	WPI - *WPI	(WPI - *WPI)^2
	Health worker	Patients	Residents			
Enforcement of regulation	4.97	4.59	4.97	4.84	1.15	1.32
Environmental management system (EMS)	4.56	4.11	4.78	4.48	0.79	0.62
Proper transportation from on-site to off-site	4.00	3.62	4.21	3.94	0.25	0.06
Identify each hazardous waste	3.42	3.04	3.49	3.32	-0.37	0.14
Count the total weight of hazardous materials	3.12	3.03	3.30	3.15	-0.54	0.29
Recycling	1.88	2.96	2.34	2.39	-1.30	1.69
Total	**21.95**	**21.35**	**23.09**	**22.12**		
***WPI**	**3.66**	**3.56**	**3.85**	**3.69**		

F. Health Workers Satisfaction

The perception of health workers was used in this section to measure the criteria for staff welfare that enhances their motivation to the job. Statistical analysis as represented in Table 14, revealed workers' welfare with Health Workers Satisfaction Index (HIS) value of 3.14 as the most preferred option among the listed criteria. This was followed by provision of equipment (HSI 3.13) with deviation of 0.20 from the mean. Values of other criteria for staff welfare analysed were lower than the mean and had negative deviation values from the mean. These are arranged in descending order in Table 14. This finding did not necessarily reflect that those criteria with negative deviation values from the mean are not among the preferred options rather they might not work effectively for health workers welfare in the study area.

Table 14: Health workers satisfaction

Criteria for Welfare	Rating					F	SWV	HIS	$\bar{x}$	(x-$\bar{x}$)	(x-$\bar{x}$)^2
	5	4	3	2	1						
Workers welfare	222	105	128	36	11	160	502	3.14		0.21	0.0441
Provision of equipment	215	173	59	38	16	160	501	3.13		0.20	0.0400
Training for the handlers	220	109	59	58	21	160	467	2.92		-0.01	0.0001
Adequate funding	205	117	71	52	19	160	464	2.90	2.93	-0.03	0.0009
Government intervention	170	121	104	44	20	160	459	2.87		-0.06	0.0036
Adherence to medical waste management procedure	135	97	125	24	36	160	417	2.61		-0.32	0.1024
Total								**17.57**			**0.1911**

CONCLUSION

Proper management of medical waste generated is an integral aspect of public health and when improperly managed can create conditions that may adversely impact on public health and the environment. This study assessed the status and challenges of medical waste management practices in Delta State University Teaching Health Institution for a period of six months spanning from March to August 2019 in order to ascertain the efficiencies of the managerial strategy adopted. The study was sectionalized into two aspects; with the first covering analysis on quantity of waste generated and the second, covering analysis on administered questionnaires to the respondents. Average total

weight generated waste from all the departments studied was estimated to be 948.366 kg/day. This consisted of infectious and non-infectious waste. Within the study period, the health institution with 250-bed capacity recorded an average number of 174 patients. Medical waste generation rate was 13.598 kg/patient/day with an average bed per day generation rate of 1.133 kg/bed/day. Kitchen department had the highest generation rate of 254.448 kg/day followed by internal department (151.31 kg/day), emergency (133.65 kg/day); outpatient clinics (131.37 kg/day); general surgery (94.22 kg/day) and least generation rate coming from NET (9.11 kg/day). The waste generation rate calculated in this study excluded seasonal variation. It was observed that segregation of waste at source exist within the health institution but poorly implemented and monitored as medical waste was still being mixed and dumped with general wastes that are collected, transported and disposed in a similar manner. Punctured proof containers, colour waste containers and plastic bags were the most commonly used waste collection and segregation equipment. It was observed that segregation was not conducted according to NHCWMP standards. Waste generated within the institution were collected on a daily basis and transported to a designated place for temporary storage. Two waste handlers were assigned to each department to do collection at different collection units. Lidded plastic container, storage house, hand cart, waste skip and wheeled trolley were mainly used to store and transport waste. A fundamental issue from the finding was insufficient waste containers to handle volumes of medical waste. Analysis from the questionnaire revealed that higher percentage of waste handlers were poorly educated. Irrespective of the availability of personal protective equipments; they were observed to be wrongly used by waste handlers. Land fill was revealed to be the most preferred final disposal option used in the study area. However, in some situation incineration and open pit burning were also adopted. This study has helped to establish a baseline data and statistics on medical waste management strategy in Delta State University Teaching Health Institution.

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