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Research Article

Assessment of Human Care Waste Generation, Composition, And Management Practice in Rivers State University Teaching Hospital, Port Harcourt

Omereji Nkesi Homa[1], Kingsley Ezechukwu Okpara[1,2*], Idawarifa Frank Cookey-Gam[1] and Amarikwa Ogechi Chukwuemeka[3]

[1]*Department of Public Health Sciences, Faculty of Basic Medical Sciences, Rivers State University, Nkpolu-Orowurukwo, Port Harcourt, Nigeria.*
[2]*Institute of Geosciences and Environmental Management, Rivers State University, Nkpolu-Orowurukwo, Port Harcourt, Nigeria.*
[3]*Basic Sciences Unit, PAMO University of Medical Sciences, Elelenwo, Port Harcourt, Nigeria.*
[*]*Corresponding author: kingsley.okpara@ust.edu.ng*

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Abstract

Improper collection, segregation, transportation, treatment, and disposal of HCW pose risk to public health and the environment. This study aimed to determine HCW generation rate, composition, and management practice in Rivers State University Teaching Hospital. An institutional-based cross-sectional study was conducted in Rivers State University Teaching Hospital from 15th September 2024 to 22nd September 2024. The quantitative data were collected for eight consecutive days using direct measurement of HCW. The qualitative data were collected by using an observational checklist and in-depth interview, and the data obtained was transcribed. A total of 957.8 kg of HCW was generated in the study period with an average of 119.7 kg ($\pm$ 12.9). The hazardous fraction of the HCW was 259.9 kg (27.1%) while the non-hazardous fraction was 697.9kg (72.9%). The generation rate of HCW was 0.328 kg bed$-$1day$-$1. General waste accounted for 659.1 kg (68.8%) of the total HCW generated in the teaching hospital, followed by infectious waste at 115.8 kg (12%). There was no segregation of HCW by type at the point of generation and there was no pre-treatment of infectious wastes. The placenta pit was used for pathological wastes and open burning was the main disposal mechanism for the remaining wastes. The finding indicated that the proportion of the hazardous waste generated from the hospital was slightly above the World Health Organization recommended threshold. There was a lack of appropriate waste segregation, storage, transport, and disposal practices in Rivers State University Teaching hospital.

1. Introduction

World Health Organization (WHO) defined healthcare waste (HCW) as waste produced by healthcare facilities, research facilities, laboratories, and home-based care [1]. It is divided into two categories: hazardous HCW and non-hazardous (general waste). The non-hazardous waste, accounts for up to 75% to 90% of HCW generated. The main compositions include administrative, housekeeping, and food storage materials and usually poses little or no risk be a health. However, 10–25% of all HCW are classified as hazardous, which includes pathological wastes, laboratory wastes, body fluids, sharps, infectious materials, hazardous chemicals, pharmaceuticals, highly heavy metal-containing substances, and genotoxic materials which pose serious public health risk [2].

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Patients, healthcare professionals, visitors, waste handlers, and the general public can be exposed to infectious agents due to inadequate management of hazardous HCW. The high-risk group is housekeeping staff [3]. Improper management techniques in the handling and disposal of HCW can also result to the outbreak of infectious diseases and environmental contamination of the air, soil, and water [4]. All levels of care (primary, secondary, and tertiary) produce HCW. Due to its ability to cause acute or epidemic diseases, this waste is observed to be some worth infectious and hazardous. Improper management and treatment of waste that are infectious could have a harmful effect on environmental and human health [1]. Insects and rodents can spread pathogens when they come in contact with improperly stored waste, body fluids or patient excretions. Inadequate HCW management significantly increases the risk of transmission of nosocomial infections [5]. Hence, the need for proper management of HCW.

The term ”healthcare waste management” describes the handling of health institutions generated waste, which involves adherence to specific protocols to minimize and prevent the transmission of nosocomial infections [1]. The HCW problem awareness; written policy or management plan in health care both in organizational level and national level; clear responsibilities and roles delineation on waste handling, regular training, effective implementation and periodic consideration and safety evaluation are important components of an efficient management system in HCW program [1]. Lower risks and lower waste management expenses are associated with the use of suitable techniques, such as the effective separation of non-hazardous and hazardous waste . Therefore, preserving environmental and public health depends on efficient HCW management [6]. A successful management process of HCW must include the following essential steps: collection, storage, transportation, treatment, segregation, and disposal [2, 7]. HCW is becoming a huge challenge, particularly for many developed countries that are lagging far behind recommended guidelines [7].

HCW management has been challenging in several developing countries, including Nigeria [8]. The sustainable management of HCW has continued to generate rising public interest due to the health issues associated with exposure of human beings to potentially harmful wastes arising from healthcare [9]. Presently significant gaps exist with regard to the assessment of HCW management practices particularly in Nigeria and in several countries in sub – Saharan Africa. Despite the potential for health risks linked to poor handling of HCW, many countries still lack adequate examination and documentation of the type and amount of HCW generated as well as practices related to HCW management, waste segregation and waste recycling [10].

HCW management (HCWM) is an intrinsic aspect of service delivery in health care and appropriate HCWM is an efficient infection control measure if correctly done [9]. However, HCWM methods in many health facilities, have not been given appropriate attention, notably in Nigeria [9]. According to literature reports, Nigerian healthcare workers' professional ethics are not strictly followed, indicating a serious global standards violation for HCWM.

At the tertiary level of healthcare, the situation is a serious concern. Inadequate institutional arrangements, poor financing and governance, limited or nonexistent opportunities for building capacity on HCWM concerns, and non-compliance to waste management rules or procedures are some of the factors linked to poor HCWM [11]. Along with the above mentioned, Nigeria's waste management policy appears to be largely ineffective in health facilities, with minimal or no systems in place to monitor compliance or ensure adherence to best practices in HCWM.

This study concentrated on Rivers State, in the Niger Delta region of Southern Nigeria with a population of over 5 million people, due to insufficient funding and a dearth of literature in the region [12]. A research conducted in Rivers State by [13], reported a high level of risky disposal of HCWs, particularly sharps, in the state. This highlights the need to explore further on this identified difficulty to provide a better understanding of the waste generation rate, composition and management practice at the tertiary healthcare level in Rivers State. As the highest level of healthcare that offers sophisticated and specialized medical care in a clinical setting, it is crucial to look at the HCWM system in Rivers State at this level of care.

It is essential to evaluate how the administrative structure and governance of the health sector impact HCWM, using RIVERS State as a case study, in order better understand the difficulties related to the management practice(s) on HCWs at this level of care. The purpose of this research is to evaluate the practices and management of HCW at the Rivers State University Teaching Hospital in Port Harcourt, Nigeria.

2. Materials and Methods

2.1. Study Area, Design and Period

The study was conducted at the Rivers State University Teaching Hospital (RSUTH) located in Port Harcourt, the capital of Rivers State. The Hospital is one of the referral hospitals in Rivers State. It serves as a practical training center for all aspects of medical practice, as well as providing curative services. RSUTH is ranked among the largest hospitals in the Niger Delta. The facility has 571 licensed beds, and 14 wards/units and 738 medical staff. An institutional-based cross-sectional survey was conducted from 15^{th} September to 22^{nd} of September 2024 for eight consecutive days to quantify the HCW generation rate, composition, and to evaluate its management practice system.

2.2. Data Collection Tools and Procedures

To evaluate HCW composition, the different types of waste collected from various units of service delivery was poured on a marked area behind the hospital for the purpose of sorting out the waste.

The weighing was conducted within an eight-day period (Monday-Monday) and the total weight of waste for each unit was recorded by adding the daily amount of waste weighed in each category per day.

The sorting and segregation of the HCW was conducted by HCW staff and recorded by trained data collectors, and the segregated waste was weighed and recorded in a daily worksheet.

Pre-treatment and disinfection of the waste with 0.5% sodium hypochlorite solution was sprayed on the waste before segregation of the HCW began.

The weight of the waste (in kilograms) by department and service delivery point was recorded by the supervisor.

To quantify the generated amount of HCW a weighing scale was used. The waste was grouped as pathological, infectious, sharps, pharmaceutical, and general waste such as plastics papers, food waste, and other domestic wastes.

The containers for the waste were labeled to easily identify the ward of the generated waste. The waste containers were transported from each ward in each shift to the temporary station designated for waste segregation and measurement.

After the waste had been sorted and measured it was finally disposed, and the waste containers were returned to their respective wards.

The physical observation was conducted using an observational checklist to evaluate the HCW collection, segregation, transportation and practices for disposal in RSUTH.

A standardized checklist adapted from the WHO HCW management assessment tool (WHO, 2014) was used for both the quantitative and qualitative analysis of data. The daily patient load and the bed occupancy rate were obtained from the hospital registers of the various units.

The waste was sprayed with disinfectant solution (0.5% sodium hypochlorite) before segregation of the HCW began.

In addition to direct observations, twenty one in-depth interviews were conducted with the hospital administrators (Directors, Deputy Director, Heads of Departments) and senior management staff involved in the HCW management of their various departments Figure 1.

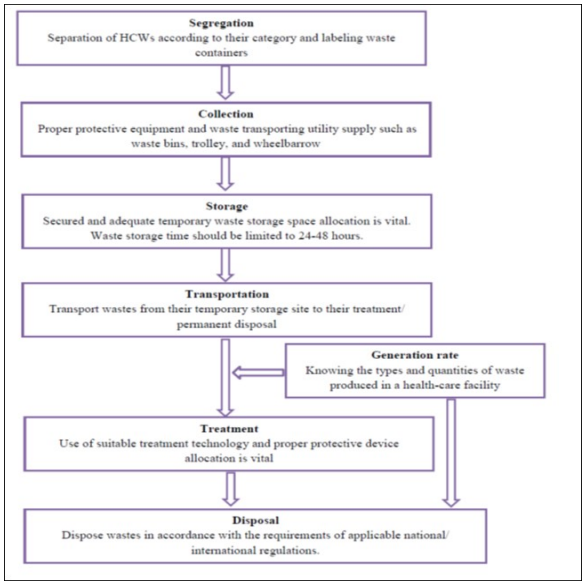

Figure 1: HCW management process in RSUTH, 2025 Adopted from [7]

2.3. Data Analysis

SPSS version 20 was utilized to enter and evaluate quantitative data. For the purpose of the normality test, the data distributions were investigated. The creation of HCW was compiled into a meaningful format using statistical descriptive survey such as mean, standard deviation, percentages and frequency.

Additionally, graphs and tables were utilized to display the results. The rates of HCW generation were expressed as kilograms per bed per day and per kilograms patient per day.

The WHO guidelines for HCWs [4] were used to classify the waste. Additionally, hazardous and non-hazardous fractions were calculated appropriately.

The Pearson Correlation Coefficient was utilized to evaluate the bivariate relationship between the number of patients treated and the quantities of HCW generated in total. In compliance with WHO criteria, the waste was characterized [3]. The 5% level of significance (95% confidence level) served as the basis for the statistical test for significance. The direction and strength of the linear association between HCW generation rate and patient flow were also recorded.

The collated qualitative data were transcribed and analyzed.

2.4. Ethical considerations

Ethical approval and clearance were obtained from the Rivers State University Teaching Hospital ethics board (RSUTH/REC/2024/579). Written permission was obtained from hospital administration and heads of the study units. Every responder received information about the study's methods, and their signed informed consent was sought before the interview took place. As they took part in the study, the participants received assurances of secrecy. Participants were also given the assurance that, in light of the research's conclusions, they would not face any disciplinary action. Participants in this study were not subjected to cruel treatment, physical injury, social prejudice, psychological distress, or financial loss.

3. Results

3.1. HCW Generation

As indicated in Table 1, a total of 957.8kg of HCW was generated in RSUTH, with a mean value of 119.7 kg ($\pm$12.9). The lowest amount of HCW generated during the study period was 96.4 kg on day six (Saturday), while the maximum HCW generated was 153.3 kg on day four

(Thursday).

The medical ward produced the highest waste, with a total waste of 153.5kg (16.0%), while the radiology unit produced the lowest 24.5kg (2.6%) of HCW in the hospital during the study period.

The waste generation rate at RSUTH was determined based on an active bed capacity of 571 beds, average bed occupancy rate of 86%, and an average daily patient load of 491.6kg. The daily waste generation rate for the hospital was calculated as 119.7 kg day−1, 0.328 kg bed−1, day−1, 0.36 kg patient−1 day−1.

Table 1: Daily HCW Generation Rate in RSUTH, September, 2024

Department	Day1 (kg)	Day2 (kg)	Day3 (kg)	Day4 (kg)	Day5 (kg)	Day6 (kg)	Day7 (kg)	Day8 (kg)	Total (kg)	Mean (kg)	SD kg)	%
Pathology	6.5	8.3	5.4	12.4	10.1	7.3	5.8	4.9	60.7	7.6	2.6	6.4
Dental	8.6	3.2	7.4	6.1	2.5	4.7	3.7	5.3	41.5	5.2	2.1	4.3
OB/GYN	12.1	12.8	19.1	10.6	24.5	5.7	8.4	21.0	114.2	14.3	6.6	11.9
Pharm	4.4	0.4	7.3	2.8	2.5	0.6	1.7	3.9	23.6	2.9	2.3	2.5
NICU	6.8	9.6	10.3	18.3	4.3	7.9	6.6	6.2	70.0	8.8	4.3	4.3
Opth	4.1	2.4	3.4	1.8	5.1	3.6	1.2	2.6	24.2	3.0	1.3	2.5
A/E	10.4	14.8	6.5	18.1	15.6	13.4	9.6	16.5	104.9	13.1	3.9	11.0
S/ward	15.2	3.5	9.7	7.4	2.8	3.7	20.2	11.2	73.7	9.2	6.4	7.7
Paed	3.1	0.8	12.3	10.8	2.6	9.4	7.2	8.3	54.5	6.8	4.2	5.7
Radiology	1.8	2.3	3.2	2.7	1.0	1.5	3.8	1.7	18.0	2.3	0.9	1.9
OPD	8.4	5.5	4.5	7.4	4.1	6.8	11.0	3.8	51.5	6.4	2.4	5.4
Med.ward	22.7	32.5	8.9	26.2	17.5	14.3	16.4	14.8	153.3	19.2	6.6	16.0
Canteen	9.2	7.3	10.4	9.8	6.3	8.7	11.4	5.6	68.7	8.6	1.9	7.2
Int. Med	3.2	1.8	4.1	5.6	4.3	2.7	2.3	3.6	27.6	3.4	1.2	2.9
Ad/fin/main	3.4	5.1	4.8	3.9	2.6	0.8	3.2	4.0	27.8	3.4	1.3	2.9
ENT	3.7	2.4	5.3	2.9	4.1	2.6	1.9	3.3	26.2	3.3	0.1	2.0
Orthopedic	2.3	3.6	1.5	3.2	2.5	1.2	0.7	2.4	17.4	2.2	0.9	1.8
Total	119.9	117.0	120.7	150.3	110.6	96.4	121.1	117.5	957.8	119.7	49	100%

CU: Intensive Care Unit, OPD: Outpatient Department, OR: Operating Room,
A/E: Accident and Emergency, NICU: Neonate Intensive Care Unit,
OB/GYN: Obstetrics and Gynecology, ENT: Ear/Nose/Throat Unit, S/Ward: Surgical Ward,
Paed: Paediatrics, Int.Med: Internal Medicine, Med.ward: Medical Ward.

3.2. Composition of HCW

The composition of HCWs generated in RSUTH is presented in Table 2. The data shows that a substantial amount of the wastes generated are composed of plastic, food, and infectious waste with mean values of 46.1kg, 15.7kg, and 12.0kg respectively. The data also shows the percentage of different categories of waste produced in the facility. The information in the table also shows that plastics had the highest constituent of the wastes with 369.1 kg (38.5%), food waste 125.3kg (13.1%), infectious waste 115.8kg (12%), carton (9.3%), and sharps (6.2%). Chemical waste had the least amount of waste generated with a value of 35.4kg (3.7%) Figure 4.

Table 2: Composition of health care waste generated in RSUTH, September 2024

Composition of HCW	**Weight in Kg**	**Mean(kg)**	**%**	**SD**	**Kg/bed/day**	**Kg/patient/day**
Paper	39.0	4.9	4.0	1.41	0.019	0.017
Food	125.3	15.7	13.1	5.53	0.054	0.046
Chemical	35.4	4.4	3.7	1.47	0.037	0.029
Sharps	59.8	7.5	6.2	2.32	0.078	0.065
Carton	89.0	11.1	9.5	3.56	0.008	0.0074
Bottles/glass	57.0	7.1	6.0	2.28	0.014	0.011
Plastic	369.1	46.1	38.5	13.26	0.065	0.054
Pathological	48.9	6.1	5.1	1.69	0.0035	0.0023
Infectious	115.8	14.5	12.0	5.20	0.042	0.037
Others(grass ,wood etc)	18.5	2.3	1.9	0	0.0026	0.0019
Total	957.8	119.7	100%	18.24	0.210	0.203

3.3. Classification of HCW

The health care waste generated within the period of the study, were classified into four categories: infectious, pathological, pharmaceutical, sharps, general, and chemical wastes. General waste with 82.4 kg day-1 was the highest type of waste produced across the days in the study period followed by infectious waste with 14.5 kg day-1. Day three recorded the highest generation rate by type (160.9kg day−1) while day 7 recorded the lowest generation rate by type (83.9 kg day−1) Figure 3.

3.4. Hazardous and Non-hazardous Fractions of the HCW

The total hazardous fraction was obtained by adding infectious waste, pathological waste, sharps, and chemical wastes (259.9kg), while the non-hazardous fraction was obtained by adding the general waste and pharmaceutical waste (697.9kg). The hazardous fraction of waste generated within the study period was 259.9 kg (27.1%). The non-hazardous fraction of the waste generated was 697.9kg (72.9%) as indicated in Table 3 and Figure 2.

Table 3: Classification of quantity of HCW (Kg/ 8 days) (%) distribution by source

HCW Source	Infectious (kg)	Pathological (kg)	Pharmaceutical (kg)	Sharps (kg)	General (kg)	Chemical (kg)	Total weight (kg)	%
Med.Lab	17.2	3.5	2.4	9.2	10.3	35.4	78	8.1
Dental.	6.3	0	2.6	2.4	22.6	0	33.9	3.5
Oby/Gyn	20.1	15.7	6.9	12.5	74.4	0	129.6	13.5
NICU	11.1	5.3	4.2	6.9	28.9	0	56.4	5.9
Opth	3.8	0	1.8	0.6	17.3	0	23.5	2.5
A/E	18.4	0	5.8	14.3	49.8	0	83.3	9.2
OR	15.2	18.2	3.7	2.8	11.5	0	51.4	5.4
Paediatrics	6.0	3.9	4.6	4.0	69.4	0	87.9	9.2
Offices	0	0	0	0	8.6	0	8.6	0.9
OPD	2.4	0	5.2	0	12.4	0	20.0	2.1
Medical Ward	1.8	0	6.7	5.1	82.2	0	95.8	10.0
Pharmacy	0	0	0	0	54.7	0	54.7	5.7
Catering	0	0	0	0	67.3	0	67.3	7.0
Internal Med.	8.5	0	3.4	1.1	58.3	0	71.5	7.5
ICU	3.7	2.3	1.8	3.2	3.8	0	11.6	0.9
Garden	0	0	0	0	84.3	0	80.3	8.4
Total	**115.8**	**48.9**	**38.8**	**59.8**	**659.1**	**35.4**	**957.8**	**100**

ICU: Intensive Care Unit, OPD: Outpatient Department, OR: Operating Room, A/E: Accident and Emergency, NICU: Neonate Intensive Care Unit, OB/GYN: Obstetrics and Gynecology

3.5. Correlation of Patient Flow with HCW Generation Rate

The number of patients treated (in-patients and out-patients) with amount of total HCW generated and its type (Non-hazardous and Hazardous) was evaluated for their linear relationship Pearson correlation coefficient (r) (table 4). The correlation coefficient showed that there was a positive linear relationship as number of patients visited (beds occupied) increased, total HCWs also increased in departments even though some were not statistically significant. A strong positive statistically significant linear relationship was observed between number of Patients and total HCW generated $(r = 0.901, p - value < 0.01)$. A negative linear relationship was seen in some departments except OPDs in the case of hazardous HCW. There was no relationship between patient flow and HCW generated in Ophthalmology department.

3.6. HCW Management Practice

Findings from the physical observation

Our physical observation results focused on four recommended steps of HCW management in the hospital. Waste management practices at the Rivers State university teaching Hospital include the use of waste bins with 15- 60-liter capacity for storage at the wards/corridors, collection from the wards to secondary storage points, and transferred to an open dumpsite for disposal by the HCW staff of the waste management unit of RSUTH.

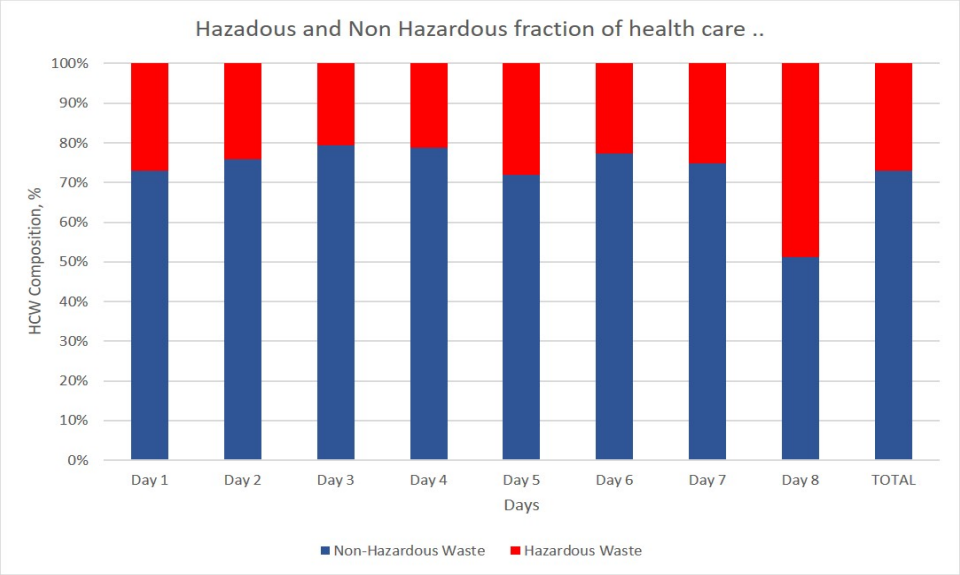

Figure 2: Daily representation of hazardous and non-hazardous fractions of health care waste in Rivers State University Teaching Hospital, Port Harcourt, 2024

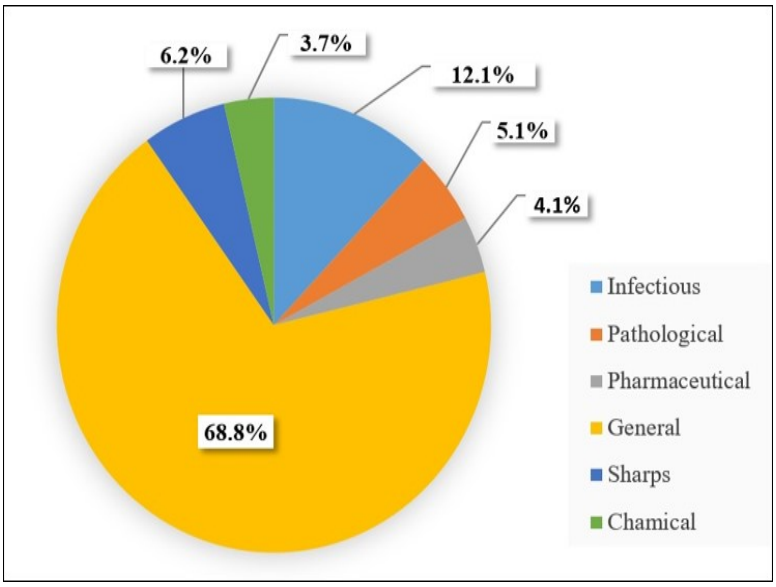

Figure 3: Classification (%) of HCW, in Rivers State University Teaching Hospital

Segregation

HCWs were temporarily stored in properly lined plastic containers. Segregation of HCW by type at the point of generation was done for only infectious and pathological and wastes. Disposal of sharps which are required to be disposed of in a safety box was practiced at the time of observation in many wards and the laboratory. Each ward had three small color-coded waste bins: red for pathological, black for general, yellow for infectious wastes, and brown paper boxes for sharp materials. The color coding of health care waste bins at the laboratory section were not strictly adhered to as an un-labeled blue colored bin was sighted at the time of the study. In general, there were separate bins for hazardous waste such as pharmaceutical waste, chemical waste, and radioactive wastes. The red or yellow bins were used for these kinds of wastes.

On-site HCW Collection and Transport

At RSUTH, on-site waste collection is conducted internally by hospital staff. Waste is gathered daily. However, the collection process does not involve the use of wheeled trolleys or other mechanical aids. Instead cleaners manually carry the waste to the designated disposal site located at the back of the facility. The most common sizes of containers observed were 15-30l containers in the wards room and 30-60l containers in the building corridors. The process of transporting HCWs without trolleys is one of the main causes of injuries to cleaners.

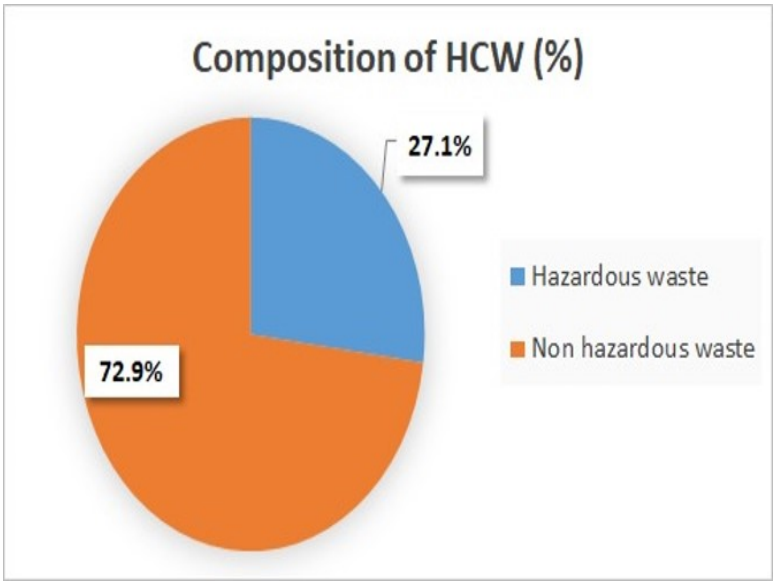

Figure 4: Composition (%) of hazardous and non-hazardous fraction of HCW, in Rivers State University Teaching Hospital

Storage

A temporary storage location was designated within the hospital (Figure 4). Sharps and infectious materials are temporarily stored close to the incineration site for subsequent incineration. All wastes (except for infectious and pathological wastes) collected from the wards using color-coded bins are transported to the disposal site at the back of the hospital. Washing and disinfecting of re-usable waste containers that were used to transport either infectious or non-infectious wastes were not regularly washed or disinfected afterward Figure 5 and 6.

Figure 5: Storage bins with and without Lid sited at RSUTH

HCW Treatment

Pre-treatment of infectious waste before final disposal was also not practiced. There was no treatment mechanism applied to the HCWs in the hospital before disposal.

On-site HCW Disposal

The hospital operated a single functional incinerator at the time of the study. Open dumping and burning were the primary means of HCW disposal except for infectious and pathological wastes. The use of PPE during waste disposal procedures was not observed. General wastes including kitchen and garden wastes were disposed in an open designated enclosure located within the hospital premises as illustrated in Figure 6.

Occupational Safety Practices

At the time of data collection, cleaners were observed wearing heavy duty-gloves and long rubber boots, but adequate and proper personal protective equipment (PPE) such as waterproof aprons, goggles, and masks were not available during waste collection. Hence, WHO guidelines on HCWM were not strictly adhered to.

Table 4: Correlation of patients flow and quantity of waste (total HCW, non-hazardous HCW, and Hazardous HCW) generated daily in each department in RSUTH (September, 2024)

HCW Source	Total HCW (pearson correlation coefficient(r)	P-value	Non-Hazardous waste (pearson correlation coefficient(r)	P-value	Hazardous waste (pearson correlation coefficient(r)	P-value
Med.ward	0.113	0.81	0.221	0.634	-0.041	0.93
Oby/Gyn	0.545	0.206	0.988*	0.002*	-0.062	0.894
A/E	-0.248	0.592	0.393	0.383	-0.374	0.408
Opthalmology	0	-	0	-	0	-
Radiology	0.901*	0.006*	0.654	0.159	0.748	0.053
OPD*	0.327	0.527	0	-	-0.381	0.456
Pharmacy	0.106	0.74	0.411	0.159	0.650	0.058
Offices	0.159	0.331	0.027	0.490	0.552	0.815
Dental	0.232	0.457	0.353	0.320	0.331	0.740
OR/SURG	0.182	0.622	0.024	0.352	0.046	0.622
NICU	0.163	0.053	0.281	0.647	0.272	0.494
Med. Lab	0.421	0.037	0.360	0.540	0.356	0.653
Internal Med.	0.320	0.721	0.052	0.163	0.049	0.084
Paediatrics	0.224	0.652	0.063	0.493	0.624	0.432
Canteen	0.517	0.492	0.601	0.179	0.310	0.525

$P - value < 0.01$ –statistically significant, *OPDs excludes generation of laboratory and Radiology units
Oby/Gyn: Obstertrics and gynecology, OPD: Out-patient Department, NICU: Neonatal intensive care unit, OR/SURG: Operating room/surgery, A/E: Accident and emergency

Figure 6: Sharp box in use at RSUTH

Findings from the in-depth interview

21 respondents (12 males and 9 females) participated in the in-depth interviews; they were various heads of departments who were also responsible for the management of HCW in their departments. The results are presented as follows:
Organization and Planning: There is an institutional structure for HCW management in the hospital. The HCW management is carried out under the infection prevention and control team. There is an infection prevention committee in all the departments and holds meetings regularly to discuss HCWM issues but the impact of the decision of this committee is limited to make the desired outcome regarding proper HCW. There is an annual HCW management plan along with the infection prevention and patient safety plan. But, policies, standard operating procedures, and working manuals or guidelines were lacking regarding HCW management in the hospital.
Staff Development: There were no developed training modules in RSUTH at the time of the study. However, trainings have been done for cleaners and the health professionals on basic infection prevention and control which includes health care waste management. There were no information, education and communication (IEC) materials on HCWs management available on ground to aid the health care staff, the patients as well as the caregivers on how to manage HCWs safely.
Waste Management Records: During the study period, the PCR unit of the lab, was the only department with existing daily total waste generation records. One of the major problems in HCW management in RSUTH was the absence of daily waste segregation, collection, and monitoring records. As a result, wastes are neither weighed daily nor monthly and their segregation, collection, transportation and disposal practices are also not monitored and recorded. The waste collection is scheduled once a day, which was either in the morning or evening Figure 7.

4. Discussion

Environmental sustainability and responsibility have emerged as important aspects of Sustainable Development Goals (SDGs) towards the generation of ever-increased wastes that are a real threat to human and environmental health. While the provision of high-quality health services improves health and well-being overall, unfortunately, it may result in the generation of potentially harmful waste if not managed

Figure 7: Disposal site at Rivers State university Teaching Hospital

Figure 8: Incinerator site at Rivers State University Teaching Hospital

appropriately. A reliable HCW management plan involves a periodic quantification of the generation rate and information of waste type [14, 15]. On daily basis, averagely 119.7kg day-1 (0.32kg bed - 1, day-1, 0.36kg patient-1, day-1) of HCW was generated from the Rivers State University teaching hospital. This result was lower than the results obtained from Edo state University teaching hospital, Nigeria which had a generation rate of 135.6kg day - 1 (0.81 kg bed-1 day-1, 0.62kg patient-1 day-1) [16].

The results were also compared with a study conducted at the Dilla University Referral University hospital, Ethiopia, which had an average of 151.7kg day-1 of waste generated daily and was found to be significantly lower than the study. This may be associated with variation in daily patient load, traffic flow management system (number of caregivers and visitors), seasonal variation and geographical related health conditions. The daily overall average obtained by this study was lower than the study conducted in Adama city Ethiopia where the average daily waste generation was 228.60 kg day-1 [17].

The overall average HCW generation rate at RSUTH was 0.320 kg bed−1day−1 and 0.36kg patient−1 day−1. This result was lower than the study in Edo state which had 0.81kg bed−1 day−1 and 0.62 kg patient−1day−1 as reported by (Abahet al., 2020) and another study in Lagos Nigeria which had an average HCW generation rate of 0.57 kg−bed−1 day−1 [18], the average HCW generation rates were reported in the range of 1.053 kg bed−1day−1 to 2.290 kg bed−1day−1 in Abuja, Nigeria [19].This difference could be mainly due to the variation in patient load as well as the dissimilarity in HCW management systems, waste characterization, and classification as well as enforcement of laws and regulation of the country which enables them to follow the same procurement policies for the purchase and consumption of commodities. The HCW generation rate was 0.866 kg bed−1 day−1.The generation rate was lower from other countries generation rate also from Bauru region Brazil 4.375 kg bed−1 day−1 Gorgan region Iran 1.83 kg bed−1 day−1 [20], India Uttarakhand 0.24 kg bed−1 day−1 [21] Ethiopia 0.35kg bed−1 day−1 . The difference in the generation rates could be due to seasonal variation, availability of different facilities, and resource allocation for the management of HCWs [22]. In the present study, relatively higher amounts of HCW was generated from the medical ward (153.3 kg) followed by gynecology (114.2 kg), emergency (104.9 kg), surgical ward (73.7kg), and laboratory (60.7 kg) as shown in (Table 4.2). The portion of hazardous and non-hazardous waste for RSUTH was 27.1% and 72.9% respectively. This proportion was higher than the hazardous waste threshold (10– 25%) predicted in 2014 by WHO (World Health Organization, 2015; Global; Fund, 2020) while nonhazardous was lower than the threshold ranged from 75% to 90% . Similar higher proportions of hazardous fraction were reported in Brazil 52%, Iran 47% [20], Nigeria Lagos 51%. Higher proportions of Health care waste were reported in Kenya Nirobi 65% and in India 63.67% [21] whereas lower proportions (11.2% to 20.64%) of hazardous waste were reported in Bangladesh HCW [23]. In this study, the higher hazardous waste fraction in HCWs was reported as opposed to the limit set by WHO might result from poor classifications and inconsistencies in the segregation methods [24]. This is a clear indication of poor HCW

Figure 9: Measurement of HCW at Rivers State University Teaching Hospital

segregation practice in the hospital. Our finding was also in contrast with the Federal ministry of health waste Management Directive, which indicated that any healthcare facility must ensure the implementation of waste minimization measures and segregation of HCWs at the point of service delivery using appropriate containers which are appropriately labeled with basic information about the content and sources of wastes or department [25]. Two mechanisms employed for the HCW disposal in Rivers State university teaching hospital were open dumping for general waste and incineration for infectious, pathological and sharp wastes. The standard practice of pre-treatment of infectious waste before incineration is not practiced in RSUTH. This type of disposal mechanism is in contrast to WHO guidelines on HCW management and may lead to the introduction of toxic substances into the environment that pose a risk to public health [1]. Since, the open dump disposal area is located closer to the mortuary and laboratory area of the hospital, the adverse health effect of the improper HCW disposal might be greater than anticipated. Different cost effective HCW disposal methods should be implemented for different HCWs in the hospital [26]. For example, onsite treatment through dilution has been suggested for chemical wastes [27]. For infectious wastes or mixed items such as cotton dressings, clothes could be disposed in an environmentally friendly technique such as Pyrolysis with energy recovery can be used for disposal instead of burning in an incinerator [28]. Incineration under high temperatures (800−1200 °C) after chemical treatment or treatment by Pyrolysis is the recommended method of treatment for sharp, infectious and wastes that are mixed with infectious wastes [26]. Good segregation practice can also help general wastes to be disposed, incinerated or treated by Pyrolysis [26]. Future researches should also focus in waste minimization and other environmentally friendly waste management systems such as waste recovery from HCW. The knowledge attitude and practices of health professionals towards the proper management of HCWM should also be given priority.

5. Conclusion

The overall findings of this study reveal that the proportion of hazardous HCW generated at RSUTH exceeds the threshold recommended by the WHO. The hospital lacks proper on-site handling, segregation, transportation, and disposal practices for HCW. These shortcomings in waste management are largely attributed to either a lack of knowledge about standard procedures or limited awareness of proper HCW management systems, both of which pose significant risks to public health and environmental safety.

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