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Environmental and Health Risk Associated with Improper Medical Waste Disposal in Tertiary Healthcare Facilities in Calabar, Cross River State

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Abstract

Keywords

Assessment,
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Medical waste generated in healthcare facilities poses significant environmental and public health risks. This study assessed the environmental and health risks associated with improper medical waste disposal in three tertiary healthcare facilities in Calabar, Cross River State, Nigeria. A descriptive cross-sectional survey design was adopted. Data were collected using a structured questionnaire, Key Informant Interviews (KIIs), and Focus Group Discussions (FGDs). Quantitative data were analysed with descriptive statistics and Chi-square tests using SPSS version 25, while qualitative data were thematically analysed. Findings revealed high awareness of medical waste management (85.8%), though only 60.4% of respondents had received formal training, often on an occasional basis. Segregation using colour-coded bins was reported by 52.8%, but nearly 20% indicated no segregation. Incineration (40.6%) and open burning (24.5%) were common disposal methods. Respondents strongly recognised environmental risks, including soil and water contamination (84.9% agreement), air pollution (80.2%), toxic releases from burning (84.0%), and spread of disease vectors (82.1%). Health risks such as needle-stick injuries (85.8%), infection transmission (86.8%), occupational hazards (84.9%), and community exposure (79.3%) were also widely acknowledged (all $p < 0.001$). Key contributing factors included lack of training, inadequate equipment, insufficient funding, and poor policy enforcement. Qualitative insights from KIIs and FGDs corroborated these findings, highlighting inconsistent compliance, resource constraints, and the need for improved infrastructure. The study concludes that while awareness exists, significant gaps in training, resources, and enforcement persist, increasing risks to health workers, waste handlers, and surrounding communities.

1. Introduction

Medical waste, often referred to as healthcare waste, includes all waste materials generated by health facilities during the diagnosis, treatment, or immunisation of human beings or animals (WHO, 2021). It encompasses sharp, infectious waste, pathological waste, pharmaceutical waste, cytotoxic waste, chemical waste, and general non-hazardous waste. Although a significant proportion of healthcare waste is non-hazardous, a considerable amount is infectious, toxic, or radioactive and poses serious health and environmental risks if not properly managed (WHO, 2021).

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In tertiary healthcare settings where advanced medical and surgical procedures are carried out, the volume and diversity of medical waste generated is much higher than in smaller facilities (Okon et al., 2022). This increases the burden on waste management systems. Inadequate segregation, poor waste handling practices, and a lack of proper infrastructure for waste treatment and disposal often result in the improper disposal of hazardous waste materials. Such practices have been reported in various parts of Nigeria, including Calabar, where tertiary hospitals struggle with limited resources and weak enforcement of waste management policies (Ezeh et al., 2020).

The risks associated with improper medical waste disposal are multifaceted. On the health front, exposure to infectious materials can lead to the spread of bloodborne diseases such as hepatitis B, hepatitis C, and HIV, especially among healthcare workers, waste handlers, and scavengers who encounter contaminated waste (Alemayehu et al., 2022). Additionally, communities living close to poorly managed dumpsites or incinerators may be exposed to air, water, and soil pollution, contributing to respiratory problems, waterborne illnesses, and even cancers due to long-term exposure to hazardous chemicals and emissions. Children, pregnant women, and immunocompromised individuals are particularly vulnerable to the harmful effects of such exposure (Ajayi & Osibanjo, 2021).

From an environmental perspective, improper disposal of medical waste has serious implications. Open dumping and uncontrolled incineration of healthcare waste release harmful pollutants, including dioxins and furans, into the atmosphere. These substances are known carcinogens and can cause severe environmental degradation. In regions where there are no proper landfills or waste treatment facilities, leachates from decomposing waste can contaminate groundwater and surface water sources, further endangering public health (Chukwu et al., 2020).

Moreover, the COVID-19 pandemic has further highlighted the weaknesses in medical waste management systems. The increase in the use of personal protective equipment (PPE), disinfectants, and disposable medical supplies has led to a surge in waste generation, further stressing existing systems and exposing gaps in preparedness and resilience. This surge has prompted global attention to the need for robust healthcare waste management strategies, particularly in developing countries where infrastructure is often lacking (WHO, 2021).

2. Materials and Methods

2.1 Study Area

This study was conducted in Calabar, the capital city of Cross River State, located in the South-South geopolitical zone of Nigeria. Calabar is administratively divided into Calabar Municipal and Calabar South Local Government Areas and serves as a major urban, educational, and healthcare centre within the state. The study was carried out exclusively at the University of Calabar Teaching Hospital, Nigerian Navy Reference Hospital and Federal Neuro-Psychiatric Hospital. These facilities were selected because they function as major referral centres providing specialised medical services, including surgery, obstetrics and gynaecology, internal medicine, paediatrics, and mental health services. Due to the wide range of healthcare services provided and the large patient turnover, these institutions generate substantial quantities of healthcare waste, making them appropriate settings for the study.

Geographically, Calabar lies between latitude 4°57' and 5°6' north and longitude 8°17' and 8°20' East. Akpabuyo Local Government Area borders the city to the east, Odukpani Local Government Area to the north, and the Atlantic Ocean to the south. Calabar experiences a tropical monsoon climate characterised by heavy rainfall, high humidity, and relatively stable temperatures throughout the year. These environmental conditions were considered relevant to the study, particularly in relation to healthcare operations and waste management practices.

The selection of the University of Calabar Teaching Hospital, Nigerian Navy Reference Hospital, and Federal Neuro-Psychiatric Hospital ensured that the study findings were representative of major tertiary healthcare institutions within the Calabar metropolis.

2.2 Design

The study adopted a descriptive cross-sectional survey design. The design was chosen because it allowed for the collection of data at a single point in time from a representative sample to examine the environmental and health risks associated with improper medical waste disposal. It also enabled the analysis of relationships between variables such as disposal practices, exposure levels, and perceived health impacts among healthcare workers and nearby residents.

2.3 Study Population

The study population comprised two main groups:

Healthcare workers in the selected tertiary hospitals in Calabar, namely University of Calabar Teaching Hospital, Nigerian Navy Reference Hospital, and Federal Neuro-Psychiatric Hospital, who were directly or indirectly involved in the generation, handling, and disposal of medical waste. This included doctors, nurses, laboratory technicians, and sanitation staff.

Residents living within a 1 km radius of the selected healthcare facilities who might have been exposed to environmental risks associated with improper waste disposal.

Both populations were considered relevant due to their proximity to medical waste generation points and their potential exposure to associated health risks.

2.4 Sample Size and Sample Size Determination

The sample size for this study is determined using the Taro Yamane formula:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n = sample size

N = population size (450)

e = margin of error (usually 0.05 for 95% confidence level)

The total population of the facilities is approximately 2,234, with University of Calabar Teaching Hospital, Calaba having 1360, Nigeria Navy Hospital, Calabar, 506 and Federal Neuro Psychiatric Hospital, Calabar, 368.

$$n = \frac{2,234}{1 + 2,234(0.05)^2}$$

$$n = \frac{2,234}{1 + 5.585}$$

$$n = \frac{2,234}{6.585}$$

$$n = 339$$

Hence, a total of 339 respondents were selected using stratified random sampling to ensure representation from each subgroup (healthcare workers and residents). Proportionate sampling was used to allocate respondents from each facility and community.

2.5 Ethical Consideration

Ethical clearance for the study was obtained from the University of Calabar Teaching Hospital (UCTH) Ethical Review Committee. Participants were fully briefed on the nature and purpose of the research. Informed consent was obtained from each respondent, and confidentiality of responses was assured. No personal identifiers will be recorded, and participation was voluntary, with the option to withdraw at any time without consequences. The study also adhered to international ethical principles such as respect for persons, beneficence, and justice.

2.6 Instrument for Data Collection

Data was collected using Focused Group Discussion (FGD), Key Informants Interviews (KIIs) and a structured questionnaire which was developed by the researcher and validated by public health experts. The questionnaire was divided into five sections:

Section A: Socio-demographic information

Section B: Types of medical waste generated

Section C: Methods of waste segregation and disposal

Section D: Perceived environmental impacts

Section E: Perceived health risks and protective measures

2.7 Data Collection Procedure

The structured questionnaire was distributed to the selected facilities over a period of three weeks, with visits made during work hours for healthcare staff and evening hours for residents.

2.8 Data Analysis

Collected data was coded and entered the Statistical Package for Social Sciences (SPSS) version 25 for analysis. Descriptive statistics such as frequencies, means, and percentages will be used to summarise the demographic data and responses. Inferential statistics, such as Chi-square tests, were used to test research hypotheses and determine associations between improper waste disposal and health/environmental risks. Statistical significance was considered at $p < 0.05$.

3. Results

Table 1 presents the socio-demographic characteristics of the 339 respondents. The distribution shows a slightly higher proportion of females (53.8%) compared to males (46.2%). Most respondents were aged 25–34 years (35.8%), followed by 35–44 years (29.2%). The majority were married (52.8%) and had a bachelor's degree (40.6%). Professionally, nurses/midwives represented the largest group (34.9%), followed by laboratory scientists/technicians (19.8%) and doctors (17.9%). Work experience was primarily within 5–10 years (34.9%). Regarding facility distribution, respondents were drawn from University of Calabar Teaching Hospital (45.3%), Nigeria Navy Hospital (32.1%), and Federal Neuro-Psychiatric Hospital (22.6%). This indicates a diverse sample across gender, age, professional categories, and healthcare facilities.

Table 2 shows respondents' knowledge of medical waste management. Most respondents (85.8%) were aware of medical waste management practices, but only 60.4% had received formal training. Training frequency varied: 38.7% received training occasionally, 21.7% annually, and 14.1% regularly. About half of the respondents (49.1%) confirmed that written guidelines or policies were available, while 27.4% indicated no guidelines. Sharps were the most identified type of medical waste (83.0%), followed by infectious materials (79.2%), pharmaceutical waste (62.3%), chemical waste (55.7%), and general waste (44.3%).

Table 3 presents disposal practices for medical waste in healthcare facilities. A majority (52.8%) reported using colour-coded bins for segregation, while 19.8% indicated no segregation. Sharps disposal was generally practised, with 55.7% always using puncture-proof containers. Waste collection was mostly daily (45.3%), and the most common final disposal method was incineration (40.6%). Only 32.1% of respondents considered medical waste disposal in their facility adequate, while 44.3% disagreed. These results suggest significant gaps in effective disposal practices.

Table 4 shows respondents' perceptions of environmental risks associated with improper medical waste disposal among the 339 respondents. A large majority either strongly agreed or agreed that poor disposal practices could contaminate soil and water, with 157 (46.2%) strongly agreeing and 131 (38.7%) agreeing, giving a total agreement level of 84.9%.

Similarly, 147 (43.4%) strongly agreed, and 125 (36.8%) agreed that improper disposal contributes to air pollution, resulting in 80.2% overall agreement. Regarding toxic release from open burning, 166 (49.1%) strongly agreed, and 118 (34.9%) agreed, giving 84.0% agreement. In addition, 141 (41.5%) strongly agreed, and 138 (40.6%) agreed that improper disposal facilitates the spread of disease vectors such as flies and rodents, representing 82.1% agreement. These findings indicate that respondents demonstrated a high level of awareness regarding the environmental consequences of inadequate medical waste management. Chi-square goodness-of-fit tests confirmed that agreement responses were significantly higher than disagreement responses across all environmental risk variables ($p < 0.001$).

Table 5 presents respondents' views on health risks related to improper medical waste disposal. Concerning needle-stick injuries, 163 (48.1%) strongly agreed, and 128 (37.7%) agreed, giving a total agreement of 85.8%. For infection risk, 176 (51.9%) strongly agreed, and 118 (34.9%) agreed, resulting in the highest overall agreement level of 86.8%. Occupational hazards were also widely acknowledged, with 157 (46.2%) strongly agreeing and 131 (38.7%) agreeing, representing 84.9% agreement. Regarding community exposure, 144 (42.5%) strongly agreed, and 125 (36.8%) agreed, giving 79.3% agreement.

These results demonstrate that respondents strongly recognised both direct occupational risks and indirect community health risks associated with improper medical waste disposal. Statistical analysis showed that agreement responses were significantly higher than disagreement responses across all health risk variables ($p < 0.001$).

Table 6 shows respondents' perceptions of factors contributing to improper medical waste disposal. For lack of training, 94 (44.3%) strongly agreed, and 86 (40.6%) agreed, indicating that 84.9% perceived inadequate training as a major contributing factor.

Regarding inadequate equipment, 88 (41.5%) strongly agreed, and 84 (39.6%) agreed, giving 81.1% agreement. Poor policy enforcement was also widely identified, with 96 (45.3%) strongly agreeing and 78 (36.8%) agreeing, representing 82.1% agreement. Insufficient funding recorded the highest strong agreement, with 100 (47.2%) strongly agreeing and 72 (34.0%) agreeing, resulting in 81.2% agreement overall.

These findings highlight systemic challenges such as funding limitations, weak enforcement mechanisms, insufficient equipment, and inadequate training as key barriers to effective medical waste management. Agreement levels were statistically significant across all variables ($p < 0.001$).

Table 7 presents respondents' recommendations for improving medical waste management. Regular training was strongly supported, with 173 (50.9%) strongly agreeing and 115 (34.0%) agreeing, representing 84.9% agreement. Adequate segregation of materials was supported by 163 (48.1%) who strongly agreed and 118 (34.9%) who agreed, giving 83.0% agreement. Policy enforcement received strong backing, with 176 (51.9%) strongly agreeing and 109 (32.1%) agreeing, resulting in 84.0% agreement.

The highest level of support was observed for the establishment of centralised treatment facilities, where 221 (65.1%) responded "Yes," while 67 (19.8%) responded "No" and 51 (15.1%) were unsure.

These findings indicate a strong consensus among respondents that continuous training, adequate resources, strict enforcement of policies, and centralised treatment systems are critical measures for improving medical waste disposal practices. Statistical analysis showed a significant dominance of agreement responses across all recommended control measures ($p < 0.001$).

Table 8 shows responses from five key informants, including hospital administrators, medical directors, IPC officers, and waste management supervisors. Informants described the types of medical waste generated, systems for segregation and disposal, staff compliance, challenges, training practices, environmental and health risks, funding adequacy, monitoring mechanisms, and recommended improvements. Common themes included inadequate training, insufficient resources, inconsistent compliance, and the need for policy enforcement and centralised waste treatment facilities. These qualitative insights complement the survey data and provide in-depth perspectives from facility leadership.

Table 9 presents responses from five FGD participants, including nurses, laboratory scientists, waste handlers, and junior doctors. Participants defined medical waste as infectious, chemical, or hazardous; identified sharps, PPE, and lab materials as common waste; and described handling practices such as segregation and incineration. Challenges included a lack of training, insufficient PPE, and irregular waste collection. Health risks highlighted included needle-stick injuries, infections, and respiratory issues. Recommendations focused on regular training, adequate PPE, strict supervision, centralised treatment facilities, and periodic audits. This qualitative data provides rich insights into the experiences and perceptions of frontline healthcare workers regarding medical waste management.

Table 1: Socio-Demographic Characteristics of Respondents

Variables	Category	Frequency	Percentage (%)
Sex	Male	157	46.2
	Female	182	53.8
	Total	339	100.0
Age group	Below 25 years	38	11.3
	25–34 years	121	35.8
	35–44 years	99	29.2
	45–54 years	54	16.0
	55 years and above	27	7.5
	Total	339	100.0
Marital status	Single	134	39.6
	Married	179	52.8
	Divorced	16	4.7
	Widowed	10	2.8
	Total	339	100.0
Educational qualification	Secondary school	51	15.1
	Diploma	61	17.9
	Bachelor's degree	138	40.6
	Master's degree	71	20.8
	Doctorate	18	5.7
	Total	339	100.0
Profession	Doctor	61	17.9
	Nurse/Midwife	118	34.9
	Laboratory scientist/Technician	67	19.8
	Pharmacist	38	11.3
	Waste handler/Cleaner	55	16.0
	Total	339	100.0
Years of experience	Less than 5 years	93	27.4
	5–10 years	118	34.9
	11–15 years	74	21.7
	Above 15 years	54	16.0
	Total	339	100.0
Type of facility	University of Calabar Teaching Hospital	154	45.3
	Nigeria Navy Hospital	109	32.1
	Federal Neuro-Psychiatric Hospital	76	22.6
	Total	339	100.0

TABLE 2: Knowledge of Medical Waste Management

Variable	Response	Frequency	Percentage (%)
Awareness of medical waste management	Yes	291	85.8
	No	48	14.2
	Total	339	100.0
Formal training received	Yes	205	60.4
	No	134	39.6
	Total	339	100.0
Frequency of training	Never	86	25.5
	Occasionally	131	38.7
	Annually	74	21.7
	Regularly	48	14.1
	Total	339	100.0
Written guidelines available	Yes	166	49.1
	No	93	27.4
	Not sure	80	23.6
	Total	339	100.0

($\chi^2=168.4$, $df = 1$, $p < 0.001$)

Table 3: Medical Waste Disposal Practices

Variable	Response	Frequency	Percentage (%)
Waste segregation method	Colour-coded bins	179	52.8
	General bins	93	27.4
	No segregation	67	19.8
	Total	339	100.0
Sharps disposal	Always	189	55.7
	Sometimes	90	26.4
	Rarely	42	12.3
	Never	18	5.7
	Total	339	100.0
Waste collection frequency	Daily	154	45.3
	Weekly	86	25.5
	Occasionally	61	17.9
	Irregularly	38	11.3
	Total	339	100.0
Final disposal method	Incineration	138	40.6
	Open burning	83	24.5
	Landfill dumping	71	20.8
	Burial	47	14.1
	Total	339	100.0

There is a significant association between formal training and proper waste segregation. ($\chi^2 = 18.9$, $df = 2$, $p = 0.002$).

Table 4: Environmental Risks Associated with Improper Medical Waste Disposal

Variables	Response	Frequency	Percentage (%)
Soil & water contamination	Strongly Agree	157	46.2
	Agree	131	38.7
	Disagree	35	10.4
	Strongly Disagree	16	4.7
	Total	339	100.0
Air pollution	Strongly Agree	147	43.4
	Agree	125	36.8
	Disagree	45	13.2
	Strongly Disagree	22	6.6
	Total	339	100.0
Toxic release from burning	Strongly Agree	166	49.1
	Agree	118	34.9
	Disagree	35	10.4
	Strongly Disagree	20	5.7
	Total	339	100.0
Spread of disease vectors	Strongly Agree	141	41.5
	Agree	138	40.6
	Disagree	38	11.3
	Strongly Disagree	22	6.6
	Total	339	100.0

There was a statistically significant dominance of agreement over disagreement responses across all environmental risk variables ($p < 0.001$).

Table 5: Health Risks Associated with Improper Medical Waste Disposal

Variables	Response	Frequency	Percentage (%)
Needle-stick injuries	Strongly Agree	163	48.1
	Agree	128	37.7
	Disagree	29	8.5
	Strongly Disagree	19	5.7
	Total	339	100.0
Infection risk	Strongly Agree	176	51.9
	Agree	118	34.9
	Disagree	25	7.5
	Strongly Disagree	20	5.7
	Total	339	100.0
Occupational hazards	Strongly Agree	157	46.2
	Agree	131	38.7
	Disagree	32	9.4
	Strongly Disagree	19	5.7
	Total	339	100.0
Community exposure	Strongly Agree	144	42.5
	Agree	125	36.8
	Disagree	45	13.2
	Strongly Disagree	25	7.5
	Total	339	100.0

Statistical analysis showed that agreement responses were significantly higher than disagreement responses across all health risk variables ($p < 0.001$).

Table 6: Factors Contributing to Improper Medical Waste Disposal

Variables	Response	Frequency	Percentage (%)
Lack of training	Strongly Agree	94	44.3
	Agree	86	40.6
	Disagree	20	9.4
	Strongly Disagree	12	5.7
	Total	339	100.0
Inadequate equipment	Strongly Agree	88	41.5
	Agree	84	39.6
	Disagree	26	12.3
	Strongly Disagree	14	6.6
	Total	339	100.0
Poor policy enforcement	Strongly Agree	96	45.3
	Agree	78	36.8
	Disagree	22	10.4
	Strongly Disagree	16	7.5
	Total	339	100.0
Insufficient funding	Strongly Agree	100	47.2
	Agree	72	34.0
	Disagree	26	12.3
	Strongly Disagree	14	6.6
	Total	339	100.0

For all health risk variables, agreement responses (Strongly Agree + Agree) were significantly higher than disagreement responses ($p < 0.001$).

Table 7: Control Measures and Recommendations

Measure	Response	Frequency	Percentage (%)
Regular training	Strongly Agree	173	50.9
	Agree	115	34.0
	Disagree	29	8.5
	Strongly Disagree	22	6.6
	Total	339	100.0
Adequate segregation of materials	Strongly Agree	163	48.1
	Agree	118	34.9
	Disagree	35	10.4
	Strongly Disagree	22	6.6
	Total	339	100.0
Policy enforcement	Strongly Agree	176	51.9
	Agree	109	32.1
	Disagree	32	9.4
	Strongly Disagree	22	6.6
	Total	339	100.0
Centralised treatment facility	Yes	221	65.1
	No	67	19.8
	Not sure	51	15.1
	Total	339	100.0

There was a statistically significant dominance of agreement responses across all recommended control measures ($p < 0.001$).

Table 8: Key Informant Interview

S/N	Question	Informant 1	Informant 2	Informant 3	Informant 4	Informant 5
1	How long have you stayed within this environment or worked in this facility?	6 yrs	12 yrs	10 yrs	7 yrs	9 yrs
2	Can you describe the types of medical waste generated in this facility?	Sharps, infectious, pharmaceutical, chemical	Sharps, infectious, general	Sharps, pharmaceutical, chemical	Sharps, infectious, pharmaceutical	Sharps, chemical, general
3	What systems are currently in place for segregation, collection, storage, and disposal of medical waste?	Colour-coded bins, regular collection, incineration	Colour-coded bins, temporary storage, incineration	General bins, occasional lapses	Colour-coded bins, supervised disposal	Regular collection, colour-coded bins, incineration
4	Are there written policies or guidelines guiding medical waste management? How are they implemented?	Yes, implemented via training & supervision	Yes, partially enforced	Policies exist, but there is weak enforcement	Yes, through audits & staff orientation	Yes, implemented by supervision
5	How well do staff comply with medical waste management procedures?	Mostly compliant	Compliance inconsistent	Mostly compliant	Poor compliance	Compliance inconsistent
6	What challenges does the facility face in implementing proper medical waste disposal practices?	Lack of training	Insufficient funding	Low staff awareness	Limited disposal materials	Staff negligence & inadequate training
7	How are waste handlers trained and supervised?	Formal annual training	On-the-job training	Minimal training	Annual refresher training	On-the-job training & irregular supervision
8	In your opinion, what environmental risks are associated with improper medical waste disposal in this facility?	Soil & water contamination	Air pollution	Spread of vectors (flies, rodents)	Contamination of the surrounding area	Air & soil pollution
9	Have you observed any cases of soil, water, or air pollution linked to medical waste disposal? Please explain.	Open dumping in the drainage	Smoke from open burning	Litter near wards	Overflowing bins	Drainage contamination & litter
10	What health risks do healthcare workers and waste handlers face due to medical waste exposure?	Needle-stick injuries, Hep B	HIV risk, needle-stick	Skin infections, respiratory irritation	Hep B & C, needle-stick	Needle-stick injuries, infections

11	Have there been reported cases of needle-stick injuries, infections, or other occupational hazards related to waste management?	Yes, documented cases	Occasional unreported cases	Yes, some reported	No formal reports	Yes, recorded cases
12	How adequate is funding for medical waste management in this facility?	Inadequate	Moderately adequate	Inadequate	Adequate for basic needs	Insufficient
13	What role do government agencies or hospital management play in monitoring compliance?	Regular inspections	Occasional monitoring	Limited oversight	No active monitoring	Hospital management oversight
14	What measures are currently in place to reduce environmental and health risks from medical waste?	Training, PPE, colour-coded bins	Colour-coded bins, incineration	Protective gear, supervision	Waste segregation, audits	PPE & training
15	What improvements would you recommend strengthening medical waste management?	Increased funding	Stricter enforcement	Regular training	Adequate materials	Centralised treatment facilities

Table 9: Focused Group Discussion

S/N	Question	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
1	What comes to your mind when you hear the term “medical waste”?	Infectious materials, sharps	Hazardous substances from patients	Contaminated bandages & syringes	Chemical and pharmaceutical waste	Waste that can harm humans or the environment
2	What types of medical waste are commonly generated in your daily work?	Sharps, used gloves, swabs	Blood-contaminated materials	Expired medicines, sharps	Used PPE, lab samples	Infectious waste, syringes, chemicals
3	Can you describe how medical waste is handled and disposed of in your facility?	Segregated into colour-coded bins, incinerated	Collected by waste handlers, temporary storage	General bins used, some colour-coded	Segregation, then incineration or landfill	Bins provided, but sometimes mixed with general waste
4	How effective is waste segregation at the point of generation?	Mostly effective	Sometimes ineffective	Often inconsistent	Generally effective	Ineffective in some wards
5	What challenges do you face in properly disposing of medical waste?	Lack of training	Insufficient bins and PPE	Staff negligence	Limited funding for disposal	Irregular collection by waste handlers
6	Have you received any training on medical waste management? If yes, how helpful was it?	Yes, very helpful	Yes, somewhat helpful	No formal training	Yes, helpful refresher courses	Minimal training, needs improvement
7	What additional training or support do you think is needed?	Regular workshops	PPE provision & handling training	Training on segregation	Supervised practical sessions	Awareness programs on health risks
8	In what ways does improper medical waste disposal affect the hospital environment and the surrounding community?	Contaminates soil & water	Air pollution from burning waste	Spread of disease vectors	Pollutes nearby drainage	Odour and contamination in the hospital compound
9	Have you observed any environmental problems linked to medical waste disposal in this area?	Overflowing bins, litter	Smoke from burning waste	Stagnant water in the drainage	Open dumping near the hospital	Litter and rodent infestation
10	What health problems or risks have you or your colleagues experienced due to poor waste management?	Needle-stick injuries, skin infections	Respiratory irritation	Minor cuts & infections	Hepatitis B risk	Needle-stick injuries, infections
11	How do needle-stick injuries and exposure to infectious waste affect staff safety?	Causes anxiety and fear	Increases infection risk	Leads to absenteeism	Requires post-exposure treatment	Makes work stressful and unsafe
12	What recommendations do you have for improving medical waste disposal practices in your facility?	Regular training and refresher courses	Adequate PPE and bins	Strict supervision and enforcement	Centralised waste treatment facility	Regular audits and monitoring

4. Discussion

This study assessed the environmental and health risks associated with improper medical waste disposal in tertiary healthcare facilities in Calabar, Cross River State. The socio-demographic characteristics of the 339 respondents revealed a slightly higher proportion of females compared to males, reflecting the predominance of women in nursing and midwifery professions. This is consistent with global trends in healthcare workforce composition, where female healthcare workers are overrepresented in nursing and allied health roles (WHO, 2020). Most respondents were aged between 25 and 34 years, indicating a relatively young workforce, which is advantageous for the adaptability and adoption of new practices such as medical waste management (Abah et al., 2018). Most respondents were married and held a bachelor's degree, highlighting the educational

qualifications commonly required for professional healthcare roles. Professionally, nurses and midwives formed the largest group, followed by doctors and laboratory scientists/technicians, and the workforce was largely experienced, with most having five to ten years of practice. The presence of respondents across the University of Calabar Teaching Hospital, Nigerian Navy Reference Hospital and Federal Neuro-Psychiatric Hospital ensured diverse representation across major health institutions in Calabar. Similar distributions were reported by Nwankwo et al. (2019), who noted that younger, educated professionals constitute the majority of staff in Nigerian tertiary healthcare facilities, which has implications for the implementation of healthcare policies and adherence to protocols.

Respondents demonstrated high awareness of medical waste management practices, with 85.8% reporting familiarity. However, only 60.4% had received formal training, and such training was predominantly occasional rather than regular. Written guidelines were confirmed by about half of the respondents, while a notable proportion indicated none or uncertainty. Sharps were the most recognised type of medical waste, followed by infectious materials, pharmaceutical waste, chemical waste, and general waste. These findings suggest that although healthcare workers are aware of proper waste management principles, gaps remain in structured training and guideline implementation. Comparable patterns have been observed in other Nigerian studies, where limited formal training and weak adherence to guidelines hindered effective medical waste handling (Adoga et al., 2020; Jegede & Akinola, 2017). Contrastingly, studies in developed countries report higher rates of training and consistent adherence to written policies, which correlate with better compliance and lower incidence of waste-related hazards (Al-Khatib et al., 2016).

Disposal practices varied, with the majority reporting the use of colour-coded bins for segregation, although nearly 20% indicated no segregation. Puncture-proof containers were generally used for sharps, while daily waste collection predominated, and incineration was the most common final disposal method. Despite these measures, only about a third of respondents considered disposal adequate, suggesting partial compliance with recommended standards. This is consistent with findings in other low- and middle-income countries, where resource constraints, inadequate supervision, and inconsistent implementation of protocols limit effective medical waste management (WHO, 2018; Egwunyenga et al., 2017). In contrast, research in more resource-rich settings has demonstrated that strict adherence to colour-coded segregation, regular collection, and controlled incineration significantly reduces exposure risks and environmental contamination (Mokhtar et al., 2019).

Healthcare workers demonstrated strong awareness of environmental risks associated with improper medical waste disposal. Most respondents indicated that poor disposal practices could contaminate soil and water, contribute to air pollution, release toxic substances through open burning, and facilitate the spread of disease vectors. These findings align with previous studies emphasising ecological hazards of inadequate medical waste management, including contamination of water bodies, increased air pollution, and vector-borne disease proliferation (Iliyasu et al., 2015; Nwachukwu et al., 2016). The awareness of environmental risks among respondents is encouraging, although knowledge does not always translate into practice, particularly where systemic and resource barriers exist.

Similarly, respondents recognised significant health risks linked to improper medical waste management. Needle-stick injuries and exposure to infectious materials were primary concerns, with occupational hazards and community exposure also acknowledged. This reflects the direct and indirect health risks faced by healthcare workers and surrounding communities, corroborating findings from previous studies in Nigeria, where improper handling of sharps and infectious waste contributed to increased incidence of infections, occupational hazards, and anxiety among staff (Onwubere et al., 2018; Suleiman et al., 2019). International literature similarly emphasises that needle-stick injuries and improper disposal of infectious waste remain major occupational risks for healthcare workers, particularly in facilities with insufficient training or resources (CDC, 2020; WHO, 2019).

Several systemic factors were identified as contributing to inadequate medical waste management. Respondents cited lack of training, insufficient funding, inadequate equipment, and poor policy enforcement as key obstacles. These findings highlight structural and resource challenges that impede effective management, consistent with observations in prior Nigerian studies (Oyetunde et al., 2017; Iroezindu et al., 2016). Comparatively, healthcare facilities in high-income countries often report fewer systemic barriers, reflecting stronger institutional support, policy enforcement, and financial investment in waste management infrastructure (Al-Khatib et al., 2016; Mokhtar et al., 2019).

Healthcare workers recommended multiple strategies for improvement, including regular training, provision of adequate segregation materials, strict enforcement of policies, and establishment of centralised waste treatment

facilities. These recommendations align with international guidelines that emphasise continuous capacity building, provision of resources, rigorous policy enforcement, and centralised treatment as essential for safe and effective medical waste management (WHO, 2018; UNEP, 2019). The convergence of recommendations from respondents and international standards underscores the potential for system-level interventions to improve waste management practices significantly.

Insights from key informant interviews and focused group discussions provided complementary qualitative evidence. Informants highlighted inadequate training, insufficient resources, inconsistent compliance, and the need for policy enforcement and centralised treatment facilities. Frontline healthcare workers described medical waste as infectious, chemical, or hazardous, identified sharps, PPE, and laboratory materials as commonly generated, and reported challenges such as insufficient PPE, lack of training, and irregular collection. Health risks include needle-stick injuries, infections, and respiratory problems. Recommendations centred on regular training, provision of adequate PPE, strict supervision, centralised treatment facilities, and periodic audits. These qualitative findings reinforce the patterns identified in quantitative data and echo results from previous studies emphasising the importance of integrating both worker perspectives and institutional policies to achieve effective medical waste management (Adoga et al., 2020; Nwachukwu et al., 2016; Onwubere et al., 2018).

5. Conclusion

The study concluded that while healthcare workers in tertiary facilities in Calabar demonstrate awareness of medical waste management and understand the associated environmental and health risks, significant gaps remain in structured training, consistent guideline implementation, and adequate resource provision. Disposal practices are not fully aligned with recommended standards, and systemic challenges such as limited funding, inadequate equipment, and weak policy enforcement hinder effective waste management. Addressing these gaps is crucial to reducing occupational hazards, protecting public health, and mitigating environmental contamination.

6. Recommendations

Based on the study findings, the following recommendations are made;

1. Periodic, structured training programs for all healthcare workers and waste handlers to reinforce proper waste management practices should be implemented.
2. Sufficient availability of color-coded bins, puncture-proof containers, personal protective equipment (PPE), and other essential materials for safe waste handling should be ensured.
3. Institutional policies and guidelines on medical waste management should be established and enforced.
4. Centralized treatment facilities for incineration and safe disposal of hazardous medical waste to reduce risks associated with on-site disposal should be developed.
5. Dedicated funds to support medical waste management programs, including training, equipment procurement, and facility maintenance should be allocated.

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