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# Compliance with Recommended Best Practices for Sustainable Healthcare Waste Management in Tertiary Hospitals in Abuja, Nigeria: A Cross-Sectional Mixed-Methods Study

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**Compliance with Recommended Best Practices for Sustainable Healthcare Waste Management in Tertiary Hospitals in Abuja, Nigeria: A Cross-Sectional Mixed-Methods Study.**

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**Abstract**

**Background**

Healthcare waste management (HCWM) is the systematic process of handling waste generated during medical procedures, including hazardous materials such as sharps, chemicals, and radioactive substances. Effective HCWM is critical for safeguarding public health and protecting workers from infectious diseases like HIV and Hepatitis B/C, as approximately 20% of medical waste is hazardous. To mitigate these risks, international WHO guidelines and Nigeria's 2021 Biomedical Waste Management Policy establish the necessary regulatory oversight and technical frameworks for safe disposal. However, compliance in Nigerian tertiary hospitals remains a significant challenge due to persistent resource constraints and systemic inefficiencies.

**Objective**

This study aimed to determine the level of compliance with recommended best practices for the sustainable management of healthcare wastes among healthcare workers (HCWs) in tertiary hospitals within Nigeria's Federal Capital Territory (FCT).

**Methods**

A cross-sectional mixed-methods study was conducted at the National Hospital Abuja and the University of Abuja Teaching Hospital. A multistage sampling technique was used to recruit 330 HCWs for structured questionnaires, while 15 key informants provided qualitative insights through interviews. Quantitative data were analyzed using SPSS v28, and qualitative data underwent thematic analysis, with results integrated through triangulation.

**Results**

The findings indicated moderate compliance levels. While 60.6% of respondents reported always following standardized color-coding, 30.3% adhered only intermittently. PPE provision was consistent for 66.7% of staff, but 6.1% never received necessary gear. Although 75.8% of facilities had designated hazardous waste storage areas, only 54.5% maintained and audited waste disposal records. Multivariate analysis identified formal training (OR=3.45, $p<0.001$) and guideline awareness (OR=3.10, $p<0.001$) as the strongest predictors of compliance. Qualitative data revealed that weak institutional monitoring, PPE shortages, and infrequent training (with 15.2% of hospitals offering none) were primary barriers to full adherence.

**Conclusion**

Compliance with healthcare waste management in tertiary hospitals in Abuja was partial. While color-coded segregation and PPE use were common, gaps existed in training, monitoring, and documentation. Younger staff and limited refresher training reduced adherence, while qualitative findings highlighted bin shortages, mislabeling, and high workloads as barriers. Strengthening structured training, enforcing policies, and improving resources and monitoring are critical for sustainable HCWM and protecting healthcare workers and communities.

## Introduction

Healthcare waste management (HCWM) is the systematic process of handling waste generated during medical procedures, research, and laboratory activities, encompassing waste minimization, segregation, collection, transportation, and disposal.[1] Globally, healthcare operations play a critical role in protecting and restoring health; however, they also produce a significant amount of waste and byproducts that can have an adverse effect on both health and the environment.[2] Approximately 80% to 85% of the waste produced by healthcare operations is general waste, while the remaining 15% to 20% is classified as hazardous material since it may be infectious, toxic, or radioactive.[3] Improper handling and disposal of these hazardous materials, particularly the contaminated sharps from the estimated 16 billion injections given annually, pose a severe threat to hospital staff, patients, and the public, often leading to the transmission of bloodborne pathogens such as HIV, Hepatitis B (HBV), and Hepatitis C (HCV).[3,4]

In low- and middle-income countries (LMICs), and specifically within sub-Saharan Africa, HCWM remains a significant challenge hindered by technological, economic, and societal issues, as well as inadequate employee training[5]. In Nigeria, persistent rural service gaps and rapid population growth are often accompanied by increased use of disposable medical supply[6], with hospitals estimated to generate between 0.56 kg and 1.68 kg of healthcare waste per bed per day.[7] Despite the 2021 National Biomedical Waste Management Policy, many healthcare facilities still lack adequate waste segregation systems, standard operating procedures, and consistent monitoring mechanisms.[6] Consequently, hazardous healthcare waste is frequently mixed with general waste or disposed of through inappropriate methods such as open dumping and uncontrolled incineration, which release toxic pollutants into the air, soil, and water resources.[7,8]

Healthcare workers (HCWs) play a central role in the success of HCWM programs because they are responsible for waste generation and initial segregation at the point of care.[9] However, their knowledge, attitudes, and practices regarding compliance with recommended guidelines remain inconsistent due to fragmented governance and resource constraints.[7] Within Nigeria's Federal Capital Territory (FCT), tertiary hospitals serve as major referral and training institutions generating substantial volumes of hazardous waste, yet there is limited empirical evidence documenting the current level of compliance with best practices in these specific facilities.[10] Addressing this gap is critical, as poorly managed healthcare waste has been inferred to pose an even higher threat to public health than the underlying diseases being treated.[11]

Therefore, this study aimed to determine the level of compliance with recommended best practices for the sustainable management of healthcare wastes among healthcare workers in two major tertiary hospitals in Abuja and the National Hospital Abuja (NHA) and the University of Abuja Teaching Hospital (UATH). By focusing on compliance, this research identifies the specific institutional and behavioral barriers to full adherence, providing a basis for developing targeted strategies and oversight models to ensure these facilities align with international safety and environmental standards.

## Methods

### Study design

This study employed a cross-sectional mixed-methods design. The study combined quantitative and qualitative approaches to provide both statistical and contextual insights.

### Study Area

The study was conducted in selected tertiary hospitals located in the Federal Capital Territory (FCT), Abuja, Nigeria. Specifically, the study was carried out at the University of Abuja Teaching Hospital, Gwagwalada, and the National Hospital, Abuja. These hospitals serve as major referral centers in the FCT and provide specialized healthcare services to patients from Abuja and neighboring states. Due to the wide range of medical services offered, these facilities generate substantial quantities of healthcare waste, making them appropriate settings for assessing healthcare waste management compliance among healthcare workers.

### Study Population

The study population consisted of healthcare workers, including doctors, nurses, laboratory scientists, pharmacists, waste handlers, and sanitation staff involved in healthcare service delivery at the University of Abuja Teaching Hospital, Gwagwalada, and the National Hospital, Abuja, in the Federal Capital Territory (FCT), Nigeria.

### Sample Size

The sample size for healthcare workers (HCWs) in this study was determined using the Cochran formula for finite populations. The calculation was based on a 95% confidence level ($Z=1.96$), an estimated non-compliance proportion of 0.5 ($p$), and a 5% margin of error ($e$). With an estimated total population of 1,200 HCWs across four tertiary hospitals in the Federal Capital Territory, the initial calculation required 300 respondents. To ensure sufficient data quality and account for potential attrition, a 10% non-response buffer was added, resulting in a final study sample of 330 HCWs.

### Sampling Technique

The study utilized a multistage sampling design to select a representative sample of participants across three distinct stages.

Stage 1: Purposive Selection of Hospitals: Two tertiary hospitals, the National Hospital Abuja (NHA) and the University of Abuja Teaching Hospital (UATH), were purposively selected from the four tertiary facilities in the Federal Capital Territory (FCT). The selection was based on their high patient load, significant healthcare waste generation capacity, and their status as major national referral and training institutions.

Stage 2: Stratification of Departments: Departments within the selected hospitals were stratified into high-risk (e.g., surgery, emergency, oncology), medium-risk (e.g., radiology, maternity,

dialysis), and low-risk (e.g., administration, outpatient) categories based on WHO guidelines. Participants were proportionally allocated across these strata, with 50% of the sample drawn from high-risk units, 30% from medium-risk, and 20% from low-risk departments.
Stage 3: Stratified Random Sampling of Participants: Healthcare workers (HCWs) were selected from the stratified departments using computer-generated random numbers applied to staff registries. To ensure the sample reflected varying levels of involvement in waste management, the final 330 participants were stratified by occupational role: waste handlers 40% (n=142), nurses 35%(n=116), doctors 15%(n=50), and laboratory staff 10%(n=33).
Qualitative Sampling: For the qualitative component, purposive sampling was used to recruit 15 key informants. These included five hospital administrators, five HCWM oversight officers, and five external waste management contractors, with recruitment continuing until thematic saturation was achieved.

**Data Collection**

Data were collected using a mixed-methods approach consisting of a structured questionnaire and Key Informant Interviews (KIIs) to assess healthcare waste management (HCWM) practices and compliance among healthcare. The structured questionnaire was divided into four sections: demographic information, current waste management procedures, knowledge assessment, and compliance with recommended practices. These sections captured participants professional background, management procedures at their facility, level of knowledge regarding HCWM guidelines, and compliance to recommended waste handling protocols. In addition, Key Informant Interviews were conducted with selected stakeholders to obtain deeper insights into institutional practices, operational challenges, and policy-related issues affecting HCWM implementation in the hospitals by triangulating data from these instruments, the study provided a comprehensive evaluation of the behavioral and systemic factors influencing compliance with international and national safety standards.

**Data Analysis**

Quantitative data obtained from the structured questionnaires were coded, cleaned, and analyzed using SPSS version 28. Descriptive statistics, including frequencies, percentages, and means, were employed to provide a summary of the participants' demographic profiles, current waste management practices, and overall knowledge and compliance levels. To evaluate the relationships between specific variables, inferential statistics were applied; Chi-square tests were used to determine associations between categorical factors—such as professional role or training status—and adherence to segregation practices, while logistic regression was performed to identify the most significant predictors of compliance with healthcare waste management (HCWM) guidelines.
Qualitative data from the key informant interviews were processed through thematic analysis. This involved a systematic coding process where open coding first identified recurring concepts in the raw data, followed by axial coding to group these into broader categories, such as institutional barriers, training gaps, and regulatory challenges. Finally, triangulation was used to integrate the findings from both the quantitative and qualitative streams. This method allowed the statistical trends observed in the questionnaires to be validated and contextualized by the lived experiences and operational insights shared by hospital administrators and waste management stakeholders.

## Ethics Approval and Consent to Participate

Ethical approval for this study was obtained from the Health Research Ethics Committee of the Federal Capital Territory Health Research Ethics Committee, Abuja, Nigeria (Approval Number: FHREC/2023/01/51/04-05-24). Written informed consent was obtained from all participants prior to enrolment in the study. Participation was voluntary, and participants were informed of their right to withdraw from the study at any time without any consequences. Confidentiality and anonymity of participants were strictly maintained throughout the study.

## Results

The results indicate that most hospitals comply with standardized color-coding (60.6%) and provide PPE for waste handling (66.7%). However, training on healthcare waste management is inconsistent, with only 36.4% conducting it quarterly, and 15.2% reporting no training at all. (Table 1)

**Table 1: Compliance with Best Practices in Healthcare Waste Management**

| Question | Category | Frequency (n=330) | Percentage (%) |
|---|---|---|---|
| 1. Does your hospital follow standardized color-coding for waste bins? | Always | 200 | 60.6 |
| | Sometimes | 100 | 30.3 |
| | Never | 30 | 9.1 |
| 2. Are staff provided with PPE (gloves, masks, etc.) during waste handling? | Always | 220 | 66.7 |
| | Sometimes | 90 | 27.3 |
| | Never | 20 | 6.1 |
| 3. How often does your hospital conduct training on HCWM? | Quarterly | 120 | 36.4 |
| | Annually | 100 | 30.3 |
| | Never | 50 | 15.2 |
| | Only for new staff | 60 | 18.2 |
| 4. Is there a designated storage area for hazardous waste? | Yes | 250 | 75.8 |
| | No | 50 | 15.2 |
| | Unsure | 30 | 9.1 |
| 5. Are waste disposal records maintained and audited? | Yes | 180 | 54.5 |
| | No | 90 | 27.3 |
| | Occasionally | 60 | 18.2 |

The chart shows that incineration (40%) is the most used method for hazardous waste disposal, followed by autoclaving (25%). Landfilling (15%), open dumping (10%), and other methods (10%) are less frequently utilized. (Figure 1)

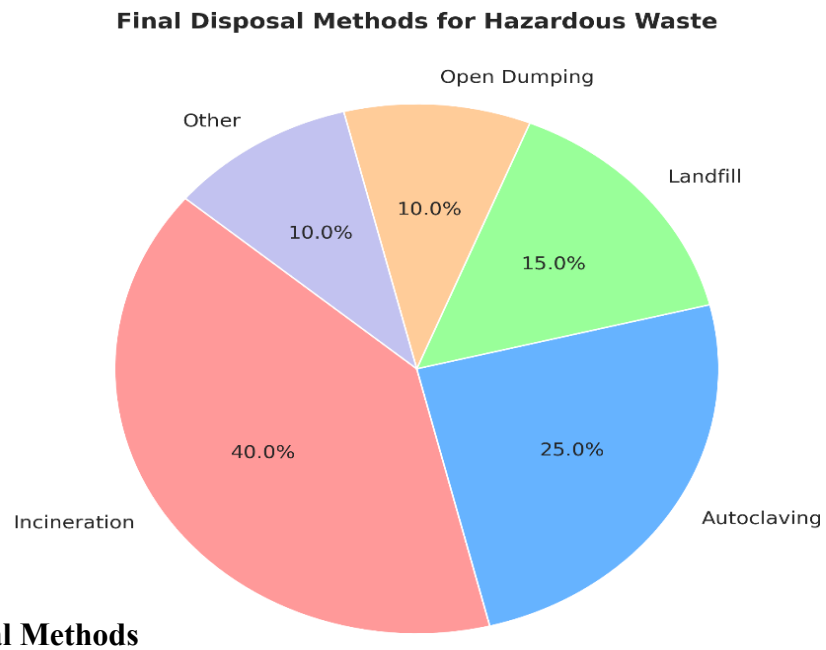



**Fig 1: Disposal Methods**

The multivariate analysis revealed that younger healthcare workers (20–29 years) and those with fewer years of experience (<1 year) are significantly less compliant with HCWM practices ($p = 0.001$ and $p = 0.005$, respectively). Formal training on HCWM (OR = 3.45, $p < 0.001$) and awareness of guidelines (OR = 3.10, $p < 0.001$) strongly influence compliance, emphasizing the importance of education and training. Additionally, the availability of PPE ($p = 0.015$) and frequent waste collection ($p < 0.001$) significantly improve adherence to HCWM protocols. (Table 2)

**Table 2: Multivariate Analysis of Factors Affecting Compliance with Healthcare Waste Management (HCWM)**

| Variable | Frequency (n) | Percentage (%) | Chi-Square ($\chi^2$) | p-value | Crude Odds Ratio (OR) | 95% Confidence Interval (CI) |
|---|---|---|---|---|---|---|
| **Age Group (Years)** | | | | | | |
| 20–29 | 60 | 18.2 | 12.45 | 0.001** | 1.85 | (1.32 - 2.60) |
| 30–39 | 120 | 36.4 | | | | |
| 40–49 | 90 | 27.3 | | | | |
| 50 and above | 60 | 18.2 | | | | |
| **Gender** | | | | | | |
| Male | 145 | 43.9 | 3.92 | 0.048* | 1.25 | (1.01 - 1.68) |
| Female | 185 | 56.1 | | | | |
| **Qualification** | | | | | | |
| Diploma/Certificate | 50 | 15.2 | 9.67 | 0.008** | 2.10 | (1.45 - 3.05) |
| Bachelor's Degree | 160 | 48.5 | | | | |
| Postgraduate Degree | 120 | 36.4 | | | | |
| **Years of Experience** | | | | | | |
| <1 year | 30 | 9.1 | 7.89 | 0.005** | 2.30 | (1.50 - 3.45) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1–5 years | 110 | 33.3 | | | | |
| 6–10 years | 95 | 28.8 | | | | |
| >10 years | 95 | 28.8 | | | | |
| **Formal Training on HCWM** | | | | | | |
| Yes | 190 | 57.6 | 20.34 | <0.001** | 3.45 | (2.15 - 5.12) |
| No | 140 | 42.4 | | | | |
| **Availability of PPE** | | | | | | |
| Yes | 220 | 66.7 | 5.89 | 0.015* | 1.75 | (1.18 - 2.43) |
| No | 110 | 33.3 | | | | |
| **Waste Collection Frequency** | | | | | | |
| Daily | 190 | 57.6 | 14.23 | <0.001** | 2.80 | (1.95 - 3.85) |
| Twice daily | 70 | 21.2 | | | | |
| Weekly | 40 | 12.1 | | | | |
| Irregularly | 30 | 9.1 | | | | |
| **Awareness of Guidelines** | | | | | | |
| Yes | 180 | 54.5 | 17.89 | <0.001** | 3.10 | (2.22 - 4.21) |
| No | 80 | 24.2 | | | | |
| Partially | 70 | 21.2 | | | | |

**Qualitative Insights and Triangulation**

Thematic analysis of Key Informant Interviews (KIIs) and field observations provided context for these findings. Respondents highlighted that bin shortages, mislabeling, and high workload pressures often force staff to mix waste types despite their knowledge of protocols. Triangulation of data confirmed that while policies are well-structured on paper, they are poorly implemented due to a lack of institutional follow-up and the absence of structured evaluations. To bridge these gaps, stakeholders emphasized the need for stricter enforcement mechanisms, including regular audits, penalties for non-compliance, and hands-on refresher demonstrations

**Discussion**

This study assessed compliance with recommended best practices for sustainable healthcare waste management (HCWM) among healthcare workers in tertiary hospitals in Abuja, Nigeria. The findings suggest that although institutional awareness of HCWM exists, implementation remains inconsistent due to systemic, infrastructural, and capacity-related challenges. The observed gaps in compliance indicate that healthcare facilities continue to experience difficulties translating established policies and guidelines into routine operational practice. These challenges are consistent with reports from other low- and middle-income settings where inadequate infrastructure, weak institutional oversight, and limited workforce capacity hinder effective HCWM implementation.[5,6]

The level of adherence to waste segregation protocols observed in this study reflects moderate institutional compliance with recommended HCWM standards. Proper segregation of healthcare

waste is considered the foundation of effective waste management because it minimizes occupational exposure, reduces environmental contamination, and improves disposal efficiency.[2,4] Despite existing national and international guidelines, inconsistent segregation practices continue to be reported across many healthcare facilities in developing countries.[5] The qualitative findings from this study further suggest that operational constraints such as inadequate waste bins, mislabelling, and excessive workload contribute substantially to improper waste handling practices. This implies that awareness alone may not guarantee compliance in the absence of adequate institutional support systems.

The study also demonstrated that access to personal protective equipment (PPE) and structured training were important facilitators of compliance with HCWM practices. Healthcare workers who had received formal training and those with better awareness of HCWM guidelines were more likely to adhere to recommended waste management procedures. This finding supports earlier reports that education and continuous professional training significantly improve healthcare workers' compliance with infection prevention and waste management protocols.[2,5] In many healthcare settings, irregular training opportunities and insufficient refresher programs contribute to poor adherence to standard precautions and waste handling guidelines. The findings therefore emphasize the importance of continuous capacity building, supportive supervision, and practical demonstrations in strengthening institutional compliance.

Another important concern identified in this study relates to the continued reliance on conventional waste disposal methods, particularly incineration and landfilling. Although these methods remain widely used in many developing countries, evidence has shown that poorly regulated incineration practices may contribute to environmental pollution through the release of toxic emissions and hazardous residues.[1,10] Inadequate final disposal practices also increase the risk of contamination of soil and water sources, thereby posing long-term public health and environmental hazards.[2,9] These concerns highlight the need for greater investment in environmentally sustainable waste treatment technologies and stricter regulatory monitoring mechanisms within healthcare institutions.

Institutional monitoring and documentation practices were also found to be suboptimal. Weak supervision, inconsistent auditing, and inadequate record-keeping systems may compromise accountability and limit the effectiveness of HCWM programs. Effective healthcare waste management requires not only the availability of policies but also active enforcement mechanisms, regular monitoring, and institutional commitment to quality improvement.[2,7] The qualitative findings further demonstrated that the absence of structured follow-up systems contributes to poor implementation of existing guidelines. Strengthening institutional governance structures and integrating routine monitoring into hospital management systems may therefore improve long-term compliance and sustainability.

## Declarations

### Ethics Approval and Consent to Participate

Ethical approval for this study was obtained from the Health Research Ethics Committee of the Federal Capital Territory Health Research Ethics Committee, Abuja, Nigeria (Approval Number:

FHREC/2023/01/51/04-05-24). Written informed consent was obtained from all participants before participation in the study.

## Consent for Publication

Not applicable.

## Availability of Data and Materials

The datasets generated and analysed during this study are not publicly available due to confidentiality considerations but are available from the corresponding author on reasonable request.

## Competing Interests

The authors declare that they have no competing interests.


## Funding

The authors received no external funding for this study.


## Authors' Contributions

IRO conceptualized the study, conducted data collection, and drafted the original thesis. SCO reviewed the thesis and contributed to manuscript preparation. AYJ validated the study and critically reviewed the manuscript. ARJ reviewed the manuscript. OAA supervised the study, revised the intellectual content, and provided overall oversight. All authors read and approved the final manuscript.


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## Clinical Trial Number

Not applicable.

## Conclusion

This study demonstrates that compliance with recommended healthcare waste management (HCWM) practices in tertiary hospitals in Abuja is partial, inconsistent, and influenced by multiple structural and behavioral factors. Strengths, including PPE provision, color-coded segregation, and designated hazardous waste storage areas, show that some standards are achievable. However, irregular training, weak monitoring, incomplete documentation, and reliance on outdated incineration methods compromise occupational safety and environmental protection. Open dumping and landfilling, though less frequent, highlight ongoing public health risks. Qualitative insights indicate that shortages of bins, mislabeling, high workloads, and inadequate institutional

follow-up undermine policy implementation, despite staff awareness of guidelines. These findings emphasize that improving HCWM requires integrated interventions: structured and frequent training, adequate resource allocation, enforcement mechanisms, and digital tracking systems. Sustainable compliance will depend on aligning policy, infrastructure, and capacity-building strategies to reduce occupational hazards and environmental contamination effectively.

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