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Knowledge and Practices of Healthcare Waste Management and Trends in Waste Segregation Among Health Workers in Tertiary Hospitals in the Federal Capital Territory, Nigeria

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ABSTRACT

Background: Healthcare waste management (HCWM) is an essential component of infection prevention, occupational safety, and environmental protection in healthcare facilities. Improper handling and disposal of healthcare waste expose healthcare workers, patients, waste handlers, and surrounding communities to infectious and environmental hazards. Although effective waste segregation and disposal practices are critical for reducing these risks, many healthcare facilities in low- and middle-income countries, including Nigeria, continue to experience challenges such as inadequate infrastructure, insufficient staff training, and weak regulatory enforcement. In the Federal Capital Territory (FCT), tertiary hospitals generate substantial amounts of healthcare waste due to the high volume of specialized healthcare services provided. However, there is limited evidence regarding healthcare workers' knowledge and practices related to healthcare waste management and waste segregation in these facilities. This study therefore assessed the knowledge and practices of healthcare waste management and examined trends in waste segregation among healthcare workers in tertiary hospitals in the FCT, Nigeria.

Methods: A descriptive cross-sectional mixed-methods study was conducted among 330 healthcare workers selected through a multistage sampling technique from two tertiary hospitals in the Federal Capital Territory, Nigeria. Quantitative data were collected using structured interviewer-administered questionnaires assessing healthcare waste management knowledge, practices, and waste segregation methods, while qualitative data were obtained through 15 key informant interviews with hospital administrators, healthcare waste management officers, and waste disposal contractors. Quantitative data were analysed using descriptive and inferential statistics with IBM SPSS version 25, while qualitative data were analysed thematically. Findings from both components were triangulated to provide a comprehensive understanding of healthcare waste management practices and challenges in the study settings.

Results: The findings showed that healthcare workers had moderate knowledge of healthcare waste management, but practices were generally poor and inconsistent across departments. About 54.5% used color-coded bins for waste segregation, while 15.2% reported no segregation. Although 75.8% recognized the importance of proper waste segregation, knowledge gaps remained: 33.3% believed all healthcare waste is hazardous, and 18.2% thought improper disposal poses no community risk. In practice, 54.5% consistently used color-coded bins and 66.7% reported constant availability of PPE. Training was inconsistent, with 36.4% of hospitals conducting quarterly training and 15.2% providing none. Key barriers included inadequate disposal facilities, insufficient training, and weak regulatory enforcement.

Conclusion: HCWM practices in tertiary hospitals in the FCT show moderate compliance with guidelines but persistent gaps in training, infrastructure, and regulatory enforcement. Strengthening training programs, improving waste segregation systems,

ensuring adequate PPE provision, and enhancing regulatory oversight are essential to improve occupational safety and environmental protection.

KEYWORDS: Healthcare waste management; waste segregation; healthcare workers; tertiary hospitals; Federal Capital Territory; Nigeria.

INTRODUCTION

Healthcare facilities play a critical role in protecting and improving population health; however, healthcare activities also generate significant quantities of waste that may pose serious risks to human health and the environment if not properly managed. Healthcare waste includes sharps, pathological waste, pharmaceuticals, chemicals, radioactive materials, and other potentially hazardous substances produced during diagnosis, treatment, and research activities.[1] Improper handling and disposal of such waste can lead to the spread of infectious diseases, environmental contamination, and occupational hazards among healthcare workers and waste handlers.

Globally, the World Health Organization estimates that approximately 85% of healthcare waste is non-hazardous, while the remaining 15% is considered hazardous, including infectious, toxic, or radioactive materials.[2] Despite representing a smaller proportion of total waste, hazardous healthcare waste poses a significant risk if not properly segregated and treated. Healthcare waste can transmit infections such as Hepatitis B virus, Hepatitis C virus, and Human Immunodeficiency virus (HIV), particularly through needle-stick injuries and improper handling of sharps.[3]

Effective HCWM, therefore, involves a systematic approach that includes waste minimization, segregation at the point of generation, safe collection and transportation, treatment, and final disposal.[4] Among these processes, waste segregation is considered the most critical step because it determines the safety and efficiency of subsequent waste management activities. Proper segregation using color-coded containers helps prevent the mixing of hazardous and non-hazardous waste, reduces treatment costs, and minimizes environmental risks.

In many low- and middle-income countries (LMICs), however, healthcare waste management systems remain inadequate due to limited financial resources, lack of infrastructure, insufficient training of healthcare workers, and weak regulatory enforcement.[5] Studies conducted in several African countries have shown that healthcare workers often lack adequate knowledge of waste segregation practices, resulting in improper disposal of hazardous waste alongside general waste.[6] This situation increases the risk of infection among healthcare workers, waste handlers, patients, and surrounding communities.

Nigeria faces similar challenges in healthcare waste management. Rapid population growth, expansion of healthcare services, and increased use of disposable medical supplies have significantly increased the volume of healthcare waste generated in healthcare facilities.[7] Estimates suggest that Nigerian hospitals generate between 0.56 kg and 1.68 kg of healthcare waste per bed per day, depending on the level of care and service utilization.[8] Unfortunately, many healthcare facilities still lack adequate waste segregation systems, standard operating procedures, and consistent monitoring mechanisms.

Previous studies in Nigeria have reported deficiencies in healthcare waste management practices, including poor waste segregation, lack of instructional materials, inadequate training of healthcare workers, and inappropriate disposal methods such as open dumping or uncontrolled incineration.[9-11] These practices contribute to environmental pollution and expose healthcare workers and nearby communities to infectious and toxic hazards.

Healthcare workers 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. Their knowledge, attitudes, and practices significantly influence compliance with recommended waste management guidelines.[10] Therefore, assessing the level of knowledge and practices of healthcare workers regarding healthcare waste management is essential for improving waste segregation practices and ensuring compliance with national and international standards.

In Nigeria's Federal Capital Territory (FCT), tertiary hospitals serve as referral centres providing specialized medical services to large populations. Consequently, these hospitals generate substantial volumes of healthcare waste that require efficient management systems. However, there is limited empirical evidence regarding the level of knowledge among healthcare workers and the trends in waste segregation practices within tertiary healthcare facilities in the FCT.

This study, therefore, aimed to assess the knowledge and practices of healthcare waste management and examine trends in waste segregation among healthcare workers in tertiary hospitals in the Federal Capital Territory, Nigeria. The findings will contribute to the evidence base needed to strengthen healthcare waste management policies, improve training programs, and promote safe and sustainable waste management practices within Nigerian healthcare facilities.

METHODS

Study design

This study employed a cross-sectional mixed-methods study 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 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 centres in the FCT and provide specialized healthcare services to patients from Abuja and neighbouring 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 practices 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 FCT, Nigeria.

Sample Size Estimation

The sample size for the study was determined using the Cochran formula for cross-sectional studies:

$$n = \frac{Z^2pq}{d^2}$$

Where:

Z = standard normal deviate at 95% confidence level (1.96)

p = estimated proportion of healthcare workers with adequate knowledge of healthcare waste management obtained from a previous study

q = 1 – p

d = margin of error (0.05)

Using this formula, the minimum sample size was calculated. A 10% allowance for non-response was added, giving a total sample size of 330 respondents. The sample was distributed equally between the two selected hospitals, resulting in 165 respondents from each hospital**.**

Sampling Technique

A multistage sampling technique was employed to select healthcare workers from tertiary hospitals in the Federal Capital Territory (FCT), Abuja.

In the first stage, two out of the four tertiary hospitals in the Federal Capital Territory (FCT) were selected using simple random sampling by balloting. The selected hospitals were National Hospital Abuja (NHA**)** and University of Abuja Teaching Hospital (UATH), Gwagwalada**.**

In the second stage, departments within the selected hospitals were stratified according to their healthcare waste generation risk levels into high-risk, medium-risk, and low-risk departments, following criteria adapted from the World Health Organization guidelines on the safe management of healthcare waste. High-risk departments included units such as emergency, surgery, oncology, and infectious disease clinics; medium-risk departments included radiology, maternity, pharmacy, and dialysis units; while low-risk departments included administrative units and outpatient clinics. Participants were proportionally allocated across these strata to ensure adequate representation of departments with varying levels of healthcare waste management responsibilities.

In the third stage, healthcare workers within these departments were selected using stratified random sampling to ensure representation of different professional categories such as doctors, nurses, laboratory staff, and waste handlers.

The sample size for each facility was 165 healthcare workers. Allocation across occupational categories was done proportionally based on their involvement in healthcare waste management activities. Consequently, 66 waste handlers (40%), 58 nurses (35%), 25 doctors (15%), and 16 laboratory staff (10%) were recruited from each hospital. Overall, a total of 330 healthcare workers were recruited from the two selected tertiary hospitals. Only healthcare workers who had worked in the facility for at least six months and who provided informed consent were included in the study.

The qualitative component used purposive sampling to select participants with relevant knowledge and direct involvement in healthcare waste management (HCWM) in tertiary hospitals. A total of 15 key informants were recruited from three stakeholder groups: hospital administrators (n = 5) responsible for policy and decision-making, HCWM officers (n = 5) involved in daily waste management operations, and external contractors (n = 5) responsible for waste transportation and disposal. Participants were

identified through hospital records and recommendations from the quantitative phase. Recruitment continued until thematic saturation was reached, ensuring comprehensive insights into HCWM policies, practices, and challenges.

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, knowledge, and compliance among healthcare workers in tertiary hospitals in the Federal Capital Territory (FCT), Nigeria. The structured questionnaire was divided into four sections: demographic information, current waste management practices and knowledge of HCWM, and compliance with these practices. These sections captured participants' professional background, existing waste management procedures, level of knowledge regarding HCWM guidelines, and adherence 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. Together, the questionnaire and interviews provided comprehensive quantitative and qualitative data for evaluating HCWM practices and knowledge.

Data Analysis

Quantitative and qualitative data obtained from the study were analysed using a mixed-methods approach. Quantitative data collected through the structured questionnaire were coded, entered, and analysed using the IBM SPSS Statistics. Data cleaning was first performed to check for completeness, inconsistencies, and missing values before analysis. Descriptive statistics, including frequencies, percentages, and means, were used to summarize respondents' demographic characteristics, healthcare waste management practices, knowledge levels, and compliance with recommended waste management protocols. The results were presented in tables and bar charts to illustrate trends in waste segregation methods, waste disposal practices, and institutional compliance with healthcare waste management guidelines.

To assess respondents' level of knowledge regarding healthcare waste management, a set of knowledge-related questions was included in the questionnaire. Each correct response was assigned a score of one (1), while incorrect or "not sure" responses were assigned a score of zero (0). Individual scores were summed to obtain a total knowledge score for each respondent. The total score was converted to percentages and categorized as follows: good knowledge (≥75%), moderate knowledge (50–74%), and poor knowledge (<50%).

Similarly, healthcare waste management practices were evaluated using practice-related questions that assessed compliance with recommended procedures such as waste segregation, use of color-coded bins, use of personal protective equipment, and adherence to institutional waste disposal protocols. Responses reflecting appropriate practices were assigned a score of one (1), while responses indicating non-compliance were assigned a score of zero (0). The total practice scores were calculated and converted into percentages. Based on the percentage scores, respondents were classified into good practice (≥75%), fair practice (50–74%), and poor practice (<50%) categories.

Inferential statistical analyses were conducted to examine relationships between key variables. Chi-square tests were used to determine associations between categorical variables such as healthcare workers' training status, job role, and adherence to waste segregation practices. Furthermore, logistic regression analysis was performed to identify predictors of compliance with healthcare waste management guidelines among healthcare workers.

Qualitative data obtained from open-ended questionnaire responses and Key Informant Interviews (KIIs) were analysed using thematic analysis. Interview transcripts were coded systematically to identify recurring concepts and patterns related to healthcare waste management practices, operational barriers, and institutional challenges. Open coding was initially applied to categorize raw data into themes, followed by axial coding to group related themes into broader categories such as training gaps, inadequate infrastructure, and regulatory challenges.

Finally, triangulation was used to integrate findings from both quantitative and qualitative data sources. This approach enabled comparison and validation of statistical findings with insights obtained from interviews, thereby providing a more comprehensive understanding of healthcare waste management practices, knowledge gaps, and compliance trends among healthcare workers in tertiary hospitals in the Federal Capital Territory.

Ethical Considerations

Ethical approval for this study was obtained from the Health Research Ethics Committee of the Federal Capital Development Authority (Approval Number: FHREC/2023/01/51/04-05-24). All issues related to good ethical procedures were ensured. Informed consent was obtained from all study respondents before they were enrolled in the study. Participants were assured that their personal information was kept confidential and would not be disclosed to anyone outside of the research team. The data collected from participants was coded and stored securely to ensure that only the research team can access it. Participants were informed that their data was used for research purposes only and wasn't shared with anyone else. Participants were informed that they can withdraw

from the study at any time without any penalty or consequences. Participants were not charged any fee for their participation in the study. Participants were not offered any incentive or compensation to unduly influence their decision to participate in the study.

RESULT

Most respondents (36.4%) were aged 30–39 years, and females (56.1%) slightly outnumbered males. Nearly half of the participants held a Bachelor's degree (48.5%), while waste management staff constituted the largest occupational group (40.0%). Furthermore, 57.6% of respondents had received formal training on healthcare waste management, indicating a moderate level of awareness (Table 1).

Table 1: Demographic Characteristics of Respondents

Variable	Category	Frequency (n)	Percentage (%)
Age Group (Years)	20–29	60	18.2
	30–39	120	36.4
	40–49	90	27.3
	50 and above	60	18.2
Gender	Male	145	43.9
	Female	185	56.1
Qualification	Diploma/Certificate	50	15.2
	Bachelor's Degree	160	48.5
	Postgraduate Degree	120	36.4
Job Role	Doctor	50	15.2
	Nurse	116	35.2
	Laboratory Staff	33	10.0
	Waste Management Staff	132	40.0
	Administrator/Other	9	2.7
Years of Experience	<1 year	30	9.1
	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
	No	140	42.4

Current Healthcare waste management practices in tertiary health institutions in Abuja shows that 54.5% used color-coded bins for waste segregation, while 15.2% did not segregate waste at all. Dedicated waste management staff handled waste collection in 48.5% of cases, and incineration (45.5%) was the most common disposal method. Major challenges reported included lack of proper disposal facilities (39.4%) and inadequate staff training (30.3%) (Table 2).

Table 2: Current Healthcare Waste Management Practices

Question	Category	Frequency (n)	Percentage (%)
6. How is healthcare waste segregated in your unit/hospital?	Color-coded bins (e.g., red, yellow, black)	180	54.5
	Labels/text on bins	80	24.2
	No segregation	50	15.2
	Other	20	6.1
7. Which type of waste is primarily separated in your facility?	Infectious (e.g., sharps, blood-soaked items)	140	42.4
	Hazardous (e.g., chemicals, pharmaceuticals)	90	27.3
	General (non-risk) waste	70	21.2
	Radioactive waste	30	9.1
8. Who is responsible for waste collection in your unit?	Dedicated waste management staff	160	48.5
	Nurses/cleaners	80	24.2
	Outsourced company	60	18.2
	No clear responsibility	30	9.1
9. How frequently is healthcare waste collected from your unit?	Daily	190	57.6

	Twice daily	70	21.2
	Weekly	40	12.1
	Irregularly	30	9.1
10. Method of final disposal for hazardous waste in your hospital.	Incineration	150	45.5
	Autoclaving	80	24.2
	Landfill	60	18.2
	Open dumping	40	12.1
11. Major challenge in managing healthcare waste	Lack of proper disposal facilities	130	39.4
	Inadequate training of staff	100	30.3
	Insufficient waste collection frequency	60	18.2
	Poor compliance with segregation guidelines	40	12.1

The knowledge assessment of healthcare workers on healthcare waste reveals that most healthcare workers (69.7%) recognized that improper disposal of waste poses a community risk, and 75.8% considered proper waste segregation to be very important. However, only 54.5% were aware of national or international healthcare waste management guidelines (Table 3).

Table 3: Knowledge Assessment of Healthcare Workers

Question	Category	Frequency (n)	Percentage (%)
All healthcare waste is hazardous.	True	110	33.3
	False	180	54.5
	Not sure	40	12.1
Yellow bins are used for sharps and infectious waste.	True	200	60.6
	False	90	27.3
	Not sure	40	12.1
Healthcare waste poses no risk to the community if disposed improperly.	True	60	18.2
	False	230	69.7
	Not sure	40	12.1
Rank the importance of proper healthcare waste segregation.	Very important	250	75.8
	Important	60	18.2
	Neutral	15	4.5
	Unimportant	5	1.5
Are you aware of national/international guidelines for HCWM?	Yes	180	54.5
	No	80	24.2
	Partially	70	21.2

The trends in waste segregation methods shows that most respondents (54.5%) used color-coded bins, followed by 24.2% who relied on labelled bins. A smaller proportion (15.2%) did not practice segregation, while 6.1% used other methods (Figure 1)

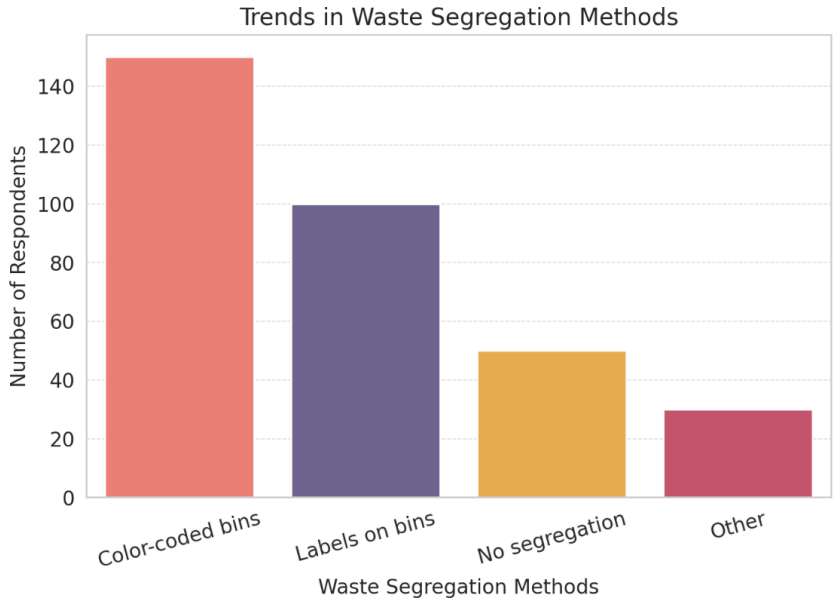

Fig. 1: waste segregation methods

Qualitative Data Results from Key Informant Interviews (KII)

Thematic analysis of key informant interviews with healthcare professionals identified four main themes:

Existing Waste Management Systems

Hospitals have formal systems for waste handling, including color-coded segregation and categorization into infectious, general, and sharps waste. However, implementation varies across units.

Challenges in Waste Segregation Practices

Respondents highlighted that bin shortages, mislabeling, and inconsistent supervision hinder proper segregation. Staff workload and resource limitations further affect consistent practice.

Knowledge Gaps Among Healthcare Workers

Training is often infrequent, leading to an incomplete understanding of HCWM protocols. Some staff do not prioritize waste management, and existing policies and posters are not always effectively reinforced.

Suggested Improvements for Knowledge and Practice

Key informants recommended more frequent refresher training, hands-on demonstrations, and ensuring sufficient resources, such as bins and PPE to support safe and consistent waste handling.

DISCUSSIONS

This study demonstrates that healthcare waste management (HCWM) practices and knowledge among healthcare workers in tertiary hospitals in the Federal Capital Territory (FCT) are shaped largely by institutional resources, training availability, and staff awareness rather than hospital infrastructure alone. Similar patterns have been reported in other Nigerian hospitals and across sub-Saharan Africa[1,14,15,] where gaps in training, supervision, and material resources compromise effective waste segregation.

The presence of color-coded segregation systems was common, yet inconsistent adherence emerged as a key issue, reflecting variations in staff workload, bin availability, and mislabelling.[1,16,17] Key informant interviews confirmed that supervision is irregular and that staff often rely on individual discretion, echoing findings from Ghana and Kenya, where sporadic training and ambiguous role allocation affected compliance.[18,16] These observations underscore the need for context-specific, resource-supported interventions to enhance HCWM practices.

Healthcare workers' knowledge of waste categorization and guideline adherence was moderate. While most recognized the risks of improper disposal, misconceptions persisted, with a third overclassifying all waste as hazardous and over a quarter incorrectly identifying color-coded bins.[1,16,15] Qualitative insights revealed that infrequent training, low prioritization of HCWM, and limited visual aids contributed to these knowledge gaps. Similar trends have been observed in Ethiopia and Bangladesh, highlighting the role of structured, repeated education and accessible guidelines in improving HCWM knowledge.[19,14]

The findings also highlight that awareness of official HCWM policies and international standards remains suboptimal, particularly among non-professional staff. Language barriers and poor dissemination practices limit the reach of training programs, a pattern documented in Pakistan and Kenya.[10,16,20] Decentralized and interactive training models, such as Rwanda's district-level workshops

and Thailand's mandatory certification programs, have proven effective in increasing knowledge and compliance, suggesting strategies adaptable to the FCT context.[15,21]

DECLARATIONS

Consent to Participate

Written informed consent was obtained from all participants before they were enrolled in the study. Participation was voluntary, and confidentiality was assured.

Consent to Publish

Not applicable: No identifying information or images of individual participants are included in this manuscript.

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Clinical trial number: Not applicable

Conflict of Interest: No Conflict of Interest

Data Availability Statement

The datasets generated and analysed during this study contain sensitive personal information and are therefore not publicly available to protect participant confidentiality. However, the identified data may be made available from the corresponding author upon reasonable request and subject to approval by the relevant ethics committee.

CONCLUSION

Healthcare waste management in tertiary hospitals in the FCT exhibits partial compliance with recommended practices, constrained by resource limitations, supervision gaps, and moderate staff knowledge. Knowledge deficits regarding waste categorization, color-coding protocols, and policy awareness persist despite existing training programs. Addressing these challenges through frequent refresher training, provision of visual aids, accessible guidelines, and adequate resources is essential for safeguarding healthcare workers and communities. Public health interventions should focus on strengthening HCWM education and institutional support to promote safer and more sustainable waste management practices in Nigerian tertiary hospitals.

REFERENCES

1) World Health Organization. Safe management of wastes from health-care activities. 2nd ed. Geneva: WHO; 2014.
2) World Health Organization. Health-care waste fact sheet. Geneva: WHO; 2023.
3) Prüss-Üstün A, et al. Safe management of wastes from healthcare activities. Geneva: WHO; 2018.
4) Chartier Y, et al. Healthcare waste management guidelines. WHO Press; 2019.
5) Windfeld ES, Brooks MS. Medical waste management – A review. *J Environ Manage.* 2015;163:98-108.
6) Manyele SV, Lyasenga TJ. Factors affecting medical waste management in low-income countries. *Afr J Environ Sci Technol.* 2018;12(1):1-10.
7) Federal Ministry of Health, Nigeria. National healthcare waste management policy. Abuja, 2019.
8) Coker A, Sangodoyin A, Sridhar M, et al. Medical waste management in Nigeria. *Waste Manage.* 2009;29(2):804-811.
9) Awodele O, Adewoye AA, Oparah AC. Assessment of medical waste management in Lagos hospitals. *BMC Public Health.* 2016;16:269.
10) Olubukola OO. Healthcare waste management practices in Nigerian hospitals. *J Public Health Afr.* 2017;8(1):673.
11) Oke IA. Healthcare waste management practices in Nigeria. *Waste Manage.* 2020;102:342-350.
12) Tudor TL, Barr SW, Gilg AW. Strategies for improving healthcare waste management. *Waste Manage.* 2018;76:3-13.
13) Ali M, Wang W, Chaudhry N, Geng Y. Hospital waste management challenges in developing countries. *Waste Manage Res.* 2017;35(6):581-592.
14) Hossain MS, Santhanam A, Norulaini NA, Omar AKM. Clinical solid waste management practices and its impact on human health and environment – A review. Waste Manag. 2011;31(4):754–766. doi:10.1016/j.wasman.2010.11.008.
15) United Nations Environment Programme (UNEP). Healthcare Waste Management Assessment Framework. Nairobi: UNEP; 2023.
16) Mwaura J, Karanja A, Mwangi M. Challenges in healthcare waste storage and transportation in Kenya. Afr J Environ Sci. 2023;17(4):112–125.
17) Naidoo S, Govender T, Mathee A. Mobile-based training for healthcare workers in South Africa. Health Educ Res. 2023;38(1):89–102.

18) Addo K, Twumasi-Ankrah S, Owusu-Ansah E. Pharmaceutical waste contamination in Ghanaian water systems. Environ Pollut. 2022;292:118342.
19) Tesfaye T, Gebrehiwot M, Abebe L. Effectiveness of healthcare waste management training in Ethiopia. Ethiop J Health Sci. 2021;31(5):1023–1032.
20) Ransing R, Vadivel R, Halabi SE, Jatchavala C, Shalbafan M, Noël C, et al. Language as multi-level barrier in health research and the way forward. Indian J Psychol Med. 2021;45(1):65–68. doi:10.1177/02537176211052071.
21) World Health Organization (WHO). Thailand's healthcare waste management success. Geneva: WHO; 2023.