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Bridging the Chasm: A nationwide assessment of Knowledge, Attitudes, and Practices of medical waste management among Nigerian medical students

Abstract

Purpose: This study assessed the Knowledge, Attitudes, and Practices (KAP) of Nigerian medical students regarding Medical Waste Management (MWM) to evaluate their preparedness for this critical aspect of patient and environmental safety.

Methods: A nationwide cross-sectional study was conducted among 200 clinical-level medical students from six universities, selected via multi-stage sampling. Participants completed a pre-validated, 40-item questionnaire. Data were analyzed using descriptive statistics and chi-square tests.

Results: A profound "know-do" gap (i.e., a disconnect between what students know they should do and what they actually do) was identified. The mean knowledge score was poor (48.7% ±12.3), with only 22% of students having received formal MWM training.

Knowledge of waste classification and color-coding was particularly deficient. In stark contrast, attitudes were overwhelmingly positive (mean score: 81.5% ±9.8). However, self-reported practices were alarmingly poor (mean score: 35.2% ±15.6), characterized by high rates of improper sharps disposal (68%) and mixing of infectious and general waste (74%). Crucially, formal training was significantly associated with higher knowledge ($p<0.001$) and better practice scores ($p<0.01$).

Conclusion: Nigerian medical students are acutely unprepared to manage medical waste safely, despite recognizing its importance. This dissonance signals a critical failure in undergraduate medical education. The findings mandate the urgent integration of structured, practical MWM training into the core curriculum to equip future physicians with the necessary competence to protect human and environmental health.

Keywords: biomedical waste, medical education, knowledge-attitude-practice, Nigeria, curriculum development, public health, environmental health

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Williams Igoniye,[1] Onuchuku Precious,[1] Christopher F Njeh[2]

[1]Department of Radiology, University of Port Harcourt Teaching Hospital, Port Harcourt, Port Harcourt City, Nigeria
[2]Department of Radiation Oncology, Indiana University School of Medicine, Franciscan Health, Indianapolis, IN 46237, USA

Correspondence: Williams Igoniye, Department of Radiology, University of Port Harcourt Teaching Hospital, Port Harcourt, Port Harcourt City, Nigeria

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Introduction

Every single day, the global healthcare industry generates thousands of tons of waste, a significant portion of which is hazardous, transforming healing environments into potential epicenters of disease and pollution.[1,2] This paradox lies at the heart of one of the most neglected challenges in modern public health: the safe management of medical waste.

Defined as waste generated during the diagnosis, treatment, or immunization of humans or animals, medical waste encompasses a spectrum of materials, from innocuous general waste to highly hazardous infectious waste (cultures, swabs), pathological waste (tissues, organs), and sharps (needles, scalpels).[3] Its improper management is not merely a logistical failure; it is a critical breach of the fundamental medical tenet: *primum non nocere* (first, do no harm).[4] When mismanaged, this waste catalyzes a cascade of risks, including nosocomial infections, needle-stick injuries transmitting blood-borne pathogens like HIV and Hepatitis B and C, and the contamination of ecosystems with toxic substances and antimicrobial-resistant organisms.[5] The World Health Organization starkly illustrates this by noting that while only 15% of medical waste is classified as hazardous, without proper management, 100% of it poses a tangible risk.[6,7]

The gravity of this challenge is magnified exponentially in low-and-middle-income countries (LMICs) like Nigeria, where rapid urbanization and expanding, yet under-resourced, healthcare systems collide.[8] Here, the narrative of medical waste management (MWM) is often framed around systemic failures: weak regulatory enforcement, chronic underfunding, and a critical lack of treatment infrastructure.[9] While these macro-level factors are undeniable, this prevailing narrative has inadvertently overshadowed a more foundational and remediable element: the human factor. The Knowledge, Attitudes, and Practices (KAP) of frontline healthcare workers are the ultimate determinants of whether protocols succeed or fail at the point of care.[10] It is at this micro-level that safe segregation and disposal either begin or break down.[11]

The cultivation of these professional behaviors does not commence in the hectic hospital ward but in the formative crucible of undergraduate medical education.[12] Medical students represent the very cornerstone of future healthcare systems; their training period is a critical window for instilling the core principles of public health, infection control, and environmental stewardship.[13] A physician who graduates without a robust understanding of MWM is not only an immediate risk to themselves and their patients but also becomes a perpetuating agent of dysfunctional systems, cementing poor practices for decades to come.[14] This is not a hypothetical concern. Emerging

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evidence from diverse contexts reveals a disturbing trend: medical and dental students frequently graduate with significant, dangerous gaps in their practical knowledge of MWM, despite holding positive attitudes about its importance.[15,16] For instance, studies from Serbia and India have documented students' inability to correctly classify waste or identify color-coded bins, highlighting a global disconnect between curricular intent and practical competence.[17,18]

This body of literature provides a crucial foundation, yet it exposes a critical, context-specific knowledge gap within the Nigerian landscape. While several studies have profiled the KAP of practicing Nigerian doctors and nurses,[19,20] a profound silence exists regarding the medical student population. This is a significant oversight. Assessing the KAP of students offers a unique and powerful diagnostic lens through which to evaluate the efficacy of the national medical curriculum.[21,22] It allows us to identify and rectify deficiencies before they become entrenched professional habits, thereby intervening at the most cost-effective and impactful point in a physician's career.[23] The central, unresolved problem is this: We are sending our future doctors into a battle against infection and environmental harm without ensuring they are proficient in handling one of the most dangerous tools in their purview, medical waste.[24]

This study is therefore guided by the overarching hypothesis that a significant "know-do" gap exists among Nigerian medical students, characterized by positive attitudes towards medical waste management undermined by critically deficient knowledge and subsequently poor self-reported practices.[25,26] This hypothesis is framed by the Theory of Planned Behavior (TPB),[27,28] which posits that behavior is directly influenced by intention, which in turn is shaped by attitude, subjective norms, and perceived behavioral control.[29,30] By measuring these constructs, we can move beyond simply documenting poor practices to understanding the underlying cognitive and social factors that drive them.[31]

This research is deliberately designed not merely to describe a problem, but to challenge the current paradigm of medical education in Nigeria. It questions the assumption that knowledge of MWM is passively absorbed through clinical exposure rather than requiring explicit, structured teaching.[32,33] It seeks to confirm the alarming trends observed in other countries within the unique, high-pressure context of Nigerian teaching hospitals. Most importantly, it aims to extend previous research by moving from a singular focus on practicing professionals to a proactive focus on the pipeline of future providers, thereby shifting the discourse from blame to prevention.

Consequently, this study is driven by the following research questions:

1. What is the level of knowledge, attitudes, and self-reported practices regarding medical waste management among clinical-level medical students in Nigeria?[34]
2. Is there a statistically significant association between the receipt of formal training in medical waste management and students' knowledge and practice scores?[35]
3. What are the perceived barriers and facilitators to adhering to proper medical waste management protocols in the clinical training environment?[36,37]

The primary purpose of this nationwide assessment is to generate robust, actionable evidence to catalyze curriculum reform. Our specific objectives are:

I. To quantitatively assess the knowledge, attitudes, and self-reported practices of medical waste management among a representative sample of Nigerian medical students.[38]

II. To identify demographic and institutional factors (e.g., year of study, prior training) associated with KAP outcomes.[39]

III. To qualitatively explore the contextual and systemic barriers that impede optimal practice.[40]

Filling this gap is not an academic exercise; it is an urgent imperative for public health. The relevance of this work extends to medical educators, curriculum designers, healthcare policymakers, and hospital administrators. For them, these findings will provide the necessary evidence base to design targeted, practical educational interventions. Ultimately, by equipping the next generation of Nigerian physicians with the competence and conviction to manage waste safely, this research contributes directly to safeguarding healthcare workers, protecting patients, preserving the environment, and fortifying the very foundations of a resilient health system.

Methods

Study design and rationale

A descriptive, cross-sectional study design was employed to conduct a nationwide assessment of medical waste management (MWM) practices among Nigerian medical students from January to June 2025. The cross-sectional design was the most appropriate and robust method to address the research aim, as it provided a "snapshot" of the knowledge, attitudes, and practices (KAP) at a single point in time, allowing for the efficient measurement of prevalence and the examination of associations between variables across a large, geographically dispersed population.[41] This design was explicitly chosen over longitudinal or qualitative-only approaches to establish the baseline state of a critical issue with high external validity and within a feasible timeframe, thereby generating immediate, actionable evidence for policy and curriculum review.

Study setting and population

The study was conducted in six medical schools strategically selected from Nigeria's six geo- political zones: North-West, North-East, North-Central, South-West, South-East, and South- South. This ensured national representation and captured the socio-cultural and institutional diversity of medical education in Nigeria.[42] The study population comprised all clinical- level medical students (from 300 to 500 level) enrolled in the selected universities.[43,44]

This group was deliberately chosen as they had transitioned from pre-clinical, theoretical learning to hands-on clinical postings in teaching hospitals, where they directly encountered and were expected to manage medical waste.[45]

Inclusion criteria were: 1) being a formally registered clinical-level medical student in one of the selected universities, and 2) providing written informed consent.

Exclusion criteria included: 1) students in their first or second year (pre-clinical) who had no direct patient contact, and 2) students who were absent during the period of data collection. The rationale for focusing on clinical-level students was that they constituted the population of immediate interest, possessing direct exposure to clinical environments where MWM is practically relevant, unlike their pre-clinical counterparts.

Sampling strategy and sample size determination

A multi-stage sampling technique was employed to ensure a representative and unbiased sample. In the first stage, one university was randomly selected from a comprehensive list of accredited medical schools within each of the six geo-political zones using a simple random sampling (computer-generated random numbers) technique. In the second stage, a proportionate-to-size quota sampling method was used to recruit participants from each clinical year (300, 400, and 500 level) within the selected universities. This ensured that the sample reflected the natural distribution of students across all clinical levels.

The minimum required sample size was calculated as 196 participants. This was determined using the Cochran formula for cross-sectional studies[46,47]: $n=Z^2P(1-P)/d^2$, where Z = 1.96 (corresponding to the 95% confidence level), P = 0.50 (the maximum proportion, assumed due to the absence of prior precise KAP data in Nigeria, ensuring a conservative estimate), and d = 0.05 (the desired precision). Anticipating a non-response rate of 10%, the final target sample size was inflated to 220.[48]

Research instrument and data collection

Data were collected using a structured, self-administered questionnaire that was developed after an extensive review of relevant literature.[49,50] The instrument was specifically adapted and contextualized for the Nigerian medical education setting. It consisted of four distinct sections[51,52]:

I. **Section A:** Collected socio-demographic and academic data (age, gender, university, year of study, and prior formal training in MWM).[53]

II. **Section B (Knowledge assessment):** Comprised 15 multiple-choice and true/false questions designed to evaluate objective knowledge. This included items on medical waste classification, colour-coding protocols for segregation, potential health hazards, and relevant national regulations.[54] Each correct response was assigned 1 point, with a total possible knowledge score of 15.

III. **Section C (Attitudes assessment):** Contained 10 statements measured on a five- point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). This section probed perceptions regarding the importance of MWM, personal responsibility, and the perceived consequences of improper disposal.[55]

IV. **Section D (Practices assessment):** Included 15 items evaluating self-reported behaviours. These questions covered actual practices related to waste segregation, sharp disposal, use of personal protective equipment (PPE), and responses to observed protocol breaches.[56]

To ensure content and face validity, the initial draft of the questionnaire was reviewed by a panel of five experts, including specialists in public health, medical education, and environmental health. The instrument was pre-tested on a sample of 30 medical students from a university not included in the main study. Cronbach's alpha was calculated from the pre-test data to assess the internal consistency[57,58] reliability of the attitude and practice scales, which yielded coefficients of 0.78 and 0.81, respectively, indicating good reliability. The knowledge scale, being a measure of factual recall, was assessed for clarity and difficulty during the pre-test. The final questionnaire was revised based on the feedback from the expert panel and the pre-test results.[59,60]

Data collection procedure and ethical considerations

The principal investigator and trained research assistants visited each site, distributed the questionnaires, and provided a standardized explanation of the study's purpose. Written informed consent was obtained from every participant before questionnaire administration. The voluntary nature of participation and the confidentiality of responses were explicitly emphasized. To ensure anonymity, no personally identifiable information (e.g., names, student ID numbers) was collected on the questionnaire forms. Completed questionnaires were sealed in envelopes immediately upon collection.

Data analysis

All collected data were screened, coded, and entered into IBM SPSS Statistics version 26.0 for analysis.[61] Descriptive statistics, frequencies, percentages, means, and standard deviations, were computed to summarize the socio-demographic characteristics and the scores for knowledge, attitudes, and practices.[62] Total scores for knowledge (range: 0-15) and practices (range: 0-15) were calculated and converted to percentages for easier interpretation. These percentage scores were then categorized into three levels: "Good" (≥80%), "Moderate" (50-79%), and "Poor" (<50%). Attitude scores were summed and categorized as "Positive" or "Negative" based on the sample's median score.

Inferential statistics were employed to test hypotheses and explore relationships.[63] The Chi-square test was used to determine the association between categorical variables, such as the association between the receipt of formal training (Yes/No) and the categorized levels of knowledge and practice.[64] For all statistical tests, a p-value of less than 0.05 was considered statistically significant.[65] The analysis was guided by the Theory of Planned Behavior framework, with variables mapped to its core constructs (attitudes, subjective norms, perceived behavioural control) to provide a theoretical explanation for the observed practices.[66]

Results

Participant demographics and response rate

A total of 220 questionnaires were distributed across six universities in Nigeria's geo-political zones. Of these, 200 were completed and returned, yielding a high response rate of 90.9%.

The socio-demographic characteristics of the respondents are summarized in Table 1. The cohort had a mean age of 22.4 years (±2.1), with a nearly balanced gender distribution (54% male, 46% female). The distribution across clinical years of study was relatively even, ensuring representation from all levels of clinical exposure.

Knowledge of medical waste management

The assessment of fundamental knowledge revealed critical deficiencies. The overall mean knowledge score was 48.7% (±12.3), which falls within the pre-defined "Poor" category (<50%). As illustrated in Figure 1, only a small minority of students (17.5%, n=35) could correctly classify common types of biomedical waste. Knowledge regarding the color-coding system for waste segregation was particularly inadequate, with only 28.0% (n=56) of participants correctly matching waste types to the appropriate colored bins.

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Table 1 Socio-demographic characteristics of study participants (N=200)

Characteristic	Category	Frequency (n)	Percentage (%)
Age (Years)	Mean ± SD	22.4 ± 2.1	-
Gender	Male	108	54.0%
	Female	92	46.0%
Year of Study	300 Level	65	32.5%
	400 Level	72	36.0%
	500 Level	63	31.5%
Prior MWM Training	Yes	44	22.0%
	No	156	78.0%

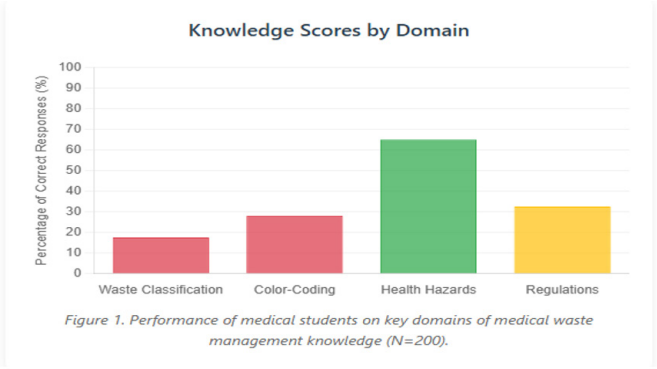

Figure 1. Performance of medical students on key domains of medical waste management knowledge (N=200).

Figure 1 Distribution of knowledge scores on Key MWM domains.

A pivotal finding was that the vast majority of respondents, 78.0% (n=156), reported having never received any formal training or dedicated lecture on medical waste management during their medical education.

Attitudes towards medical waste management

In stark contrast to the knowledge scores, the attitudes of medical students towards MWM were overwhelmingly positive.[67] The mean attitude score was 81.5% (±9.8). As detailed in Figure 2, over 95% of respondents agreed or strongly agreed with core attitudinal statements, such as "Proper medical waste management is a professional duty" (96.5%) and "Inadequate MWM poses a serious public health risk" (95.0%). Furthermore, 92.0% (n=184) expressed a willingness to participate in future training programs on MWM.

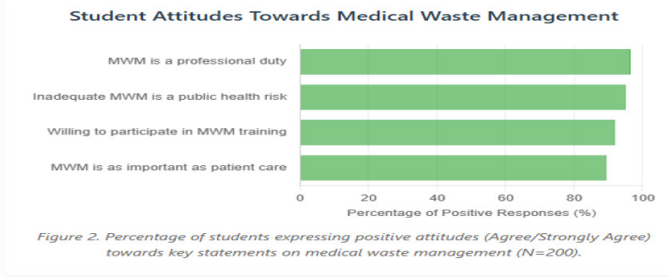

Figure 2. Percentage of students expressing positive attitudes (Agree/Strongly Agree) towards key statements on medical waste management (N=200).

Figure 2 Student attitudes towards medical waste management.

Self-reported practices regarding medical waste management

The self-reported practices constituted the most deficient area of the KAP triad.[68] The mean practice score was 35.2% (±15.6), significantly lower than both attitude and knowledge scores. The data, visualized in Figure 3, uncovered prevalent unsafe practices. A substantial 74.0% (n=148) of students admitted to occasionally disposing of non-sharp infectious waste (e.g., soiled gauze, gloves) into general waste bins. Even more alarmingly, 68.0% (n=136) reported having observed or been personally involved in the improper disposal of sharps. The consistent use of appropriate Personal Protective Equipment (PPE) during procedures that generate waste was reported by only 31.0% (n=62) of the participants.[69]

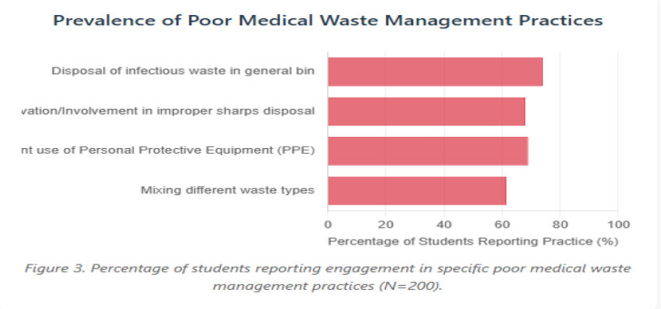

Figure 3. Percentage of students reporting engagement in specific poor medical waste management practices (N=200).

Figure 3 Prevalence of self-reported poor medical waste management practices.

The impact of formal training on knowledge, attitudes, and practices

The analysis revealed a stark divergence in outcomes between students who had received prior formal MWM training (n=44) and those who had not (n=156). As presented in Table 2, the trained group demonstrated a mean knowledge score of 65.8% (±10.1), classifying it as "Moderate," compared to a "Poor" score of 43.1% (±9.8) in the untrained group. This difference was statistically significant ($p < 0.001$).

The positive effect of training extended to self-reported practices. The mean practice score for the trained cohort was 45.5% (±14.9), significantly higher than the 32.1% (±14.2) recorded for the untrained cohort ($p < 0.01$). This relationship is further illuminated in Figure 4, which shows the distribution of practice scores, clearly demonstrating a rightward shift (towards better practices) in the trained group. In contrast, formal training showed no significant effect on the already high attitude scores ($p = 0.215$).

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Table 2 Association between formal training and KAP scores

KAP Domain	Trained Group (n=44)	Untrained Group (n=156)	p - value
Knowledge Score (Mean % ± SD)	65.8% ± 10.1	43.1% ± 9.8	**< 0.001**
Attitude Score (Mean % ± SD)	83.1% ± 8.5	81.1% ± 10.0	0.215
Practice Score (Mean % ± SD)	45.5% ± 14.9	32.1% ± 14.2	**< 0.01**

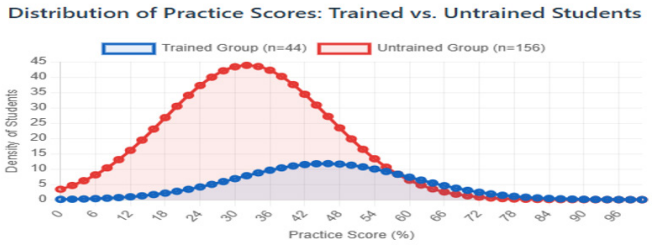

Figure 4. Comparative distribution of self-reported practice scores between students who had received formal MWM training and those who had not. The trained group demonstrates a clear shift towards higher (better) practice scores.

Figure 4 Distribution of practice scores: Trained vs. Untrained students.

Discussion

This nationwide study provides a stark and unambiguous diagnosis of a critical vulnerability within Nigeria's future healthcare workforce. The central hypothesis of this research, that a significant "know-do" gap (i.e., a disconnect between what students know they should do and what they actually do) exists among Nigerian medical students, is overwhelmingly confirmed by the data. We identified a troubling triad of outcomes: professionally conscientious attitudes undermined by profound knowledge deficits and subsequently dangerous self-reported practices.[70,71] This dissonance is not merely an academic concern; it represents a active failure in the foundational training of our future physicians, with direct consequences for patient safety, occupational health, and environmental integrity.[72]

Interpretation of key findings: A system under stress the knowledge deficit: A curricular failure

The profoundly low mean knowledge score of 48.7% is the cornerstone of this crisis. The finding that 78% of students had received no formal training in MWM points unequivocally to a systemic omission in the undergraduate medical curriculum. This aligns with a global pattern of neglect; studies from Serbia and India similarly reported that medical and dental students graduate with hazardous gaps in their understanding of waste classification and color-coding.[73,74] However, the Nigerian context reveals a more acute void. This is not a case of students forgetting taught material; it is a case of the material never being formally delivered.[75] The curriculum appears to prioritize diagnostic and therapeutic knowledge while overlooking the fundamental environmental and safety protocols that enable safe healthcare delivery. This creates a generation of doctors who are, from their first day of practice, operationally ill-equipped in a critical domain of infection prevention and control.[76]

The most compelling and troubling finding of this study is the stark disconnect between the overwhelmingly positive attitudes (81.5%) and the abysmal self-reported practices (35.2%).[77] where intention fails to translate into action.[78] This study's results move beyond simply identifying this gap; they provide a diagnostic framework for its causes. The "know- do" gap here is not a reflection of apathy but a consequence of multiple, intersecting barriers:

1. **The foundational knowledge gap:** It is axiomatic that one cannot correctly execute a procedure one does not understand. The inability to classify waste or identify the correct bin makes proper segregation a matter of chance, not competence.
2. **The environmental deficit:** The clinical training environment itself is a powerful, and in this case, negative, teacher. When color-coded bins are absent, broken, or inconsistently available, and when Personal Protective Equipment (PPE) is not accessible, the system actively reinforces poor practices. Students learn to adapt to a dysfunctional environment, and this adaptation becomes their professional norm.[79]
3. **The social and cultural contagion:** The high percentage (68%) of students who reported observing improper sharps disposal indicates that poor practice is culturally embedded and passively transmitted. When senior colleagues and consultants model non-compliance, it establishes a powerful "subjective norm" that overrides formal knowledge and positive attitudes, a concept central to the Theory of Planned Behavior which frames this study.[80]

The alarming rate of improper sharps disposal and low PPE usage are not just statistical findings; they are direct predictors of needle-stick injuries and occupational exposure to blood-borne pathogens.[81] This translates the abstract concept of "poor practice" into a tangible, imminent health risk for the students themselves and for the ancillary hospital staff.[82]

A pivotal and hopeful finding was the strong, statistically significant association between prior formal training and improved knowledge ($p<0.001$) and practices ($p<0.01$). This is not a subtle correlation; it is a clear dose-response relationship demonstrating that education works. Students who received training were not only more knowledgeable but also reported engaging in safer practices. This provides irrefutable, evidence-based justification for curricular intervention. It demonstrates that the knowledge and practice gaps are not intrinsic to the students but are a remediable result of an educational shortfall. The implications of this study extend far beyond the lecture hall and demand a multi-level response.

For medical education regulators (Medical and Dental council of Nigeria):

The findings serve as an urgent mandate for curriculum reform. MWM must be transitioned from an implicit expectation to an explicit, standardized, and examinable core competency. This involves integrating a dedicated, practical module that moves beyond theory to include hands-on simulations, site visits to waste treatment facilities, and competency-based assessments.

For university and hospital management:

Accountability must be enforced at the institutional level. Teaching hospitals, as the clinical classrooms for students, have a non-negotiable responsibility to provide the necessary infrastructure. This includes ensuring the ubiquitous availability of functional, color-coded bins,

adequate supplies of PPE, and clear institutional protocols that are actively enforced. The environment must be reconfigured to make the correct practice the easiest practice.

For public health policy:

This research highlights a critical leak in the public health system. Incompetence in MWM among healthcare workers contributes to environmental pollution and community-level health risks. Strengthening this weakest link through improved education is a cost-effective public health intervention that safeguards the wider community.

Limitations and future research directions

While this study provides critical insights, its limitations must be acknowledged. The reliance on self-reported practices is susceptible to social desirability bias, where participants may have over-reported good practices. Consequently, the actual practice levels may be even worse than our data suggests. Furthermore, the cross-sectional design establishes association but not causation. While the link between training and better outcomes is strong, longitudinal studies are needed to confirm that training directly causes sustained improvements in practice.

Future research should therefore pursue several avenues:

1. **Mixed-methods deep dive:** Employ qualitative interviews and focus groups to explore the nuanced cultural and systemic barriers to good practice that quantitative surveys cannot fully capture.
2. **Intervention studies:** Develop and test the efficacy of specific educational interventions (a simulation-based MWM module) using a randomized controlled trial design.
3. **Longitudinal tracking:** Follow cohorts of students into their housemanship and early careers to understand how practices evolve and what institutional factors most influence long-term behavior.

This study moves the discourse on medical waste management in Nigeria from a focus on infrastructure and regulation to a critical, and previously overlooked, human factor: the competence of the future healthcare provider. We have diagnosed a "know-do" gap of alarming proportions, rooted in educational neglect and perpetuated by a dysfunctional clinical environment. The solution, as our data clearly shows, lies in a dual strategy: equipping students with knowledge through mandatory, practical education while simultaneously holding their training institutions accountable for providing an environment that enables, rather than undermines, safe practice. Filling this gap is not merely an academic exercise; it is an essential investment in the safety of healthcare workers, the well-being of patients, and the environmental health of the nation.

Conclusion and recommendations

This study conclusively demonstrates that Nigerian medical students possess a dangerous dissonance between their intentions and their capabilities in medical waste management (MWM). While their attitudes reflect a strong sense of professional responsibility, this is critically undermined by a profound knowledge deficit and the subsequent adoption of high- risk practices. This "know-do" gap is not a minor curricular oversight but a fundamental systemic failure that actively cultivates a generation of physicians unprepared for a core aspect of infection control and environmental stewardship. The clinical training environment, often characterized by inadequate infrastructure and inconsistent role modeling, currently serves as a classroom for poor practice, normalizing behaviors that directly jeopardize occupational safety and public health.

The implications of these findings are immediate and actionable. At the policy level, national medical education regulatory bodies must mandate the integration of a standardized, practical, and assessable MWM module into the core undergraduate curriculum. This cannot be an elective topic but a non-negotiable competency. Simultaneously, healthcare accreditation agencies must enforce stricter standards for teaching hospitals, ensuring the consistent availability of color-coded segregation bins, personal protective equipment, and functional disposal systems. The environment must be engineered to make the safe choice the easy choice. For future research, this study provides a foundational dataset and a clear trajectory for further inquiry. The research agenda should now expand in three key directions: First, applying this same KAP methodology to other critical healthcare cadres, such as nurses, laboratory scientists, and hospital support staff, to gain a holistic view of the hospital ecosystem. Second, conducting longitudinal studies to track how MWM practices evolve from student to houseman to independent practitioner, identifying critical intervention points. Third, and most critically, developing and rigorously testing the efficacy of specific educational interventions, such as virtual reality simulations, gamified learning modules, or community-based projects, through randomized controlled trials to determine the most effective pedagogical tools for this context.

Ultimately, addressing this gap transcends academic exercise. It is a vital investment in health system resilience. By bridging the chasm between attitude and practice, we do more than teach proper waste disposal; we foster a culture of safety and environmental consciousness that will resonate throughout the careers of future healthcare leaders. This safeguards the well-being of healthcare workers, protects the communities they serve from androgenic pollution, and fortifies the very foundations of a sustainable and responsible healthcare system in Nigeria and beyond.

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None.

Conflict of interest

The authors declare that there is no conflict of interest.

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