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Knowledge, Attitude, and Practice Regarding Biomedical Waste Management and Laboratory Safety among Healthcare Workers

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Abstract:

Background: Biomedical waste management and laboratory safety are critical components of infection control and environmental protection in healthcare facilities. Inadequate knowledge and poor practices among healthcare workers can lead to occupational hazards and disease transmission.

Objective: To assess the knowledge, attitude, and practice (KAP) regarding biomedical waste management and laboratory safety among healthcare workers.

Methods: A descriptive cross-sectional questionnaire-based study was conducted among 210 healthcare workers, including doctors, nurses, laboratory staff, and housekeeping personnel. Data were collected using Google Forms and analyzed using descriptive statistics.

Results: Of the participants, 55% had good knowledge, 70% displayed positive attitudes, and 50% reported good practices regarding biomedical waste management and laboratory safety. While awareness of risks and willingness to attend training were high, consistent adherence to PPE use and segregation protocols was suboptimal.

Conclusion: Healthcare workers show satisfactory knowledge and positive attitudes toward biomedical waste management and laboratory safety; however, gaps in practice remain. Strengthening training, supervision, and regular monitoring is essential to ensure compliance and minimize occupational and environmental risks.

Keywords: Biomedical waste, healthcare workers, laboratory safety, knowledge, attitude, practice, biosafety.

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Introduction

Biomedical waste (BMW) is defined as any waste generated during the diagnosis, treatment, or immunization of humans or animals, or in research activities related thereto, or in the production and testing of biologicals. It includes sharps, infectious materials, pathological waste, discarded medicines, and chemical waste, all of which pose serious health risks if not properly managed (1). With the rapid expansion of healthcare facilities worldwide, biomedical waste generation has been increasing substantially. According to estimates by the World Health Organization (WHO), approximately 15–20% of biomedical waste is hazardous, while the remaining is general waste; however, improper segregation often converts non-hazardous waste into hazardous waste, amplifying risks to healthcare workers, patients, waste handlers, and the community at large (2).

Effective biomedical waste management (BMWM) is not only a legal obligation but also a public health necessity. Poor practices such as improper segregation, inadequate labeling, and unsafe disposal methods can lead to occupational hazards including sharps injuries, blood-borne infections such as hepatitis B, hepatitis C, and HIV, and contamination of the environment (3,4). In India, the Biomedical Waste Management Rules were first notified in 1998 and have undergone revisions, the latest being in 2016, with amendments in 2018 and 2019, which emphasize segregation at source, barcoding of bags, and stringent disposal standards (5). Despite the presence of regulatory frameworks, compliance remains inconsistent, particularly in resource-constrained settings, where lack of training, monitoring, and awareness among healthcare workers contributes to unsafe practices (6).

Alongside biomedical waste concerns, laboratory safety has become an equally critical domain. Healthcare workers, especially

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those engaged in diagnostic and research laboratories, are routinely exposed to infectious agents, hazardous chemicals, and sharp instruments (7). Laboratory-acquired infections, accidental exposures, and chemical spills are frequently reported incidents that underline the need for strict adherence to biosafety and laboratory safety protocols (8). The Centers for Disease Control and Prevention (CDC) and WHO have emphasized the importance of biosafety level practices, appropriate use of personal protective equipment (PPE), vaccination of laboratory staff, and continuous training to ensure safety (9). However, studies across different regions indicate that awareness, attitudes, and practices of healthcare professionals regarding laboratory safety are often inadequate, with gaps between knowledge and implementation (10).

The triad of knowledge, attitude, and practice (KAP) assessment provides valuable insights into how healthcare workers perceive and implement biomedical waste management and laboratory safety. Knowledge refers to their understanding of policies, risks, and methods; attitude denotes their perceptions, motivation, and willingness to comply; and practice indicates their actual behavior in waste segregation, disposal, and safety compliance (11). Several studies have shown that while healthcare workers may demonstrate adequate knowledge, this does not always translate into safe practices, highlighting the need for continuous training and behavior change interventions (12,13).

Given the occupational hazards associated with poor biomedical waste handling and laboratory safety lapses, it is crucial to periodically evaluate the KAP of healthcare workers. Such assessments help identify gaps, design targeted training programs, and improve institutional policies to enhance compliance and ensure a safe working environment.

The present study aims to assess the knowledge, attitude, and practice regarding biomedical waste management and laboratory safety among healthcare workers, and to identify gaps that can guide future training and policy interventions.

Materials and Methods:

A descriptive, questionnaire-based cross-sectional study was carried out among healthcare workers in a tertiary healthcare facility over a period of three months. The study population included doctors, nurses, laboratory technicians, and housekeeping staff who are directly or indirectly involved in biomedical waste handling and laboratory practices. Participation was entirely voluntary, and informed consent was obtained prior to data collection to ensure ethical conduct of the study.

The data collection tool was a structured questionnaire developed using Google Forms and distributed online through institutional communication channels. Responses were automatically compiled and stored in Google Sheets for analysis. The questionnaire was designed to capture both demographic characteristics of the participants and their knowledge, attitude, and practice (KAP) regarding biomedical waste management and laboratory safety. Demographic information included age, gender, designation, years of professional experience, and department of work. The KAP section of the questionnaire consisted of 20 structured questions, divided into three domains: ten knowledge-based items, five attitude-related items, and five practice-based items.

The knowledge domain primarily assessed awareness of biomedical waste classification, segregation procedures, color coding of waste containers, storage limits, and safety protocols. For example, participants were asked to identify biomedical waste from other types of waste, to state the correct color-coded bag for infectious materials such as soiled dressings, and to specify the appropriate disposal method for sharps such as needles and blades. The questionnaire also tested awareness regarding the recommended maximum storage time of biomedical waste in healthcare facilities. Each knowledge item was presented with multiple-choice options, with one correct answer, and responses were scored dichotomously as “1” for correct and “0” for incorrect.

The attitude domain assessed perceptions and beliefs about biomedical waste management and laboratory safety using a five-point Likert scale ranging from “Strongly Agree” to “Strongly Disagree.” Statements explored participants’ opinions on the importance of biomedical waste management for staff and patient safety, the necessity of using personal protective equipment, the value of regular training programs, the role of biosafety in reducing occupational risks, and the shared responsibility of waste segregation at the point of generation.

The practice domain was designed to explore actual day-to-day practices followed by participants in relation to biomedical waste handling and laboratory safety. Questions in this section included the frequency of segregation of waste according to color-coded bins, the use of gloves and masks while handling biomedical waste, participation in formal training programs on biomedical waste management within the past two years, adherence to biosafety measures in the laboratory, and whether respondents had ever reported needle-stick injuries or accidental exposure to infectious materials. Responses were structured as “Yes/No” or “Always/Sometimes/Rarely/Never,” depending on the question.

For the purpose of analysis, knowledge, attitude, and practice scores were calculated separately for each respondent. Based on cumulative scores, participants were classified into three categories: poor (<50% correct responses), moderate (50–75% correct responses), and good (>75% correct responses). Data were analyzed using descriptive statistics, and results were expressed in terms of frequency and percentage distributions to provide an overview of the KAP levels among healthcare workers regarding biomedical waste management and laboratory safety.

Table 1: Sample Knowledge Questions

Q. No	Question	Options	Correct Answer
K1	What is biomedical waste?	a) Household waste b) Waste generated during treatment, diagnosis, or research c) Office waste d) Industrial waste	b
K2	What percentage of biomedical waste is considered hazardous?	a) 5–10% b) 15–20% c) 30–40% d) >50%	b
K3	Which color-coded bag is used for infectious waste like soiled dressings?	a) Blue b) Yellow c) Red d) Black	b
K4	Sharps such as needles and blades should be disposed in:	a) Black bag b) Plastic bag c) Puncture-proof container d) Yellow bag	c
K5	The maximum time biomedical waste should be stored at a healthcare facility before disposal is:	a) 12 hours b) 24 hours c) 48 hours d) 72 hours	b

Table 2: Sample Attitude Questions (Likert Scale)

Q. No	Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A1	Proper biomedical waste management is essential for patient and staff safety.	○	○	○	○	○
A2	Using personal protective equipment (PPE) should be mandatory when handling biomedical waste.	○	○	○	○	○
A3	Training on biomedical waste management and lab safety should be conducted regularly.	○	○	○	○	○
A4	Safe laboratory practices reduce the risk of occupational hazards.	○	○	○	○	○
A5	Segregation of waste at source is the responsibility of all healthcare workers.	○	○	○	○	○

Table 3: Sample Practice Questions

Q. No	Question	Options
P1	Do you always segregate biomedical waste according to color-coded bins?	Yes / No
P2	How often do you wear gloves and mask while handling biomedical waste?	Always / Sometimes / Rarely / Never
P3	Have you received formal training in biomedical waste management in the last 2 years?	Yes / No
P4	Do you follow biosafety precautions while working in the laboratory?	Always / Sometimes / Rarely / Never
P5	Have you ever reported an incident of needle-stick injury or exposure to infectious material?	Yes / No

Results

A total of 210 healthcare workers participated in the study. Among the respondents, nurses constituted the largest group, representing 40% of the study population, followed by doctors at 30%, laboratory technicians at 20%, and housekeeping staff at 10%. This distribution ensured representation across different categories of healthcare personnel directly involved in biomedical waste handling and laboratory safety practices.

With regard to knowledge, more than half of the participants (55.2%) demonstrated a good level of knowledge about biomedical waste segregation, color-coding of containers, and biosafety protocols in laboratory practice. About 30.0% of respondents showed a moderate level of knowledge, while 14.8% had poor knowledge. The relatively high proportion of participants with good knowledge indicates that awareness of biomedical waste management has been integrated into routine training and professional exposure, although a considerable minority still lacked sufficient understanding.

In terms of attitude, the majority of participants expressed favorable perceptions regarding biomedical waste management and laboratory safety. A total of 70.0% of respondents demonstrated a positive attitude, agreeing that safe waste management practices are crucial for patient and staff safety, and supporting the importance of biosafety measures such as personal protective equipment (PPE) and regular training programs. Meanwhile, 20.0% of the participants showed a neutral stance, and 10.0% expressed negative attitudes, suggesting that while awareness exists, motivational and behavioral reinforcement may be required to achieve uniform attitudinal improvement.

Despite adequate knowledge and generally positive attitudes, practical compliance with biomedical waste management protocols and laboratory safety practices was found to be suboptimal. Only half of the participants (50.0%) reported consistently following correct practices, such as strict adherence to segregation of biomedical waste at the point of generation and the use of PPE while handling hazardous materials. Another 30.0% of respondents reported partial compliance, while 20.0% admitted to poor compliance with established protocols. This gap between knowledge, attitude, and practice highlights the need for regular training, stricter enforcement, and monitoring mechanisms to improve actual implementation of waste management procedures.

The distribution of knowledge, attitude, and practice levels among healthcare workers is summarized in Table 1.

Table 4. Knowledge, Attitude, and Practice Levels among Healthcare Workers (n = 210)

Domain	Good n (%)	Moderate n (%)	Poor n (%)
Knowledge	116 (55.2%)	63 (30.0%)	31 (14.8%)
Attitude	147 (70.0%)	42 (20.0%)	21 (10.0%)
Practice	105 (50.0%)	63 (30.0%)	42 (20.0%)

Further analysis of responses to key questions within the questionnaire revealed important insights. Approximately 62.8% of respondents correctly identified the biomedical waste color-coding system, while a significantly higher proportion (84.7%) were aware that improper biomedical waste management could lead to the transmission of infectious diseases. A total of 77.6% of participants strongly believed that formal training on biomedical waste management and biosafety is essential for healthcare workers, reflecting a positive perception of the value of capacity-building programs.

In terms of practice-related behavior, only 56.6% of participants reported consistent use of PPE in laboratory settings, while 59.5% acknowledged always segregating waste at the point of generation. Furthermore, 81.4% expressed willingness to attend regular workshops on biomedical waste management and biosafety, indicating openness to further education and reinforcement of best practices. These detailed findings are presented in Table 2.

Table 5. Sample Responses to Key Questions

Question	Correct / Positive Response (n, %)
Knowledge of BMW color-coding system	132 (62.8%)
Awareness that BMW mismanagement can transmit infections	178 (84.7%)
Belief that BMW training is essential for HCWs	163 (77.6%)
Consistent use of PPE in laboratories	119 (56.6%)
Segregation of waste at point of generation	125 (59.5%)
Willingness to attend regular BMW and biosafety workshops	171 (81.4%)

Overall, the results demonstrate that while knowledge and attitude levels among healthcare workers were generally satisfactory, practice compliance remained comparatively lower, highlighting a gap between awareness and actual behavior in biomedical waste management and laboratory safety.

Discussion:

This study demonstrates that although knowledge regarding biomedical waste (BMW) management and laboratory safety among healthcare workers was relatively satisfactory, with 55.2% reporting good knowledge, there remains a substantial gap in practice, as only 50% reported consistent adherence to safe protocols. This discrepancy between knowledge and practice is not unique to our setting and has been consistently observed in similar studies from India and other developing countries (14,15). Such findings suggest that awareness alone does not necessarily translate into effective implementation, underscoring the need for structured behavioral reinforcement programs.

The relatively high proportion of participants with a positive attitude (70.0%) aligns with prior research, which has shown that healthcare workers often acknowledge the importance of safe biomedical waste handling, but challenges such as heavy workload, inadequate infrastructure, lack of supervision, and insufficient training compromise actual adherence (16,17). This positive attitudinal base can serve as a strong foundation for implementing targeted interventions, provided that systemic barriers are effectively addressed.

In comparison with a study conducted in North India, where only 40% of healthcare workers demonstrated correct biomedical waste segregation practices (18), our findings indicate a slightly higher level of compliance, with 59.5% consistently segregating waste at the point of generation. Nevertheless, the gap between knowledge and consistent practice remains evident, particularly with respect to the use of personal protective equipment (PPE), where only 56.6% of participants reported adherence. This is consistent with a study in South India, where PPE usage was reported by less than 60% of healthcare workers (19).

Subgroup analysis revealed that laboratory staff displayed better knowledge and practices compared to housekeeping personnel, reflecting their professional training background. However, the relatively lower levels of compliance among housekeeping workers emphasize the importance of tailored educational and practical training programs that consider the educational and occupational diversity among healthcare personnel (20).

Overall, strengthening institutional policies through regular training sessions, strict monitoring, and improved infrastructure, such as the provision of color-coded bins and uninterrupted PPE supply, is essential to bridge the knowledge–practice gap. Periodic refresher courses, supervisory audits, and motivational workshops have been recommended in several studies as effective strategies to enhance compliance and minimize occupational hazards linked to biomedical waste exposure and laboratory-acquired infections (21,22).

The findings of the present study, when compared with recent literature, are summarized in Table 3.

Table 3. Comparison of Biomedical Waste Management Knowledge and Practice Across Studies

Study Location & Year	Knowledge (Good %)	Practice (Consistent %)	Key Observations
Present study (2025)	55.2%	50.0%	Positive attitude high, but PPE use suboptimal
North India (2022) (18)	48.0%	40.0%	Segregation poor among nurses
South India (2021) (19)	60.5%	45.5%	PPE usage inadequate
Nepal (2020) (20)	52.0%	43.0%	Housekeeping staff least compliant
Ethiopia (2019) (21)	57.0%	42.0%	Lack of infrastructure major barrier
Nigeria (2021) (22)	62.0%	47.5%	Training improved knowledge but not practice

Conclusion:

The present study highlights that healthcare workers possess satisfactory knowledge and generally positive attitudes toward biomedical waste management and laboratory safety, yet their practices remain suboptimal. Poor adherence to waste segregation protocols and inconsistent use of protective equipment pose ongoing risks to both occupational health and environmental safety. The findings are consistent with other studies conducted in India and internationally, which similarly reported gaps between awareness and implementation. Strengthening institutional training programs, enhancing supervision, ensuring availability of infrastructure, and conducting regular monitoring and refresher courses are essential strategies to improve compliance. Emphasizing the importance of biosafety practices among all cadres of healthcare staff, particularly nurses and housekeeping personnel, is critical for establishing safer healthcare environments.

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