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KNOWLEDGE, ATTITUDE, AND PRACTICES REGARDING BIOMEDICAL WASTE MANAGEMENT AMONG HEALTHCARE PROVIDERS IN A TERTIARY CARE HOSPITAL IN SURAT: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Appropriate biomedical waste management is essential for preventing occupational injuries, healthcare-associated infections and environmental contamination. Its effectiveness depends substantially on the knowledge, attitudes and routine practices of healthcare providers. This study assessed biomedical waste management among different categories of healthcare providers in a tertiary care hospital in Surat. The aim is to assess the knowledge, attitude and practices regarding biomedical waste management among healthcare providers in a tertiary care hospital in Surat.

Materials and Methods: A hospital-based cross-sectional study was conducted among 171 healthcare providers at SMIMER Hospital, Surat, Gujarat. Participants included 36 resident doctors, 94 nursing staff and 41 sanitation workers. Data were collected using a pre-designed and pre-tested instrument comprising eight knowledge questions, six attitude questions and five practice indicators. Knowledge and attitudes were assessed through a structured questionnaire, while practices were evaluated using direct observation. Categorical data were summarized as frequencies and percentages with 95% confidence intervals. Differences among occupational groups were assessed using the chi-square test, with $p<0.05$ considered statistically significant.

Results: Satisfactory knowledge was observed in 155 (90.6%; 95% CI: 85.3%–94.2%) participants, a positive attitude in 159 (93.0%; 95% CI: 88.1%–95.9%) and satisfactory overall practice in 154 (90.1%; 95% CI: 84.7%–93.7%). Knowledge was satisfactory among 100.0% of resident doctors, 95.7% of nurses and 70.7% of sanitation workers ($\chi^2=25.77$, $p<0.001$). Positive attitudes were demonstrated by 100.0%, 94.7% and 82.9%, respectively ($\chi^2=9.49$, $p=0.009$), while satisfactory practices were observed in 100.0%, 94.7% and 70.7%, respectively ($\chi^2=23.32$, $p<0.001$). Under the stricter classification, 81.3% had good practice, 14.0% had fair practice and 4.7% had poor practice. Knowledge of colour-coded containers was present in 92.4%, and 90.1% correctly segregated waste at the point of generation. Compliance with injury or accidental-exposure reporting was comparatively lower at 80.1% overall and 53.7% among sanitation workers.

Conclusion: Healthcare providers demonstrated generally satisfactory knowledge, positive attitudes and safe practices regarding biomedical waste management. Nevertheless, sanitation workers showed significant deficiencies compared with resident doctors and nurses, particularly in colour coding,

segregation, sharps disposal and reporting of occupational exposure. Regular practical training, supportive supervision, adequate protective resources and periodic audits should be prioritized for sanitation personnel.
Keywords: Biomedical waste management; Healthcare providers; Knowledge, attitude and practices.

INTRODUCTION

Biomedical waste comprises waste generated during the diagnosis, treatment or immunization of humans or animals and during related healthcare and research activities. Although approximately 85% of healthcare waste is non-hazardous, the remaining 15% may contain infectious, toxic, chemical, pharmaceutical, radioactive or sharp materials capable of causing significant occupational and environmental harm.[1] Improper segregation, collection, transportation, treatment or disposal of biomedical waste may expose healthcare personnel, sanitation workers, patients and the surrounding community to needle-stick injuries, blood-borne infections, toxic substances and environmental contamination. Safe biomedical waste management is therefore an essential component of infection prevention, occupational safety and quality healthcare delivery. In India, biomedical waste is regulated through the Bio-Medical Waste Management Rules, 2016, and subsequent amendments, which prescribe responsibilities for healthcare facilities and establish colour-coded categories for segregation, collection, treatment and disposal.[2] The Central Pollution Control Board has also issued detailed guidelines for implementation of these rules, emphasizing segregation at the point of generation, appropriate labelling, use of personal protective equipment, staff training, record maintenance and disposal through authorized treatment facilities.[3] Nevertheless, compliance with these requirements depends largely on the knowledge, attitude and routine practices of healthcare providers. Doctors and nurses may possess better theoretical knowledge because of their professional training, whereas sanitation workers, who directly collect and transport waste, may have comparatively limited access to formal education and periodic training. Previous Indian studies have demonstrated generally favourable attitudes toward biomedical waste management but have also identified gaps in knowledge of colour coding, disposal of sharps, reporting of occupational exposure and translation of knowledge into practice.[4,5] Regular assessment of knowledge, attitude and practices can identify occupational groups and specific components requiring corrective training, supervision and administrative support. Tertiary care hospitals generate substantial quantities and diverse categories of biomedical waste because of their high patient load and wide range of diagnostic and therapeutic services.

AIM: To assess the knowledge, attitude and practices regarding biomedical waste management among healthcare providers in a tertiary care hospital in Surat.

Objectives

1. To assess the knowledge of resident doctors, nursing staff and sanitation workers regarding biomedical waste segregation, colour coding and safe disposal.
2. To evaluate the attitudes of healthcare providers toward the importance, responsibility and implementation of biomedical waste management.
3. To assess and compare biomedical waste management practices among resident doctors, nursing staff and sanitation workers.

MATERIALS AND METHODS

Source of Data: The study participants comprised healthcare providers working at Surat Municipal Institute of Medical Education and Research (SMIMER), a tertiary care teaching hospital in Surat, Gujarat. Data were obtained from resident doctors, nursing staff and sanitation workers who were involved directly or indirectly in the generation, segregation, collection or handling of biomedical waste. The final study population consisted of 171 healthcare providers, including 36 resident doctors, 94 nursing staff and 41 sanitation workers.

Study Design: A hospital-based descriptive cross-sectional study was conducted to assess the existing knowledge, attitudes and practices of healthcare providers regarding biomedical waste management.

Study Location: The study was conducted in the clinical departments, wards and service areas of SMIMER Hospital, Surat, Gujarat. The hospital provides tertiary-level outpatient, inpatient, emergency, diagnostic, surgical and intensive-care services and consequently generates different categories of biomedical waste.

Study Duration: The source document did not specify the exact study dates. Therefore, the final manuscript should report the approved data-collection period in the following form. The duration should include participant enrolment, questionnaire administration, observation of practices, data entry and analysis.

Sample Size: The study included 171 healthcare providers. The sample comprised:

- **Resident doctors:** 36 (21.05%)
- **Nursing staff:** 94 (54.97%)
- **Sanitation workers:** 41 (23.98%)

All eligible and consenting healthcare providers who were available during the study period were approached until the required sample of 171 participants was obtained. Participants were enrolled from the three occupational categories to permit comparison of their knowledge, attitudes and practices.

Inclusion Criteria

- Resident doctors working in the selected clinical departments and wards.
- Nursing staff involved in direct patient care or biomedical waste segregation.
- Sanitation workers engaged in the collection, handling or transportation of biomedical waste.
- Healthcare providers who were present during the data-collection period.
- Participants who provided informed consent and agreed to complete the questionnaire or participate in the observational assessment.

Exclusion Criteria

- Healthcare providers who were on prolonged leave during the study period.
- Undergraduate students, interns, visitors and administrative personnel who were not routinely involved in biomedical waste handling.
- Contractual or temporary workers with insufficient exposure to the hospital's biomedical waste management system.
- Participants who declined consent.
- Healthcare providers who submitted incomplete questionnaires or could not be assessed for the required study variables.

Procedure and Methodology: Permission to conduct the study was obtained from the concerned hospital authorities and, where applicable, approval was obtained from the Institutional Ethics Committee before data collection. The purpose and procedure of the study were explained to eligible participants, and informed consent was obtained. Confidentiality was maintained by avoiding the recording of personally identifiable information.

A pre-designed and pre-tested structured questionnaire containing 19 questions was used. The instrument consisted of three domains:

1. Knowledge domain: Eight questions assessed awareness of biomedical waste categories, colour-coded bags and containers, segregation at the point of generation and the appropriate disposal of different types of waste.
2. Attitude domain: Six questions assessed perceptions regarding the importance of safe segregation, individual and institutional responsibility, occupational and environmental risks, the usefulness of training and whether biomedical waste management was perceived as an additional workload or financial burden.
3. Practice domain: Five items assessed adherence to recommended biomedical waste management practices, including segregation at source, correct use of colour-coded containers, safe handling of sharps, use of personal protective equipment and compliance with hospital disposal protocols.

The knowledge and attitude sections were circulated through an online questionnaire. Assistance was provided to participants who experienced difficulty understanding or completing the form, particularly where language or digital literacy was a concern. Practices were assessed through direct observation in the wards and work areas using a structured checklist. The observation method was used to reduce reliance on self-reported behaviour and to determine whether participants performed segregation and disposal in accordance with hospital protocols.

Each correct knowledge response or appropriate practice was assigned one point, while an incorrect or inappropriate response was assigned zero. Positively framed attitude items were scored according to the degree of agreement, and reverse scoring was applied to negatively framed items. Domain scores were calculated and converted into percentages. Participants were classified into good, fair and poor categories according to the predetermined scoring criteria used in the study protocol.

Sample Processing: No biological specimen or laboratory sample was collected; therefore, laboratory sample processing was not applicable. The "sample" consisted of completed electronic questionnaires and observational checklist records. Responses were checked for completeness, coded and entered into a master spreadsheet. Duplicate entries and questionnaires with substantial missing information were excluded. Negatively worded attitude items were reverse-coded before calculation of the total attitude score. The cleaned dataset was categorized according to occupational group and prepared for statistical analysis.

Data Collection: Data were collected using a pre-tested online questionnaire and a structured observational checklist. Basic occupational information, including participant category, was recorded. Knowledge and attitude data were obtained from individual questionnaire responses, while practice data were obtained primarily through direct observation in the participants' working areas. Completed records were reviewed regularly for completeness and consistency. Access to the final dataset was restricted to the investigators, and results were reported in aggregate form.

Statistical Methods: Data were entered into Microsoft Excel and analyzed using an appropriate statistical software package. Categorical variables were summarized as frequencies and percentages. Knowledge, attitude and practice scores were presented as mean with standard deviation or median with interquartile range, depending on their distribution. The prevalence of good, fair and poor KAP levels was reported with 95% confidence intervals.

The chi-square test or Fisher's exact test was used to compare categorical outcomes among resident doctors, nursing staff and sanitation workers. Continuous scores were compared using independent-samples t-test or one-way analysis of variance when normally distributed; the Mann–Whitney U test or Kruskal–Wallis test was used for non-normally distributed data. Associations between previous training and satisfactory KAP levels could be examined using univariable and multivariable logistic regression, with adjusted odds ratios and 95%

confidence intervals. Correlations among knowledge, attitude and practice scores were evaluated using Pearson's or Spearman's correlation coefficient, as appropriate. All tests were two-tailed, and $p<0.05$ was considered statistically significant.

RESULTS

Table 1: Overall assessment of knowledge, attitude and practices regarding biomedical waste management (N=171)

KAP outcome	Total, n (%)	Resident doctors (n=36), n (%)	Nursing staff (n=94), n (%)	Sanitation workers (n=41), n (%)	95% CI for total proportion	Test of significance	P value
Satisfactory knowledge	155 (90.6)	36 (100.0)	90 (95.7)	29 (70.7)	85.3%–94.2%	χ^2=25.77	<0.001*
Positive attitude	159 (93.0)	36 (100.0)	89 (94.7)	34 (82.9)	88.1%–95.9%	χ^2=9.49	0.009*
Satisfactory overall practice	154 (90.1)	36 (100.0)	89 (94.7)	29 (70.7)	84.7%–93.7%	χ^2=23.32	<0.001*
Good practice category†	139 (81.3)				74.8%–86.5%		
Fair practice category†	24 (14.0)				9.6%–20.0%		
Poor practice category†	8 (4.7)				2.4%–8.9%		

*χ^2 test compared the three categories of healthcare providers.
†Good, fair and poor practice figures were reported directly in the source poster. "Satisfactory overall practice" represented achievement of the selected minimum practice threshold and was therefore not identical to the stricter "good practice" classification.
*Statistically significant at $p<0.05$.

[Table 1] presents the overall knowledge, attitude and practices regarding biomedical waste management among 171 healthcare providers. Satisfactory knowledge was observed in 155 (90.6%; 95% CI: 85.3%–94.2%) participants. All resident doctors had satisfactory knowledge, compared with 95.7% of nursing staff and 70.7% of sanitation workers. This intergroup difference was statistically significant (χ^2=25.77, $p<0.001$). A positive attitude was documented in 159 (93.0%; 95% CI: 88.1%–95.9%) participants, including all resident doctors, 94.7% of nurses and 82.9% of sanitation workers; the difference was also significant (χ^2=9.49, p=0.009). Overall satisfactory practice was observed in 154 (90.1%; 95% CI: 84.7%–93.7%) participants. It was universal among resident doctors, present in 94.7% of nursing staff and 70.7% of sanitation workers, demonstrating a significant occupational difference (χ^2=23.32, $p<0.001$). Based on the stricter practice classification, 139 (81.3%) participants had good practices, 24 (14.0%) had fair practices and eight (4.7%) had poor practices.

Table 2: Knowledge regarding biomedical waste segregation, colour coding and safe disposal

Knowledge indicator	Total (N=171), n (%)	Resident doctors (n=36), n (%)	Nursing staff (n=94), n (%)	Sanitation workers (n=41), n (%)	95% CI for total proportion	Test of significance	P value
Correctly identified colour-coded waste containers	158 (92.4)	36 (100.0)	91 (96.8)	31 (75.6)	87.4%–95.5%	χ^2=22.02	<0.001*
Knew that waste should be segregated at the point of generation	152 (88.9)	35 (97.2)	89 (94.7)	28 (68.3)	83.3%–92.8%	χ^2=23.33	<0.001*
Correctly identified the container used for sharps	158 (92.4)	36 (100.0)	92 (97.9)	30 (73.2)	87.4%–95.5%	χ^2=28.55	<0.001*
Correctly identified waste disposed of in the yellow category	152 (88.9)	35 (97.2)	90 (95.7)	27 (65.9)	83.3%–92.8%	χ^2=29.03	<0.001*
Knew the occupational risks of improper biomedical waste disposal	151 (88.3)	35 (97.2)	88 (93.6)	28 (68.3)	82.6%–92.3%	χ^2=21.24	<0.001*
Knew that sharps should not be recapped after use	149 (87.1)	35 (97.2)	87 (92.6)	27 (65.9)	81.3%–91.3%	χ^2=23.86	<0.001*
Aware of the need for biomedical waste management training	142 (83.0)	34 (94.4)	84 (89.4)	24 (58.5)	76.7%–87.9%	χ^2=23.47	<0.001*
Overall satisfactory knowledge	155 (90.6)	36 (100.0)	90 (95.7)	29 (70.7)	85.3%–94.2%	χ^2=25.77	<0.001*

Chi-square test; $p<0.05$ was statistically significant.

[Table 2] shows that knowledge regarding biomedical waste segregation, colour coding and safe disposal was generally high, although substantial differences existed among occupational groups. Overall, 158 (92.4%; 95% CI: 87.4%–95.5%) participants correctly identified colour-coded waste containers, including all resident doctors, 96.8% of nurses and 75.6% of sanitation workers (χ^2=22.02, p<0.001). Knowledge that waste should be segregated at its point of generation was present in 88.9% of participants, ranging from 97.2% among resident doctors to 68.3% among sanitation workers (χ^2=23.33, p<0.001). Similarly, 92.4% correctly identified the container used for sharps, with significantly higher awareness among resident doctors and nurses than sanitation workers (χ^2=28.55, p<0.001). Correct identification of waste belonging to the yellow category was reported by 88.9%, while 88.3% knew the occupational risks associated with improper disposal. Knowledge that sharps should not be recapped was present in 87.1% of participants. Awareness of the need for biomedical waste management training was comparatively lower at 83.0%, particularly among sanitation workers, of whom only 58.5% demonstrated awareness. Overall satisfactory knowledge was recorded in 90.6% of participants, with a significant difference between resident doctors, nursing staff and sanitation workers (χ^2=25.77, p<0.001).

Table 3: Attitudes toward the importance, responsibility and implementation of biomedical waste management

Positive attitude indicator	Total (N=171), n (%)	Resident doctors (n=36), n (%)	Nursing staff (n=94), n (%)	Sanitation workers (n=41), n (%)	95% CI for total proportion	Test of significance	P value
Agreed that correct BMW management was essential for healthcare safety	167 (97.7)	36 (100.0)	93 (98.9)	38 (92.7)	94.1%–99.1%	χ^2=5.98	0.050
Believed that BMW segregation was the responsibility of every healthcare provider	162 (94.7)	36 (100.0)	91 (96.8)	35 (85.4)	90.3%–97.2%	χ^2=10.03	0.007*
Supported periodic training in BMW management	161 (94.2)	35 (97.2)	90 (95.7)	36 (87.8)	89.6%–96.8%	χ^2=4.05	0.132
Agreed that segregation should be performed at the point of generation	164 (95.9)	36 (100.0)	92 (97.9)	36 (87.8)	91.8%–98.0%	χ^2=8.18	0.017*
Disagreed that BMW management was an unnecessary work or financial burden†	103 (60.2)	24 (66.7)	55 (58.5)	24 (58.5)	52.8%–67.3%	χ^2=0.79	0.674
Supported reporting of needle-stick injuries and unsafe disposal	155 (90.6)	35 (97.2)	88 (93.6)	32 (78.0)	85.3%–94.2%	χ^2=10.49	0.005*
Overall positive attitude	159 (93.0)	36 (100.0)	89 (94.7)	34 (82.9)	88.1%–95.9%	χ^2=9.49	0.009*

†The source indicated that approximately 40% of participants considered BMW management an additional burden; this item was reverse-scored.
Chi-square test; p<0.05 was statistically significant.

[Table 3] demonstrates that healthcare providers generally had favourable attitudes toward biomedical waste management. Almost all participants 167 (97.7%; 95% CI: 94.1%–99.1%) agreed that appropriate biomedical waste management was essential for healthcare safety. This attitude was shared by all resident doctors, 98.9% of nurses and 92.7% of sanitation workers; the occupational difference was at the threshold of statistical significance (χ^2=5.98, p=0.050). Overall, 94.7% believed that segregation was the responsibility of every healthcare provider, with a significant difference among groups (χ^2=10.03, p=0.007). Support for periodic training was expressed by 94.2% of participants, without a significant occupational difference (χ^2=4.05, p=0.132). Furthermore, 95.9% agreed that waste should be segregated at the point of generation, with significantly lower agreement among sanitation workers than resident doctors and nurses (χ^2=8.18, p=0.017). Only 60.2% disagreed that biomedical waste management represented an unnecessary work or financial burden, indicating that approximately 40% perceived it as an additional burden; this perception did not differ significantly among the groups (χ^2=0.79, p=0.674). Support for reporting needle-stick injuries and unsafe disposal was observed in 90.6%, although it was lower among sanitation workers (78.0%) than resident doctors (97.2%) and nurses (93.6%; χ^2=10.49, p=0.005). Overall, 93.0% demonstrated a positive attitude, with resident doctors showing the most favourable response and sanitation workers the least favourable response (χ^2=9.49, p=0.009).

Table 4: Comparison of observed biomedical waste management practices

Observed practice indicator	Total (N=171), n (%)	Resident doctors (n=36), n (%)	Nursing staff (n=94), n (%)	Sanitation workers (n=41), n (%)	95% CI for total proportion	Test of significance	P value
Segregated biomedical waste at the point of generation	154 (90.1)	36 (100.0)	89 (94.7)	29 (70.7)	84.7%–93.7%	χ^2=23.32	<0.001*
Disposed of waste in the correct colour-coded container	151 (88.3)	35 (97.2)	88 (93.6)	28 (68.3)	82.6%–92.3%	χ^2=21.24	<0.001*
Disposed of sharps immediately in a puncture-proof container	154 (90.1)	36 (100.0)	91 (96.8)	27 (65.9)	84.7%–93.7%	χ^2=35.59	<0.001*
Used appropriate personal protective equipment while handling waste	150 (87.7)	34 (94.4)	86 (91.5)	30 (73.2)	82.0%–91.8%	χ^2=10.81	0.004*
Did not mix biomedical waste with general municipal waste	153 (89.5)	36 (100.0)	90 (95.7)	27 (65.9)	83.9%–93.2%	χ^2=31.77	<0.001*
Followed procedures for reporting injuries or accidental exposure	137 (80.1)	33 (91.7)	82 (87.2)	22 (53.7)	73.5%–85.4%	χ^2=24.02	<0.001*
Overall satisfactory observed practice	154 (90.1)	36 (100.0)	89 (94.7)	29 (70.7)	84.7%–93.7%	χ^2=23.32	<0.001*

Chi-square test; p<0.05 was statistically significant.

[Table 4] compares observed biomedical waste management practices among the three categories of healthcare providers. Biomedical waste segregation at the point of generation was correctly performed by 154 (90.1%; 95% CI: 84.7%–93.7%) participants, including all resident doctors, 94.7% of nurses and 70.7% of sanitation workers (χ^2=23.32, p<0.001). Correct disposal in colour-coded containers was observed in 88.3%, with adherence ranging from 97.2% among resident doctors to 68.3% among sanitation workers (χ^2=21.24, p<0.001). Immediate disposal of sharps in puncture-proof containers was practiced by 90.1%; however, only 65.9% of sanitation workers complied, compared with 100% of resident doctors and 96.8% of nurses (χ^2=35.59, p<0.001). Appropriate use of personal protective equipment was observed in 87.7%, with significantly lower compliance among sanitation workers (73.2%; χ^2=10.81, p=0.004). Similarly, 89.5% avoided mixing biomedical waste with general municipal waste, although this practice was followed by only 65.9% of sanitation workers (χ^2=31.77, p<0.001). Compliance with procedures for reporting injuries or accidental exposure was the weakest practice, documented in 80.1% overall and only 53.7% of sanitation workers (χ^2=24.02, p<0.001). Overall satisfactory observed practice was found in 90.1% of participants and differed significantly across occupational groups (χ^2=23.32, p<0.001).

DISCUSSION

The present hospital-based study demonstrated a generally high level of knowledge, favourable attitude and appropriate practice regarding biomedical waste management among healthcare providers. Satisfactory knowledge was observed in 90.6% of participants, 93.0% had a positive attitude and 90.1% achieved the minimum satisfactory practice threshold. Under the stricter practice classification, 81.3% had good practice, while 14.0% and 4.7% had fair and poor practice, respectively. These results were closely comparable to Reddy et al. (2024),[1] who reported adequate knowledge in 91%, a positive attitude in 93% and safe practices in 96% of nursing personnel. Pravinraj et al. (2023),[2] similarly observed favourable attitudes and practices in 98.2% and 89.6% of doctors and nurses, respectively. In that study, favourable practice was higher among doctors than nurses (97.3% versus 86.4%), which closely corresponded with the occupational pattern observed in the present study. In contrast, Thapa et al. (2024),[3] reported adequate knowledge, favourable attitude and good practice in only 66%, 66% and 60% of primary healthcare workers, respectively. Likewise, Thirunavukkarasu et al. (2022),[4] reported high knowledge, attitude and practice scores in 47.1%, 65.1% and 49.5% of healthcare workers in northern Saudi Arabia. The comparatively better findings in the present tertiary-care setting may reflect greater access to infection-control protocols, colour-coded containers, professional training and institutional supervision. However, differences in study populations, questionnaires and scoring thresholds should be considered when interpreting these comparisons.

A clear occupational gradient was evident in the present study. Satisfactory knowledge and practice were universal among resident doctors and exceeded 94% among nurses, whereas only 70.7% of sanitation workers achieved the corresponding thresholds. Positive attitude was also higher among resident

doctors (100.0%) and nurses (94.7%) than sanitation workers (82.9%). These differences were statistically significant for knowledge (χ^2=25.77, p<0.001), attitude (χ^2=9.49, p=0.009) and practice (χ^2=23.32, p<0.001). Ostwal et al. (2015),[5] reported a similar professional gradient before training: satisfactory knowledge was found in 91% of doctors and 87% of nurses but only 56% of sanitation workers, while satisfactory practice was present in 79%, 86% and 34%, respectively. Following training, sanitation workers' knowledge increased from 56% to 90% and their practice from 34% to 76%, demonstrating that the disparities observed in Surat are potentially modifiable. Mehta et al. (2018),[6] also found that knowledge and practice scores differed across professional groups and that trained participants had better attitude and practice scores than untrained personnel. Thapa et al. (2024),[3] similarly identified the greatest knowledge gaps among medical support staff and reported that trained healthcare workers were approximately four times more likely to demonstrate good practices. Collectively, these findings indicate that sanitation workers should not be regarded merely as auxiliary personnel; because they directly collect and transport waste, they require structured induction, repeated practical demonstrations and competency-based assessment.

Knowledge of colour coding was high in the present study: 92.4% correctly identified colour-coded containers, compared with 32% reported by Nath et al. (2024),[7] and the lower levels reported in several earlier hospital-based studies. Knowledge of segregation at the point of generation was found in 88.9%, while 92.4% correctly identified the appropriate sharps container and 88.9% correctly identified waste belonging to the yellow category. Pravinraj et al (2023),[2] found that 97.7% of doctors and nurses regarded colour coding as essential and 97.9% stated that they would advise subordinates to follow it. However, knowledge in the present study was significantly weaker among sanitation workers: only 75.6% correctly identified colour-coded containers, 68.3% knew that segregation must occur at source, 73.2% correctly identified the sharps container and 65.9% identified yellow-category waste. Mehta et al. (2018),[6] reported even larger operational gaps, as only 35.2% knew the permissible waste-storage time and only 38% were aware of post-exposure prophylaxis. Rao et al (2018),[8] likewise found that knowledge, attitude and practices varied significantly between categories of healthcare professionals. The consistently better performance of doctors and nurses may be attributable to their professional curriculum and greater exposure to formal infection-control training, whereas sanitation workers may depend largely on informal, task-based instruction.

The present study also found that 88.3% understood the occupational risks of inappropriate waste disposal and 87.1% knew that sharps should not be recapped. Nevertheless, corresponding knowledge among sanitation workers was only 68.3% and 65.9%, respectively. This is important because sanitation personnel experience direct exposure to improperly discarded sharps and contaminated materials but may have less access to information about blood-borne infections and post-exposure measures. Deress et al. (2018),[9] reported good knowledge, favourable attitude and good practice among 56.8%, 66.2% and 77.4% of Ethiopian healthcare professionals, respectively, and found that higher educational qualifications and the availability of colour-coded bins were associated with favourable KAP scores. In the present study, only 58.5% of sanitation workers recognized the need for biomedical waste management training, compared with 94.4% of doctors and 89.4% of nurses. This finding suggests that training programmes must first explain the personal relevance of safe waste handling, including prevention of needle-stick injuries, hepatitis B, hepatitis C and other occupational hazards.

Attitudes toward biomedical waste management were highly favourable. Almost all participants (97.7%) regarded correct management as essential for healthcare safety, 94.7% believed that segregation was the responsibility of every provider and 95.9% supported segregation at the point of generation. These findings were consistent with Mehta et al. (2018),[6] who reported positive attitudes in more than 90% of healthcare workers, and Pravinraj et al. (2023),[2] who found that 99.7% considered BMW management essential for healthcare delivery. Support for periodic training in the present study was also high at 94.2%, and the absence of a significant occupational difference (p=0.132) indicated broad acceptance of continued education. Nevertheless, only 60.2% rejected the view that BMW management was an unnecessary work or financial burden, meaning that approximately two-fifths continued to perceive it as burdensome. Pravinraj et al (2023),[2] similarly reported that only 61.5% felt it was safe or comfortable to work with biomedical waste, while 38.5% did not. This residual negative perception may arise from workload, time pressure, insufficient staffing, inconvenient bin placement or inadequate availability of protective equipment. Training should therefore be accompanied by organizational measures that make proper disposal practical and efficient.

Observed practice was satisfactory in most domains. Segregation at source was performed by 90.1%, correct colour-coded disposal by 88.3%, immediate sharps disposal by 90.1%, appropriate personal protective equipment use by 87.7% and prevention of mixing biomedical with municipal waste by 89.5%. These findings were much higher than those of Mehta et al. (2018),[6] in which only 40% practiced segregation at the point of generation and biomedical-waste bag labelling was practiced by 23.2% of nurses and 27.4% of doctors. They were also higher than the 60% good-practice level reported by Thapa et al (2024),[3] and the 49.5% high-practice score reported by Thirunavukkarasu et al. (2022),[4] Conversely, the present results closely matched

Pravinraj et al. (2023).[2] who documented segregation of infectious and non-infectious waste in 94.5%, use of dedicated waste containers in 90.4% and overall favourable practice in 89.6%. Jalal et al. (2021),[10] emphasized that professional category, training and access to institutional guidelines influence the conversion of knowledge into practice. In the present study, the significant professional differences across all observed practices suggested that good institutional performance was driven predominantly by resident doctors and nurses, while sanitation workers remained vulnerable to unsafe practices.

The weakest practice in the present study was compliance with procedures for reporting injuries or accidental exposure, which was observed in 80.1% overall and only 53.7% of sanitation workers. Nath et al. (2024),[7] reported an even more pronounced reporting gap, with only 4% regularly reporting incidents. Under-reporting may result from poor awareness of reporting pathways, fear of blame, perceived triviality of injuries, lack of time or uncertainty about eligibility for post-exposure care. The findings therefore underline the need for a simple, confidential and non-punitive reporting system linked to immediate first aid, medical assessment, post-exposure prophylaxis and follow-up. Overall, the study shows that tertiary-care healthcare providers in Surat possessed strong BMW-related knowledge and attitudes, with generally satisfactory practice. However, the persistent and statistically significant disadvantage among sanitation workers demonstrates that hospital-wide averages can conceal important occupational disparities. Regular practical training in the local language, visual colour-coding aids, hepatitis B immunization, ready availability of personal protective equipment, supportive supervision and periodic observational audits should be prioritized, particularly for personnel directly involved in waste collection and transportation.

CONCLUSION

The study demonstrated that healthcare providers at the tertiary care hospital in Surat generally possessed satisfactory knowledge, favourable attitudes and appropriate practices regarding biomedical waste management. Satisfactory knowledge was observed in 90.6% of participants, 93.0% had a positive attitude and 90.1% achieved satisfactory overall practice. Under the stricter classification, 81.3% demonstrated good practice, whereas 14.0% and 4.7% had fair and poor practices, respectively. Resident doctors consistently achieved the highest levels of knowledge, attitude and practice, followed by nursing staff, while sanitation workers showed comparatively lower performance. Significant occupational differences were identified in knowledge, attitude and observed practice. Important deficiencies among sanitation workers concerned colour coding, segregation at the point of generation, sharps disposal, use of personal protective equipment and reporting of occupational injuries or accidental exposure. Although most participants considered safe biomedical waste management essential and supported periodic training, a considerable proportion perceived it as an additional workload or financial burden. Regular competency-based training, particularly for sanitation workers, should therefore be conducted at recruitment and repeated periodically. Practical demonstrations in the local language, adequate availability of colour-coded containers and protective equipment, supportive supervision, occupational immunization, simplified exposure-reporting systems and regular observational audits are recommended to sustain safe biomedical waste management throughout the hospital.

Limitations

1. The study was conducted at a single tertiary care hospital in Surat; therefore, its findings may not be generalizable to other hospitals, primary healthcare facilities or private institutions.
2. The cross-sectional design assessed knowledge, attitudes and practices at one point in time and could not establish causal relationships.
3. The sample size was relatively limited, particularly for resident doctors and sanitation workers, which may have affected the precision of subgroup estimates.
4. The occupational groups were unequal in size, with nursing staff constituting more than half of the study population.
5. Knowledge and attitude were assessed using self-reported responses and were therefore susceptible to recall bias and social-desirability bias.
6. Online questionnaire administration may have disadvantaged participants with limited digital literacy, particularly sanitation workers.
7. Direct observation of practice could have produced a Hawthorne effect, whereby participants temporarily improved their behaviour because they were aware of being observed.
8. The duration and number of observational encounters per participant may not have been sufficient to represent routine practices across all work shifts.
9. Differences in education, work experience, previous training and frequency of exposure to biomedical waste were not fully controlled through multivariable analysis.
10. Availability and accessibility of colour-coded containers, personal protective equipment and institutional guidelines were not independently evaluated.
11. The study did not assess the effectiveness of previous training programmes or changes in KAP following an educational intervention.
12. Microbiological contamination, needle-stick injury incidence and environmental outcomes

were not measured; therefore, the clinical impact of observed practices could not be determined.

REFERENCES

1. Reddy NS, Chandra S, Manjunath M, Devendrappa S. Biomedical waste, infection control, public health, nursing staff, questionnaire, hospital: a knowledge, attitude and practice study. Heart Vessels Transplant. 2024;8:498. Available from: Heart, Vessels and Transplantation Journal
2. Pravinraj S, Zala D, Janakiram M. Knowledge, attitude and practice of biomedical waste management among doctors and nurses during the COVID-19 pandemic in Puducherry: a cross-sectional study. Cureus. 2023;15(12):e51290. doi:10.7759/cureus.51290. Available from: PubMed
3. Thapa S, Karki S, Basnet R, et al. Biomedical waste management among healthcare workers in a primary health centre in Sikkim, India: a KAP study. J Educ Health Promot. 2024;13:354. Available from: PubMed Central
4. Thirunavukkarasu A, Alruwaili BF, Alruwaili ZM, et al. Knowledge, attitude and practice towards bio-medical waste management among healthcare workers: a northern Saudi study. PeerJ. 2022;10:e13773. doi:10.7717/peerj.13773. Available from: PubMed Central
5. Ostwal K, Jadhav A, More S, Shah P, Shaikh N. Knowledge, attitude and practice assessment of biomedical waste management in tertiary care hospital: it's high time to train ourselves. Int J Environ Sci. 2015;5(6):1115-1121. doi:10.6088/ijes.2014050100105.
6. Mehta TK, Shah PD, Tiwari KD. A knowledge, attitude and practice study of biomedical waste management and bio-safety among healthcare workers in a tertiary care government hospital in Western India. Natl J Community Med. 2018;9(5):327-333. Available from: National Journal of Community Medicine
7. Nath DB, Das M, Boro A, Hazarika K, Baruah P. Knowledge, attitude and practice of biomedical waste management among healthcare workers in Tezpur Medical College and Hospital, Tezpur. Eur J Cardiovasc Med. 2024;14(5):665-672.
8. Rao D, Dhakshaini MR, Kurthukoti A, Doddawad VG. Biomedical waste management: a study on assessment of knowledge, attitude and practices among healthcare professionals in a tertiary care teaching hospital. Biomed Pharmacol J. 2018;11(3):1737-1743.
9. Deress T, Hassen F, Adane K, Tsegaye A. Assessment of knowledge, attitude, and practice about biomedical waste management and associated factors among healthcare professionals at Debre Markos Town healthcare facilities, Northwest Ethiopia. J Environ Public Health. 2018;2018:7672981. doi:10.1155/2018/7672981. Available from: PubMed Central
10. Jalal SM, Akhter F, Abdelhafez AI, Alrajeh AM. Assessment of knowledge, practice and attitude about biomedical waste management among healthcare professionals during COVID-19 crises in Al-Ahsa. Healthcare (Basel). 2021;9(6):747. doi:10.3390/healthcare9060747. Available from: PubMed Central