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Assessment of Knowledge, Attitude and Practice regarding Biomedical Waste Management among Resident Doctors

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ABSTRACT

Background: Safe biomedical waste (BMW) management requires proper segregation, colour coding, safe sharps handling, and reporting of occupational exposures. This study assessed knowledge, attitude, and self-reported practice of BMW management among resident doctors and compared scores according to prior BMW training.

Methods: This cross-sectional, questionnaire-based study used convenience sampling to include 60 junior residents from five departments. The questionnaire comprised 10 knowledge items (maximum score 10), five attitude statements rated on a five-point Likert scale (maximum score 25) and eight practice items (maximum score 24), including reverse scoring for needle recapping. Scores were summarised descriptively. Owing to marked ceiling effects, trained and untrained groups were compared using the Mann-Whitney U test.

Results: The mean age was 27.63 ± 1.88 years, with equal male and female representation. Half of the residents had prior BMW training. Mean knowledge, attitude, and practice scores were 9.30 ± 0.83, 23.63 ± 1.47, and 21.87 ± 2.38, respectively. Training was associated with higher scores across all domains ($p<0.001$). Needle recapping avoidance and needle-stick injury reporting were the least consistent practices.

Conclusion: Overall KAP scores were high, but clinically important practice gaps remained in needle recapping, occupational-exposure reporting, waste-bag labelling and standard precautions. Regular competency-based training, periodic audit, direct observation of segregation and mandatory reporting of needle-stick injuries should be integrated into hospital infection-control programmes.

Key-words: Biomedical Waste Management, Resident Doctors, Knowledge, Attitude, Practice, Colour Coding, Needle-Stick Injury, Teaching Hospital

INTRODUCTION

Health-care waste is not a uniform stream. Most of it resembles ordinary municipal waste, while a smaller hazardous fraction contains infectious material, sharps, chemicals, pharmaceuticals, pathological tissue or radioactive substances.

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When segregation fails at the point of generation, the hazardous fraction expands unnecessarily and exposes health-care workers, patients, waste handlers and the surrounding community to preventable injury, infection and environmental contamination.[1]

India's Bio-Medical Waste Management Rules, 2016 established a statutory framework for segregation, collection, treatment and disposal through defined colour-coded categories. The operational logic is simple but unforgiving: the correct container must be selected at the bedside, laboratory bench, procedure room or operating theatre before different waste streams become mixed.[2] Resident doctors occupy this critical point in the chain. They handle sharps, specimens,

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blood-contaminated material and pathological waste while working under time pressure, frequently across multiple clinical areas.

Resident doctors are especially important in BMW management because they generate waste during bedside procedures, specimen collection, emergency care and operative work, while also influencing the practices of interns and other team members. A segregation error made at this point follows the waste stream downstream. It can increase manual handling, sharps exposure and contact with blood or body fluids, create opportunities for cross-contamination, and weaken hospital infection-prevention systems. Repeated non-compliance may also be recorded as a quality-system deficiency during hospital or laboratory accreditation.[1,2]

Earlier Indian studies have repeatedly shown an uneven pattern. General awareness and attitude may be favourable, but knowledge of legal provisions, colour coding and disposal routes remains incomplete in particular groups.[3] Junior doctors have also demonstrated gaps in practical aspects of waste management despite routine clinical exposure.[4] Similar work among operation-room personnel found that positive attitude did not necessarily translate into adequate knowledge or practice.[5] Studies conducted after the 2016 Rules further emphasised that familiarity with updated categories and amendments cannot be assumed merely because personnel work in a tertiary-care institution.[6]

A focused assessment among resident doctors is therefore useful for identifying whether the remaining weaknesses lie in factual knowledge, professional commitment or day-to-day behaviour. The present study assessed knowledge, attitude and self-reported practice regarding BMW management among resident doctors in a teaching hospital. A secondary objective was to compare domain scores according to previous attendance at BMW training sessions.

MATERIALS AND METHODS

Study Period and Population- The study was conducted from April to May 2024 and included 60 junior residents from Pathology, Medicine, Paediatrics, Surgery, and Obstetrics and Gynaecology.

Sampling Method- Convenience sampling was used. All eligible junior residents who were available during the study period and willing to participate were invited.

Eligibility Criteria

Inclusion criteria- Junior residents from the selected departments who were available during data collection and provided informed consent.

Exclusion Criteria- Interns, faculty members, nursing staff and other healthcare workers; resident doctors absent during the data-collection period; residents who declined consent; and questionnaires with incomplete responses.

Questionnaire Response- Sixty completed questionnaires were included. The total number of eligible residents approached was not recorded; therefore, an overall response rate could not be calculated.

Study Instrument and Scoring- A structured, study-specific questionnaire recorded age, gender, year of residency, department and previous attendance at BMW training. It covered statutory colour coding, waste treatment, occupational hazards and routine segregation practices. Formal pilot-testing and psychometric validation details were not available, and Cronbach's alpha was not reported; the domain totals were therefore treated as descriptive composite scores.

The knowledge domain contained 10 statements scored as 1 for a correct response and 0 for an incorrect response, yielding a total score from 0 to 10.

The attitude domain contained five statements rated on a five-point Likert scale: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree. The total attitude score ranged from 5 to 25, with higher scores indicating a more favourable attitude.

The practice domain contained eight items scored as 3=always, 2=sometimes and 1=never for desirable behaviours. Needle recapping was reverse-scored: never=3, sometimes=2 and always=1. The total practice score ranged from 8 to 24, with higher scores representing safer self-reported practice.

Outcome Measures- The primary outcomes were total knowledge, attitude and practice scores. Item-level proportions were used to identify specific strengths and

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gaps. The secondary analysis compared domain scores between residents who had and had not attended BMW training.

Statistical Analysis- Continuous variables were summarised using mean and standard deviation, together with median and interquartile range where relevant. Categorical variables were presented as frequency and percentage. The score distributions showed substantial ceiling effects; therefore, the Mann-Whitney U test was used for unadjusted comparison of trained and untrained residents. The smaller U statistic was reported, and effect size was expressed as $r=|Z|/\sqrt{N}$. A two-sided p-value <0.05 was considered statistically significant. No adjusted model was fitted because training status completely overlapped with gender in this sample.

RESULTS

A total of 60 complete questionnaires were analysed. Because the number of eligible residents approached was not recorded, an overall response rate could not be estimated. The mean age was 27.63 ± 1.88 years (range 25-31 years). Men and women were equally represented. First-, second- and third-year residents accounted for 20 (33.3%), 25 (41.7%) and 15 (25%) participants, respectively. Pathology contributed the largest departmental group, with 22 residents (36.7%). Previous BMW training had been attended by 30 participants (50%) (Table 1). The departmental composition is shown in Fig. 1.

Table 1: Sociodemographic and professional characteristics of the study participants (n=60)

Characteristic	Category/summary	n (%) or mean ± SD
Age (years)	Mean ± SD; range	27.63 ± 1.88; 25–31
Gender	Male	30 (50)
	Female	30 (50)
Year of residency	First year	20 (33.3)
	Second year	25 (41.7)
	Third year	15 (25)
Department	Pathology	22 (36.7)
	Medicine	10 (16.7)
	Paediatrics	10 (16.7)
	Surgery	9 (15)
	Obstetrics and Gynaecology	9 (15)
BMW training attended	Yes	30 (50)
	No	30 (50)

BMW: biomedical waste; SD: standard deviation

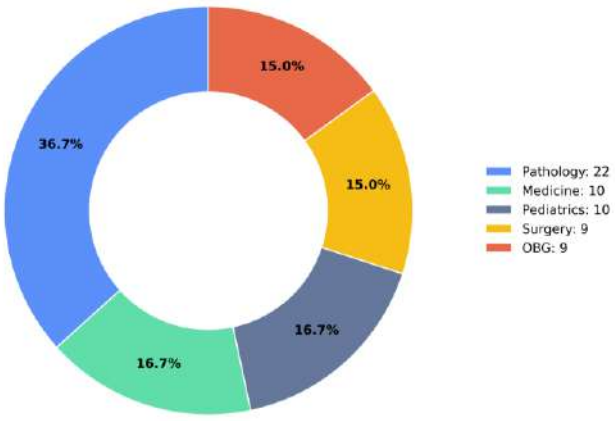

Fig. 1: Departmental distribution of resident doctors

Donut segments represent the proportion of participants contributed by each department; counts are shown in the legend

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The mean knowledge score was 9.30 ± 0.83 out of 10, equivalent to 93% of the maximum score. All residents answered the question on infectious-waste colour coding correctly. Knowledge of human anatomical waste inclusion and HIV/HBV transmission risk was also high (98.3% each). The lowest correct-response rate concerned disposal of sharps in puncture-proof containers (86.7%). Item-level findings are presented in Table 2 and Fig. 2.

Table 2: Item-wise knowledge regarding biomedical waste management (n=60)

Knowledge item	Correct response, n	Correct response, %
Correct colour code for infectious waste	60	100
Biomedical waste includes human anatomical waste	59	98.3
Sharps disposed in puncture-proof containers	52	86.7
Correct colour code for sharps	56	93.3
BMW Management Rules enacted in 2016	57	95
Incineration used for pathological waste	53	88.3
BMW poses HIV/HBV transmission risk	59	98.3
Yellow bag used for human anatomical waste	56	93.3
Autoclaving is a waste-treatment method	53	88.3
General waste disposed in black bags	53	88.3

Each correct response was scored 1; incorrect responses were scored 0

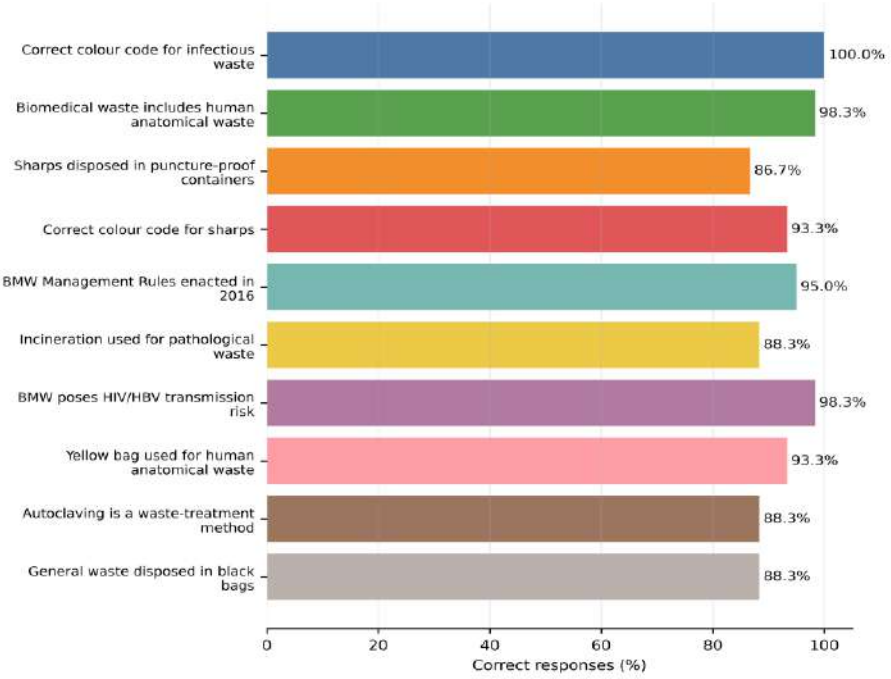

Fig. 2: Correct-response percentages for individual knowledge items

Bars display the percentage of residents answering each knowledge item correctly

The mean attitude score was 23.63 ± 1.47 out of 25 (94.5% of the maximum). Every participant either agreed or strongly agreed with all five statements. Strongest endorsement was recorded for the need for regular training, with 50 residents (83.3%) strongly agreeing. The mean practice score was 21.87 ± 2.38 out of 24 (91.1% of the maximum). Optimal responses were most frequent for disposal of sharps in puncture-proof containers and glove use (80% each). The weakest practice items were avoidance of needle recapping (61.7%), reporting of needle-stick injuries (68.3%), proper labelling of waste bags (70%) and adherence to standard precautions (71.7%) (Table 3). Overall domain percentages are compared in Fig. 3, and the four weakest practice items are highlighted in Fig. 4.

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Table 3: Item-wise attitude and self-reported practice regarding biomedical waste management (n=60)

Domain and item	Most favourable response, n (%)	Alternate response, n (%)	Mean item score ± SD
Attitude items			
BMW management is important for patient safety	Strongly agree: 38 (63.3)	Agree: 22 (36.7)	4.63 ± 0.49
Personal responsibility for proper BMW segregation	Strongly agree: 41 (68.3)	Agree: 19 (31.7)	4.68 ± 0.47
Regular BMW training is necessary	Strongly agree: 50 (83.3)	Agree: 10 (16.7)	4.83 ± 0.38
Improper disposal is a serious health hazard	Strongly agree: 44 (73.3)	Agree: 16 (26.7)	4.73 ± 0.45
Willingness to attend BMW training sessions	Strongly agree: 45 (75)	Agree: 15 (25)	4.75 ± 0.44
Practice items			
Segregates waste at source	Optimal: 46 (76.7)	Sometimes: 14 (23.3)	2.77 ± 0.43
Uses colour-coded bins correctly	Optimal: 47 (78.3)	Sometimes: 13 (21.7)	2.78 ± 0.42
Disposes sharps in puncture-proof containers	Optimal: 48 (80)	Sometimes: 12 (20)	2.80 ± 0.40
Wears gloves while handling BMW	Optimal: 48 (80)	Sometimes: 12 (20)	2.80 ± 0.40
Avoids recapping needles after use	Optimal: 37 (61.7)	Sometimes: 23 (38.3)	2.62 ± 0.49
Follows standard precautions	Optimal: 43 (71.7)	Sometimes: 17 (28.3)	2.72 ± 0.45
Ensures proper labelling of waste bags	Optimal: 42 (70)	Sometimes: 18 (30)	2.70 ± 0.46
Reports needle-stick injuries	Optimal: 41 (68.3)	Sometimes: 19 (31.7)	2.68 ± 0.47

For attitude items, strongly agree was the most favourable response. For practice items, the optimal response was "always" except for needle recapping, where "never" was optimal. No participant selected the least desirable practice response (score 1)

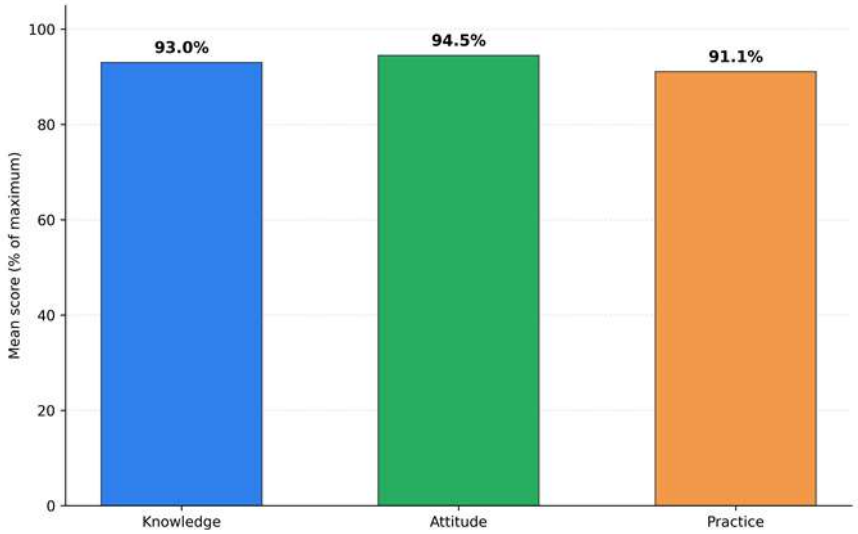

Fig. 3: Overall knowledge, attitude and practice domain scores

Bars compare mean domain scores after standardisation to the maximum possible score; values are shown above each bar

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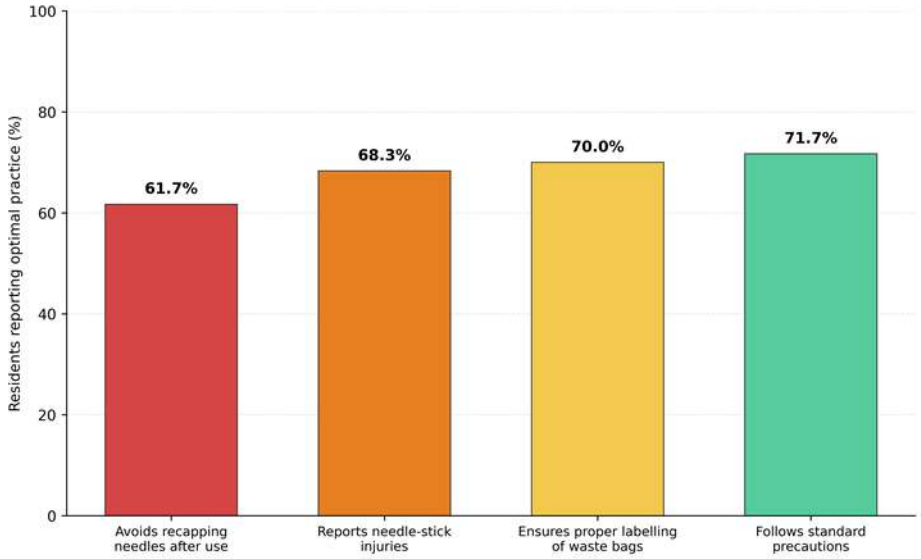

Fig. 4: Practice items with the lowest proportions of optimal responses

Bars display the percentage of residents reporting the optimal response for each of the four weakest practice items

Residents who had attended BMW training had higher scores in all three domains. The trained group had mean knowledge, attitude and practice scores of 9.93 ± 0.25, 24.93 ± 0.25 and 23.93 ± 0.25, respectively, compared with 8.67 ± 0.71, 22.33 ± 0.92 and 19.80 ± 1.61 among residents without previous training. Unadjusted comparisons were statistically significant for knowledge (U=63, r=0.81), attitude (U=4, r=0.91) and practice (U=1, r=0.91), with p<0.001 for each domain (Table 4 and Figure 5). All trained residents were men and all untrained residents were women. Training was also patterned by residency year and department, so these associations cannot be interpreted as an independent or causal effect of training.

Table 4: Knowledge, attitude and practice scores according to previous BMW training

Domain	Training attended: mean ± SD	Training attended: median (IQR)	Training not attended: mean ± SD	Training not attended: median (IQR)	Mann-Whitney U; p-value; effect size r
Knowledge	9.93 ± 0.25	10 (10–10)	8.67 ± 0.71	9 (8–9)	63; <0.001; 0.81
Attitude	24.93 ± 0.25	25 (25–25)	22.33 ± 0.92	22 (22–23)	4; <0.001; 0.91
Practice	23.93 ± 0.25	24 (24–24)	19.80 ± 1.61	20 (19–21)	1; <0.001; 0.91

Mann-Whitney U test; the smaller U statistic is reported.
Effect size r=|Z|/√N.
Comparisons are unadjusted and completely confounded with gender, with additional patterning by residency year and department.
IQR: interquartile range; SD: standard deviation

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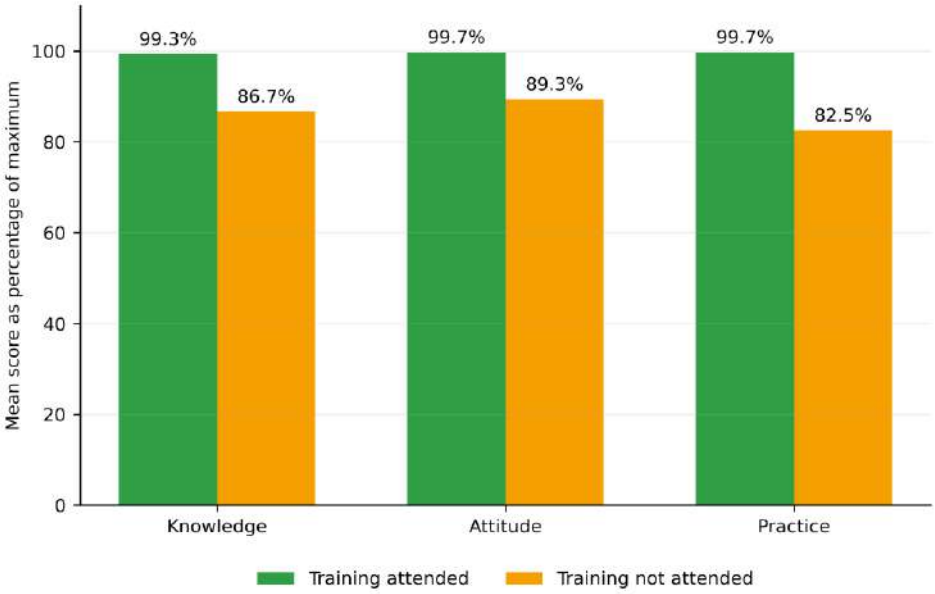

Fig. 5: Mean domain scores according to previous BMW training

Scores are expressed as percentages of the maximum possible domain score. The observed differences are unadjusted and should not be interpreted causally because training status was confounded by participant characteristics

DISCUSSION

This study found high overall knowledge, attitude and self-reported practice scores among resident doctors. The broad picture is reassuring, but the item-level findings are more useful than the totals. Nearly universal recognition of colour coding, anatomical waste and infection risk indicates that core concepts were well established. Yet the remaining weaknesses involved behaviours with direct occupational-safety implications: needle recapping, reporting of needle-stick injuries, labelling of waste bags and consistent standard precautions.

The overall knowledge score of 9.30 out of 10 was higher than the mean score of approximately 8.06 reported among resident doctors by Dey and Das.[7] Training coverage in the present cohort was 50%, comparable to the proportion of resident doctors and nursing personnel reported to have received BMW training in the Puducherry survey by Malini and Eshwar.[8] Earlier work from Bijapur also documented uneven knowledge and practice despite broad awareness of BMW hazards.[9] These comparisons should remain cautious because the questionnaires, participant composition and scoring thresholds differed across studies.

The attitude domain showed a marked ceiling effect. Every participant agreed that BMW management is important, personally relevant and deserving of regular training. Such unanimity is encouraging, but it also demonstrates the limitation of attitude scores as a proxy for behaviour. Aanandaswamy and colleagues reported a comparable disconnect among operation-room personnel, where favourable attitudes did not ensure satisfactory knowledge or practice.[5] In the present study, the same gap was visible in the lower proportion of residents who consistently avoided recapping needles or reported needle-stick injuries.

The training analysis produced large score differences, and the direction agrees with interventional evidence. Singh and colleagues reported an increase in mean BMW knowledge score from 14 before training to 19.94 after a structured programme at a North Indian teaching institute.[10] Studies conducted during the COVID-19 period also emphasised repeated, context-specific training as waste streams and infection-control demands changed rapidly.[11,12] Pravinraj and colleagues found that previous training was associated with better knowledge among doctors and nurses, while knowledge and practice were positively related.[13] More recent work among Indian staff nurses similarly identified training and higher knowledge as predictors of satisfactory practice.[14]

Nevertheless, the observed training difference in this study must be interpreted conservatively. All trained participants were men, whereas all untrained participants were women; trained residents were also

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generally more senior and were concentrated in particular departments. Multivariable adjustment would not resolve this complete overlap reliably in a sample of 60. The result therefore shows an association within this cohort, not an independent training effect. A future study should recruit a larger, more balanced sample with trained and untrained participants represented across gender, residency year and department.

The practice gaps suggest that educational content should move beyond lectures on colour codes. Needle recapping and exposure reporting are behavioural and system-dependent. They are better addressed through induction-based demonstrations, easily accessible sharps containers, non-punitive reporting pathways, simulation, ward-level observation and immediate feedback. Process-based interventions that combine training with signage, supplies, inspection rounds and audit have shown practical value in teaching hospitals.[15] For pathology and laboratory areas, the same approach should include specimen containers, contaminated plastics, glassware, microbiological waste and pathological tissue, because errors at these interfaces may be less visible than errors on wards. Regular competency-based BMW training, periodic audits, direct observation of segregation practices and mandatory reporting of needle-stick injuries should be incorporated into hospital infection-control programmes.

These measures are consistent with World Health Organization recommendations on waste minimisation, segregation at source, safe containment, treatment and workforce training.[16] They also support compliance with India's Bio-Medical Waste Management Rules and subsequent amendments.[2,6] Current NABH hospital standards place biomedical waste monitoring within infection-prevention and quality systems,[17] while NABL criteria for medical laboratories require disposal in accordance with current national healthcare-waste requirements.[18] BMW competence among residents is therefore both a patient- and worker-safety obligation and an auditable component of institutional quality assurance.

LIMITATIONS

The study was conducted in a single teaching hospital and included only 60 residents, limiting generalisability and the precision of subgroup estimates. The number of eligible residents approached was not documented, so an overall response rate could not be established. Practices were self-reported rather than directly observed and may therefore be affected by recall and social desirability bias. Formal pilot-testing and psychometric validation data for the questionnaire were not available, and internal-consistency reliability was not reported. Strong ceiling effects reduced discrimination in the attitude domain and among trained residents. Finally, the complete alignment of training status with gender, together with its association with seniority and department, prevented estimation of an independent training effect. The cross-sectional design also precludes causal inference.

CONCLUSIONS

Resident doctors demonstrated high overall knowledge, favourable attitudes and generally safe self-reported biomedical waste practices. The residual gaps were concentrated in a small number of high-risk behaviours, particularly needle recapping and reporting of needle-stick injuries. Regular competency-based BMW training, periodic audits, direct observation of segregation practices and mandatory reporting of needle-stick injuries should be integrated into hospital infection-control programmes. Larger multicentre studies using observational assessment are needed to determine whether training produces sustained behavioural improvement independent of seniority, gender and departmental exposure.

CONTRIBUTION OF AUTHORS

Research concept- Subhashini H. Bevinakatti, Zubiya Suha Fathima

Research design- Subhashini H. Bevinakatti, Zubiya Suha Fathima

Supervision- Subhashini H. Bevinakatti

Materials- Subhashini H. Bevinakatti, Zubiya Suha Fathima

Data collection- Subhashini H. Bevinakatti, Zubiya Suha Fathima

Data analysis and Interpretation- Subhashini H. Bevinakatti

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Critical review- Subhashini H. Bevinakatti

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Article editing- Subhashini H. Bevinakatti
Final approval- Subhashini H. Bevinakatti

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