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AWARENESS ABOUT BIOMEDICAL WASTE MANAGEMENT AMONG LABORATORY STAFF IN KANPUR: A SURVEY-BASED OBSERVATIONAL STUDY

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ABSTRACT

Background: Biomedical waste generated in diagnostic and clinical laboratories carries a direct risk of infection and injury for the staff who handle it, and mishandled waste extends that risk to patients and the wider community. India's Biomedical Waste Management Rules, 2016 set clear standards for segregation, colour-coding and disposal, but how well laboratory staff specifically — as distinct from healthcare workers in general — know and follow these standards is not well documented for a city such as Kanpur.

Objective: To assess awareness of, and attitude toward, biomedical waste management (BMWM) among laboratory staff working in government and private healthcare institutions in Kanpur.

Methods: In this cross-sectional, survey-based observational study, 400 laboratory staff completed a structured, pre-tested questionnaire covering demographic and professional background, nine knowledge items, and five Likert-scale attitude statements. Participants were recruited by convenience sampling across pathology laboratories, hospitals, and academic institutions. Data were summarised as frequencies and percentages, with chi-square tests used to check for associations between demographic variables and knowledge or attitude level.

Results: Most respondents were under 26 years old (65.8%), male (71.5%), and held a BMLT degree (54.3%). Knowledge was good (≥80% correct) in 93.5% of participants and moderate in the remainder; nobody scored poor. Awareness was strongest for the definition of biomedical waste, its categories, and the 2016 Rules (93–96% correct), and slightly weaker for the precise colour-coding of infectious and chemical waste (89.0–89.3%). Attitude was positive in 98.0% of respondents: almost everyone agreed that BMWM matters for laboratory safety, that mishandling raises infection risk, and that training should be mandatory. Ninety-eight percent reported always following their laboratory's waste rules, and a similar proportion felt confident handling biomedical waste safely. Knowledge level was significantly associated with educational qualification ($p < 0.05$); attitude did not differ significantly by gender.

Conclusion: Laboratory staff in Kanpur know the fundamentals of biomedical waste management well and feel strongly that it matters. The small remaining gap sits at a specific technical point — colour-coding — which is where knowledge actually becomes correct practice, making it a more useful target for refresher training than a repeat of general awareness content.

KEYWORDS: Biomedical waste management; Awareness; Attitude; Laboratory staff; Colour coding; Cross-sectional study; Kanpur

1. INTRODUCTION

Biomedical waste is anything generated during diagnosis, treatment, or laboratory investigation that carries a risk of infection or injury — used syringes, blood-soaked swabs, discarded cultures, expired reagents, and the sharps and glassware that pass through a laboratory every working day. Handled correctly, this waste is contained and neutralised before it can do harm. Handled carelessly, it becomes a route for hepatitis, HIV, and other blood-borne infections to reach not only the staff who work with it, but sanitation workers, patients, and, if it enters the municipal waste stream, the wider community [1,2].

India generates an estimated 500–600 tonnes of biomedical waste every day, and hospitals and laboratories account for a substantial share of it. The Biomedical Waste Management Rules, 2016, framed under the Environment Protection Act, set out how this waste should be categorised, segregated at source through a colour-coded system, and tracked through to final disposal, along with the training that generators of biomedical waste are required to provide their staff [3,4].

Laboratory staff occupy an unusual position within this system. Where a nurse or doctor generates waste largely as a by-

product of patient care, laboratory personnel work directly with the hazardous material itself
— processing specimens, handling sharps as a matter of routine, working with reagents and cultures — which is part of why needle-stick injuries, chemical exposure, and glassware cuts feature so heavily in occupational-safety reporting from laboratory settings [3–5]. Waste that is poorly segregated does not stay contained either: chemical reagents, formalin, and heavy metals from laboratory work can contaminate soil and water if disposed of incorrectly.
Kanpur illustrates fairly well how laboratory services have grown across urban Uttar Pradesh: government hospital laboratories, private diagnostic chains, teaching-hospital labs, and small independent pathology centres all operate side by side, generating biomedical waste at very different scales and under very different levels of institutional oversight [5]. Much of the published work on BMWM awareness in India treats healthcare workers as a single group, or is based in accredited tertiary hospitals where training tends to be more structured than elsewhere. Laboratory staff specifically, and the private pathology laboratories that make up a large share of Kanpur's diagnostic sector in particular, are less well represented in that literature. This study set out to address that gap — to find out what laboratory staff in Kanpur actually know about biomedical waste management, what they think about it, and where the two diverge [11,12].

1.1 Objectives
The study assessed awareness of, and attitude toward, biomedical waste management among laboratory staff in Kanpur, with the following specific objectives: (1) to evaluate knowledge of biomedical waste categories and segregation practice; (2) to assess awareness of the colour-coded bin and container system set out in the BMWM Rules, 2016; (3) to determine awareness of the occupational hazards linked to improper handling; (4) to assess awareness of the environmental consequences of mismanagement; (5) to evaluate knowledge of the relevant institutional and national regulations; and (6) to identify demographic and professional factors — education and experience in particular — associated with awareness.

2. MATERIALS AND METHODS
2.1 Design and setting
This was a cross-sectional, descriptive, survey-based observational study carried out among laboratory staff in government and private healthcare institutions across Kanpur — hospital-based clinical laboratories, standalone pathology and diagnostic centres, medical colleges, and nursing homes. A cross-sectional design suited the study's purpose, which was to establish what staff currently know and think rather than to track change over time, and it kept the study non-interventional and low-risk for participants who are themselves healthcare professionals.

2.2 Population and sample
Eligible participants were laboratory personnel — technicians, technologists, assistants, phlebotomists, and other laboratory professionals — directly or indirectly involved in generating, handling, segregating, or storing biomedical waste, working in either the public or private healthcare sector in Kanpur.
Sample size was calculated with the standard single-population-proportion formula, $n = Z^2pq/d^2$, using a 95% confidence level ($Z = 1.96$), an assumed prevalence of 50% (used in the absence of local baseline data, since it yields the most conservative sample estimate), and an allowable error of 5%. This gave a minimum requirement of 384 participants; adding roughly 5% to allow for incomplete responses brought the target to 400. Participants were recruited through convenience sampling, deliberately spread across government hospitals, private hospitals, medical colleges, and independent laboratories so the sample was not dominated by any single institution type. Of 411 staff approached, 400 returned complete questionnaires
— a response rate of 97.8%.
Staff were included if they worked in a government or private healthcare institution in Kanpur, were actively involved in diagnostic or clinical laboratory work, had some role in generating or handling biomedical waste, were present during data collection, and gave informed consent. Administrative and managerial staff without direct laboratory involvement, anyone with less than a month in the role, staff on extended leave, and incomplete questionnaires were excluded.

2.3 Instrument
Data were collected with a structured, self-administered questionnaire developed after reviewing the BMWM Rules, 2016, Ministry of Health and Family Welfare guidance, and published literature on the topic. It had three parts. The first covered demographic and professional background — age, gender, qualification, job designation, years of experience, and type of institution. The second assessed knowledge across nine items: the definition and source of biomedical waste, awareness of the 2016 Rules, the categories of waste, colour-coding for infectious waste, sharps, and chemical waste, whether expired reagents count as biomedical waste, and recognition of the biohazard symbol; each item was scored correct (1) or incorrect/"don't know" (0), with cumulative scores grouped as good (≥80%), moderate (60–79%), or poor (<60%). The third part measured attitude with five-point Likert statements — strongly disagree to strongly agree — covering the importance of BMWM, the infection risk from mishandling, whether training should be mandatory, adherence to laboratory rules, and confidence in handling waste safely; responses were grouped as positive, neutral, or negative.
The questionnaire was piloted on 10% of the target sample to check clarity and flow. A few items were reworded based on that feedback, and pilot responses were excluded from the final dataset.

2.4 Ethics and data collection
The study received clearance from the Institutional Ethics Committee before data collection began. Participants were briefed on the study's purpose and their right to withdraw at any point without consequence, and written informed consent

was obtained from everyone who took part. No names or employee identifiers were recorded; questionnaires were coded, stored securely, and accessible only to the research team. Staff meeting the inclusion criteria were approached in person, completed the questionnaire on the spot, and returned it immediately, partly to keep responses independent and partly to avoid disrupting laboratory workflow.

2.5 Statistical analysis

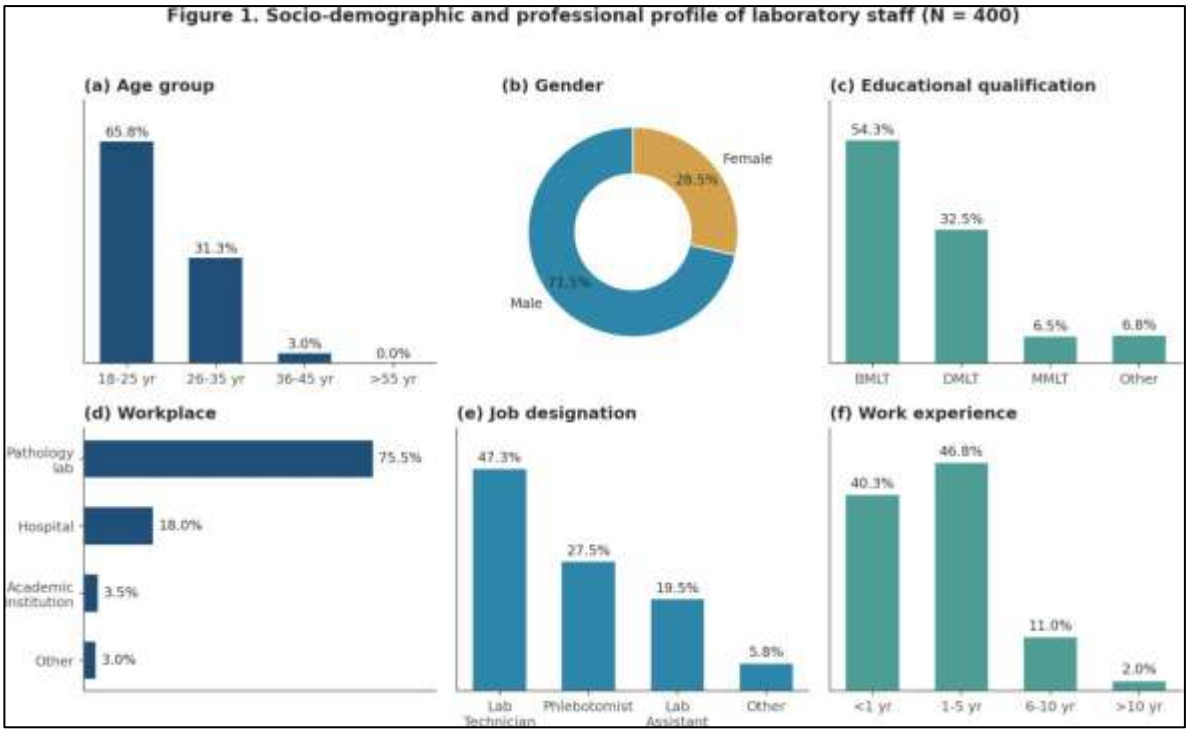
Responses were coded, entered into a database, and checked for errors before analysis. Descriptive statistics (frequency, percentage) summarise the demographic, knowledge, and attitude data throughout; the chi-square test was used to check for associations between educational qualification or gender and knowledge or attitude level, with significance set at $p < 0.05$.

3. RESULTS

Complete data were available for 400 laboratory staff, a 97.8% response rate from the 411 approached.

3.1 Who took part

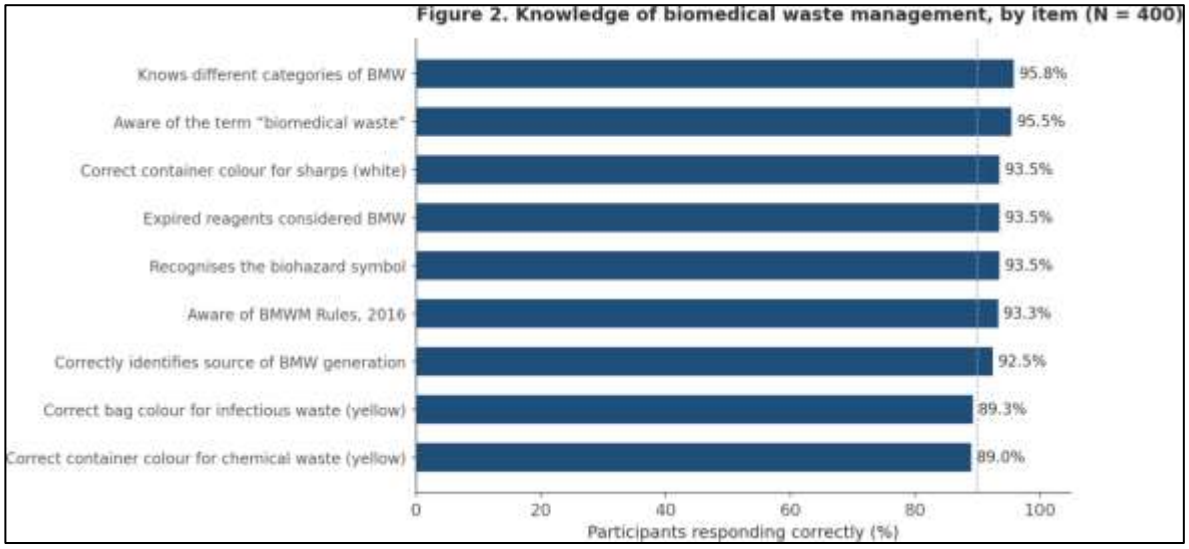
The workforce sampled skewed young: nearly two-thirds of participants (65.8%) were 18–25 years old, another 31.3% were 26–35, and only 3.0% were older than 35, with nobody in the sample above 55. Men outnumbered women roughly seven to three (71.5% vs 28.5%). A BMLT degree was the most common qualification (54.3%), followed by a DMLT diploma (32.5%); postgraduate (MMLT) staff made up a small 6.5%. Three-quarters of respondents (75.5%) worked in standalone pathology laboratories rather than hospital-based labs (18.0%), which matters given how much of Kanpur's day-to-day diagnostic testing runs through private, non-hospital laboratories. By role, laboratory technicians were the largest group (47.3%), followed by phlebotomists (27.5%) and laboratory assistants (19.5%). Most staff were relatively new to the job: 40.3% had under a year of experience and a further 46.8% had one to five years, leaving only about 13% with more than five years behind them. Figure 1 sets out the full profile.



3.2 Knowledge of biomedical waste management

Knowledge of the basics was strong across the board. Ninety-five and a half percent of staff recognised the term "biomedical waste," 92.5% correctly named healthcare activities as its source, and 95.8% could identify its different categories. Awareness of the BMWM Rules, 2016 specifically stood at 93.3%, and 93.5% correctly identified the biohazard symbol. A similar 93.5% knew that expired laboratory reagents count as biomedical waste — a detail that is easy to miss, since expired reagents do not look obviously hazardous the way a used needle does.

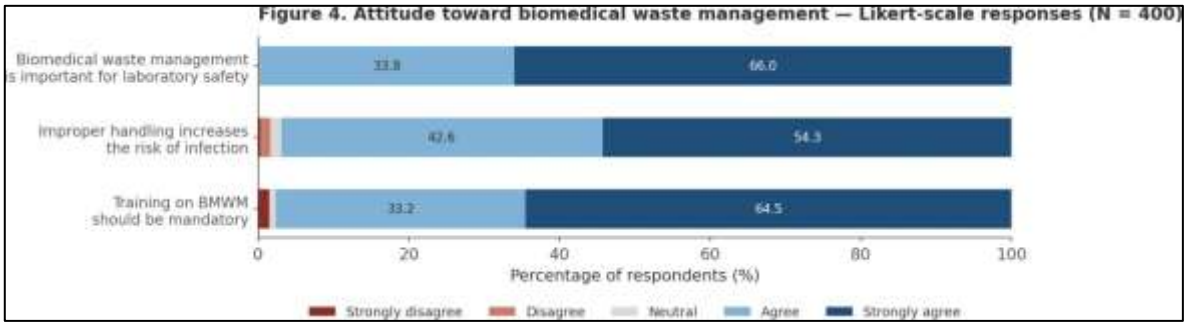
Scores dipped slightly for the exact colour-coding used in segregation. Eighty-nine percent knew that chemical waste goes into a yellow container and 89.3% knew infectious waste goes into a yellow bag; container colour for sharps fared better, with 93.5% correctly naming white. Figure 2 lays all nine knowledge items out side by side, sorted from lowest to highest — the gap between the weakest and strongest item is under seven percentage points, a fairly narrow spread for a workforce of this size.



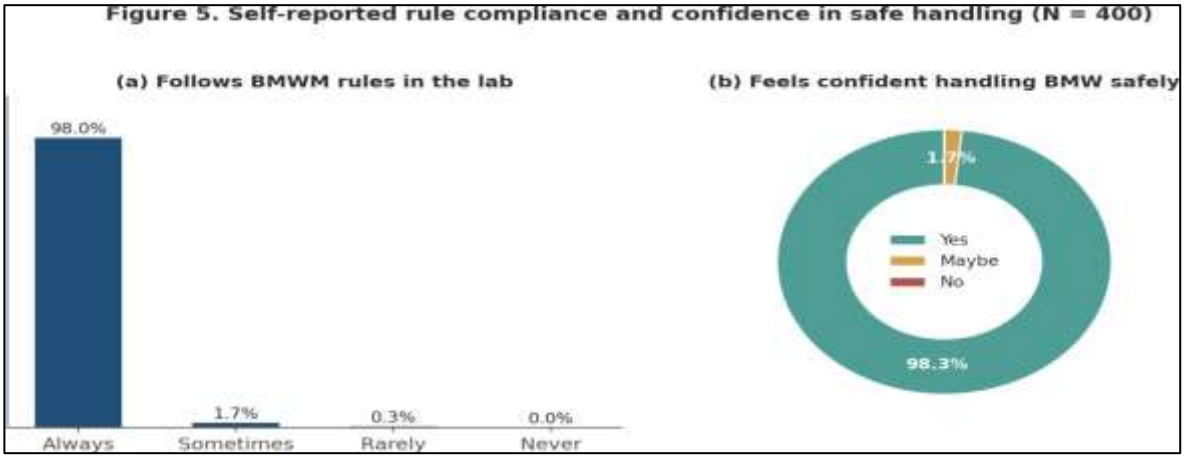
Combining these nine items into a single score placed 93.5% of participants in the "good" knowledge band and the remaining 6.5% in "moderate"; nobody scored below 60%. Figure 3(a) shows this distribution.

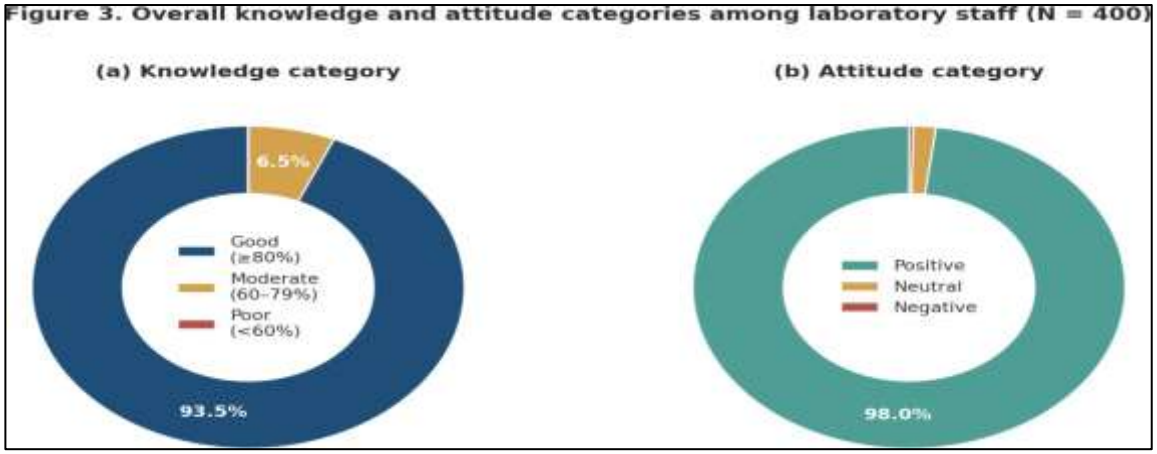
3.3 Attitude toward biomedical waste management

If knowledge was strong, attitude was close to unanimous. Almost every respondent (99.8%) agreed or strongly agreed that biomedical waste management matters for laboratory safety, and 96.9% agreed that mishandling it raises infection risk. Support for mandatory training was nearly as high, at 97.7%. Figure 4 breaks these three statements down by response category; what stands out is not so much the average as how little disagreement there was at all — across three statements and 400 respondents, fewer than a dozen people chose "disagree" or "strongly disagree" on any of them.



Self-reported practice followed the same pattern. Ninety-eight percent of staff said they always follow their laboratory's biomedical waste rules, with the rest split between "sometimes" (1.7%) and "rarely" (0.3%); nobody selected "never." A near-identical 98.3% said they felt confident handling biomedical waste safely (Figure 5). Combined into an overall score, 98.0% of respondents fell into the positive attitude category, 1.7% were neutral, and one participant (0.3%) was coded negative — shown alongside the knowledge distribution in Figure 3.





3.4 What predicted knowledge and attitude

Educational qualification was significantly associated with knowledge level ($p < 0.05$): staff with a BMLT or MMLT degree were more likely to fall into the "good" knowledge band than those with a DMLT diploma. Gender showed no significant relationship with attitude ($p > 0.05$) — men and women were about equally likely to hold a positive attitude toward biomedical waste management, which suggests that whatever is driving this workforce's strongly favourable attitude (training, supervision, professional norms) is reaching staff fairly evenly regardless of gender.

4. DISCUSSION

This sample of 400 laboratory staff in Kanpur knew the fundamentals of biomedical waste management well, felt strongly that it mattered, and reported following the rules almost without exception — a considerably more reassuring picture than earlier Indian studies painted before the 2016 Rules were in force, when awareness among healthcare workers was often described as patchy at best [5,6,9,25–28]. Two things stand out against that older literature. First, nobody in this sample scored in the "poor" knowledge band, which is unusual; most comparable surveys report at least a small tail of staff with weak awareness. Second, the gap between what staff know in principle and what they know in technical detail — specifically, colour-coding — was real but modest, three to seven percentage points depending on the waste category. That gap is worth taking seriously precisely because it is small and specific rather than large and diffuse: it points to where a training intervention would need to focus, rather than requiring a wholesale re-education of the workforce.

Why colour-coding lags slightly behind general awareness is not hard to explain. Knowing that biomedical waste exists, that rules govern it, and that mishandling it is dangerous are things a lecture or induction session can convey reasonably well. Remembering which colour goes with which waste category under time pressure, in the middle of a busy pathology lab, is a different kind of knowledge — closer to a reflex than a fact — and reflexes are built through repetition and visual cues, such as colour charts on the wall and correctly labelled bins actually present at the workstation, rather than a one-off training session. Earlier work on this exact point found a similar pattern: staff who could describe the colour-coding system correctly on paper did not always apply it correctly in practice [19].

The strength of attitude in this sample, 98% positive with barely any disagreement across five separate statements, is worth pausing on, since attitude research does not usually come out this lopsided. Part of the explanation is likely timing: data collection took place well after COVID-19 had pushed infection control and waste handling into every healthcare worker's daily awareness, and after several years of BMWM Rules enforcement had had time to filter into institutional training. It is also possible that a workforce this young (two-thirds under 26) and this recently trained (over half BMLT-qualified, most with under five years' experience) simply has not had time to develop the fatigue or shortcuts that longer-serving staff sometimes report elsewhere.

The finding that education level, not gender, predicted knowledge fits a pattern seen elsewhere in this literature: degree-

level training (BMLT, MMLT) appears to give staff a stronger theoretical grounding than diploma-level training (DMLT) does [9,26,27]. The practical implication is fairly direct — refresher training should probably be pitched differently, or delivered more intensively, for diploma-qualified staff rather than assuming a single course suits everyone equally well. The absence of a gender effect on attitude is reassuring from a programme-design standpoint, since it means training and messaging do not need to be tailored separately by gender.

One caveat runs through all of this: everything reported here — knowledge scores, attitude, and especially the practice figures (98% "always" follow the rules, 98.3% "confident" handling waste) — is self-reported.

Self-report is a reasonable way to measure what people know and think, but a much less reliable way to measure what people actually do, particularly for a question like rule compliance, where under-reporting non-adherence is the socially easier answer. A 98% compliance figure is best read as roughly the ceiling of what this workforce believes about its own behaviour, not as an independently verified compliance rate. Pairing a survey like this one with direct observation of how waste is actually segregated on a normal shift would be the natural next step, and is the single limitation most worth addressing in follow-up work.

4.1 Strengths and limitations

The study's main strengths are its size (400 participants, comfortably above the calculated minimum), its spread across institution types rather than a single hospital, and a 97.8% response rate that leaves little room for non-response bias to distort the picture. Its main limitations are the convenience sampling method, which cannot fully rule out selection effects; reliance on self-report for both knowledge and, especially, practice; and the fact that all participating institutions were in Kanpur city, so the findings may not extend cleanly to laboratory staff in smaller towns or rural facilities with different levels of institutional oversight.

5. CONCLUSION

Laboratory staff in Kanpur's healthcare institutions know the fundamentals of biomedical waste management, believe strongly that it matters, and report following the rules almost without exception. Ninety-three and a half percent scored in the good knowledge band and 98% held a positive attitude, with nobody falling into the poor-knowledge or negative-attitude category — a picture that speaks well of the training and institutional oversight currently in place. What remains is narrower than a general awareness gap: colour-coding for infectious and chemical waste sits a few percentage points behind everything else staff know, and the compliance figures reported here have not yet been checked against what actually happens on the laboratory floor. Both are addressable with fairly targeted next steps rather than a broad new awareness campaign.

6. Recommendations

1. Target refresher training specifically at colour-coding, the one area where scores consistently lagged, using visual aids such as wall charts and correctly labelled bins at the point of use, rather than repeating general BMWM content staff have clearly already absorbed.
2. Pay particular attention to diploma-qualified (DMLT) staff, who scored lower on knowledge than degree-holders; a shorter, more frequent refresher cycle may suit this group better than a single annual session.
3. Extend training and institutional support to independent pathology laboratories specifically, since three-quarters of this sample worked outside the hospital system, where structures such as infection-control committees are less likely to exist by default.
4. Add direct observation of segregation practice to future assessments, since the self-reported compliance figures in this study (98%) almost certainly overstate real-world adherence to some degree.
5. Build biomedical waste management practicals, not just theory, into laboratory technology curricula, given that qualification type was the strongest predictor of knowledge in this sample.
6. Repeat this kind of survey periodically, or follow a cohort over time, to see whether the favourable picture found here — particularly the complete absence of "poor" knowledge scores — holds up as the workforce ages and turns over.

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