

A Cross-Sectional Study to Assess the Knowledge, Attitude and Practices of Biomedical Waste Management among Healthcare Professionals in a Tertiary Care Hospital, Jharkhand

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Abstract: *Biomedical waste management is an essential component of safe health-care delivery. WHO reports that approximately 85% of health-care waste is general non-hazardous waste and the remaining 15% is hazardous. But the effectiveness of these BMW depends a lot of on the KAP of the healthcare professionals who use them. This descriptive cross-sectional study aims to evaluate knowledge, attitude and practices regarding biomedical waste management among healthcare professionals in a tertiary care teaching hospital in Ranchi, Jharkhand. A standardized, self-administered questionnaire was used that included important areas of biomedical waste management awareness, perception, and its practical use. A cross-sectional study looked at the KAP levels of 200 healthcare professionals, designed for an eight-month study at selected clinical areas of RIMS, Ranchi. The google dataset contains 200 records and 51 questionnaire variables as data tools. Descriptive and appropriate inferential statistics were used. Detailed KAP scoring and statistical testing presented after validation of item coding and scoring against the approved questionnaire. The study was intended to identify gaps between knowledge, attitudes and routine biomedical waste management practices and to inform practical interventions.*

Keywords: Biomedical waste management (BMW), Knowledge, Attitude, Practice (KAP), Healthcare professionals (HCPs), Healthcare waste, Tertiary-care hospital.

1. Introduction

Biomedical waste (BMW) is defined as any type of waste that is generated during diagnosis, treatment, immunization, laboratory or research activities in human beings or animals in healthcare institutions or in health camps [1]. As per the World Health Organization (WHO), around 85% of the total amount of waste generated during healthcare activities is non-hazardous waste similar to domestic waste, and only 15% is considered hazardous waste that includes various form of wastes infectious, pathological, sharps, pharmaceutical, chemical and radioactive waste apart from general waste, such as human anatomical parts, blood and tissues, radiation waste, chemo-toxic drugs, and broken medical equipment. BMW is commonly generated in hospitals, primary health care facilities, medical colleges, research centre, and veterinary hospitals. Advancement in medical care and the introduction of more advanced equipment has dramatically increased the amount of waste generated per patient in healthcare facilities worldwide. Globally, a large amount of health care waste generated everyday ranges from 0.9 kg/bed/day to 3 kg/bed/day [1]. In India uniform guidelines for practice in the country have been laid down under the Bio-medical Management and handling Rules 1998. The waste management programme in hospitals are in accordance to these guidelines and aim to minimize cross infection, improve the general hygiene in hospitals and minimize environmental pollution through proper treatment and disposal of waste. The success of biomedical waste management programme rests on the knowledge and practice of the Healthcare personnel (HCP). Inadequate and inappropriate handling of health-care wastes have serious public health issues and significant influence on the environment. Approximately 75–90% of biomedical waste is non-hazardous, the remaining 10–25% is

hazardous and can be injurious to human, animals, and harmful to environment. If both these types are mixed together, the whole waste is going to become dangerous. It is estimated that annually about 0.33 million tons of hospital waste is produced in India and waste generation rate ranges from 0.5 to 2.0 kg/bed/day [2].

Although there is an increased global awareness among health professionals about the waste hazards and also proper management techniques but the level of awareness in India is still found to be unsatisfactory. Adequate knowledge about the health hazards of hospital and laboratory waste, proper techniques and methods of handling the waste, and practice of safety measures is needed. The quantity of waste generated varies depending on the hospital policies and practices and the type of care being provided. The quantity of waste generated in developed countries range from 1 to 5 kg/pt./day and in developing countries it ranges from 1–2 kg/pt./day. According to World Health Organization report, about 85% of the waste is domestic waste and non-hazardous, 10% is infectious and remaining 5% is non-infectious but hazardous [3]. With this view of context, this study is being carried out to assess the knowledge and awareness about various aspects of biomedical waste management among paramedical personnel at this institute so that their status of knowledge and practice can help the authority to develop the strategy for improving the situation in future.

India has policies and structures for the management of biomedical waste. The rules for biomedical waste management were revised and were enforced in 2016. The Bio-Medical Waste management rules prescribe guidelines and regulations for the segregation, collection, storage, transportation, treatment, and disposal of biomedical waste.

The Central Pollution Control Board (CPCB) has developed a system for biomedical waste management wherein four categories of biomedical wastes are indicated by specific colours for easy identification. In addition to institutional structures, human resources play a critical role in biomedical waste management [4].

Though legal provisions Biomedical Waste (management and handling) Rules 1998] amended in 2016, 2022, 2024 exist to mitigate the impact of hazardous and infectious hospital waste on the community, still these provisions are yet to be fully implemented [4]. The absence of proper waste management, lack of awareness about the health hazards from biomedical wastes, insufficient financial and human resources, and poor control of waste disposal are the most critical problems connected with healthcare waste [5]. The hazardous impact of medical waste on the public and environment is enhanced manifold if adequate and appropriate handling of these wastes is not adopted.[6] The hospital waste management has diverse ramifications as it not only affects the health of patients but also of healthcare workers (doctors, nurses, sanitary staff, etc.) and general public [7]. This study fills an important gap in knowledge, attitude and practices regarding biomedical waste management among healthcare professionals working in a tertiary care teaching hospital in Ranchi.

The results will fill the gaps, misinformation and barriers in knowledge, attitude, and practices for improve BMWM. The health system leader to develop specific task, regular training intervention and policy initiatives. By providing specific information and data can support national strategies BMWM and Healthcare associated infection control. The results will support evidence-based decision-making for resource allocation, healthcare staff development, and quality improvement initiatives, ultimately to enhanced patient safety and reduced healthcare associated infection in tertiary care facilities.

2. Literature Review

Biomedical waste management (BMWM) plays an important role in infection control, occupational safety, environment protection, and healthcare improvement. Healthcare institutions produce various types of waste, ranging from the ordinary municipal type to infectious, sharps, pathological, pharmaceutical, chemical, and others. The impact of improper healthcare waste management extends beyond the hospital, posing a hazard to waste workers, patients, communities, and the environment[3].

The World Health Organization (WHO) reports that approximately 85% of total healthcare waste is non-hazardous, while the remaining 15% is hazardous. Infectious, toxic, carcinogenic, corrosive, reactive, explosive, and radioactive wastes are some of the healthcare waste categories[1][5]. Moreover, sharps require special attention due to the increased risk of sharps injury, which can result in blood-borne disease transmission. Additionally, proper segregation at the point of origin reduces the volume of healthcare waste requiring special treatment and minimizes occupational and environmental exposure [6].

Appropriate biomedical waste management plays a critical role in preventing healthcare-associated infections. Improper segregation can lead to infectious waste getting mixed with other types of wastes [7]. Therefore, a chain of infection control measures starting with waste minimization and segregation should be enforced. Implementation of proper collection, internal transportation, storage, treatment, and disposal of biomedical waste also play an essential role in reducing the spread of infection [5].

Needle-stick injuries, exposure to infectious agents, chemicals, and physical hazards can result from inadequate management of biomedical waste [8]. In addition, manual separation of biomedical waste, overfilling of containers, improper disposal of sharps, and lack of personal protective equipment can contribute to occupational exposure [9]. In addition, training and supervision also play an essential role in preventing sharps injury and infection transmission [10].

India has a regulatory framework for biomedical waste management, starting with the Bio-Medical Waste (Management and Handling) Rules, 1998, and the Bio-Medical Waste Management Rules, 2016, which amended the previous rules and guidelines. Moreover, the Central Pollution Control Board (CPCB) is responsible for technical guidance and oversight of the implementation of biomedical waste management rules at the national level [11]. The rules specify requirements for occupiers and operators and emphasize the importance of biomedical waste management, including segregation, collection, storage, transportation, treatment, and disposal [12].

India's biomedical waste management system follows the four-color segregation system: yellow, red, white/translucent, and blue. Yellow bags/waste containers are meant for anatomical waste, contaminated waste, and certain categories of wastes, including discarded chemicals and medicines. Red bags are used for disposable items contaminated with bodily fluids. White bags are used for sharp waste, including metals. Blue bags are assigned to certain categories of glassware and metal implants [6]. It is noteworthy that segregation at the point of origin is the responsibility of healthcare workers and depends on their knowledge and access to appropriate containers [13].

Knowledge regarding biomedical waste management

Knowledge encompasses definitions, categories, color codes, segregation, sharps management, transportation, treatment, and disposal procedures [15]. It has been demonstrated that knowledge about biomedical waste management is often higher among healthcare workers who received training. However, the level of knowledge may not always correspond to attitudes and practices. Therefore, it is important to conduct a KAP assessment to identify gaps in knowledge, attitudes, and practices [16].

Attitude towards biomedical waste management

Attitude is defined as a feeling or belief about something, often reflected in one's behavior. In relation to biomedical waste management, attitude also encompasses a commitment to adhering to institutional rules and regulations and a sense of responsibility for safe biomedical waste management [16]. A positive attitude can promote compliance with proper

biomedical waste management practices, including waste segregation and the use of PPE. At the same time, negative attitudes, such as the belief that biomedical waste management is inconvenient or that it is the responsibility of housekeeping staff, can lead to poor compliance with biomedical waste management practices [17].

Practices of biomedical waste management

Practices refer to the specific actions undertaken by an individual or organization, such as waste segregation at the point of origin, use of color-coded sharps containers, safe disposal of sharps, use of PPE, spill management, and incident reporting [18]. Good practices can be promoted by a supportive environment and strong organizational leadership. For instance, the availability of appropriate bins and PPE, worker training, and supervision can contribute to improved practices [19].

Training and continuing education

Training is an essential component of any biomedical waste management program and should be conducted regularly. New healthcare workers should receive training upon hire, while those already employed should attend training sessions on a regular basis [20]. In addition to general instructions, training programs can include practical courses and feedback on individual performance. It is important that healthcare workers understand the rationale for following established procedures, as well as the consequences of poor biomedical waste management and appropriate actions to take in case of an accident [21].

Role of hospital administration

The administrative staff plays a crucial role in biomedical waste management since they are responsible for enforcing institutional rules and regulations concerning biomedical waste management [22]. In particular, hospital administrators are responsible for ensuring the availability of color-coded bins for waste segregation, appropriate PPE, and training programs for healthcare workers [23]. The administrative staff should also monitor compliance with institutional rules and regulations and take action in case of an incident [24].

Barriers to effective BMW

Various barriers can hinder effective biomedical waste management, including the availability and accessibility of sharps containers and PPE, improper waste segregation, insufficient training, and poor supervision [25]. In addition, a lack of knowledge about color coding and inadequate monitoring systems can also contribute to poor compliance with biomedical waste management rules and regulations [19]. The above-mentioned barriers can be categorized as behavioral or organizational. Therefore, it is essential to conduct a KAP assessment to identify the main barriers to effective biomedical waste management at the hospital [26].

Numerous studies conducted among doctors, nurses, laboratory personnel, students, and other healthcare workers have examined biomedical waste management knowledge, attitude, and practices. The results of these studies indicate that biomedical waste management knowledge, attitudes, and practices vary across hospitals and occupations [27]. However, healthcare workers who received training demonstrated better knowledge about color coding and safer biomedical waste

management practices [28]. Nonetheless, healthcare workers lacked knowledge about proper sharps disposal, PPE use, and segregation of different types of biomedical waste [29].

Relationship between knowledge, attitude and practice

The KAP theory is based on the assumption that knowledge influences attitudes, while attitudes determine practices. In other words, healthcare workers may possess adequate knowledge about biomedical waste management; however, their attitudes may prevent them from adopting safe practices. For instance, healthcare workers may know that yellow bags are used for specific categories of biomedical waste; however, if blue bags are more accessible, they will utilize them to dispose of the same type of waste [19]. In addition, a positive attitude and knowledge about biomedical waste management are of little significance if there are no supportive measures, such as training, supervision, and monitoring [20].

3. Materials and Method

A cross-sectional design to assess the knowledge attitude and practices (KAP) regarding biomedical waste management among the health care professionals in a tertiary care teaching hospital during approved study period. The study was conducted at Rajendra Institute of Medical Sciences (RIMS), Ranchi which is a tertiary-care teaching hospital in Jharkhand. The study areas include the outpatient department (OPD), Emergency, OT complex and indoor patients department/Ward, ICU and laboratories. These departments were selected because they generate waste as a result of outpatient services, emergency services, surgeries, diagnostic tests and indoor patient admission. The study site involves a range of clinical and diagnostic services making it ideal for conducting a survey on biomedical waste management among the healthcare personnel. The study population focused on health care professionals working in the specified department in the study site, who are involved either directly or indirectly in biomedical waste management. This includes doctors, para-medical personnel, staff nurse, lab technicians and housekeeping staff are the main target audience for this study. The final sample size of 200 respondents based on the prevalence assumption and power analysis. The study used a convenience sampling procedure. This procedure entails targeting health-care workers who are available for the screening process and meet the inclusion criteria. Stratified sampling by healthcare professionals category (doctors, nurses, lab techs and housekeeping staffs) Within each stratum, consecutive sampling from staff rosters will be used to select participants proportionate to size.

Health-care professionals who met the inclusion criteria, were available for screening and gave informed consent to participate in the study were included. The inclusion criteria were based on the eligibility criteria described in the protocol and the questionnaire. Health-care professionals who did not give informed consent to participate in the study, were not available for screening and did not meet the inclusion criteria were excluded.

The study used a questionnaire as the research tools. The questionnaire consisted of four major section (1) participant socio-demographics, (2) knowledge about biomedical waste management, (3) Attitude towards biomedical waste

management, (4) Self-reported biomedical waste management practices and (5) Barriers and institutional factors affecting biomedical waste management. Collected data will be entered in Microsoft excel and analysed using SPSS version 26. Appropriate statistical test will be applied as per the normality of the data. Chi-square test was used to assess association between categorical variables and year of experiences.

The scoring for KAP was formulated as below:

Score	Knowledge	Attitude	Practice	Kap	Grade
1	<16	<20	<30	<6	Poor
2	16-20	20-40	30-50	6-7	Average
3	>20	>40	>50	>7	Good

4. Result and Discussion

Amongst the 200 participants 85 were male and 115 were female, of which 104 were below 29 years age, 65 were between 30 to 49 years age group and rest were above 50 years. While 8 participants worked in the CCU, 15 in emergency, 25 in laboratory, 70 in OPD, 2 in OT complex and 80 in the ward. The designation was that 82 participants were doctors, 68 were staff nurse, 28 were house keeping staff, and 22 were lab and OT technicians. While 60 had less than 1 year of work experience, 67 had 1-5 years, 25 had 6-10 years and 48 had >10 years of work experience.

Table 1.1 shows the knowledge indicators

Table 1.1: Knowledge indicators

Indicator	Frequency	Percentage
Correct/adequate BMW definition	174	87.0
Correct complete set of listed BMW examples without distractors	71	35.5
Aware of applicable BMW rules	171	85.5
Adequate understanding of BMW purpose	179	89.5
Identified ≥ 2 health hazards	141	70.5
Aware of colour-coded segregation	186	93.0
Correct safe used-needle disposal	128	64.0
Aware segregation is required at source	184	92.0
Aware of maximum storage period	166	83.0
Knows whom to contact after needle-stick/exposure	179	89.5
Aware of PPE	186	93.0

Table 1.2 shows the distribution of knowledge.

Table 1.2: Distribution of knowledge among the 200 subjects

Category	Frequency	Percentage
Poor	8	4.0
Average	32	16.0
Good	160	80.0
Total	200	100.0

Regarding the attitude of health care workers towards the biomedical waste management questions were asked and a range from strongly agree to strongly disagree were set on a scale and scored. Table 1.3 mention the score of participants based on a set of questions.

Table 1.3: Distribution of ATTITUDE Score

Grade	Frequency	Percentage
Poor	10	5.0
Average	105	52.5
Good	85	42.5
Total	200	100.0

Finally the practice score was based on a scale of questions with score of responses accordingly like below is Figure of distribution of participants who are willing to check that if waste bins are overfilled or not.

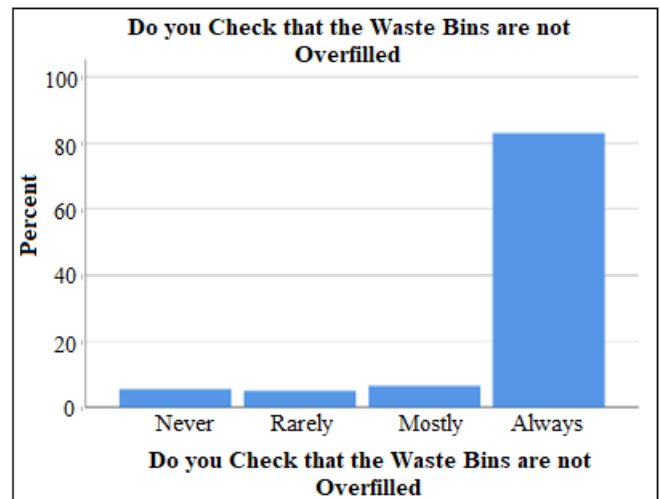


Figure 1.1: Distribution of participants on Practice of willing to check bins overfilled or not

Based on such questions Practice score was calculated which is shown in Table 1.4

Table 1.4: Distribution of Practice Score

	Frequency	Percentage
Poor	14	4.5
Average	17	5.4
Good	169	53.8
Total	200	63.7

Finally, the KAP Score was calculated as shown in Table 1.5

Table 1.5: Distribution of KAP Score in 200 HCW

Grade	Frequency	Percentage
Poor	8	2.5
Average	32	10.2
Good	160	51.0
Total	200	63.7

SPSS 26 was used to see the association between participants characteristics and KAP as summarised in table 1.6

Table 1.6: Association between participant characteristics and KAP

KAP variable	Associated factor	χ^2	df	P - value	Interpretation
Knowledge	Designation	58.294	10	<0.001	Significant
	Formal BMWWM training	33.591	6	<0.001	Significant
	Work experience	42.119	8	<0.001	Significant
	Sex	50.212	4	<0.001	Significant
	Department	60.051	12	<0.001	Significant
Attitude	Designation	15.857	10	0.1038	Not significant
	Formal BMWWM training	15.913	6	0.0142	Significant
	Work Experience	26.026	8	0.0010	Significant
	Sex	24.418	4	<0.0001	Significant
	Department	23.121	12	0.0267	Significant
Practice	Designation	34.703	10	0.0001	Significant
	Formal BMWWM training	36.588	6	<0.0001	Significant
	Work experience	25.744	8	0.0012	Significant
	Sex	16.679	4	0.0022	Significant
	Department	37.706	12	0.0002	Significant

The study datasets comprised 200 participants records were analysed.

Staff Nurse were the largest occupational group (32.0%).

Mean age was 41.24 +/-10.11 years.

57.2% had recent BMWWM training.

Mean knowledge performance score was 80.23%, with 64.5% classified as Good.

Mean attitude performance score was 78.75%, with 78.4% classified as Good.

Mean practice performance score was 78.23%, with 76.5% classified as Good.

Mean overall KAP performance was 78.33%

Knowledge category was significantly associated with designation (p value 0.013).

Several demographic and occupational variables showed statistically significant associations with KAP categories; these are associations and do not establish causality.

The finding demonstrates a reasonable level of BMWWM knowledge and strong positive attitude, but comparatively weaker reported practice. The knowledge practice gap was particularly evident for segregation and PPE use. The results indicate that education alone may be insufficient and that hospital system should reinforce training with adequate bins and PPE, visuals reminders, supportive supervision, regular audits, hands-on training on infection, prevention and control (IPC) healthcare associated infections (HAI) and occupational exposure management.

5. Conclusion

The present cross-sectional study assessed knowledge, attitude and practices related to biomedical waste management among healthcare professionals in a tertiary care hospital in Ranchi, Jharkhand. Healthcare workers demonstrated good awareness of selected aspects of BMWWM and generally favourable reported practices. The analysis included 200 participant records representing doctors, nurses, laboratory technicians, housekeeping personnel and other healthcare workers.

These findings indicate that the study population had substantial exposure to BMWWM education. A total of 68.0% reported receiving formal training within the previous one year, while 10.0% had received training more than one year

earlier and 13.0% reported no formal training. Awareness of applicable BMWWM regulations was reported by 89.1% of respondents, while 73.0% of participants with available practice-level data demonstrated good practices. However, important procedure-specific gaps remained, particularly in sharps disposal and post-exposure management. Although most injured participants reported washing the affected area, substantially fewer reported the incident or received post-exposure prophylaxis.

In addition, 82.5% provided a comprehensive definition of biomedical waste consistent with the broad concept of waste generated from healthcare activities.

These findings support the need for regular, practical and competency focused BMWWM training and multidisciplinary hospital responsibility. Training should cover not only colour-coded segregation but also sharps safety, injury reporting, post-exposure management, and appropriate use of PPE. Institutional support through adequate infrastructure, monitoring, documentation, supervision, and corrective action is equally important for translating knowledge into consistent BMWWM practices.

Overall, the analytical datasets demonstrate moderate to good knowledge, good attitude and moderate practice regarding biomedical waste management. Safe management depends not only on individual knowledge but also on adequate infrastructure, appropriate segregation containers, PPE, staff training, supervision, monitoring, documentation and an effective response to sharps injuries and other occupational hazards. Institutional strengthening through refresher training, adequate infrastructure, PPE availability, clear signage, supervision and regular BMWWM audit.

The study should not classify participants into good, moderate or poor overall KAP categories, nor report associations or statistical significance, until the approved questionnaire scoring key and cut-off criteria are confirmed. This protects the scientific validity of the dissertation and prevents arbitrary assignment of scores.

In conclusion, the study supports the need for a structured, continuous and institution-wide BMWWM programme. Regular training, strong administrative monitoring, adequate logistics, clear accountability and continuous quality

improvement should be integrated into routine hospital operations. Effective implementation can protect healthcare workers, patients, waste handlers, the community and the environment while supporting compliance with national biomedical waste-management requirements.

6. Recommendations

Based on the findings and the hospital-administration implications of BMWWM, the following recommendations are proposed:

- Develop an annual BMWWM training calendar covering all categories of healthcare personnel.
- Make BMWWM induction training mandatory for all newly appointed employees, including outsourced and housekeeping workers.
- Conduct periodic refresher sessions using practical demonstrations, bedside/ward teaching, posters and short competency assessments.
- Ensure adequate colour-coded bins and bags are continuously available at the point of waste generation.
- Display standardized BMWWM colour-coding charts and concise instructions in wards, OPD, laboratories, emergency areas, OT complexes and other relevant locations.
- Establish routine departmental BMWWM audits with documented feedback and corrective-action plans.
- Strengthen the reporting, documentation and review of needle-stick and sharps injuries.
- Use root-cause analysis for repeated segregation errors and occupational incidents.
- Include BMWWM performance indicators in infection-control, quality and hospital-administration review meetings.
- Strengthen monitoring of outsourced/contractual personnel and ensure that their training is equivalent to that of regular staff.
- Use periodic competency assessment to verify that staff can correctly identify waste categories and perform segregation procedures.
- Review procurement and logistics to minimize interruptions in the supply of bins, bags, PPE and other BMWWM materials.
- Encourage waste minimization and environmentally responsible practices wherever clinically safe and legally appropriate.
- Repeat KAP assessment after implementation of interventions to evaluate improvement over time.

7. Limitations of Study

- The cross-sectional design provides a snapshot of knowledge, attitudes and practices and cannot establish temporal relationships or causality.
- The study was conducted in a single tertiary-care hospital; therefore, generalization to other hospitals or healthcare settings should be made cautiously.
- The dataset contains missing responses for several variables. The extent of missingness varies across questionnaire items and may affect interpretation of individual variables.

- Some practice and attitude information is self-reported and may be affected by recall bias or social-desirability bias.

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