

Original Research Article

Understanding gaps in biomedical waste management in India: from policy frameworks to hospital practice

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ABSTRACT

Background: Effective Biomedical Waste (BMW) management remains a critical challenge in Indian healthcare system, with serious implications for individual health and environmental sustainability. This study assesses the knowledge, attitudes and practices of healthcare workers (HCWs) regarding BMW segregation and treatment in two tertiary care oncology hospitals in Varanasi, India.

Methods: A total of 377 HCWs from diverse categories—including nurses, housekeeping staff, doctors and technicians participated in a prospective cross-sectional survey conducted from January 2022 to October 2023. A structured questionnaire was used to evaluate participants' behavioral challenges, knowledge gaps and underlying contributing factors behind improper BMW segregation.

Results: This study showed while 94.43% of HCWs were aware of the importance of BMW segregation, only 59.95% of participants had adequate knowledge about its treatment and disposal. Insufficient knowledge, hurried work practices and excessive workload were identified as major barriers to proper waste segregation. Notably high incidents of needle stick injuries (NSIs) due to improper sharp handling and disposal were reported, among nurses and housekeeping staff. Additionally, 92.57% of participants expressed a strong desire for monthly or semi-annual re-training sessions on BMW segregation and its treatment.

Conclusions: The findings emphasize the importance of regular, structured training programs and reinforcement of individual accountability to improve compliance with BMW management protocols. Incorporating foundational BMW management training with practical exposure into MBBS, nursing and paramedical curricula may further enhance awareness and responsible handling practices among healthcare professionals.

Keywords: Biomedical waste management, Healthcare workers, Waste segregation, Needle stick injury, Infection control, Hospital waste, Occupational health

INTRODUCTION

The healthcare sector in India, serving a population of over 1.4 billion people, is constantly evolving, with

increasing innovations and technological advancements. In the field of medicine, increased consumption of resources has some negative impact on the environment. Rise in Health Care Facilities (HCF) under the

Government and Private sectors and an increase in standalone individual and/or chains of diagnostic laboratories and clinics have been the main reasons for the increased production of BMW in India. BMW is hazardous and poses a significant risk to human health and the local environment, if not managed properly.^{1,2} This waste contains harmful microorganisms, which can infect HCW and the local population who come in direct contact with untreated BMW. Another major area of concern is the spread of multidrug-resistant organisms from such hazardous waste into the environment.

As per the World Health Organization (WHO) assessment conducted in the year 2000, around 18-64% of health care facilities in 22 developing countries did not have proper BMW disposal facilities.³ Epidemiological studies indicated that 30%, 1.8% and 0.3% respectively, are the potential risks of getting infection of Hepatitis B Virus (HBV), Hepatitis C Virus (HCV) and Human Immunodeficiency Virus (HIV) through reuse of needles used on infected patient sources.^{1,4} According to the annual report of the Central pollution control board, 2023, around 72% of HCFs are utilizing Common BMW treatment facilities (CBWTF) and 3.6% of HCFs follow captive treatment protocol, including deep burial for the treatment of BMW.⁵ Operational HCFs without legal authorization, a gap in the generation and treatment of BMW, hospitals without effluent treatment plants and HCFs still following traditional captive BMW treatment facilities are the main discrepancies identified in India for management of BMW.⁶

The Government of India has revised and replaced BMW management guidelines in 2016, and further amended them in 2018 and 2019.⁷ This guideline aims to ensure a uniform and elaborate framework toward proper segregation, transportation, treatment and final disposal of BMW. This guideline also ensures legal and ethical accountability for all sorts of healthcare sectors. Effective handling of the BMW requires discipline, awareness and accountability at the institutional and individual level.⁸ Continuous training, monitoring, motivation and community involvement can improve BMW treatment protocols in India. The purpose of this study was to assess and analyze knowledge, along with individual approaches towards handling BMW in a tertiary care oncology setup among different categories of HCWs. Additionally, the survey aimed toward the identification of probable reasons for improper BMW segregation, its impact on HCWs through needle stick injury along with practical intervening steps to control mishandling of BMW at medical institutions. The input of this study will assist hospital administration, especially the Hospital BMW Management Committee, to take effective steps for proper handling of BMW at the institutional level, which can act as a backbone in formulating effective BMW management protocols.

METHODS

A prospective cross-sectional questionnaire-based survey was conducted from January 2022 to October 2023 at two tertiary care cancer units at Varanasi, Uttar Pradesh, India, Homi Bhabha Cancer Hospital (HBCH) and Mahamana Pandit Madan Mohan Malaviya Cancer Centre (MPMMCC), tertiary care cancer hospitals and the study was approved by the Institutional Ethics Committee with letter number 11000528.

Inclusion criteria

Participants directly or indirectly involved in patient care and biomedical waste handling, including doctors, nurses, housekeeping staff, technicians, phlebotomists, pharmacists and administrative staff.

Exclusion criteria

HCWs who declined to participate or did not provide informed consent. HCWs not involved in hospital activities related to patient care or biomedical waste handling.

A total of 377 HCWs has participated through convenience sampling methods; after obtaining informed written consent from them, a well-structured questionnaire was utilized to assess their knowledge and attitude towards management of BMW within a hospital setup. Participants were identified by a specific code number in subsequent study records and their identity was never revealed at any forum. Participants were requested to answer the questionnaire according to their convenience and in their preferred language, either in English or Hindi. As per the willingness of the participants, training regarding segregation and treatment of BMW was also provided to them along with the survey. The survey conducting team consisted of 5 MD clinical Microbiologists, 2 Infection control nurses (ICN), and 2 Microbiology technical officers. The survey was initiated only after ensuring, all auditors have acquired the necessary skills and knowledge in order to ensure accurate, reliable and unbiased data collection. Data from the questionnaire was extracted into an excel sheet. The statistical analysis was performed using SPSS (version 21). All the data were in categories; hence, they were represented as numbers and percentages.

RESULTS

A total of 377 HCWs, including 132 nurses (35.01%), 108 housekeeping staff (28.65%), 57 technical staff (15.12%), 50 doctors (13.26%), 14 administrative staff (3.71%), 11 phlebotomists (2.92%) and 5 pharmacists (1.33%) participated in the survey. The survey questionnaire was structured for the awareness regarding segregation and treatment of BMW, accountability for inappropriate BMW segregation and measures to improve its management within the institution.

Table 1: Demographics details of HCWs participated in the survey.

Variables/HCW category	Nurses	House-keeping staff	Technicians	Doctors	Administration	Phlebotomist	Pharmacist
Total participant (N)	132	108	57	50	14	11	05
Gender	Male	45	73	37	31	12	09
	Female	87	35	20	19	02	03
Age (years)	20-30	108	65	44	10	03	10
	31-40	24	41	13	35	10	01
	41-50	00	02	00	05	00	00
	>50	00	00	00	00	01	00
Work experience (years)	<1	05	02	00	00	00	01
	1-5	75	104	46	12	10	08
	6-10	49	02	10	18	02	02
	>10	03	00	01	20	02	00
Biomedical waste segregation protocol	Aware	132	105	56	50	03	10
	Willingness for retraining	127	94	51	47	14	11
Biomedical waste treatment protocol	Aware	108	31	41	39	02	05
	Willingness for retraining	132	108	57	49	1	11
Recommended frequency of such survey	Monthly	69	52	39	10	04	11
	Twice in a year	49	48	14	16	10	00
	Yearly	14	08	04	24	00	00

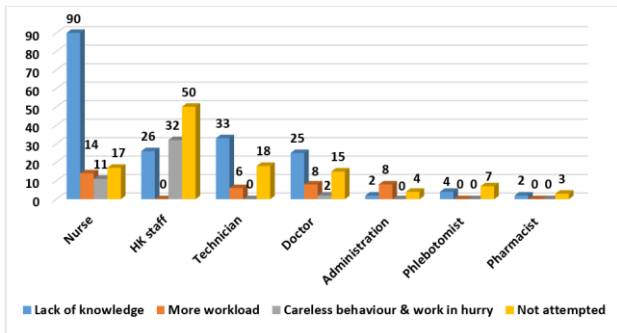


Figure 1: Reason for improper biomedical waste segregation.

Table 1 shows that the majority of the participants (63.7%) were from the age group of 20-30 years. In terms of work experience, 255 (67.6%) and 83 (22%) had work experience of 1-5 years and 6-10 years, respectively. Only 26 (6.9%) HCWs had more than 10 years of work experience. Around 209 (55.44%) male and 168 (44.56%) female candidates had undergone this survey. According to Table 1, 356 (94.43%) and 226 (59.95%) HCWs were aware of segregation and treatment of BMW respectively, but still the majority of them were willing for retraining about segregation (n=349, 92.57%) and treatment (n=363, 96.29%) of BMW at monthly or half-yearly intervals.

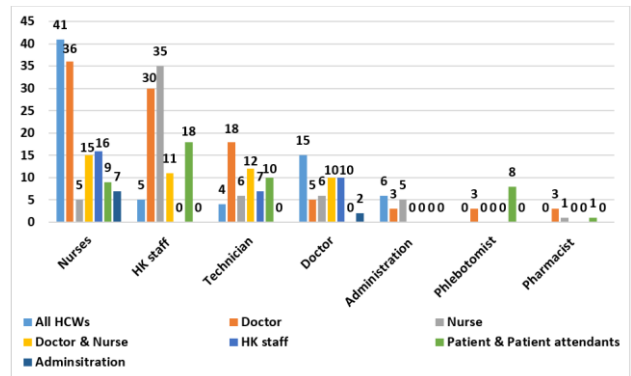


Figure 2: Responsible for improper biomedical waste segregation.

Figure 1 reveals that insufficient knowledge, careless behavior, hurry to complete allocated work and excessive workload are the main reasons for improper BMW segregation. According to nurses and doctors, they themselves, along with housekeeping staff, are accountable for improper waste segregation. As per the housekeeping staff and technical team; nurses, doctors, and patient attendants, and according to the phlebotomist, patients and their attendants are mainly responsible for improper waste segregation.

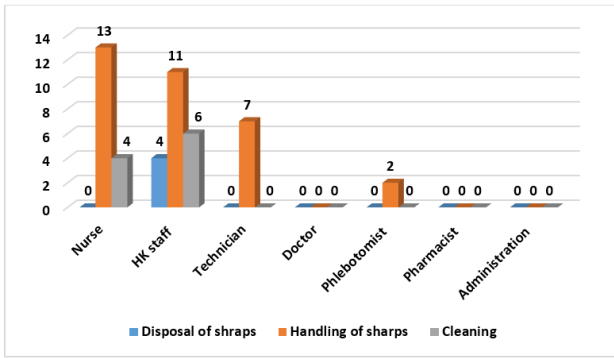


Figure 3: NSI during disposal/handling of sharps and cleaning.

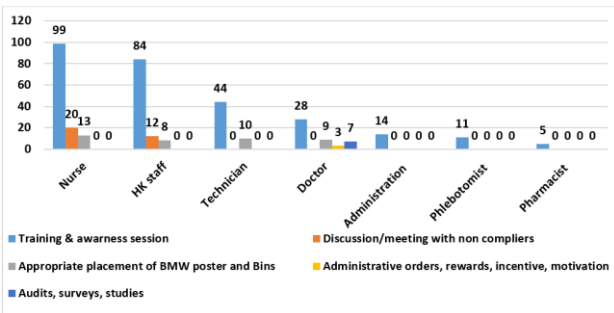


Figure 4: Measures for improvement in biomedical waste management.

Administration staff considered nurse and housekeeping staff mainly responsible for inappropriate waste segregation (Figure 2). As per the survey, the incidence of needle stick injury due to improper BMW segregation is high among nurses and housekeeping staff (Figure 3). Repetitive training and one-to-one discussion with non-complier HCWs are effective ways to improve BMW management within the institution.

DISCUSSION

The Government of India has revised BMW Management guidelines in the year 2016, for its effective implementation across all states in India. The issue of mishandling of BMW has gained more importance due to an increase in awareness about the adverse impact of BMW on human health and the environment.⁹ Effective handling of BMW is not only a legal requirement, but also a social responsibility of all HCWs, whether working within the medical centers, clinics, or even outside during any health camps or community outreach medical programs.

The majority of doctors, nurses and technical team members believe lack of knowledge, and administrative staff believe excessive workload over HCW, as the common cause for improper BMW segregation. According to housekeeping staff, careless behavior and rush to finish the medical activities for patients are the main reasons for such non-compliance. A similar study

conducted by Sahoo et al states the unavailability of color-coded bags and rapid staff turnover as the important causes of incorrect waste segregation.¹⁰ Mugabi et al, figured out the knowledge gap as the important factor for protocol deviation in BMW segregation.¹¹ Ignorance about the importance of effective management of BMW and the serious consequences of untreated/partially treated BMW over one's own health, the general population and the local surrounding environment is the main reason for apathy and lack of motivation among HCWs to adhere to the set standard protocols of handling BMW.

Real-time assessment for its causative factors and developing the most practical solutions is necessary for any institution to improve protocols for BMW management. Compliance towards handling of BMW at the institutional level may also be improved by involving representatives of all concerned categories of HCW in formulating institutional policies for BMW management. Uninterrupted supply of all essential resources for proper handling of BMW, regular supervision for protocol compliance and appropriate actions against non-compliers by the hospital BMW management committee and/or hospital administration may further assist in streamlining BMW segregation at the source of its generation.

According to Figure 3, nurses (13/132), housekeeping staff (11/108) and technical team (7/57) were the most common HCW categories affected by needle stick injury (NSI) due to incorrect sharp waste disposal protocols. Nursing personnel are consistently identified at high risk for NSIs; a recent meta-analysis revealed a pooled prevalence of NSI is around 41 % among nurses globally.¹² According to Mitra M et al, the majority of nursing professionals and housekeeping staff acquired NSI due to mishandling of sharps.¹³ This study revealed that handling of sharps (70%;33/47), cleaning activities (21%;10/47), and transportation of used sharps for disposal (9%;4/47) were the main contributory factors for NSI. Recapping of needles, movement of used sharps, or disposal of sharps in sharps containers were the activities included in handling of sharps waste. Dhayagude S et al, noted handling of sharps (18.54%) and discarding of sharps (11.7%) as the common contributory factor for NSI.¹⁴ Neha Dang et al and M Mitra et al also reported handling BMW as the most common risk factor for NSI.¹³⁻¹⁵ While training for BMW handling, more emphasis must be given on the consequences of improper BMW Management over the health of HCWs and administration must support in uninterrupted supply of good-quality waste bins, color-coded bags and puncture-proof containers. A significant number of staff get needle stick injury while discarding sharps in sharps containers. Depending upon the type of sharps utilized, every hospital location may require some customization in their sharp containers, like their capacity, size and shape of opening at the top of the sharp container. Customization of sharp containers as per the type and quantity of sharps

to be discarded plays a vital role in minimizing NSI during handling and disposal of sharps.

While assessing HCW category specific accountability for incorrect waste segregation, nurses and technicians claimed that doctors; housekeeping staff held nurses and doctors accountable for such noncompliance. Doctors felt they themselves, along with nurses, are mainly responsible for incorrect waste segregation. Housekeeping staff and phlebotomists have observed a good number of patients and their attendants involved in wrong practice for biomedical discarding at the Outpatient department (OPD) and at some Inpatient department (IPD) counters. Raghuvanshi et al also have figured out doctors and nurses involved in poor BMW segregation practices.¹⁶ Such audits provide valuable information about the target audience within the institution for training and supervising their work practices. Cultural inertia, apathy towards effective BMW Management, especially among senior officials, high workload due to understaffing and work stress/fatigue are some of the important personal factors leading to inadequate BMW segregation at any medical center.

High attrition rate, low education level of some HCW categories, lack of prior knowledge or foundational understanding about key concepts of BMW, casual approach in training, or ineffective training methodology might be the attributable factors for having misconceptions or a knowledge gap among trained HCWs. Incorporation of basic BMW Management guidelines with practical exposure in a health care setup in foundation courses of MBBS, Nursing and Paramedical field, along with inclusion of BMW training in various medical sessions like conferences, workshops, and online webinars for postgraduates, may have a high impact in developing sympathy among medical professionals towards understanding the importance of adequate handling of BMW. Customization of training methodology, like pictorial representation, role play, case-based learning, e-learning modules with easy access to recorded videos, according to various HCW categories, and its evaluation through mock drills and audits, along with scheduled interval re-training, is highly recommended to improve the effectiveness of such training programs. In the present study, though 94.43 % and 59.95% of HCWs claimed to have awareness about BMW segregation and treatment, respectively, this study also identified a certain level of knowledge gap, inadequacies, and/or misconceptions among different categories of surveyed HCWs for conceptual information about segregation and treatment of BMW. According to the survey, regarding segregation of waste, 92.57% and for treatment of waste, 96.29% staff showed willingness for re-training at regular intervals. Among surveyed staff, 189 (50.13%), 137 (36.33%), and 51 (13.54%) staff recommended monthly, half-yearly and yearly training frequencies, respectively. A similar study conducted by Sarotra P et al also emphasized regular and more frequent

training of staff to strengthen management of BMW at the institution level.¹⁷

Similarly study by Verma et al recommends regular induction training, written policies and motivational strategies as essential steps to improve BMW handling in small-scale healthcare organizations.¹⁸

Fixed interval training sessions, one-to-one discussion with the identified non-complier and appropriate placement of waste bins and sharp containers were the common measures suggested by surveyed staff for improvement in handling of BMW, as shown in Figure 4. A couple of doctors also suggested providing administrative orders/letters, monetary rewards, other incentives and monthly announcements of location-specific BMW handling champions as an additional measure to improve its effective management.

This study highlights the knowledge gap along with attributable factors towards efficient management of BMW among various categories of HCWs, including administrative staff. It outlines the hospital location-specific concerns in the management of BMW. This approach will help in developing a comprehensive work plan for effective handling of BMW among various healthcare categories. Administrative support in framing policies, uninterrupted supply of required resources and positive reinforcement steps act as a backbone in sustaining good practices in handling hospital BMW. Training of the staff and role modeling by senior officials towards proper handling of BMW will ensure compliance and enhance accountability towards effective segregation of BMW at all levels.

Limitations

This study was limited to two tertiary oncology centers in Varanasi, which may affect the generalizability of findings to other regions or healthcare settings. The cross-sectional design captures only a single point in time, without assessing changes over time. Data collection relied on self-reported responses, which may be influenced by social desirability bias. Convenience sampling could have introduced selection bias. Additionally, the study lacked direct observation of BMW practices, limiting validation of reported behavior. Differences in literacy levels among participants may have impacted response accuracy, and the absence of pre- and post-training evaluation restricts conclusions about the effectiveness of the training provided.

CONCLUSION

This study highlights important gaps in BMW management practices among healthcare workers in tertiary oncology centers, despite a generally high level of awareness regarding waste segregation. Deficiencies in knowledge about BMW treatment and disposal, combined with excessive workload, hurried work practices and

careless handling, contribute significantly to improper waste segregation and increased occupational hazards such as needle stick injuries. Nurses, housekeeping staff, and technical personnel were identified as the most vulnerable groups affected by unsafe sharps disposal practices.

The findings emphasize that effective BMW management requires more than regulatory compliance; it demands continuous education, institutional accountability, adequate infrastructure and sustained administrative support. Regular retraining programs, practical demonstrations, supervision and behavior-oriented interventions are essential to improve adherence to BMW protocols. Incorporation of BMW management principles into foundational medical, nursing and paramedical education may further strengthen long-term awareness and responsibility among healthcare professionals.

An integrated approach involving healthcare workers, hospital administration, and BMW management committees is crucial for ensuring safe segregation, handling, transportation and disposal of biomedical waste. Strengthening these systems will not only reduce occupational risks and environmental contamination but also enhance overall infection prevention and public health safety within healthcare institutions.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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