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## Frontline defenders: Assessing healthcare workers' awareness in handling biomedical and COVID-19 waste

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### Abstract

**Background:** Appropriate handling of biomedical waste (BMW) is important for maintaining safe healthcare practices. The COVID-19 pandemic laid bare the gaps, as there was a clear increase in the generation of infectious waste. This felt the need for enhancing healthcare workers' knowledge of appropriate waste handling practices.

**Methods:** A quasi-experimental study was conducted among 50 healthcare workers at a tertiary care hospital. Participants were required to complete a structured questionnaire prior to and post the intervention to determine their level of knowledge. Training was through lectures, presentations, and role-plays. Retention of knowledge was measured immediately after training.

**Results:** Preliminary results indicated significant gaps, particularly in segregation and disposal practices of waste. Following the educational intervention, knowledge scores were found to average an increase of approximately 27.8%. Individuals with greater educational attainment and greater professional experience were found to retain information.

**Conclusion:** Systematic training programs significantly raise awareness and practices regarding biomedical waste management. On-going, practical training is required to safeguard healthcare workers, patients, and the environment, particularly in the case of health emergencies.

**Keywords:** Health risk, mobile phone, knowledge, students

### 1. Introduction

**Let the wastes of the sick not contaminate the lives of the healthy"**

**-K Park**

A hospital provides medical care to the injured and sick and produces harmful waste. Hospital waste, as defined by the World Health Organization (WHO), is any product of healthcare activity, such as used syringes, body parts, chemicals, and drugs. It is important that proper waste management is provided in order to avoid health and environmental hazards.

Biomedical waste is generated by diagnostics, treatment, and research and must be disposed of in a proper manner to protect the environment and public health, especially for sanitation workers. The hazardous waste is approximately 10-15% biomedical waste, and the remaining is nonhazardous. Hazardous waste is disposed of in an improper manner by open incineration, which emits toxic gases and pollutes the environment. Exposed individuals are susceptible to diseases such as HIV, Hepatitis B, Hepatitis C, cholera, tuberculosis, and parasitic infections.

Research indicates knowledge deficiencies among medical workers in managing biomedical waste. In Parida *et al.* [1] research conducted in Safdarjung Hospital, 68% recognized the need for segregation of infectious waste and 82% recognized color codes for segregation. However, Bhagawati *et al.* [2] indicated that even though 68% recognized the need for segregation, 32% failed to distinguish between infectious and non-infectious waste. Furthermore, only 41% of the housekeeping personnel correctly recognized color codes. The above findings indicate the imperative of training and knowledge programs in order to enhance the competency of health workers in the management of biomedical waste and mitigation of health hazards and pollution in the environment.

Divya Rao, MR. Dhakshaini, Ameet Kurthukoti, and Vidya G. Doddawad wrote an article in 2018 [3] on the knowledge, attitude, and practices of 2056 health workers in a teaching hospital in Karnataka. More than 50% of them had knowledge deficits.

Health workers stay with the patients in the ward, hence their exposure and susceptibility to the hazards of the hospital setup mainly due to biomedical waste. They should thus be adequately equipped with the latest information and knowledge in the management of this waste that will further reduce infection rates and will provide protection to their health and health of other hospital staff.

Researchers felt that awareness through structured teaching programs is effective way healthcare workers regarding biomedical waste management, including the disposal of covid-19 infectious waste, in a tertiary care hospital to equip them with knowledge on biomedical waste management which will help them to work effectively in their clinical settings. A review conducted by Sharma *et al.* [4] emphasizes the necessity of biomedical waste management to improve public and environmental health. Biomedical waste is a health concern, posing threats to society, healthcare professionals, and the environment. Its management needs to be brought to limelight to ensure a safe future.

## 2. Materials and Methods

A quasi-experimental study which involves one group pre-test and post-test design was conducted at a tertiary care hospital in the Northern Sector, with the aim of evaluating the effectiveness of a Structured Teaching Programme (STP) on biomedical waste management among healthcare workers.

**2.1 Study Design:** Quasi-experimental study with a one-group pre-test post-test design.

**2.2 Study Location:** A tertiary care hospital in Northern Sector of India.

**2.3 Study Duration:** March 17 and March 23, 2022.

**2.4 Sample Size:** A total of 50 healthcare workers, selected through a non-probability convenience sampling technique, participated in the study. The inclusion criteria involved healthcare personnel with five or more years of experience in biomedical waste management, and those on night shift or off duty during the data collection period were excluded.

**2.5 Sample Size Calculation:** Since the total population of healthcare workers involved in biomedical waste management was approximately 250, the finite population correction was applied:  $N=96/1+(95/250)=70$ .

**Thus, the corrected sample size was 70 participants**

However, considering the operational challenges and availability of participants, a final sample size of 50 participants was selected for the study. This sample size is acceptable for exploratory and educational intervention research aiming at initial assessments and improvement strategies.

## 2.6 Instrument Development and Data Collection

The structured knowledge questionnaire was the main data collection instrument, developed after a detailed literature review and expert opinion from subject matter specialists in biomedical waste management. The Structure Teaching Program (STP) was made in an endeavor to transfer knowledge on practices linked to biomedical waste management, with study materials made in line with the guidelines provided by the Central Pollution Control Board [13, 14], World Health Organization [11], and Ministry of Health and Family Welfare [15]. English and Hindi were used as the languages for instruction, in which instructional materials were employed for learning support.

## 2.7 Data Analysis

The information was analyzed using descriptive and inferential statistics. Sociodemographic data were arranged in terms of frequency distribution and percentages. Pre-test and post-test mean scores were determined, and paired t-tests were used to determine the statistical significance of the difference between knowledge scores prior to and following the intervention. A significance level of 0.05 was set as statistically significant.

## 2.8 Ethical Considerations

Ethical clearance for the study was granted by the hospital institution ethical committee. Written Informed consent was obtained from all the respondents after giving information about the purpose, nature of the study, and confidentiality of the data.

## 3. Results and Discussion

### 3A. Results

**Table 1:** Distribution based on socio-demographic variables, (N=50)

S. No	Variable	Category	Subjects (n)	Percentage (%)
1	Age	20–25 years	4	8%
		26–30 years	19	38%
		31–35 years	16	32%
		36–40 years	9	18%
		41–45 years	1	2%
		>45 years	1	2%
2	Marital Status	Married	39	78%
		Unmarried	11	22%
3	Educational Qualification	12th grade or less	32	64%
		High school graduate or GED	7	14%
		Some college/AA Degree/Technical training	0	0%
		College graduate (Bachelor's Degree)	11	22%
4	Professional Qualification	Postgraduate (Master's/Doctorate)	0	0%
		Class I	34	68%

		Class II	0	0%
		Class III	5	10%
		Housekeeping Staff	11	22%
5	Pay Scale	20K–25K	2	4%
		26K–30K	24	48%
		31K–35K	8	16%
		36K–40K	9	18%
		>40K	7	14%
6	Experience in Service	5–10 years	25	50%
		11–15 years	12	24%
		16–20 years	11	22%
		21–25 years	1	2%
		>25 years	1	2%

**Table 1, Summary of socio-demographic profile of samples**

**The study comprised 50 participants**

- **Age-wise distribution:** The majority 19 (38%) were from the 26-30 years age group, followed by 16 (32%) in the 31-35 years group. A smaller proportion 9 (18%) belonged to the 36-40 years group, and only 4 (8%) were in the 20-25 years age group, while 1 (2%) each were in the 41-45 years and > 45 years categories.
- **Marital status:** A majority 39 (78%) were married, while 11 (22%) were unmarried.
- **Educational qualification:** Most participants 32 (64%) had studied up to 12th grade or less, 7 (14%) were high school graduates or equivalent, and 11 (22%) were college graduates with a bachelor's degree.
- **Professional classification:** Showed that 34 (68%) participants belonged to Class I category, 5 (10%) to Class III, and 11 (22%) were employed as housekeeping staff.
- **Pay scale:** Nearly half 24 (48%) of the participants earned between ₹26,000-₹30,000, followed by 9 (18%) earning between ₹36,000 ₹40,000, 8 (16%) between ₹31,000-₹35,000, and 7 (14%) earning more than ₹40,000. Only 2 (4%) were in the ₹20,000-₹25,000 salary bracket.
- **Years of Service experience:** Half of the participants

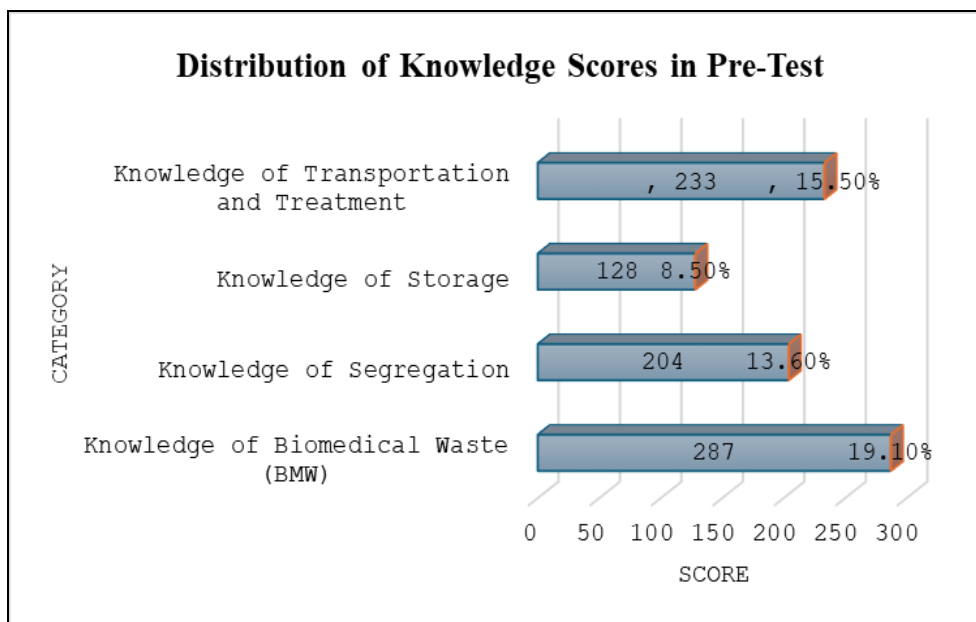
25 (50%) had 5-10 years of experience, 12 (24%) had 11-15 years, 11 (22%) had 16-20 years, and 1 (2%) each had 21-25 years and more than 25 years of service experience.

Thus, the majority of the study population were young adults, married, moderately educated, professionally classified under Class I, and had mid-level earnings and service experience.

**Table 2:** Distribution of knowledge scores in pre-test, (N=50)

Category	Total Marks Obtained	Percentage (%)
Knowledge of Biomedical Waste (BMW)	287	19.1%
Knowledge of Segregation	204	13.6%
Knowledge of Storage	128	8.5%
Knowledge of Transportation and Treatment	233	15.5%

Table 2 presents the distribution of knowledge scores in the pre-test. The highest score was in Knowledge of Biomedical Waste (BMW) at 19.1%, while the lowest was in Knowledge of Storage at 8.5%. Segregation and Transportation and Treatment scored 13.6% and 15.5%, respectively, indicating a general need for improvement in all areas.



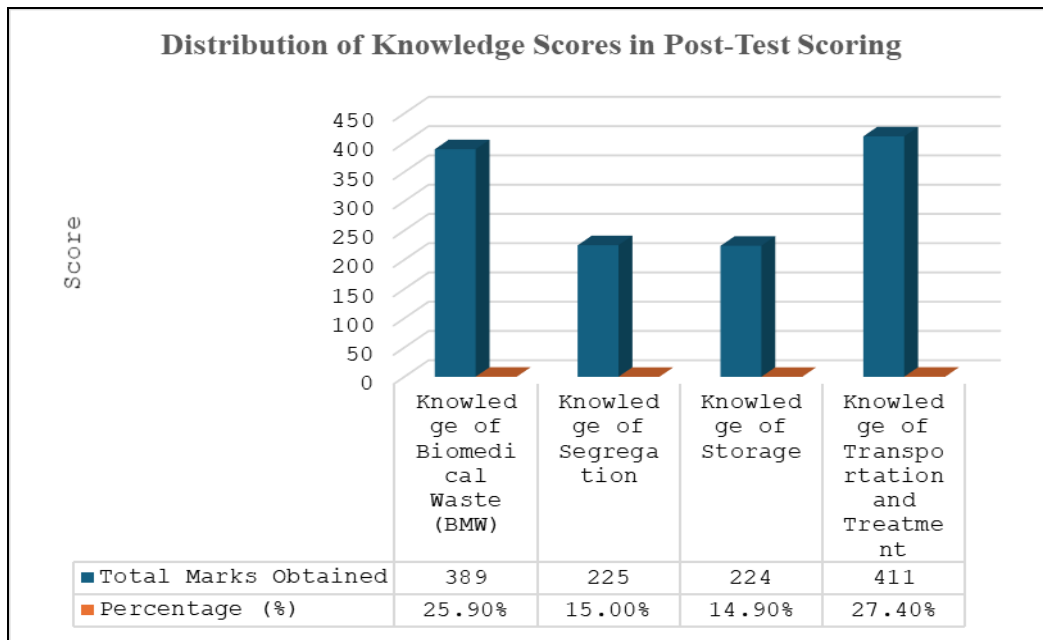
**Fig 1:** Distribution of knowledge scores in pre-test

The bar graph titled "Distribution of Knowledge Scores in Pre-Test" illustrates participants' knowledge across four categories of biomedical waste management. The highest score was in general knowledge of Biomedical Waste (BMW) at 287 (19.1%), followed by knowledge of Transportation and Treatment (233; 15.0%), Segregation (204; 13.6%), and the lowest in Storage (128; 8.5%).

Table 3, the post-test results show overall low knowledge among healthcare workers in biomedical waste management. Transportation and Treatment had the highest score at 27.4%, while Segregation (15.0%) and Storage (14.9%) scored the lowest. BMW knowledge scored 25.9%, indicating the need for further training in all areas.

**Table 3:** Distribution of knowledge scores in post-test scoring, (N=50)

Category	Total Marks Obtained	Percentage (%)
Knowledge of Biomedical Waste (BMW)	389	25.9%
Knowledge of Segregation	225	15.0%
Knowledge of Storage	224	14.9%
Knowledge of Transportation and Treatment	411	27.4%



**Fig 3:** Distribution of knowledge scores in post-test scoring

The bar graph titled "Distribution of Knowledge Scores in Post-Test Scoring" presents the post-intervention knowledge levels across four categories of biomedical waste management. The highest score was in *Transportation and Treatment* (411; 27.4%), followed closely by *Biomedical Waste (BMW)* knowledge (389; 25.9%). *Segregation* and

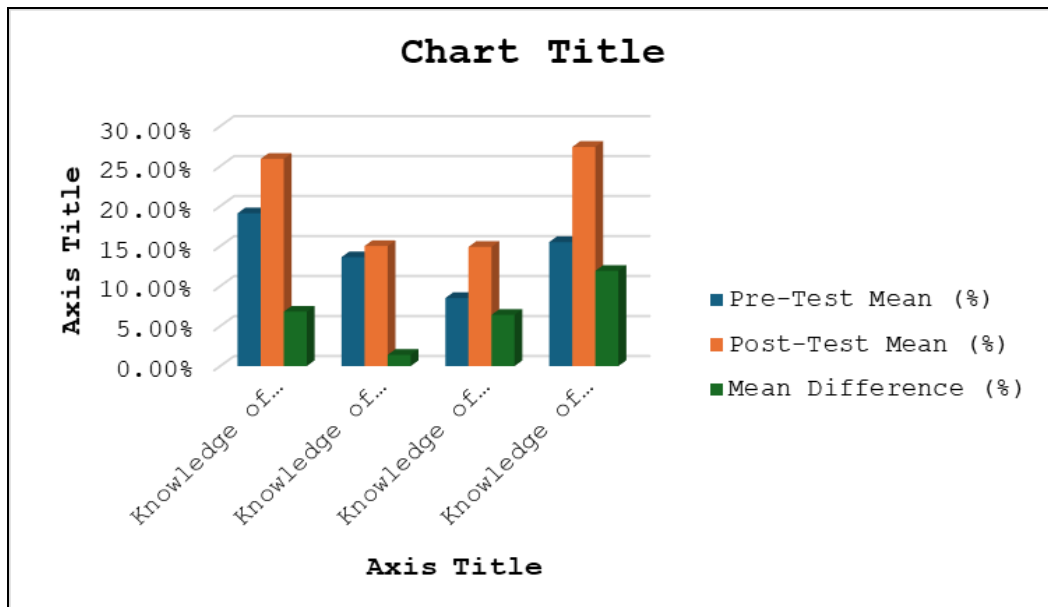
*Storage* scored 225 (15.0%) and 224 (14.9%) respectively. These results indicate a marked improvement in knowledge, particularly in operational areas like transportation, treatment, and general BMW awareness after the educational intervention.

**Table 4:** Comparison of pre-test and post-test scores, (N=50)

Category	Pre-Test Mean (%)	Post-Test Mean (%)	Mean Difference (%)	T-Value	P-Value	Inference
Knowledge of Biomedical Waste (BMW)	19.1%	25.9%	6.8%	3.08	0.033	Significant improvement
Knowledge of Segregation	13.6%	15.0%	1.4%			
Knowledge of Storage	8.5%	14.9%	6.4%			
Knowledge of Transportation & Treatment	15.5%	27.4%	11.9%			

Table 4 shows the comparison of pre-test and post-test mean scores for four categories. The mean differences between pre-test and post-test scores range from 1.4% to 11.9%, indicating improvements. The t-value is consistently 3.08 across all categories, with a p-value of 0.033, suggesting significant improvement in all areas since the p-value is below the 0.05 threshold. The clustered bar chart compares the Pre-Test Mean (%), Post-Test Mean (%), and Mean Difference (%) across four knowledge domains related to

biomedical waste management. Although the axis and category titles are truncated or missing, it is evident that post-test scores (orange bars) are consistently higher than pre-test scores (blue bars), indicating improved knowledge. The green bars represent the mean difference between post- and pre-test percentages, with the greatest improvement observed in the first and fourth categories. Overall, the chart illustrates a positive impact of the intervention on participants' knowledge across all assessed domains.



**Fig 4:** Comparison of pre-test and post-test scores

### 3B. Discussion

This research sought to evaluate the biomedical waste (BMW) management knowledge of healthcare workers based on different areas such as segregation, storage, transport, and treatment. The results obtained were contrasted with literature to know trends and knowledge gaps regarding BMW management among medical professionals.

#### Knowledge of Biomedical Waste Management (BMW)

In this research, post-test scores for knowledge of biomedical waste management (BMW) also improved from 287 marks (19.1%) in the pre-test to 389 marks (25.9%) in the post-test. This result is consistent with results obtained by Rao *et al.* [3], who proved that structured teaching interventions contributed positively toward improving healthcare workers' knowledge and practices on BMW management in a tertiary care hospital. Moreover, Singh *et al.* [5] cited that raising awareness on BMW within hospitals would minimize risk associated with unsafe disposal of harmful waste.

#### Understanding Segregation and Storage

On segregation and storage, it was observed through the study that scores on segregation significantly improved (from 204 to 225) and those on storage significantly improved (from 128 to 224). This trend was based on the findings of Chand *et al.* [6], where it was underscored that standardized education programs were able to immensely enhance the knowledge of healthcare workers regarding segregation and storage practices safely. Nagaraju *et al.* [7] also supported such findings by pointing out that the structured teaching program resulted in enhanced knowledge regarding segregation and storage among healthcare professionals working in rural regions.

#### Knowledge of Transportation and Treatment

The post-test scores of the study in the knowledge of transportation and treatment were the most (411 marks or 27.4%), indicating a substantial improvement from the pre-test (233 marks or 15.5%). The improvement is in line with research by Ojah and Sharma [4], which revealed that

following educational interventions, the awareness of healthcare workers regarding the importance of safe transportation and treatment of BMW significantly improved. Further, the Bio-Medical Waste (Management and Handling) Rules, 1998 [8], put a greater value on safe transport of biomedical waste to check infections from being disseminated.

#### Comparison with Other Studies

Findings in the current study conform to what has been presented by other research concerning BMW management. Singh, S *et al.* [9] found notable advancements among healthcare workers regarding BMW management after educational intervention within a teaching hospital. Likewise, Basavaraj *et al.* [10] proved that training programs had significantly improved healthcare workers' knowledge and practice levels, especially around safe waste handling during the COVID-19 pandemic. These results are also consistent with WHO recommendations emphasizing the essentiality of ongoing education to cover the BMW management knowledge gaps [11].

#### Limitations and Future Recommendations

While the study observed notable improvements in knowledge post-intervention, its generalizability is limited due to the small sample size (N=50). Future research should involve a larger sample and explore the long-term effects of structured educational programs. Additionally, continuous training and regular assessments should be incorporated into healthcare institutions to maintain and further improve healthcare workers' knowledge of BMW management.

In summary, the research showed there were marked increases in the knowledge of biomedical waste management among healthcare workers after having structured education interventions. This conforms to existing evidence, implying that such interventions can improve knowledge and practice on biomedical waste management. Nevertheless, continuing training and sporadic reinforcement remain critical to promoting long-term adherence and optimal waste management practices across healthcare facilities.



#### 4. Conclusion

The study achieved its goals, which involved determining healthcare workers' knowledge and practice regarding managing biomedical waste (BMW). The first goal was to assess the baseline knowledge of the healthcare workers, which was evaluated using a pre-test. Results indicated a vast knowledge gap, especially in the segregation, storage, transportation, and treatment of BMW. The second goal, which involved implementing a structured educational intervention, indicated a significant improvement in knowledge in all areas, with post-test scores reflecting a better understanding of BMW management. These results are consistent with earlier studies, for example, by Rao *et al.*<sup>[3]</sup>, Singh *et al.*<sup>[5]</sup>, and Ojah and Sharma<sup>[4]</sup>, who reported positive change after educational interventions.

The third objective was to assess the effectiveness of the teaching intervention in improving the knowledge level of BMW management. The findings showed a high level of improvement in post-test scores, especially in segregation and storage areas, thus confirming the effectiveness of the structured teaching program. This result supports the study of Chand *et al.*<sup>[6]</sup>, and Nagaraju *et al.*<sup>[7]</sup>, emphasizing the beneficial impacts of teaching programs in increasing knowledge among healthcare professionals.

Finally, the study aimed to analyse the impact of improved knowledge on healthcare practices. The results indicated that increased awareness would lead to better management practices, reducing the risk of inappropriate biomedical waste disposal and consequent health hazards. This study concurred with the results indicated by Singh, S *et al.*<sup>[8]</sup> and Basavaraj *et al.*<sup>[10]</sup>, who also noted improvement in healthcare practitioners' practices after educational interventions.

Therefore, the research achieved its aim by measuring the degree of knowledge and showing the efficacy of structured education in enhancing the understanding of BMW management among healthcare professionals. The long-term implications of such interventions and larger samples should be the focus of future research to solidify further the evidence base for continuing education in BMW management.

#### Conflict of Interest

Not available

#### Financial Support

Not available

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