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An Empirical Study on Employee Awareness and Training Status in Dehradun Hospitals about Effective Biomedical Waste Management

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Abstract

Background – Biomedical Waste (BMW) management is important for environment and infection control in hospitals in India, especially as per BMW Management Rules, 2016. This study investigates the efficiency of employee training programs on BMW management practices and the relationship between compliance and employee awareness among hospital staff in private tertiary care hospitals in Dehradun. There are gaps in waste segregation, safe disposal, and PPE usage, which require empirical investigation on the impacts of training.

Methodology – Stratified random sampling technique is used with a cross-sectional research design to target 250 employees (including lab technicians, nurses, doctors, and housekeeping staff). Sample size was calculated with Yamane's formula and yielded 250 responses. There are three variables assessed in 20-item questionnaire – Employee Awareness, Staff Training, and BMW Management Practices. Primary data was collected with Google Forms during staff meetings and through email to ensure ethical compliance and anonymity.

Results – With SPSS analysis, it is confirmed that Cronbach's alpha test achieved excellent reliability of instrument (α = 0.984). H1 is tested with linear regression, which has found staff training as a major predictor of BMW practices, suggesting 78.8% of variance. Each single point score of employee training increases 0.77-point predicted to improve BMW practices. Hence, H1 was accepted. In addition, Pearson's Correlation test was conducted using H2 and identified very strong and positive relationship between employee awareness and BMW management practices ($p<0.001$).

Conclusion – Structured awareness initiatives and training programs are found to be important interventions to comply with BMW Rules. It enables hospital management with evidence-based training for improved injury prevention, waste segregation, and success of regulatory audits in facilities in Dehradun.

Keywords – biomedical waste management, BMW, private hospitals, employee awareness, staff training, BMW management practices

1. Introduction

Initially, Biomedical Waste Management (BMW) was first introduced in 1998 in India and have been revised constantly, with the recent amendment took place in 2016. Still around half of tertiary care hospitals in India have lack of proper BMW management system. Every year, medical waste causes over 5.2 million deaths because of diseases (Datta et al, 2018; Rahman et al, 2020). Injuries caused by waste syringes and needles cause harmful illnesses like Hepatitis B and C, and HIV. Along with contaminating the ground water, improper disposal of waste also contaminates the environment. One of the most harmful effects of lack of adherence to BMW rules is development of antibiotic tolerance because of poor waste management (Abosse et al, 2024). There is a strong relationship between adherence to BMW management standards and proper knowledge. Still, the healthcare staff has lack of knowledge about waste management standards (Krishnan et al, 2015; Sharma et al, 2013). The guidelines require annual training sessions to be conducted for handling BMW as it is reported that proper training is very important to improve awareness and knowledge (Basarkar, 2014; Shafee et al, 2010).

1.1. Background

The term "Biomedical Waste" refers to the waste generated during immunization, treatment, or diagnosis of animals and humans or in the research related to or in testing/production of biological and it consists of categories discussed in Schedule I of BMW Rules, 1998 by the Govt of India (Ministry of Environment and Forests, 2000). A lot of infectious and harmful waste are produced worldwide in the course of several biomedical processes. India produces around 2 kg of waste per bed per day (Patil and Shekdar, 2001), which includes sharps (which could spread deadly diseases like hepatitis B/C and HIV, if not segregated well (Ananth et al, 2010); animal and human tissues (which can have pathogens); and recyclable and cytotoxic waste like unsoiled or soiled rubber and plastic items which would adversely affect environmental balance if not disposed well (Lakshmikantha, 2006; Misra and Pandey, 2005). Evaluation is an important and vital aspect of all systems as it is not easy to know the failure or success without it. One can understand the actual impact with investigation. Quality BMW management covers not just following the protocol properly at healthcare facility, but also disposal and recycling at terminal level (Pattnaik and Reddy, 2010). Success of later relies on initial processing at the point of generation in hospitals in the first place, which relies on the attitude, knowledge, and practices of several health workers working over there. India has established protocols to manage and handle biowaste. These rules require healthcare units to dispose biowaste and disinfect those wastes in a way that ensures the safety of the environment and healthcare staff (Misra and Pandey, 2005).

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1.2. Research Gap

Training of several healthcare experts related to BMW management is adopted in job orientation and curricula. Evidence from different parts of the country suggests that lacunae and knowledge in practices and attitudes are prevalent to a worrying extent among several healthcare experts (Verma et al, 2008; Kumar et al, 2009; Pandit et al, 2005; Hanumantha Rao, 2008). Being the matter of concern, a study was needed to determine their attitudes, practices, and knowledge related to biomedical wastes in India. This study will fill this gap by investigating the effectiveness of training programs and relation between awareness and improved outcomes.

1.3. Research Objectives

- To determine the effectiveness of employee training programs on biomedical waste management in Dehradun hospitals
- To investigate the relationship between employee awareness and improved biomedical waste management in hospitals in Dehradun

1.4. Hypotheses

H1 – There has been a significant impact of employee training programs on biomedical waste management in hospitals
H2 – There is a significant positive association between employee awareness and biomedical waste management in hospitals

2. Literature Review

Effective BMW reduces the risks posed to patients, healthcare workers, and the community while improving sustainability. With the rise in healthcare services, it is important to address challenges related to BMW management for better future. Sachan et al (2024) conducted a study to increase awareness about staff nurses on the recent advancements on BMW management and evaluate the efficiency of training session. They conducted a quasi-experimental study among 119 nurses and four sessions on 4 days back-to-back. They collected data on a structured questionnaire to determine knowledge of staff nurses related to BMW management. After collection of pre-intervention data, participants of the study were trained on management of BMW. Most of the participants had average knowledge about managing BMW. Drastic improvement was found in the knowledge after training. They discussed the problems during segregation of waste to find a solution reflected in staff nurses. It is found that adopting guidelines for proper training can be helpful to adhere with BMW regulations. Timely availability of consumables can help in practical use of knowledge for proper BMW management practices.

A lot of infectious and toxic waste are produced in hospitals worldwide in the course of several biomedical processes. India has protocols for managing and handling biomedical waste like the “BMW (Management and Handling) Amendment Rules, 2000.” For these rules, healthcare facilities are mandatory to dispose biomedical wastes and disinfect them in a way to protect the safety of health workers and the environment. Agarwal et al (2022) conducted an intervention study to know the gaps and levels in attitudes, knowledge, and practices for BMW management among several healthcare experts. The study was conducted with a pre-tested structured questionnaire distributed in “JAH Group of Hospitals, Gwalior”. An audio-visual presentation and planned teaching were prepared for biomedical waste management for assessment. Before training, the level of knowledge was 70% among senior doctors and 65% among junior doctors. After training, knowledge about BMW management was significantly improved among nursing and sanitary staff as well.

Training of health workers about several aspects of BMW handling and management rules can enhance safe removal of waste and protect the public and patients from hazards. Singh et al (2020) evaluated the existing studies related to rules for BMW management among selected health professionals and to determine the impact of training on BMW management on the practices and knowledge of health workers. When it comes to rules related to BMW management, the training program was started in April 2018 and trained total 250 participants. The data was analyzed with a structured questionnaire and mean pre- and post-test scores were compared using paired samples t-test. There are 56% males and 83% females aged 20 to 30 years in this study. Around 74% of participants were married and 74% from urban areas. The mean pre-test score was 14.00 and post-test score was 19.94 ($p<0.000$). On all aspects of BMW management, the structured training had statistically significant improvement in the knowledge.

BMW refers to the waste which is infective, contagious, and toxic and segregated from the health system. Without proper management of harmful waste, it can cause several health risks. Hence, housekeeping staff need to maintain cleanliness in hospitals and get rid of waste. Singhal et al (2023) determined the pre-test practice and knowledge of housekeeping staff related to BMW, assessed post-test knowledge and housekeeping staff practice related to BMW management, effectiveness of structured training program on practice and knowledge about BMW management among housekeeping team, correlation between practice and knowledge about BMW management among housekeeping team, and association between practice score and pre-test level of housekeeping staff and knowledge with their selected variable. They adopted a quantitative research approach with pre-experimental design to determine post-test and pre-test practice and knowledge of housekeeping staff related to BMW management. They took total 70 samples with convenience sampling and used self-structured checklist and questionnaire to determine practice and knowledge of housekeeping staff. There is a drastic difference among practice and knowledge after structured teaching program among housekeeping staff. There was significant improvement observed in practice and knowledge level about BMW management among housekeeping staff of Doon Medical College, Dehradun.

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Healthcare facilities are almost like double-edge sword. It fulfils healthcare needs of the people by providing promotive, preventive, or curative services. It also produces waste inevitably, which is also harmful for health if not managed well. It is vital to evaluate the right practices and understand them in biomedical waste management to improve BMW management and identify the gaps. Imchen et al (2017) conducted the study to determine the practice of BMW among healthcare staff at tertiary hospital. A cross-sectional study was conducted in a hospital among 314 healthcare staff, which includes 85 staff nurses, 36 lab technicians, and 193 doctors. A semi-structured questionnaire was used for data collection. Total 78% healthcare staff had got training on management of biomedical waste. Around 70.6% of staff nurses, 76.2% of doctors, and 72.2% of lab technicians had been vaccinated with hepatitis B. With multivariate linear regression, there was significant association observed between occupation status and waste segregation practices and training. Satisfactory practices have been revealed in the study among health staff. It also showed the relationship between training and waste segregation practices.

3. Methodology

3.1. Research Design

A cross-sectional quantitative research design was adopted in this study to determine the effectiveness of employee training on BMW management and relationship between BMW practices and employee awareness in hospitals in Dehradun. This study employs a correlational approach for hypothesis testing using Simple Linear Regression and Pearson's Correlation using SPSS software.

3.2. Study Population and Sampling

This study targets population of 500 employees (including nurses, doctors, lab technicians, and housekeeping) from private tertiary care hospitals in Dehradun registered with the "Uttarakhand Pollution Control Board". For this cross-sectional study, the sample size is calculated with the formula used for calculating sample size by Taro Yamane (1967), which is used for limited populations in survey. It makes it easy to determine sample size with margin of error (0.05), confidence level of 95% and known population (N).

$$n = \frac{N}{1 + N(e)^2}$$

Here,

- N: Population size (assumed to be 500 employees in hospitals)
- n: Sample size needed
- e: It refers to margin of error (0.05)

Here, conservative estimate of population is 800 participants from staff directories.
This way,

$$e^2 = (0.05)^2 = 0.0025$$
$$N(e)^2 = 800 \times 0.0025 = 2$$

Denominator is calculated to be 1 +2 = 3

$$\text{Hence, } n = \frac{500}{3} \approx 166.67$$

Accounting for up to 25% of non-response, target population would be 167 x 1.25 = 209. So, this study targets questionnaires to be distributed among 250 participants for robustness.

3.3. Data Collection Tool

A structured questionnaire was developed with 20 items, developed as per BMW Rules, 2016 to measure three variables - biomedical waste management in hospitals, employee training, and employee awareness. In addition, demographics enable control variables like gender, age, and experience.

3.4. Data Collection Process

Questionnaires were distributed through email across private tertiary care hospitals after recent BMW training sessions. After collection, data has been exported to Excel spreadsheet for SPSS analysis. Ethical clearance had been obtained from ethics committee or institutional review board, as per the ICMR guidelines.

3.5. Data Analysis

Demographics has been summarized with frequency analysis using SPSS software. In addition, inferential tests were conducted –

- Simple Linear Regression test was conducted to determine the impact of employee training programs on biomedical waste management in hospitals
- Pearson's correlation test was conducted on the association between employee awareness and biomedical waste management in hospitals

3.6. Reliability Testing

Reliability of questionnaire will be tested using Cronbach's Alpha test to determine the potential bias and consistency of responses. Alpha value above 0.7 is considered excellent for statistical testing.

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4. Data Analysis

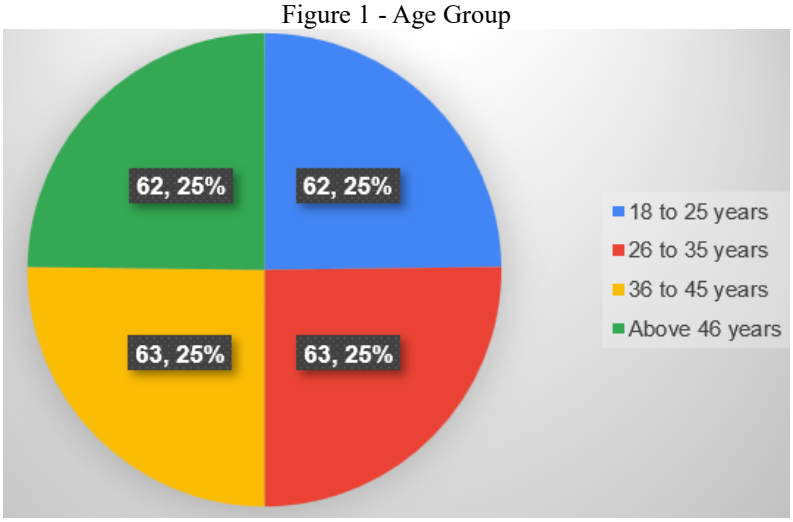
4.1. Demographics

In this study, 62 (25%) participants are aged 18 to 25 years, 63 (25%) participants are aged 26 to 35 years, 63 (25%) participants are aged 36 to 45 years, and 62 (25%) participants are aged above 46 years (Table 1) (Figure 1).

Table 1 - Age Group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18 to 25 years	62	24.8	24.8	24.8
	26 to 35 years	63	25.2	25.2	50.0
	36 to 45 years	63	25.2	25.2	75.2
	Above 46 years	62	24.8	24.8	100.0
	Total	250	100.0	100.0	

Figure 1 - Age Group

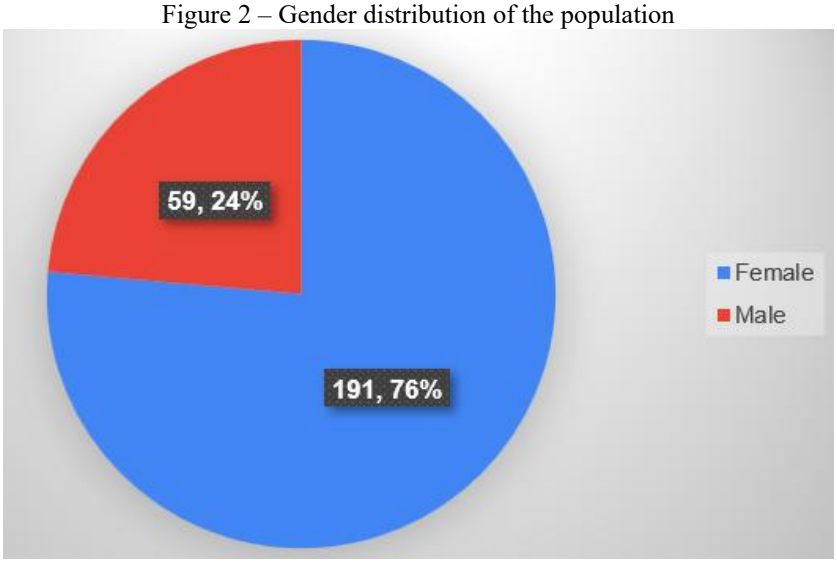


There are 191 (76%) participants who are female in this study and 59 (24%) participants are male in this study (Table 2) (Figure 2).

Table 2 - Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	191	76.4	76.4	76.4
	Male	59	23.6	23.6	100.0
	Total	250	100.0	100.0	

Figure 2 – Gender distribution of the population



When it comes to designation, there are 141 (56%) participants who are nurse, 84 (34%) participants are lab technicians, 12 (5%) participants are housekeeping staff, and 13 (5%) participants are doctors (Table 3) (Figure 3).

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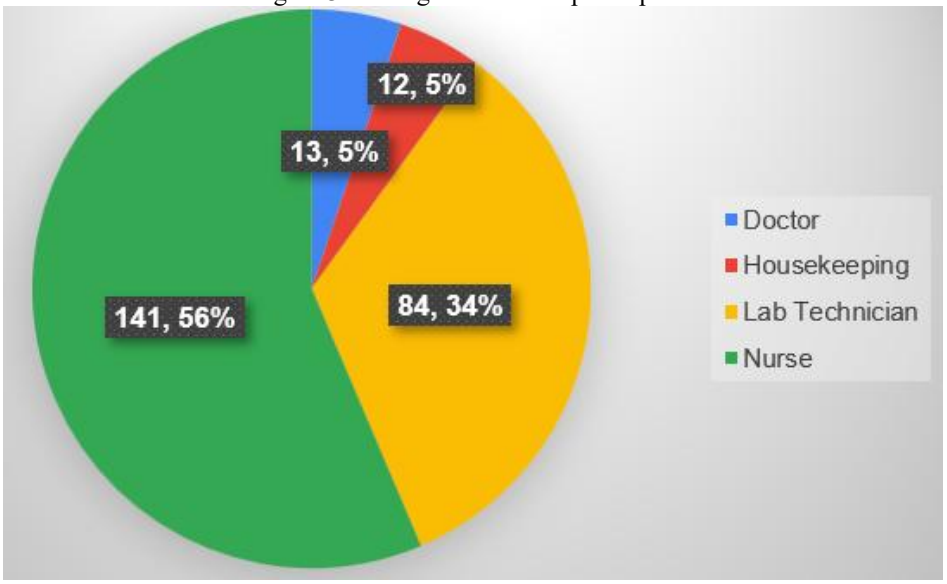
Table 3 – Designation of the participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Doctor	13	5.2	5.2	5.2
	Housekeeping	12	4.8	4.8	10.0
	Lab Technician	84	33.6	33.6	43.6
	Nurse	141	56.4	56.4	100.0
	Total	250	100.0	100.0	

Figure 3 – Designation of the participants

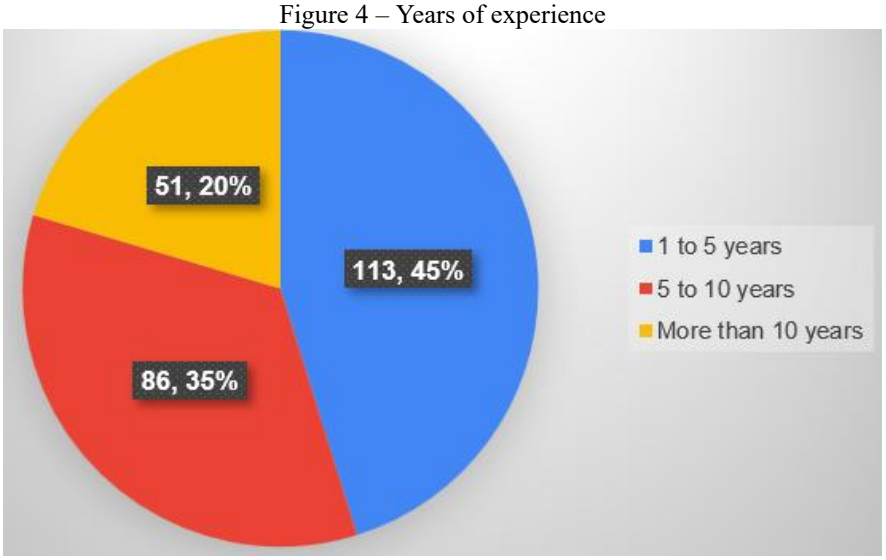


When it comes to years of experience, 113 (45%) participants have less than 5 years of experience, 86 (34%) participants have 5 to 10 years of experience, and 51 (20%) participants have more than 10 years of experience (Table 4) (Figure 4).

Table 4 - Years of Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 to 5 years	113	45.2	45.2	45.2
	5 to 10 years	86	34.4	34.4	79.6
	More than 10 years	51	20.4	20.4	100.0
	Total	250	100.0	100.0	

Figure 4 – Years of experience



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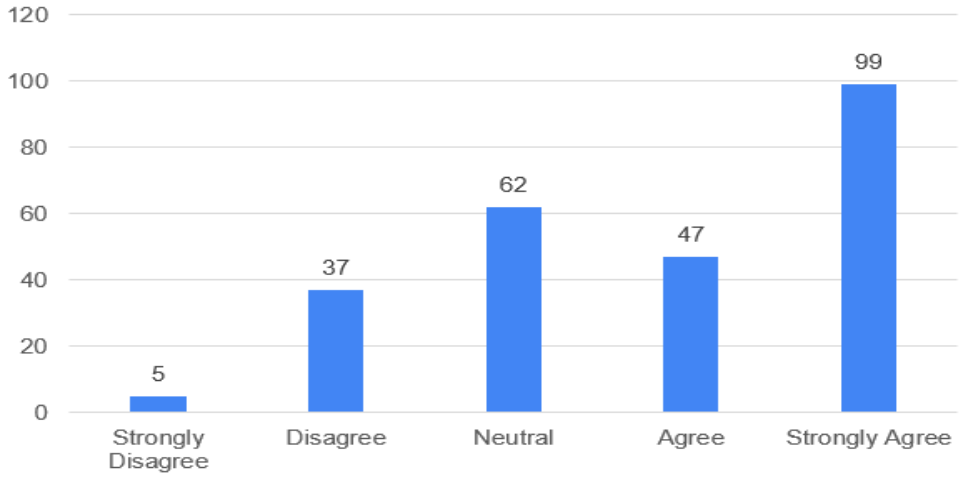
4.2. Staff Training

There are 47 (19%) participants who agree and 99 (40%) participants strongly agree that staff training covers proper segregation of waste (red/yellow/blue/black), while 62 (25%) participants were neutral, 37 (15%) participants disagree, and only 5 (2%) participants strongly disagree (Table 5) (Figure 5).

Table 5 - Staff training covers proper segregation of waste (red/yellow/blue/black)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	5	2.0	2.0	2.0
	Disagree	37	14.8	14.8	16.8
	Neutral	62	24.8	24.8	41.6
	Agree	47	18.8	18.8	60.4
	Strongly Agree	99	39.6	39.6	100.0
	Total	250	100.0	100.0	

Figure 5 – Staff training covers proper segregation of waste (red/yellow/blue/black)

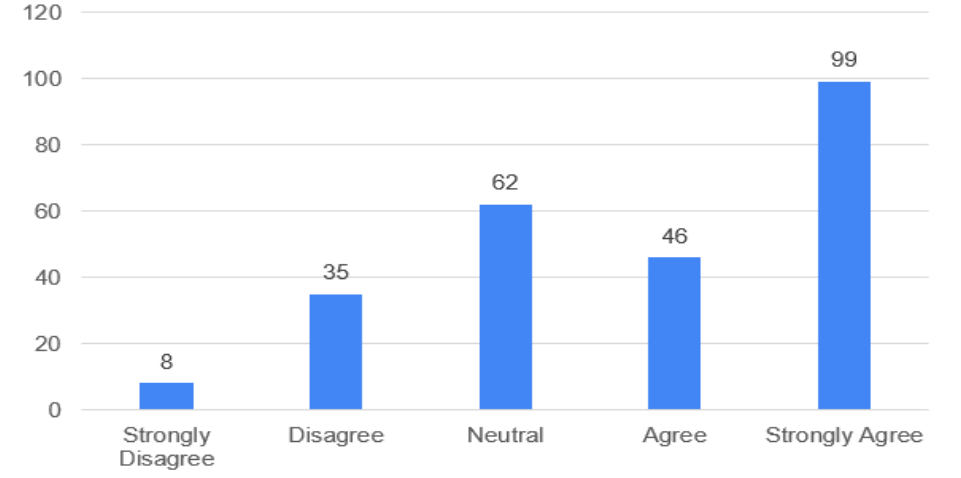


There are 99 (40%) participants who strongly agree and 46 (18%) participants agree that waste handling has been improved with practical training, while 62 (25%) participants were neutral, 35 (14%) participants disagree, and 8 (3%) participants strongly disagree (Table 6) (Figure 6).

Table 6 - Waste handling has been improved with practical training

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	8	3.2	3.2	3.2
	Disagree	35	14.0	14.0	17.2
	Neutral	62	24.8	24.8	42.0
	Agree	46	18.4	18.4	60.4
	Strongly Agree	99	39.6	39.6	100.0
	Total	250	100.0	100.0	

Figure 6 - Waste handling has been improved with practical training



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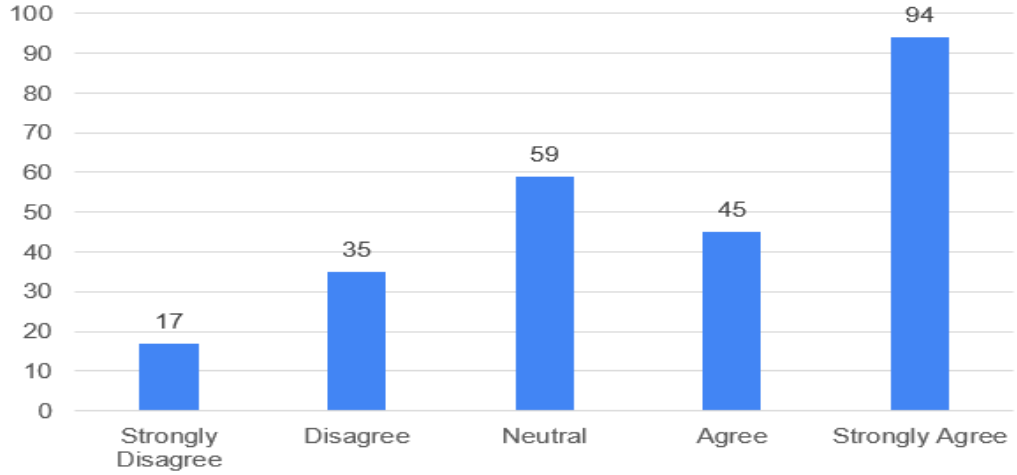
There are 45 (18%) participants who agree and 94 (38%) participants strongly agree that training has been provided every once in a while, while 59 (24%) participants were neutral, 35 (14%) participants disagree, and 17 (7%) participants strongly disagree (Table 7) (Figure 7).

Table 7 - Training has been provided every once in a while

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	17	6.8	6.8	6.8
	Disagree	35	14.0	14.0	20.8
	Neutral	59	23.6	23.6	44.4
	Agree	45	18.0	18.0	62.4
	Strongly Agree	94	37.6	37.6	100.0
	Total	250	100.0	100.0	

Figure 7 - Training has been provided every once in a while

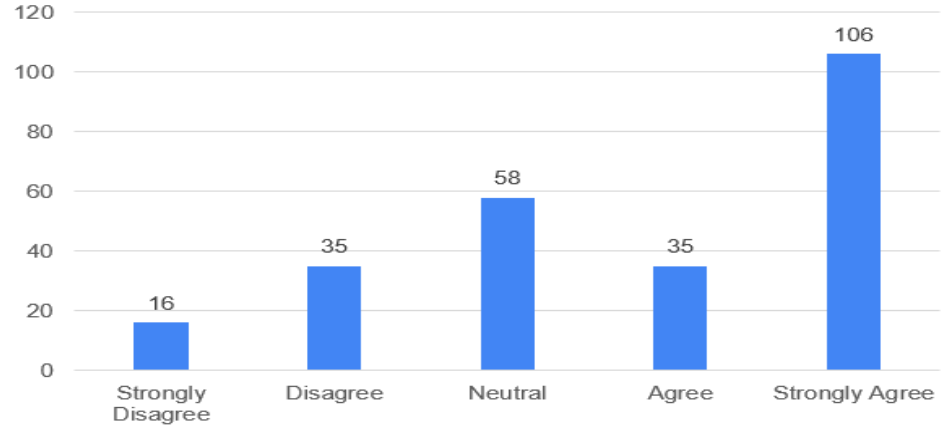


There are 35 (14%) participants who agree and 106 (42%) participants strongly agree that training has reduced the risk of injuries from sharps like needles, while 58 (23%) participants were neutral, 35 (14%) participants disagree, and 16 (6%) participants strongly disagree (Table 8) (Figure 8).

Table 8 - Training has reduced the risk of injuries from sharps like needles

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	16	6.4	6.4	6.4
	Disagree	35	14.0	14.0	20.4
	Neutral	58	23.2	23.2	43.6
	Agree	35	14.0	14.0	57.6
	Strongly Agree	106	42.4	42.4	100.0
	Total	250	100.0	100.0	

Figure 8 – Training has reduced the risk of injuries from sharps like needles



There are 36 (14%) participants who agree and 96 (38%) participants strongly agree that all BMW categories are easy to identify after training, while 72 (29%) participants were neutral, 35 (14%) participants disagree, and 11 (4%) participants strongly disagree (Table 9) (Figure 9).

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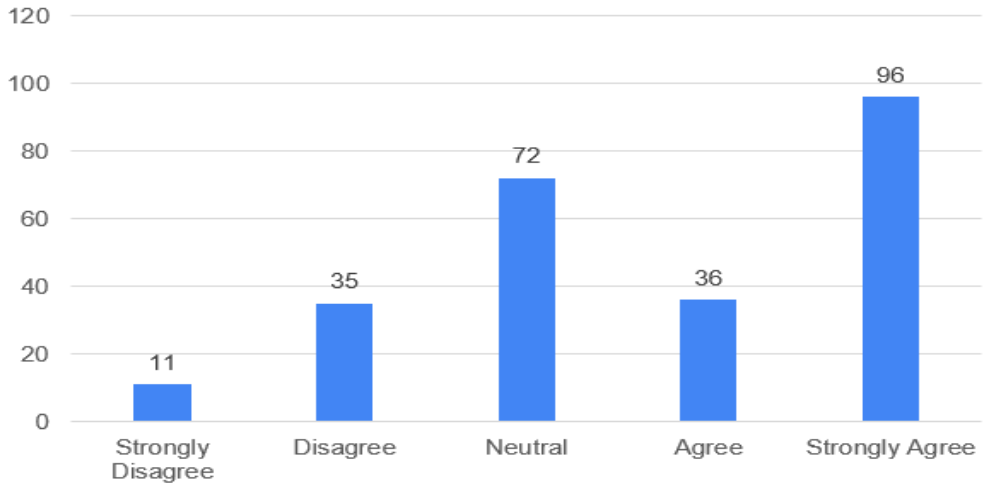
Table 9 - All BMW categories are easy to identify after training

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	11	4.4	4.4	4.4
	Disagree	35	14.0	14.0	18.4
	Neutral	72	28.8	28.8	47.2
	Agree	36	14.4	14.4	61.6
	Strongly Agree	96	38.4	38.4	100.0
	Total	250	100.0	100.0	

Figure 9 – All BMW categories are easy to identify after training

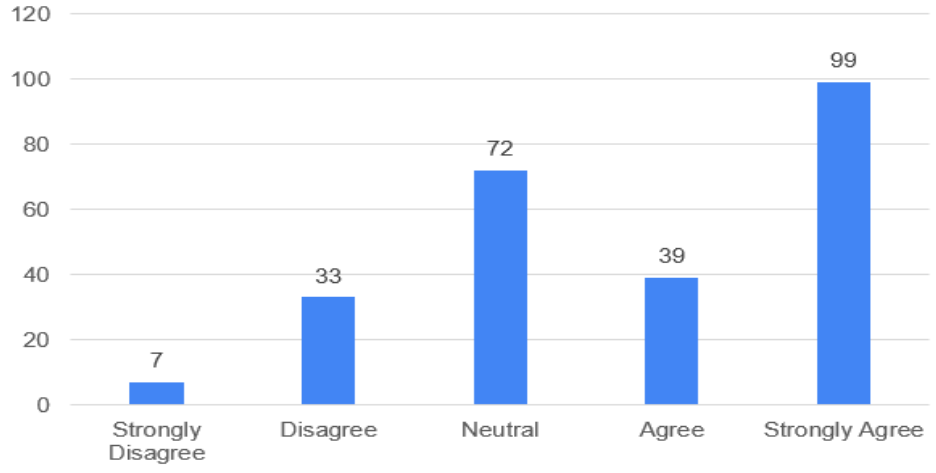


There are 39 (16%) participants who agree and 99 (40%) participants strongly agree that BMW safety has been improved by training, while 72 (29%) participants were neutral, 33 (13%) participants disagree, and 7 (3%) participants strongly disagree (Table 10) (Figure 10).

Table 10 - Overall, BMW safety has been improved by training

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	7	2.8	2.8	2.8
	Disagree	33	13.2	13.2	16.0
	Neutral	72	28.8	28.8	44.8
	Agree	39	15.6	15.6	60.4
	Strongly Agree	99	39.6	39.6	100.0
	Total	250	100.0	100.0	

Figure 10 - Overall, BMW safety has been improved by training



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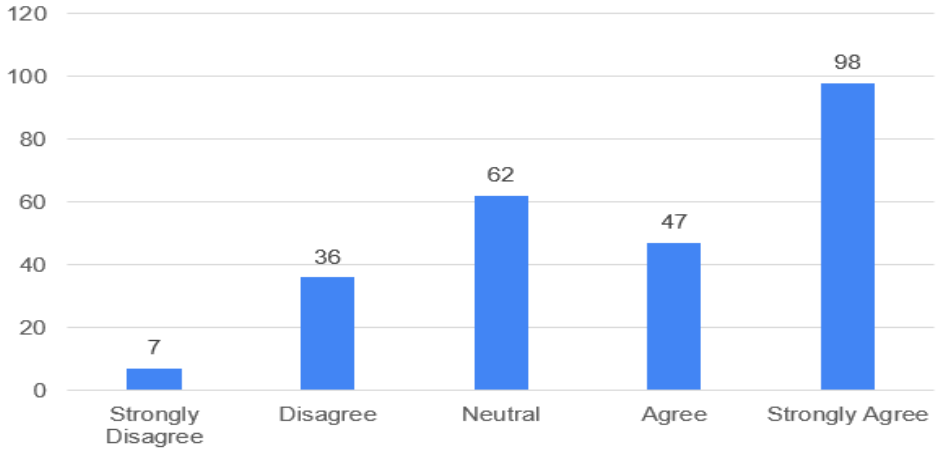
4.3. Employee Awareness

There are 47 (19%) participants who agree and 98 (39%) participants strongly agree they understand different types of BMW like sharps, infectious, and cytotoxic, while 62 (25%) participants were neutral, 36 (14%) participants disagree, and 7 (3%) participants strongly disagree (Table 11) (Figure 11).

Table 11 - I understand different types of BMW like sharps, infectious, and cytotoxic

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	7	2.8	2.8	2.8
	Disagree	36	14.4	14.4	17.2
	Neutral	62	24.8	24.8	42.0
	Agree	47	18.8	18.8	60.8
	Strongly Agree	98	39.2	39.2	100.0
	Total	250	100.0	100.0	

Figure 11 - I understand different types of BMW like sharps, infectious, and cytotoxic

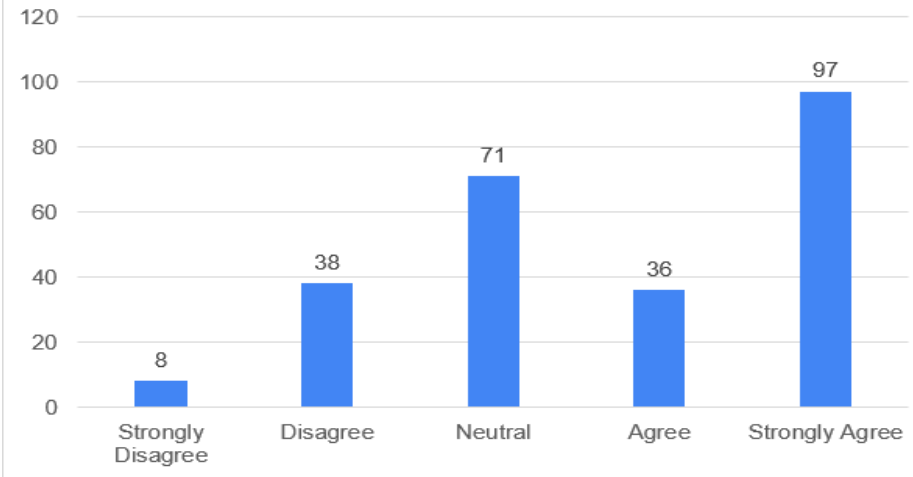


There are 36 (14%) participants who agree and 97 (39%) participants strongly agree barcoding/tracking is mandatory as per BMW Rules 2016, while 71 (28%) participants were neutral, 38 (15%) participants disagree, and 8 (3%) participants strongly disagree (Table 12) (Figure 12).

Table 12 - Barcoding/tracking is mandatory as per BMW Rules 2016

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	8	3.2	3.2	3.2
	Disagree	38	15.2	15.2	18.4
	Neutral	71	28.4	28.4	46.8
	Agree	36	14.4	14.4	61.2
	Strongly Agree	97	38.8	38.8	100.0
	Total	250	100.0	100.0	

Figure 12 - Barcoding/tracking is mandatory as per BMW Rules 2016



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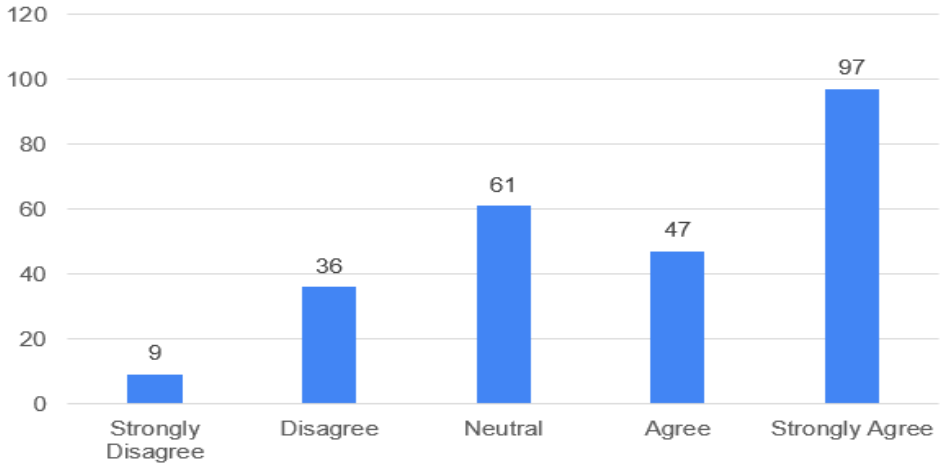
There are 47 (19%) participants who agree and 97 (39%) participants strongly agree that Hep B/HIV transmission risk is increased by improper BMW management, while 61 (24%) participants were neutral, 36 (14%) participants disagree, and 9 (4%) participants strongly disagree (Table 13) (Figure 13).

Table 13 - Hep B/HIV transmission risk is increased by improper BMW management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	9	3.6	3.6	3.6
	Disagree	36	14.4	14.4	18.0
	Neutral	61	24.4	24.4	42.4
	Agree	47	18.8	18.8	61.2
	Strongly Agree	97	38.8	38.8	100.0
	Total	250	100.0	100.0	

Figure 13 - Hep B/HIV transmission risk is increased by improper BMW management

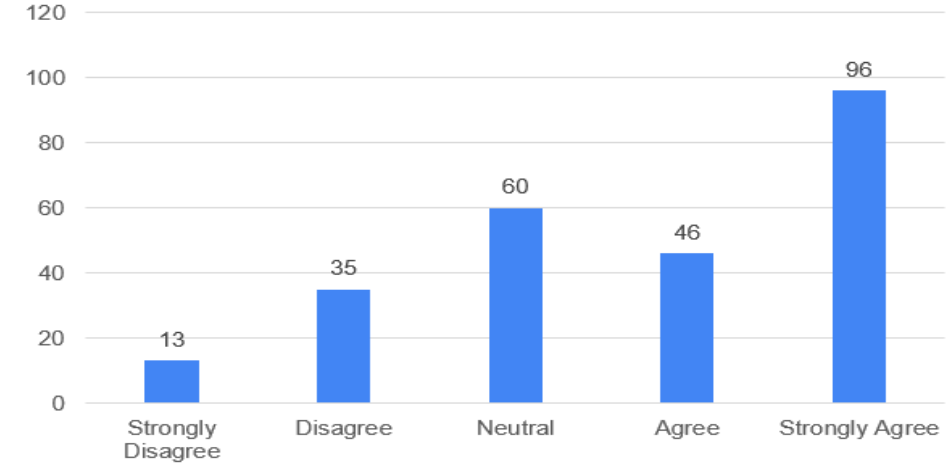


There are 46 (18%) participants who agree and 96 (38%) participants strongly agree that they clearly understand the guidelines by Dehradun Pollution Control Board, while 60 (24%) participants were neutral, 35 (14%) participants disagree, and 13 (5%) participants strongly disagree (Table 14) (Figure 14).

Table 14 - I clearly understand the guidelines by Dehradun Pollution Control Board

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	13	5.2	5.2	5.2
	Disagree	35	14.0	14.0	19.2
	Neutral	60	24.0	24.0	43.2
	Agree	46	18.4	18.4	61.6
	Strongly Agree	96	38.4	38.4	100.0
	Total	250	100.0	100.0	

Figure 14 – I clearly understand the guidelines by Dehradun Pollution Control Board



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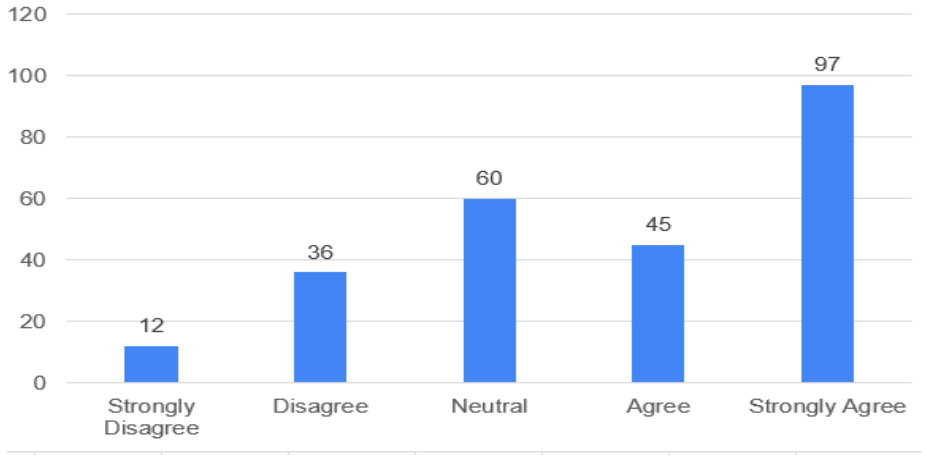
There are 45 (18%) participants who agree and 97 (39%) participants strongly agree that their team is properly aware of 4-color bin system, while 60 (24%) participants were neutral, 36 (14%) participants disagree, and 12 (5%) participants strongly disagree (Table 15) (Figure 15).

Table 15 - My team is properly aware of 4-color bin system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	12	4.8	4.8	4.8
	Disagree	36	14.4	14.4	19.2
	Neutral	60	24.0	24.0	43.2
	Agree	45	18.0	18.0	61.2
	Strongly Agree	97	38.8	38.8	100.0
	Total	250	100.0	100.0	

Figure 15 - My team is properly aware of 4-color bin system



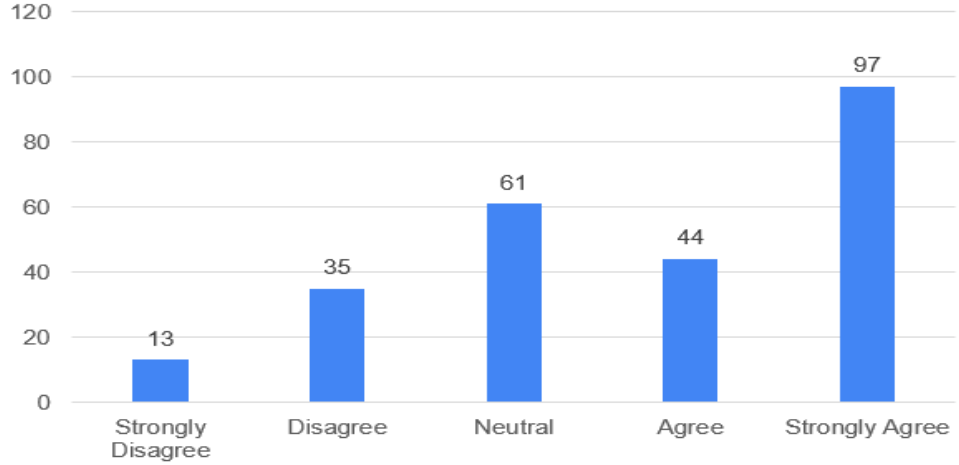
4.4. BMW Management in Hospitals

There are 44 (18%) participants who agree and 97 (39%) participants strongly agree that they segregate waste directly at the source without mixing every day, while 61 (24%) participants were neutral, 35 (14%) participants disagree, and 13 (5%) participants strongly disagree (Table 16) (Figure 16).

Table 16 - I segregate waste directly at the source without mixing every day

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	13	5.2	5.2	5.2
	Disagree	35	14.0	14.0	19.2
	Neutral	61	24.4	24.4	43.6
	Agree	44	17.6	17.6	61.2
	Strongly Agree	97	38.8	38.8	100.0
	Total	250	100.0	100.0	

Figure 16 - I segregate waste directly at the source without mixing every day



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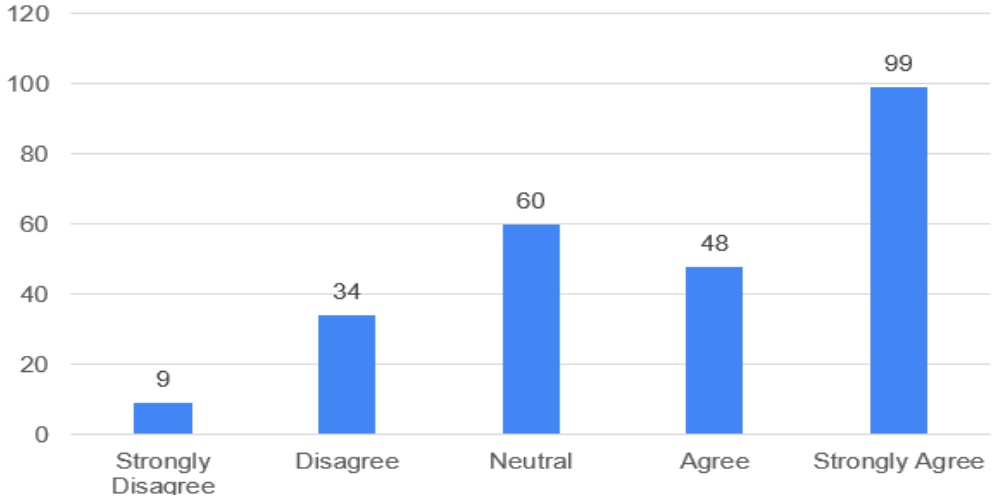
There are 48 (19%) participants who agree and 99 (40%) participants strongly agree that there has been a consistent use of PPE kits after training, while 60 (24%) participants were neutral, 34 (14%) participants disagree, and 9 (4%) participants strongly disagree (Table 17) (Figure 17).

Table 17 - There has been a consistent use of PPE kits after training

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	9	3.6	3.6	3.6
	Disagree	34	13.6	13.6	17.2
	Neutral	60	24.0	24.0	41.2
	Agree	48	19.2	19.2	60.4
	Strongly Agree	99	39.6	39.6	100.0
	Total	250	100.0	100.0	

Figure 17 - There has been a consistent use of PPE kits after training

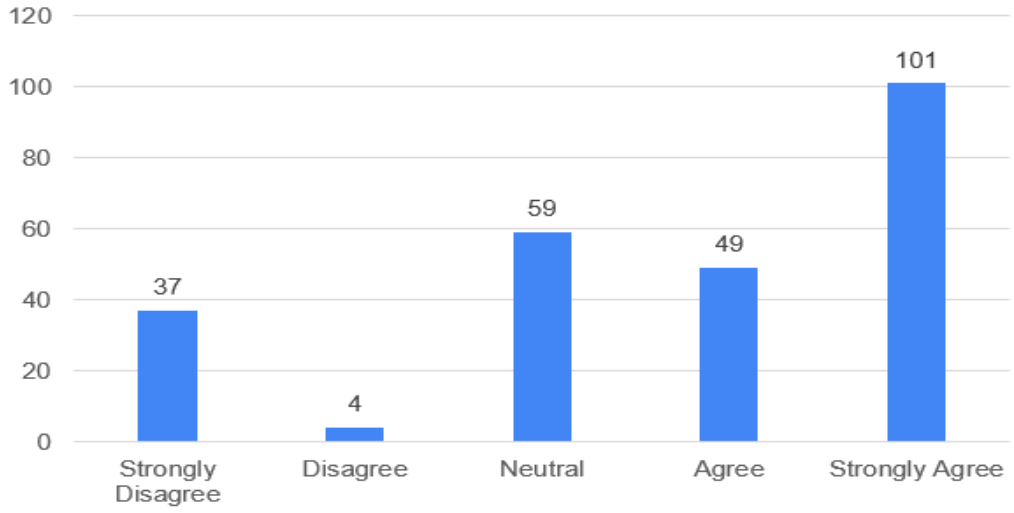


There are 49 (20%) participants who agree and 101 (40%) participants strongly agree that daily BMW practices have been improved with training, while 59 (24%) participants were neutral, 4 (2%) participants disagree, and 37 (15%) participants strongly disagree (Table 18) (Figure 18).

Table 18 - Daily BMW practices have been improved with training

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	37	14.8	14.8	14.8
	Disagree	4	1.6	1.6	16.4
	Neutral	59	23.6	23.6	40.0
	Agree	49	19.6	19.6	59.6
	Strongly Agree	101	40.4	40.4	100.0
	Total	250	100.0	100.0	

Figure 18 - Daily BMW practices have been improved with training



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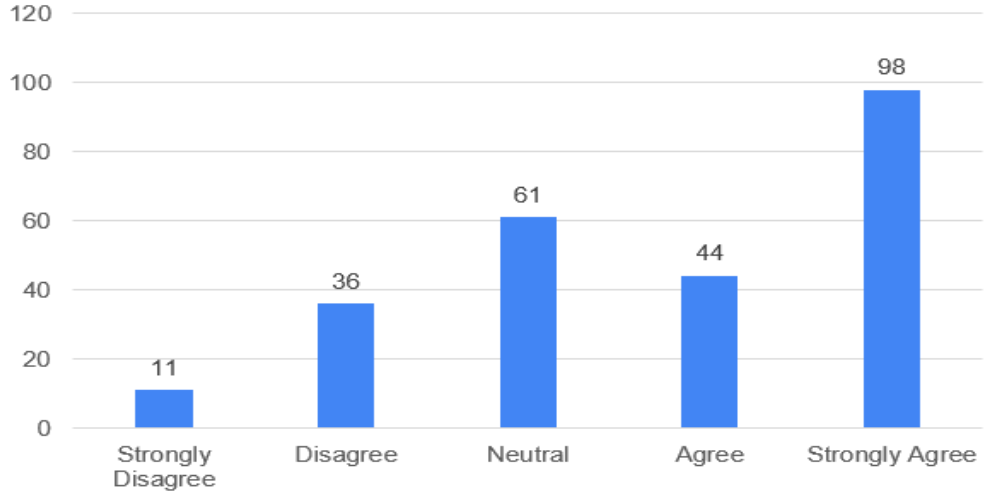
There are 44 (18%) participants who agree and 98 (39%) participants strongly agree that compliance has been improved with awareness levels, while 61 (24%) participants were neutral, 36 (14%) participants disagree, and 11 (4%) participants strongly disagree (Table 19) (Figure 19).

Table 19 - Compliance has been improved with awareness levels

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	11	4.4	4.4	4.4
	Disagree	36	14.4	14.4	18.8
	Neutral	61	24.4	24.4	43.2
	Agree	44	17.6	17.6	60.8
	Strongly Agree	98	39.2	39.2	100.0
	Total	250	100.0	100.0	

Figure 19 - Compliance has been improved with awareness levels

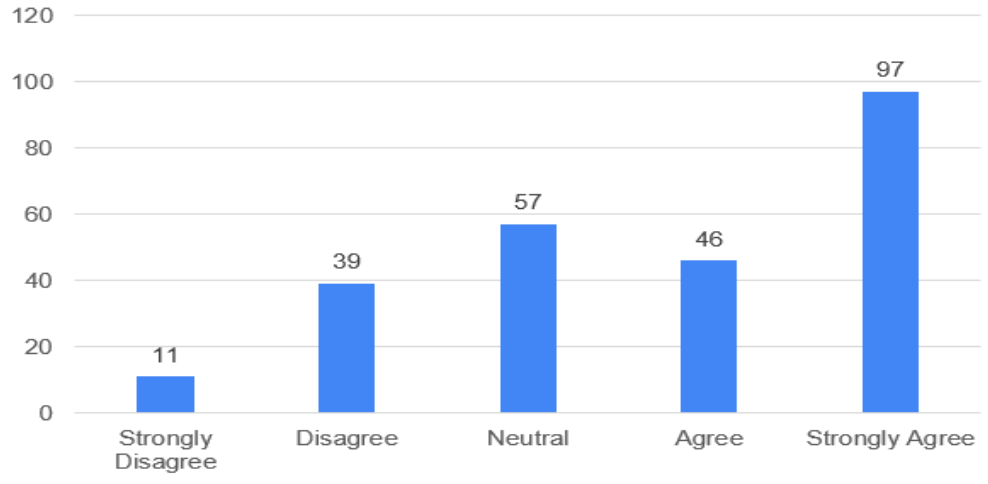


There are 46 (18%) participants who agree and 97 (39%) participants strongly agree that their practices meet standards in hospitals followed in Dehradun, while 57 (23%) participants were neutral, 39 (16%) participants disagree, and 11 (4%) participants strongly disagree (Table 20) (Figure 20).

Table 20 - My practices meet standards in hospitals followed in Dehradun

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	11	4.4	4.4	4.4
	Disagree	39	15.6	15.6	20.0
	Neutral	57	22.8	22.8	42.8
	Agree	46	18.4	18.4	61.2
	Strongly Agree	97	38.8	38.8	100.0
	Total	250	100.0	100.0	

Figure 20 – My practices meet standards in hospitals followed in Dehradun



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4.5. Hypotheses Testing

Before hypothesis testing, Cronbach's Alpha test was done using SPSS software. The questionnaire achieves excellent internal consistency with alpha value of 0.984, exceeding the threshold of 0.7 for reliability of research. It confirms robust scores for all three variables – Staff Training, BMW management practices, and Staff awareness, supporting valid hypothesis testing with correlation and regression tests (Table 21).

Table 21 - Reliability Statistics

Cronbach's Alpha	N of Items
.984	16

H1 – There has been a significant impact of employee training programs on biomedical waste management in hospitals

For testing H1, Simple Linear Regression test was conducted. In Table 22, the Model Summary presents the overall fit for the model of linear regression to predict BMW practices with staff training. The R value of 0.888 in multiple correlation coefficient suggests very strong and positive linear relationship between BMW practices and staff training. There is 78.8% of variance (with R-square value of 0.788) in BMW practices, which represents significant predictive power. The adjusted R-square is almost similar (i.e., 0.787), confirming stability of the model around 250 participants without overfitting.

Table 22 - Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.888[a]	.788	.787	2.72909

a. Predictors: (Constant), Staff_Training

In Table 23, the null hypothesis is tested, i.e., there is no impact of staff training on BMW practices. The explained variance is shown in the Regression row (with Sum of Squares value of 6875.812, Mean square value of 6875.812 and degree of freedom of 1), while Residual value has unexplained variance (Mean Square = 7.448, 1847.088, and degree of freedom of 248). With $p<0.001$, the F-statistic (923.183) provides excellent evidence, rejecting null hypothesis, which confirms the overall significance of regression model (Table 23).

Table 23 – ANOVA Table to test null hypothesis[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6875.812	1	6875.812	923.183	.000[b]
	Residual	1847.088	248	7.448		
	Total	8722.900	249			

a. Dependent Variable: BMW

b. Predictors: (Constant), Staff_Training

The Coefficients table (Table 24) represents the regression equation of 1.386 + 0.770 (BMW + Staff Training). The intercept ($p = 0.020$) suggests baseline score of BMW when training is statistically significant. The unstandardized coefficient shows that 0.77 point is increased with improvement of BMW with each point rise in training score ($B = 0.770$). The dominant influence of training is confirmed in standard deviation with standardized Beta (0.888). The $p<0.001$ value shows highly significant predictive power of Staff Training with accurate estimate (Table 24).

Table 24 - Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.386	.593		2.338	.020
	Staff_Training	.770	.025	.888	30.384	.000

a. Dependent Variable: BMW

H2 – There is a significant positive association between employee awareness and biomedical waste management in hospitals

To test H2, Pearson's Correlation test was conducted, which supports alternate hypothesis. It identifies significant positive relationship between employee awareness and BMW management in hospitals ($p<0.001$). It is confirmed that there is a direct relationship between increased awareness and waste management behaviors among hospital staff. Awareness is found to be an important antecedent to safe BMW practices in context of hospitals in Dehradun (Table 25).

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Table 25 – Correlation between EA and BMW Management

		EA	BMW
EA	Pearson Correlation	1	.903**
	Sig. (2-tailed)		.000
	N	250	250
BMW	Pearson Correlation	.903**	1
	Sig. (2-tailed)	.000	
	N	250	250

**. Correlation is significant at the 0.01 level (2-tailed).

Overall, both hypotheses have been accepted with statistical tests. Employee training suggests around 80% of variance and awareness. Awareness initiatives and structured training programs have been validated as vital interventions for compliance of BMW as per BMW Rules, 2016. Findings of the study are aligned with objectives of the study, which suggests causal relationships and pathways that can be used by hospital admins for staff development and policy improvements in hospitals in Dehradun.

5. Discussion and Conclusion

This study provides compelling and supportive evidence for both hypotheses. It shows that improved employee awareness and staff training programs have a positive role in improving BMW management practices among hospital staff. For H1, Linear Regression test was performed to reveal very strong and predictive relationship between actual BMW practices and effectiveness of employee training. This magnitude of size of effect goes beyond usual findings in healthcare compliance and organizational behavior literature, where interventions usually show moderate influence over behaviors. It is found that the training operates as a major factor for safe handling of waste around diverse roles played by hospitals, positioning structured experiences which are needed for compliance culture.

These findings are closely aligned with pre-experimental study conducted by local researchers at Govt. Doon Medical College in Dehradun and documented significant pre- and post-improvements in knowledge and practices adopted by housekeeping staff after structured interventions. However, the current cross-sectional study goes beyond those findings by quantifying the impact of training around various categories like nurses, doctors, housekeeping staff, and lab technicians, instead of focusing on individual group. This approach reveals universal applicability of training in multicultural ecosystem of hospitals, where diverse dynamics might fragment effectiveness of intervention.

For H2, the Pearson's Correlation analysis was conducted and found robust positive relationship between BMW practices and awareness levels, which are aligned with the prevalent "Knowledge-Attitude-Practice (KAP)" models with public health research. This relationship goes beyond typical strengths of correlation reported in studies related to environmental management, which may be attributable to the accuracy of instrument and specific regulatory enforcement in Dehradun under the monitoring of SPCB. The findings support key behavioral theories (like Ajzen's Theory of Planned Behavior) where attitudes are shaped by cognitive knowledge which ultimately manifest as observable behaviors of compliance like proper use of PPE, segregation at source, and standard disposal processes (Ajzen, 1991).

5.1. Theoretical Contributions

The study findings are also relevant to Social Learning Theory, where practical learning with staff training and live demos improve practical skills (Akers and Jennings, 2015). Testing H1 has shown the dominant effect of training over awareness for supporting the frameworks established, which focus on antecedent behaviors instead of depending only on cognitive mediators. It confirms construct validity around various items in the questionnaire with excellent internal consistency of responses, enabling generalizability to similar contexts in Indian healthcare.

When comparing with existing literature, findings of this study both extend and corroborate global evidence when it comes to highlight patterns which are specific to Dehradun. Previous studies based on Karnataka identified major knowledge gaps among healthcare workers regarding protocols of color-coding among support staff, still current analysis on different roles suggest that complete training bridges these disparities in occupations. During increased demands about healthcare like

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recent pandemic, Uttarakhand faced significant challenges of generating BMW which highlighted the urgency of intervention. Findings of the study suggested that core compliance gaps are addressed by proper training.

Nuanced knowledge was attained with demographic characteristics about impacts around professional categories. Nursing staff have strongest responses to training, who face BMW constantly, while housekeeping staff benefit most widely from the components of awareness building. There are different patterns related to allocation of resources which affect effectiveness of service delivery and training infrastructure. These variations in organization need targeted strategies instead of one-size-fits-all methods.

The sampling approach adopted in this study ensures that representation of demographic variables like experience levels, age groups, and facility type of healthcare landscape of Dehradun. The cross-sectional research design provides robust evidence for correlation, while limitations are acknowledged to build temporal precedence. With anonymous questionnaires, collection of self-reported data reduces bias of social desirability in compliance studies, especially in regulatory environment. Future studies could focus on longitudinal research to track long-term interventions over various training cycles.

Hospital administrators in Dehradun must prefer regular training to incorporate practical segregation with color-coded bins, localized training materials, and supervisor follow-ups related to challenges in facilities. The predictive association enables allocation decisions which connect training to measurable outcomes. Awareness measures with videos, posters, and team discussions work together with training programs to target poor-performing items related to identification of challenges and reporting of incidents. Hospitals should work with SPCBs to improve training certification and integrate the same into licensing protocols to create accountability going beyond checkboxes.

There are several integration opportunities related to national frameworks to embed modules of BMW management in the curricula of healthcare training to ensure transfer of generational knowledge. Training delivery can be improved with "public-private partnerships (PPP)" around different types of facilities to address disparities of resources which influence quality of programs. Effective practices have a direct mitigating impact on risks of transmission of blood-borne illnesses with proper disposal and segregation protocols. The training efficiency has a drastic potential to prevent injuries, reduce environmental pollution, and compliance across healthcare network in Uttarakhand. These findings can be used by hospitals to justify the allocations of their budget for complete initiatives for staff growth.

5.2. Future Directions and Limitations

Future studies could use structural equation modeling to explore mediated pathways where practices may be influenced by training with intermediate awareness programs. With focus groups, qualitative aspects would reveal challenges related to implementation ahead of survey identification. Future studies could also perform comparative analyses across other districts in Uttarakhand to test generalizability of findings. In addition, experimental designs could be adopted to compare in-person versus digital delivery of services to improve intervention for different preferences.

While the robust statistical approach and comprehensive sampling improve the internal validity of responses, findings of the study are specific to context and regulatory environment in Dehradun. Validation is needed for generalization to various regulatory jurisdictions or facilities. Current states are captured with cross-sectional timing but they cannot address seasonal changes in delivery of training or BMW management.

5.3. Conclusion

Overall, this study establishes structured programs for employee training as the foundation of effective BMW management in hospital ecosystem in Dehradun. The empirical relationships are exceptionally strong in this study between practical implementation and training effectiveness, apart from robust correlations of awareness to provide evidence-based strategies to administrators to improve compliance under national BMW laws. Theoretically this study fills the principles of organizational behavior with public health knowledge, showing causal dominance of training over cognitive factors in high-stakes environments. The study provides validated tool for similar contexts in healthcare.

For implementation in hospitals, short-term priorities must be focused on housekeeping staff to train employees with practical segregation protocols. In addition, dashboards may be adopted for awareness tracking to monitor progress. Finally, long-term sustainability adopts completion of training with evaluation to create long-term compliance. With persistent challenges related to BMW management for healthcare sector in India, hospitals in Dehradun act as exemplars of implementation, showing ROI from structured programs. Administrators have to predict improvements from investments in training with established pathways, which justify allocation of resources in competitive environments.

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