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Challenges and Insights into Biomedical Waste Management in a Tertiary Care Hospital: A KAP Study

Wyzwania i spostrzeżenia dotyczące gospodarki odpadami medycznymi w szpitalu trzeciego stopnia: Badanie KAP

Abstract

Introduction. Due to limited knowledge and inadequate practices, improper biomedical waste (BMW) management remains a pressing issue in developing countries. This study evaluates the knowledge, attitudes, and practices (KAP) regarding BMW management among healthcare personnel in a tertiary care hospital.

Aim. The study aims to assess the knowledge, attitudes, and practices of healthcare personnel concerning BMW management and identify gaps in the implementation of BMW management protocols.

Materials and methods. 296 participants, including doctors, nurses, laboratory technicians, and multi-purpose workers, were surveyed using a semi-structured, pre-tested questionnaire.

Results. The results revealed that 70% of sanitary, 58.8% of nursing, and 42.9% of laboratory assistants demonstrated excellent knowledge levels (scores >10). In contrast, doctors exhibited average expertise (scores between 5-10). While healthcare personnel displayed a generally positive attitude toward BMW management, disagreements emerged regarding the notion of "safe management as teamwork." As mandated by regional regulations, the hospital lacked essential BMW management facilities, such as autoclaving, microwaving, hydroclaving, shredding, and disinfection. Partial incineration was the sole method available for final disposal.

Conclusion. This study underscores the urgent need for targeted training programs and the strict enforcement of BMW management regulations to ensure effective and sustainable practices.

Keywords: medical waste; infectious waste, KAP, waste disposal, incineration, biomedical waste

Streszczenie

Wprowadzenie. Z powodu ograniczonej wiedzy i niewłaściwych praktyk, nieprawidłowe zarządzanie odpadami medycznymi (BMW) pozostaje palącym problemem w krajach rozwijających się. Niniejsze badanie ocenia wiedzę, postawy i praktyki (KAP) dotyczące zarządzania odpadami medycznymi wśród personelu medycznego w szpitalu opieki trzeciorzędowej.

Cel. Celem badania jest ocena wiedzy, postaw i praktyk personelu medycznego w zakresie zarządzania odpadami medycznymi oraz zidentyfikowanie luk w implementacji protokołów zarządzania odpadami medycznymi.

Materiał i metody. Przebadano 296 uczestników, w tym lekarzy, pielęgniarki, techników laboratoryjnych i pracowników wielozadaniowych, przy użyciu półstrukturyzowanego, wstępnie przetestowanego kwestionariusza.

Wyniki. Wyniki wykazały, że 70% pracowników sanitarnych, 58,8% pielęgniarek i 42,9% asystentów laboratoryjnych wykazało się doskonałą wiedzą (wyniki >10). Z kolei lekarze wykazali się średnim poziomem wiedzy (wyniki między 5-10). Chociaż personel medyczny wykazywał ogólnie pozytywne nastawienie do zarządzania odpadami medycznymi, pojawiły się rozbieżności dotyczące koncepcji „bezpiecznego zarządzania jako pracy zespołowej". Zgodnie z wymogami regionalnych przepisów, szpital nie posiadał niezbędnych urządzeń do zarządzania odpadami medycznymi, takich jak autoklawowanie, mikrofalowanie, hydroklawowanie, rozdrabnianie i dezynfekcja. Jedyną dostępną metodą utylizacji końcowej była częściowa inkineracja.

Wnioski. Badanie podkreśla pilną potrzebę wprowadzenia ukierunkowanych programów szkoleniowych oraz ścisłego egzekwowania przepisów dotyczących zarządzania odpadami medycznymi, aby zapewnić skuteczne i zrównoważone praktyki.

Słowa kluczowe: odpady medyczne, odpady zakaźne, KAP, utylizacja odpadów, spalanie, odpady biomedyczne

Introduction

The rapid expansion of healthcare services has led to a parallel increase in biomedical waste (BMW) generation, posing severe challenges for public health and environmental sustainability. BMW refers to waste produced during the diagnosis, treatment, immunization, or research involving humans or animals [1,2]. It includes waste from

healthcare facilities that may pose significant risks to human health and the environment. In India, the Biomedical Waste (Management and Handling) Rules, 2016 define and categorize BMW in Schedule I, specifying 85% as general, non-hazardous waste, while the remaining 15% is hazardous, potentially infectious, toxic, or radioactive [3,4]. Effective BMW management involves multiple stages, including monitoring, segregation, collection, storage, transportation, and final disposal.

Healthcare professionals such as doctors and nurses generally demonstrate higher knowledge levels than other HCWs, including paramedical staff and sanitary workers [5]. However, KAP studies consistently reveal significant gaps in BMW management practices across healthcare settings. For example, a study involving doctors, residents, nurses, and paramedical staff in 10 patient care settings reported significant deficiencies, with most groups benefitting from training interventions [6,7]. These findings emphasize the critical need for comprehensive training programs and stringent enforcement of regulations to improve compliance and mitigate risks associated with biomedical waste.

Previous studies analyzing BMW disposal practices have highlighted significant gaps in understanding and adherence among healthcare workers, particularly in private healthcare facilities, where practices were substantially worse than in government health centers [8]. The high cost of clinical waste treatment compared to general waste disposal underscores the importance of proper waste segregation, which can lead to considerable cost savings. Another Observational research using a validated checklist of 41 factors to assess compliance revealed that tertiary care hospitals largely adhered to BMW management regulations [9]. However, statistical analyses indicated poor awareness and attitudes towards BMW management among healthcare workers, emphasizing the need for regular training and supervision to improve practices [10].

Analytical KAP studies with pre-tested questionnaires demonstrated that knowledge and awareness significantly influence BMW management practices [11]. These findings highlight the need for comprehensive training and supervision to ensure healthcare workers adhere to BMW management protocols. Also, the related studies have consistently emphasized the role of strict regulatory oversight in ensuring effective BMW management. Segregation, collection, and disposal of medical waste are essential for environmental safety and legal obligations that require focused attention [12,13].

The current study aimed to assess the level of knowledge, awareness, and practices regarding BMW management among healthcare workers in a tertiary care institute. The specific objectives were: (1) to evaluate the knowledge and attitudes of healthcare workers regarding BMW management, (2) to assess compliance with the BMW Management Rules, 2016, and (3) to propose strategies for effectively implementing these rules and enhancing BMW management practices.

Materials and methods

This study was conducted in a 1015-bed tertiary healthcare hospital encompassing over 50 departments, including medicine, surgery, and allied specialties. Data collection involved a validated, pre-tested questionnaire comprising 29 questions divided into three parts: demographic information, knowledge (15 questions on BMW management and rules), and attitude (14 questions on safe handling, segregation, and finances). The questionnaire was developed following a set of rules as per the literature review and focused group discussions (FGDs). It was validated through expert"s review and a pilot study. The internal consistency of the questionnaire was tested using Cronbach"s α coefficient. Responses were scored to assess knowledge levels and analysed using a Likert scale for attitudes. Observational data on BMW management practices were recorded thrice daily using a checklist, evaluating compliance with BMW rules, 2016. Data analysis included descriptive statistics and frequency distribution using SPSS version 25.

Results

A total of 296 healthcare personnel (knowledge & attitude-158 and practices-138) participated in the study. Mean knowledge score concerning designation of the participants involved in the studyis mentioned in Table 1. The details regarding BMW Management in the study area were gathered using a pre-designed questionnaire and Checklist.

Knowledge

Table 1. Mean knowledge score concerning designation of the participants involved in the study

Designation	Mean knowledge Score ± S.D.	Excellent	Average	Poor	n
Resident	8.91 ± 0.56	0 (0%)	54 (100%)	0 (0%)	54
Nursing staff	10.51 ± 1.48	47 (58.8%)	33 (41.2%)	0 (0%)	80
Laboratory assistants	9.86 ± 1.03	6 (42.9%)	8 (57.1%)	0 (0%)	14
Sanitary workers	10.70 ± 0.48	7 (70%)	3 (30%)	0 (0%)	10

The respondents" knowledge level was analysed and presented concerning their designation, age, location of work, qualification, gender, and experience.

Knowledge vs Designation

Among the entire study group, a wide variation of the mean knowledge was observed among the healthcare professionals. Down the ladder, the nursing staff was observed applying knowledge of BMW management at a level slightly lower than sanitary workers. The study also revealed that among sanitary workers, 70% had excellent knowledge scores, followed by nursing staff, where 58.8% were graded as excellent, followed by laboratory assistants, where 42.9% were graded as excellent. 100% of the residents were graded average knowledge scores. Among staff nurses, 41.2%, laboratory assistants, 57.1% and sanitary attendants, 30% were graded as average knowledge scores.

Knowledge vs. Age

Table 2 Mean knowledge score concerning age of the participants

Designation	**Age group**	**Mean knowledge Score ± S. D**	**n**
Doctors	20–40 40–60	8.90 ± 0.59 9.0 ± 0.01	54
Nursing staff	20–40	10.51 ± 1.48	80
Laboratory assistants	20–40 40–60	11.0 ± 0.04 9.0 ± 0.03	14
Sanitary workers	20–40 40–60	10.0 ± 0.01 11.0 ± 0.02	10

Table 2 presents the data analysis based on the healthcare workers" age group. The age group between 40–60 years had the highest range of knowledge, whereas the age group of 20–40 had average knowledge except for laboratory assistants.

Knowledge vs. Place of Work

The observations for mean knowledge of HCWs concerning their place of work are shown in Table 3.

Table 3. Mean knowledge score concerning place of work of respective participants

Designation	Work area	Mean knowledge score ± S. D	n
Residents/Doctors	Ward OT Lab Emergency	9.00 ± 0.02 9.00 ± 0.03 8.50 ± 0.52 9.05 ± 0.69	54
Nursing staff	Ward OT Lab Emergency	10.51 ± 1.48 10.23 ± 0.85 - 10.43 ± 0.24	80
Laboratory assistants	Ward OT Lab Emergency	- 10.09 ± 1.04 9.00 ± 1.23 -	14
Sanitary workers	Ward OT Lab Emergency Other	11.00 ± 0.02 - - - 10.57 ± 0.53	10

It was observed that there was no considerable variation in mean knowledge score among doctors in terms of their place of work.

Knowledge vs Qualification

Table 4. Mean knowledge score with respect to qualification of the participants working in the field

Designation	Qualification	Mean knowledge Score ± S. D	n
Residents/doctors	Graduates Postgraduates	9.33 ± 0.48 8.96 ± 0.46	54
Nursing staff	Diploma Graduates Postgraduates	10.24 ± 0.89 10.52 ± 1.47 10.25 ± 1.53	80
Laboratory assistants	Diploma/certificate Graduates	9.34 ± 0.98 9.86 ± 1.02	14
Sanitary workers	Matric and above	10.57 ± 0.53	10

The knowledge regarding BWM among the HCWs compared with their qualifications is presented in Table 4. The observations revealed that among HCWs, no significant difference in their knowledge of BWM was observed concerning their qualifications.

Knowledge vs Gender

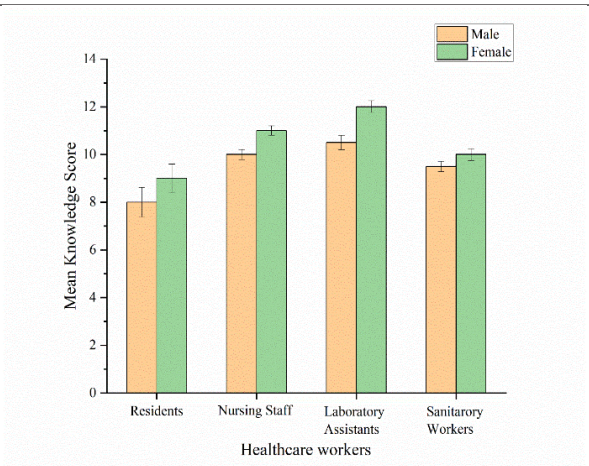

Fig. 1: Mean knowledge score of HCWs concerning Gender

Mean knowledge score vis-à-vis gender among the HCWs is presented in Figure 1. The study indicated no considerable difference in knowledge level among the HCWs with respect to their gender.

Knowledge vs Experience

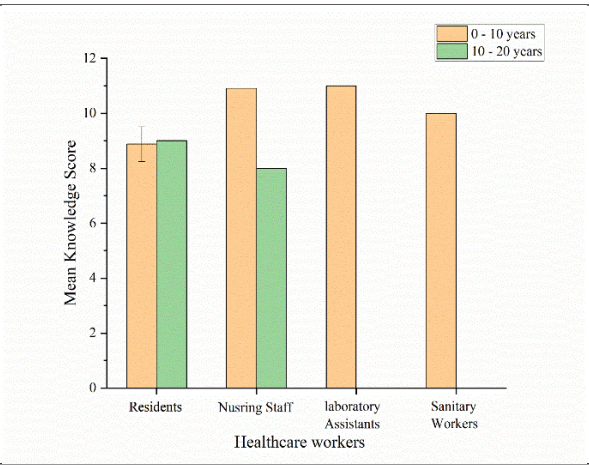

Fig. 2: Mean knowledge score of HCWs with respect to work experience

Figure 2 shows the mean knowledge score *vis-à-vis* the work experience of HCWs in the respective cadre. It was observed that the sanitary workers followed a progressive trend in their knowledge level with experience. While the doctors showed no significant change in knowledge level concerning their experience, the nurses and laboratory assistants showed an inverse trend with experience.

Attitude Domain

The attitude of HCWs was assessed using a questionnaire presented/asked to the study population to assess their attitude towards various key elements of BMW management. The attitude questionnaire had 14 questions regarding the safe management of BMW: *responsibility for safe management of BMW"*, *„waste management is a teamwork*," „finances *involved in BMW management"*, *„hazardous nature of BMW, segregation of BMW"*, etc. As attitude is the perception of HCWs about biomedical waste, it can differ for different HCWs. So, the responses of HCWs regarding the elements of BMW management were presented in the form of *Likert scale*.

While assessing the attitude of health care workers, the assessment revealed that everyone agreed with fundamental responsibilities towards BMW management. It can be, therefore, inferred that every HCW had a fair and genuine attitude towards handling and managing the biomedical waste without any ambiguity except the opinion regarding "*safe management is teamwork*", where varying opinions had been expressed; a significant proportion (78.6%) of the respondents among the laboratory assistants "*strongly disagreed*" to the above statement as shown in Table 5.

Table 5. Attitude vs waste management is a teamwork

Designation	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree	n
Residents/ Doctors	66.7%	33.3%	0%	0%	0%	54
Nursing Staff	87.5%	12.5%	0%	0%	0%	80
Laboratory Assistants	21.4%	0%	0%	0%	78.6%	14
Sanitary Workers	100%	0%	0%	0%	0%	10

However, the other categories, viz., Residents/doctors, nursing staff, and Sanitary workers, exhibited an agreement of 66.7%, 87.5%, and 100%, respectively. Response of HCWs to *"safe management efforts by hospital increasing financial burden on hospital*" indicated that 33.3% of residents, 12.5% of staff nurses and 21.4% of laboratory assistants "*disagreed*" with the statement. 22.2% of residents and 25% of nursing staff "*strongly agreed"* that safe management efforts increase the financial burden on the hospital. 35.7% of laboratory assistants, 22.2% of residents, and 12.5% of nursing staff "*neither agreed nor disagreed*" with the statement. Significant portion of 42.9% of laboratory assistants and 100% of the sanitary workers "*agreed*" to the statement.

Responses to the question "*Biomedical Waste highly hazardous than Municipal Waste*" revealed that 77.8% of residents, nursing staff 75%, 21.4% of laboratory assistants, and 100% of sanitary workers "*strongly agreed*" that biomedical waste is highly hazardous. A significant proportion (78.6%) of laboratory assistants "*agreed*" with

the statement. The responses of HCWs to the question "*How much do you agree that biomedical waste requires segregation?*" showed that 33.3% of residents and 64.3% of laboratory assistants "*agreed*" with the statement. 66.7% of residents, 100% of nursing staff, 35.7% of laboratory assistants, and 100% of sanitary workers "*strongly agreed*" that biomedical waste requires segregation. Responses of HCWs to the question "*Should Biomedical Waste be Treated and Disposed of Separately from Municipal Waste?*" revealed that 66.7% of residents, 62.5% of nursing staff, 35.7% of laboratory assistants, and 100% of sanitary workers "*strongly agreed*" to the above statement and Significant portion of laboratory assistants (64.3%) "*Agreed*" to the statement.

Responses to the statement "*You Agree Labelling the Container before filling it with BMW Is of Any Clinical Significance?*" disclosed that 55.6% of residents, 87.5% of nursing staff, and 100% of sanitary workers "*strongly agreed*" to the statement. 33.3% of residents, 12.5% of nursing staff and 35.7% of laboratory assistants "*agreed*" that labelling the containers before filling with biomedical waste is of clinical significance. A significant proportion of laboratory assistants (64.3%) "*Neither agreed nor disagreed*" with the statement. Respons of HCWs to the question "*Do You Agree that You Are at Risk of getting Blood Borne Infections While Handling Biomedical Waste?*" reported that 78% of residents, 62.5% of nursing staff, and 30% of sanitary workers "*strongly agreed*". 100% of laboratory assistants "agreed" to the statement. Significant portion (25%) of nursing staff "*disagreed*" to the statement.

Practice Domain

The practice of BMW management was assessed using the Checklist consisting of protocols described in the BMW (Management and Handling) Rules, 2016, i.e., Generation, Segregation, Storage, and Transportation. A total of 138 observations were made among staff nurses, nursing aid, and sanitary staff, as shown in Table 6.

Table 6. Total number of different Healthcare workers observed

Designation	Wards	Emergency	n
Staff nurses	44	33	77
Nursing aid	20	15	35
Sanitary staff	16	10	26
Total	80	58	138

Use of hub cutter for needles and syringes

The practice of the HCWs using a hub cutter for needles and syringes is shown in Figure 3. Observations through the Checklist revealed 91.3%, 70.1%, and 65.7% non-compliance rates among the residents/doctors, nursing staff, and nursing aids. The

highest compliance rate of 34.3% was observed among nursing aids using hub cutters for needles and syringes. Over a 31.3% compliance rate using as confirmed by healthcare workers, there was a complete absence of hub cutters/mutilators in emergency areas.

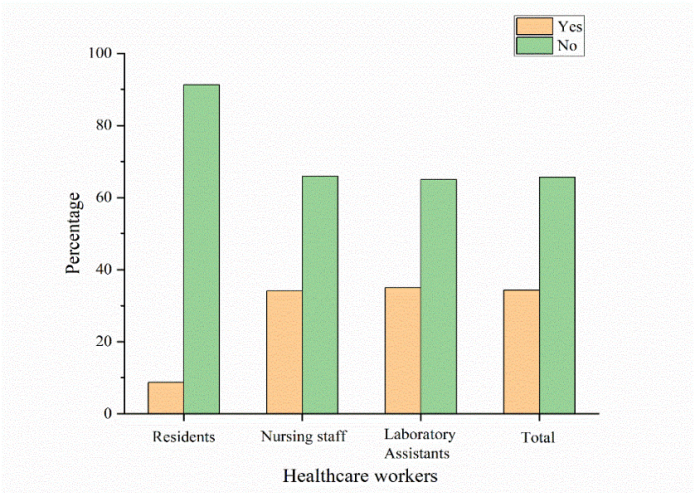

Fig. 3. Use of hub cutter for needles and syringes in percentage

Availability of an adequate number of bins

Adequacy of the number of bins, as per the BMW guidelines (red, yellow, blue), was observed. However, white bins for waste sharps were not provided. An extended observation revealed noncompliance with the requirement of puncture-proof containers for sharps.

Segregation and generation

The study inferred that the segregation of BMW, as per the BMW management rules 2016, was not practiced properly. Importantly, in emergency wards, the segregation was found completely missing, plausibly due to patient overload and lack of staffing. At generation sites, the compliance with the segregation of wastes as per the guidelines for yellow, red, and blue coloured bins was 66.1%, 66.1%, and 75%, respectively, as shown in Table 7.

Table 7. The Compliance rates regarding Generation, Segregation, Storage and Transportation.

Segregation and Generation			
Designation	**n**	**YES**	**NO**
Human Anatomical Waste Vs Yellow Container			
Staff Nurses	77	70%	30%
Nursing Aid	35	57%	43%
Contaminated Wastes (Recyclable) vs. Red Bins			
Staff Nurses	77	70%	30%
Nursing Aid	35	57%	43%
Glassware vs. Blue Bins			
Staff Nurses	77	76.60%	23.40%
Nursing Aid	35	71.40%	28.60%
Storage and Transportation			
Designation	**n**	**YES**	**NO**
Transporting Biomedical Waste and Domestic Waste Separately			
Sanitary Attendants	26	100%	0%
Transporting BMW in the Early Morning			
Sanitary Attendants	26	77%	33%

Observations regarding the "*segregation of Human Anatomical waste into yellowcontainer*,"as tabulated in Table 7, revealed a noncompliance rate of 43% among nursing aid and 30% staff nurses. In comparison, nursing staff, including staff nurses and nursing aids, had a better compliance rate of 70% and 57%, respectively. Response to "*segregation of disposable items (without needles and fixed needle syringes) into the red container*," as shown in Table 7, revealed that nursing aid had a lower% compliance rate of 43%. A better compliance rate was observed among 70%, and 57% of staff nurses of nursing aids segregated infected waste properly into red containers. Responses to segregation of waste sharps, including metals (e.g., needles, syringes with fixed needles,

needles from needle tip cutter or burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts) into alternate white bins as tabulated revealed that 55.40% noncompliance was noted among both staff nurses and nursing aid for "*segregation of sharps and needles into sharp containers*."

Storage and Transportation

The study found that all the containers were labelled. Continuing the study, a 75% compliance rate has been seen within the premises for a safe, ventilated, and secured location for storing segregated biomedical waste in coloured bags or containers, except in the paediatric emergency section where ventilation and safety still seem a big challenge. The untreated biomedical waste was not mixed with other wastes within all wards except emergency wards, where untreated waste was mixed with other wastes by sanitary workers who didn't comply with the rules. The probable reason was that healthcare workers did not follow segregation tenants at different generation sites. For the transportation of BMW, only labelled vehicles were used.

An observation regarding the statement "*Transporting Biomedical Waste and Domestic Waste Separately*" and "*Transporting BMW in Early Morning*" by sanitary attendants, as shown in Table 7, revealed that there was 100% compliance except in emergency areas where complete mixing has been found. The observation regarding the statement "*Transporting BMW in Early Morning*" by sanitary workers, revealed that 77% of sanitary workers transported the BMW during morning hours rather than in the evening.

Treatment and Disposal

Observations regarding the treatment and disposal of biomedical wastes revealed that out of a total of 1015 beds, anatomical waste, soiled waste, all types of waste, discarded medicine, microbiology and all other clinical laboratory waste, contaminated waste, waste sharps, including metals, glassware, etc. except a liquid waste of only 500 beds was being incinerated in the premises. The waste of the remaining 510 beds was sent to a private biomedical waste treatment facility. Also observed/validated that waste (microbiology waste and all other clinical laboratory waste) pre-treatment by sterilization or disinfection before sending it to a common biomedical waste treatment facility was not practiced. Expired medicine was rejected and returned to the supplier. Apart from this, discarded medicine was sent to incineration treatment as well. Processes such as autoclaving, microwaving, hydroclaving, shredding, disinfection, etc., were not applied to biomedical waste in the health care institute.

Discussion

The knowledge, awareness, and practice regarding BMW Management among the HCWs in the study area were gathered using a pre-formulated and pre-tested question-

naire. Healthcare facilities generate a significant amount of biomedical waste, a portion of which, estimated to be 10-25%, is infectious [14]. Improper disposal of this waste poses a high risk of disease transmission. Effective waste management requires handling the waste correctly at every stage, from collection to disposal, using various methods [15]. Healthcare workers need to have proper knowledge, attitudes, and practices regarding biomedical waste management. Therefore, this study aimed to assess the knowledge and attitudes of healthcare workers in a tertiary care hospital, highlighting that adequate knowledge and a positive attitude are crucial in preventing the harmful effects of poor waste management [16].

Knowledge

In our study, sanitary workers had the highest percentage of excellent knowledge score at 70%, followed by nursing staff at 58.8% and laboratory assistants at 42.9%. Additionally, 100% of the residents were graded as having an average knowledge score. Among staff nurses, 41.2%, laboratory assistants, 57.1%, and sanitary attendants, 30% were graded as having an average knowledge score. The results of this study were found to be in contravention to the reported study wherein the highest knowledge score was attributed to the doctors (86%), followed by nursing staff (70%) and lab technicians (46%) [17]. This could be due to inadequate response from the doctors due to work pressure. The age group between 40 - 60 years had the highest range of knowledge, whereas the age group of 20-40 (years) had average knowledge except for laboratory assistants. Also, the observations revealed that among HCWs, no significant difference in their knowledge of BWM was observed concerning their qualifications. However, a similar study regarding KAP of biomedical waste among nurses revealed better knowledge among the nurses with a diploma than those with BSc (Nursing) qualification [18].

Attitude

While assessing the attitudes of HCWs towards BMW management, all respondents agreed on their fundamental responsibilities, demonstrating a fair and genuine attitude. However, perspectives on teamwork varied, with 78.6% of laboratory assistants strongly disagreeing that "safe management is teamwork," compared to agreement levels of 66.7% among residents, 87.5% among nursing staff, and 100% among sanitary workers. Similar studies have shown that more than 50% of HCWs perceive BMW management as a form of teamwork [19, 20]. Additionally, 73.8% of HCWs disagreed that "safe management of healthcare waste is an issue," while responses varied among different staff categories. Most HCWs agreed that BMW segregation and disposal require proper management, with prior studies supporting this view [21, 22].

Furthermore, a majority expressed willingness to attend voluntary training programs to enhance their knowledge of BMW management. These findings align with

prior studies indicating a strong agreement among HCWs on the importance of labeling and training in effective BMW management [10].

Practice

Regarding the practices, it has been inferred that the segregation of BMW as per the BMW Management Rules 2016, was not practiced properly. Importantly, the segregation process was found completely missing in emergency wards, plausibly due to patient overload and lack of staffing. While contrary results were found in a tertiary hospital, healthcare waste management was adhered to by all nurses, 70% of housekeeping staff, and just 47% of technical personnel [23] and the hospital strictly followed standard procedures for the segregation, collection, transport, storage, and final disposal of infectious waste. Also, in one district of Gujarat, hospitals lacked an effective system for the segregation, collection, transportation, and disposal of waste [24].

Conclusion

A knowledge, attitude, and practice (KAP) study was conducted among the healthcare workers in a tertiary care hospital. Data was collected through structured questionnaires and an observational Checklist. The study indicated that the sanitary workers and nursing staff possessed higher levels of knowledge about BMW management among the healthcare workers. Only a 31.25% compliance rate to using hub cutters for needles and syringes was observed among all healthcare personnel, with a complete absence of hub cutters/mutilators in emergency areas. Although adequate bins (red, yellow, and blue) were placed per guidelines, white bins for waste sharps were missing. The study also revealed that every healthcare professional had a fair and genuine attitude towards handling and managing BMW, except for the opinion regarding "safe management is teamwork," where a significant proportion (78.6% of laboratory assistants) strongly disagreed with the above statement. The segregation process, the most important part of BMW management, was not practiced properly in the study area. The healthcare institute did not practice pre-treatment by sterilization or disinfection before sending it to a common biomedical waste treatment facility. Processes demanded by the BMW Rules, 2016, such as autoclaving, microwaving, hydroclaving, shredding, disinfection, etc., were not implemented by the healthcare institute except for partial incineration. There is a dire need for proper training of healthcare personnel regarding BMW handling and management to implement the BMW management rules properly.

Recommendations for nursing practice

Based on the findings of this study, it is imperative to enhance nursing practice through structured and continuous training programs focused on BMW management. Nurses should receive regular updates on the Biomedical Waste Management Rules, 2016,

emphasizing practical protocols such as proper segregation, labeling, and the use of protective equipment and hub cutters. Training should be tailored to address specific gaps identified, particularly in emergency and high-pressure areas where compliance tends to decline. Nurse leaders and supervisors must play an active role in monitoring adherence, promoting teamwork, and fostering a culture of safety. The administration must ensure the availability of appropriate resources, such as color-coded bins, sharps containers, and disinfectants, to support compliance. Integrating BMW management modules into nursing curricula and continuing education programs will empower nurses with the knowledge and confidence to uphold safe, ethical, and environmentally responsible waste-handling practices in all healthcare settings**.**

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