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Assessment of Knowledge, Attitude, and Practice (KAP) of Healthcare Workers on Medical Waste Management: A Cross-Sectional Study in Sarayan, Iran

Senobar Imanian [a], **Malihe Ram** [b, c], **Fatemeh Samiei** [d], **Farzaneh Fanaei** [e, f *], **Masoumeh Heravi** [b], **Mahla Abbasi** [b]

a. Department of Environmental Health Engineering, School of Health, Isfahan University of Medical Sciences, Isfahan, Iran.
b. Student Research Committee, Birjand University of Medical Sciences, Birjand, Iran.
c. Social Determinants of Health Research Center, Birjand University of Medical Sciences, Birjand, Iran.
d. Department of Environmental Health Engineering, School of Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
e. Department of Environmental Health Engineering, Ferdows Faculty of Medical Sciences, Social Determinants of Health Research Center, Birjand University of Medical Sciences, Birjand, Iran.
f. Clinical Research Development Unit (CRDU), Hazrat Rasoul Hospital of Ferdows, Birjand University of Medical Sciences, Birjand, Iran.

***Corresponding author:** Department of Environmental Health Engineering, Ferdows Faculty of Medical Sciences, Social Determinants of Health Research Center, Birjand University of Medical Sciences, Birjand, Iran. Postal Code: 9714994389. E-mail: farzaneh.fanaei@bums.ac.ir

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ABSTRACT

Background: Proper management of hospital waste is crucial for maintaining public health and ensuring biosafety. Given the importance of personnel in this area and the need to evaluate the current situation, this study aimed to assess the knowledge, attitude, and practice (KAP) of staff at Imam Ali Hospital in Sarayan, Iran, regarding hospital waste management.

Methods: This descriptive-analytical cross-sectional study was conducted in 2024 among 95 staff members of Imam Ali Hospital in Sarayan, Iran, using a full census approach. Data were collected using a validated 44-item questionnaire assessing KAP regarding hospital waste management. Following assessment of data normality, Spearman's correlation coefficient, Mann–Whitney U test, and Kruskal–Wallis test were used for statistical analysis.

Results: The mean scores for KAP were 10.43 ± 2.14, 38.39 ± 5.28, and 8.66 ± 2.87, respectively, indicating moderate levels across all domains. A significant positive correlation was observed among KAP, with the strongest correlation identified between knowledge and practice ($r = 0.702$, $p < 0.001$). However, awareness of the national medical waste management law was notably low (31.9%). Participation in training programs was associated with significantly higher knowledge and practice scores ($p < 0.05$).

Conclusion: The present study demonstrates that hospital personnel possess a reasonably acceptable level of knowledge and attitude towards waste management. The study also highlights the significant relationship between knowledge and practice, as well as the positive influence of training courses on both.

1. Introduction

In recent decades, the generation of healthcare waste has substantially increased in both quantity and variety (Banstola et al., 2017; Letho et al., 2021). This is primarily due to population growth, the proliferation of hospitals, and the expansion of healthcare facilities (Ma et al., 2022; Moorat et al., 2022). Medical waste includes all materials produced

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during diagnostic, therapeutic, immunization, or research activities involving humans or animals (Parida et al., 2019; Sahragard et al., 2024). Approximately 80% of waste produced in hospital settings is non-hazardous or general waste, while 15 to 25% constitutes hazardous waste (Sharma & Devi, 2017). Improper management of medical waste poses significant threats to human health, safety, and the environment (Abd-Rabboh et al., 2022). These threats include risks of infections (e.g., HIV and hepatitis B/C transmitted via unsterilized syringes), needlestick injuries, poisoning, and environmental pollution (Mortazavi et al., 2019; Parida et al., 2019; Wankhede & Wanjari, 2021).

Hospital personnel face an elevated risk of acquiring diseases and complications due to their direct and ongoing exposure to healthcare waste (HCWM) resulting from inadequate waste management (Manchanda et al., 2015; Thirunavukkarasu et al., 2022). Consequently, their behavior and performance are crucial in effective medical waste management (Dewi et al., 2024). Knowledge and attitude have a significant impact on an individual's behavior and performance, ultimately affecting the effectiveness of waste management practices (Banstola et al., 2017). Thus, a fundamental strategy for preventing and mitigating hazards involves evaluating the knowledge, attitudes, and practices of hospital personnel in relation to hospital waste management (Letho et al., 2021). Although awareness among health professionals worldwide regarding the associated risks and proper management techniques has increased, evidence indicates persistent gaps in knowledge, as well as deficiencies in attitudes and practices that still exist among healthcare workers (Eslami et al., 2017; Karmakar et al., 2016). Many studies have been conducted to assess the training status of personnel and to provide insights for enhancing strategies (Ali et al., 2025). For example, research conducted in Iran, Brazil, and Bhutan has revealed a lack of knowledge despite previous training. However, it also shows that higher knowledge and positive attitudes are associated with improved practices (Banstola et al., 2017; Letho et al., 2021; Matos et al., 2018; Vosoughi-Niri et al., 2017).

High awareness and positive attitudes are essential for successful waste management. Shortcomings in these areas can result in unsafe handling, increased infections, environmental damage, and higher costs (Elsayed et al., 2025). In summary, understanding the knowledge and attitudes of individuals towards hospital waste management is crucial for improving safety, optimizing waste management practices, and identifying educational needs within healthcare environments (Kusuma et al., 2024). Despite widespread awareness and extensive research in the domain of hospital waste management, some regions lack comprehensive investigations into the knowledge, attitudes, and practices of personnel in this field (Yousefi et al., 2021).

The research gap is particularly evident in South Khorasan Province, Iran, where comprehensive assessments of hospital staff's knowledge, attitudes, and practices toward waste management remain scarce. Addressing this gap is especially important given the projected increases in healthcare demand and waste generation associated with population growth and economic inflation (Akkajit et al., 2020; Imanian et al., 2024). Accordingly, the present study investigated the knowledge, attitudes, and practices of personnel at Imam Ali Hospital in Sarayan, South Khorasan. The results are expected to clarify the current status of hospital waste management and serve as a basis for developing targeted educational interventions that can mitigate health risks and enhance the effective implementation of waste management programs within the hospital.

2. Materials and Methods

2.1 Study Population and Sampling Method

This cross-sectional descriptive-analytical study was conducted in 2025 at Imam Ali Hospital in Sarayan, South Khorasan Province, Iran. The hospital operates with a capacity of 32 active beds. The study population comprised the entire staff of Imam Ali Hospital, including clinical personnel (physicians and nurses), paraclinical staff, and administrative and service personnel. Given the finite and manageable size of the target population, a full census approach was employed instead of sampling. Consequently, data was sought from all eligible members of the workforce. This methodology was chosen to achieve complete population coverage, eliminate sampling error, and thus minimize potential selection bias.

2.2 Data Collection Tool

The questionnaire used in this study was a previously developed and validated Persian instrument for assessing knowledge, attitudes, and practices (KAP) regarding medical waste management among healthcare personnel (Mousavi et al., 2020; Mousavi et al., 2016). The original questionnaire was constructed based on relevant literature and internationally recognized guidelines, including items recommended by the U.S. Environmental Protection Agency (EPA) for hospital-generated waste materials. Content validity was established through evaluation by a panel of experts and researchers specializing in environmental engineering and medical waste management. A pilot test involving 30 participants with different professional backgrounds (doctors, nurses, and official staff) was conducted to ensure clarity and applicability, resulting in minor revisions. In its original validation, the questionnaire demonstrated excellent internal consistency, with a Cronbach's alpha coefficient of 0.90 (Mousavi et al., 2020; Mousavi et al., 2016). In the present study, the reliability of the questionnaire was reassessed separately for each domain. Since the knowledge and practice items produced dichotomous (0/1) responses, the Kuder–Richardson 20 (KR-20) coefficient was calculated for these two domains, yielding values of 0.701 for knowledge and 0.767 for practice. The attitude domain, which used multiple response categories, was assessed using Cronbach's alpha, yielding a coefficient of 0.852. Overall, all three coefficients met the commonly used threshold of 0.70, indicating acceptable to

good internal consistency across the three domains. The final questionnaire comprised 44 items divided into four separate sections. The first part of the study focused on collecting demographic and background information from the participants. This information included their age, gender, employment status, history of working in hospitals, completion of waste management training courses, and exposure to diseases related to hospital waste.

The second section consisted of 13 multiple-choice questions that assessed the participants' level of knowledge regarding hospital waste and the correct methods of collecting it. Each correct answer was awarded one point, while incorrect answers received zero points.

The third part of the questionnaire evaluated staff practices with 12 questions. These questions covered topics such as how to handle and separate waste, the use of personal protective equipment, compliance with hospital waste management guidelines, and the history of vaccination against hepatitis B. In order to evaluate this section, a point was awarded for a "Yes" response, indicating adherence to the specified criteria, while a "No" response received no points. The fourth segment of the questionnaire assessed the staff's attitudes toward hospital waste management using a 4-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). This section included both positively and negatively worded items to capture a balanced range of perspectives and minimize response bias.

In order to ensure participation, it is important to conduct thorough research before administering the questionnaire to each participant. It is crucial to fully explain the confidentiality of the information and responses provided. By ensuring that these aspects are comprehensive and obtaining the consent of the volunteers, the questionnaires were administered among active personnel in various job categories and collected after completion. Data collection took place from Saturday to Thursday, specifically during the morning shift.

2.3 Data analysis

Data were entered into SPSS version 26 software and described using descriptive statistics, including frequency tables and measures of central tendency and dispersion. Following assessment of normality using the Kolmogorov-Smirnov test, which indicated non-normality of the variables, Spearman's correlation coefficient, the Mann-Whitney U test, and the Kruskal-Wallis test were employed to examine the research hypotheses.

3. Results and Discussion

3.1 Demographics of the Study Population

The demographic profile of the study participants depicted a diverse staff composition (Table S1). The majority of participants were female (58.9%) and held a bachelor's degree (72.3%). Nurses represented the largest occupational group (42.6%), followed by physicians and paraclinical personnel. Additionally, 45.6% reported completing formal training courses in waste management.

Given their crucial role in the production and primary handling of medical waste in clinical settings, the substantial representation of nurses in the study population enhances the relevance and interpretability of the findings. This workforce composition allows the results to be more closely aligned with routine waste generation and handling processes at the point of care, thereby strengthening the contextual validity of the study outcomes. This emphasizes the relevance of focusing on nurses' practices to understand broader institutional compliance and potential gaps.

According to Table S2, the study subjects had a mean age of 33.72 ± 7.08 years and a mean work experience of 8.34 ± 6.89 years. The youngest participant was 22 years old, while the oldest was 56. The range of work experience ranged from 1 to 33 years. These findings suggest that the workforce is relatively young and encompasses a broad spectrum of professional experience, a characteristic that may influence both responsiveness to training interventions and consistency in the application of waste management protocols. In the study by Mousavi et al. (2020), 64.4% (n = 96) had completed waste management training courses. The average age of the participants in this study was 33.35 ± 8.59 years, and their average work experience was 7.8 years (Mousavi et al., 2020). Similarly, in another study, 75.78% (n = 291) of participants reported having received relevant training (Ahmad et al., 2024). In contrast, the study by Letho et al. (2021) reported that most participants had not received any formal training in waste management (56.8%), which is comparable to the findings of the present study. Variations observed in training coverage across studies may be attributed to differences in institutional priorities, availability of structured educational programs, and the extent of regulatory enforcement related to healthcare waste management.

3.2 Assessment of Knowledge, Attitude, and Practice among Healthcare Workers

According to Table S3, the mean scores for knowledge, attitude, and practice among the research subjects were 10.43 ± 2.14, 38.39 ± 5.28, and 8.66 ± 2.87, respectively. These results reflect an overall average to good level of knowledge, attitude, and practice toward hospital waste management among personnel at Imam Ali Hospital in Sarayan. The findings indicate that healthcare workers are generally aware of the importance of proper waste management and the potential risks associated with inappropriate handling.

However, the comparatively lower practice score highlights a gap between knowledge and actual implementation. This divergence suggests that positive knowledge and attitudes do not necessarily translate into optimal practice unless supported by continuous supervision, adequate infrastructure, and clearly defined operational procedures. Consequently, targeted educational programs combined with systematic monitoring may be required to improve compliance at the practical level.

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Consistent with these findings, Dewi et al. (2024) reported that knowledge and attitude exert a positive and significant influence on medical waste management practices. The favorable attitudes observed in this study are consistent with the findings of Soyam et al. (2017), who also reported a similar disposition among healthcare workers towards hospital waste management. Nevertheless, discrepancies in reported practice levels across studies may reflect contextual factors such as workload intensity, institutional monitoring systems, and the availability of standardized guidelines. In line with the present study, Letho et al. (2021) demonstrated that despite adequate awareness, compliance with waste management procedures remained suboptimal in practice.

3.3 Level of Knowledge

Regarding the frequency of correct responses concerning knowledge (Table 1), the highest levels of knowledge were observed for methods of hospital waste management (95.5%) and the transmission of disease through medical waste (94.6%). In contrast, the lowest level of knowledge (the smallest proportion of correct responses) concerned knowledge of the 2010 Hospital Waste Management Law, with only 31.9%. These findings indicate a general understanding of the infectious risks posed by hospital waste among hospital personnel. Nevertheless, a significant knowledge gap concerning the specifics of the 2010 Hospital Waste Management Law was identified, potentially hindering compliance and effective implementation of waste management policies.

A study conducted by Agyekum et al. (2022) similarly showed that a significant proportion of healthcare professionals (95.9%) had adequate knowledge about proper medical waste management practices, and 92.1% followed the necessary guidelines related to hospital waste. These results are largely consistent with the findings of the present study, highlighting a general trend of high knowledge among healthcare personnel. In line with the present study, Dewi et al. (2024) also concluded that both knowledge and attitude exert a positive and significant influence on individuals' practical performance in medical waste management.

According to Chowdhary (2018), knowledge of biomedical waste management regulations was at an acceptable level among healthcare professional groups, including physicians, nurses, and laboratory technicians, although certain groups exhibited lower levels of knowledge. In contrast, the study by Soyam et al. (2017) reported that approximately 75% of personnel were aware of hospital waste management regulations. This variability in knowledge levels may reflect differences in access to educational and promotional programs related to the Biomedical Waste Management (BMWM) law. Furthermore, increased knowledge has been facilitated through media coverage, government initiatives, and political commitments aimed at promoting public knowledge, including among healthcare personnel (Soyam et al., 2017).

According to the data presented in Table 1, a high percentage of participants were familiar with the color-coding system used for hospital waste collection bins. These findings are consistent with the results of previous studies, suggesting that color-coding is a widely recognized and implemented element of hospital waste management systems. For instance, Akkajit et al. (2020) reported that most respondents used color coding to identify and classify waste, indicating its practicality and effectiveness in daily clinical routines. In another study, it was also found that a significant majority of individuals (82%) across different professional groups within healthcare facilities demonstrated satisfactory knowledge of color-coded waste bins (Parida et al., 2019). Furthermore, Letho et al. (2021) found that most waste bins were color-coded (83.85%), reflecting respondents' ability to distinguish between infectious and non-infectious waste streams.

Based on these findings, segregation of medical waste at its source emerges as the most fundamental and indispensable step in any effective and safe waste management strategy. As recommended by the U.S. EPA, this process should begin at the point of waste generation (Adu et al., 2020). Therefore, it can be concluded that a thorough understanding of color-coded container systems, combined with their consistent and accurate application, is crucial for ensuring proper waste separation and for reducing potential health and environmental risks (Ahmad et al., 2024).

Findings from Table S4 regarding knowledge of disease transmission through medical waste showed that the highest frequency of responses (71.6%, corresponding to 68 participants) related to general infectious disease transmission. In contrast, 48.4% (46 participants) identified AIDS, and 45.3% (43 participants) recognized hepatitis B as transmissible through medical waste. Knowledge regarding the transmission of tuberculosis (16.8%) and hepatitis A (17.9%) via hospital waste was comparatively lower, indicating uneven knowledge across different disease categories. If contaminated hospital waste is not properly segregated and disposed of, there is a considerable risk of transmitting waste-related infectious diseases to both healthcare staff and the surrounding environment. Accordingly, these results highlight the need for more comprehensive educational interventions that emphasize the full range of diseases associated with medical waste exposure. In the study by Soyam et al. (2017), similar to the present findings, most participants (95.8%) had knowledge of the various health problems associated with medical waste. This similarity may be attributed to comparable training approaches and institutional safety policies. Likewise, Chowdhary (2018) reported a general knowledge of biomedical waste-related risks among healthcare personnel, although knowledge varied by disease type; while most physicians and nurses recognized HIV and hepatitis B transmission, knowledge of hepatitis C was significantly lower. In contrast, Letho et al. (2021) observed higher knowledge levels, with approximately 80% and 90% of respondents recognizing the transmission of HIV/AIDS and hepatitis B and C, respectively, possibly reflecting differences in national guidelines, training intensity, or occupational exposure.

Table 1. Frequency Distribution of Correct Responses to Knowledge-Related Items among Study Participants

	Questions about the field of knowledge	Number of Respondents	Percentage
1	Having information about BMW (Bio Medical Waste)	58	63.7
2	Having knowledge of the 2010 Hospital Waste Management Law	30	31.9
3	Having information about hospital waste management	65	69.1
4	Knowing the 2010 Hospital Waste Management Law	48	51.6
5	Having information about the current generation of medical waste in the hospital.	82	92.1
6	Having familiarity with managing all types of hospital waste	66	72.5
7	Having information about the hospital's specific management practices regarding medical waste disposal	81	92
8	Being aware of the health risks associated with medical waste	83	90.2
9	Being aware that medical waste causes disease transmission	87	94.6
10	Being familiar with different colors for hospital waste collection bins	86	91.5
11	Having guidelines for color coding in the workplace	57	63.3
12	Identifying methods for hospital waste management	84	95.5
13	Knowing what type of waste each colored box is designated for collection	78	87.6

3.4 Attitude Level

Table 2 shows that the attitude survey revealed a predominance of positive attitudes among hospital personnel. Specifically, 74.2% (69 participants) expressed agreement with the implementation of documented training programs for hospital waste management. Additionally, 76.7% (69 participants) agreed that the waste management situation could be improved by assigning responsibility for hazardous waste disposal directly to hospitals. Strong positive attitudes were also observed regarding the necessity of employing specialized personnel in the field of hospital waste management (66% agreement) and the importance of holding regular training programs (64.9% agreement). In contrast, the lowest level of agreement (56.3%) was related to transferring hospital waste management responsibilities to the private sector.

The presence of a positive attitude among hospital personnel can be considered a key enabling factor for the successful implementation of hospital waste management programs, as active employee participation can reduce resistance to organizational change (Dewi et al., 2024). The positive attitude observed in the present study is in line with findings from other studies in the field of waste management.

For example, Akkajit et al. (2020) reported that the majority of respondents (97.4%) agreed that medical waste generated in clinical settings should be managed properly. Moreover, 71.5% of respondents believed that medical waste management should be overseen by local government organizations, such as municipalities, under closer regulatory supervision. Most respondents also expressed a willingness to participate in training programs and seminars provided by public health authorities, highlighting the perceived value of continuous education in this domain (Akkajit et al., 2020).

Overall, the findings of the present study, together with previous research, emphasize the central role of ongoing education in medical waste management (Kumar et al., 2013). However, the effectiveness of such training programs and the actual reduction of associated risks largely depend on establishing and reinforcing positive attitudes, as well as ensuring active engagement of personnel. A positive attitude serves as a crucial link between knowledge acquisition and its translation into effective practice. Therefore, fostering positive attitudes among hospital personnel is essential for achieving sustainable and effective waste management outcomes, as it not only enhances participation but also contributes substantially to the overall improvement of medical waste management practices (Khaled & Ali, 2022; Manchanda et al., 2015).

3.5 Practice Level

According to the results presented in Table 3 under the practice dimension, 95.6% of personnel demonstrated correct practices in collecting sharps and needles, while 92.1% adhered to the required instructions related to hospital waste management.

These findings suggest that staff practice is generally satisfactory, particularly with respect to compliance with safety guidelines for handling sharps. However, lower levels of practice were observed regarding knowledge of the number of injuries associated with medical waste (28.1%) and knowledge of appropriate methods for collecting disposable plastic materials (57.8%). This gap in practice may be attributed to insufficient training programs that do not properly cover these specific aspects, or to the lack of clearly defined standard operating procedures for medical waste segregation at the point of generation (Anozie et al., 2017).

The observed practice patterns are largely comparable to those reported in similar studies. For instance, Akkajit et al. (2020) found that 95.6% of respondents correctly disposed of medical sharps in safety boxes. Similarly, Gupta et al. (2016) reported that more than 80% of healthcare personnel used puncture-resistant containers for sharps. Moreover, Soyam et al. (2017) observed that approximately 70% of healthcare workers followed a consistent approach to medical waste segregation. These similarities likely reflect shared safety priorities in clinical environments, while the remaining gaps may be explained by differences in training depth, institutional monitoring, and availability of clear operational guidelines.

Table 2. Frequency Distribution of Responses to Attitude-Related Items among Study Participants

	Attitude domain questions Frequency (%)	strongly disagree	disagree	agree	strongly agree
1	Having appropriate practices of officials regarding waste management at Imam Ali Hospital	2 (2.2)	4 (4.4)	68 (74.7)	17 (18.7)
2	The necessity of periodically implementing hospital waste management training programs	1 (1.1)	5 (5.3)	61 (64.9)	27 (28.7)
3	The necessity of hiring specialists in the field of hospital waste management	0	3 (3.2)	62 (66)	29 (30.9)
4	Implementing a recycling program at the source of hospital waste production reduces both health and environmental impacts	3 (3.4)	4 (4.5)	52 (58.4)	30 (33.7)
5	Improving the state of hospital waste management should be a top priority for hospital management activities	1 (1.1)	19 (20.2)	57 (60.6)	17 (18.1)
6	The waste management status of Imam Ali Hospital is at a desirable and acceptable level	1 (1.1)	7 (7.7)	67 (73.6)	16 (17.6)
7	Compliance with safety precautions by the staff in the waste management department of Imam Ali Hospital	1 (1.1)	11 (12.1)	57 (62.6)	22 (24.2)
8	Adequacy of equipment used in the waste management sector	2 (2.2)	20 (22.2)	58 (64.4)	10 (11.1)
9	Having the desired role of launching the hospital elimination system in improving the management of Imam Ali Hospital	1 (1.1)	7 (7.8)	60 (66.7)	22 (24.4)
10	Improving the situation with the presence of an environmental health expert in the waste management department of Imam Ali Hospital	1 (1.1)	7 (7.6)	60 (65.2)	24 (26.1)
11	Improving the situation of hospital waste management by transferring hospital waste management to the private sector	2 (2.3)	22 (25.3)	49 (56.3)	14 (16.1)
12	The need for documented training programs for hospital waste management	0	5 (5.4)	69 (74.2)	19 (20.4)
13	Effectiveness of improving waste management by transferring responsibility for hazardous hospital waste disposal to the hospital	1 (1.1)	5 (5.6)	69 (76.7)	15 (16.7)

Table 3. Frequency Distribution of Responses to Practice -Related Items among Study Participants

	Questions about the field of practice	Number of Respondents	Percentage
1	Comply with the necessary instructions regarding hospital waste in every place of work.	82	92.1
2	Separation of hospital waste at the production site	79	90.8
3	Disinfection of hospital waste before disposal on site	63	74.1
4	Use of personal protective equipment when handling hospital waste	68	80
5	Proper storage of hospital waste collected at the workplace	71	84.5
6	Using a safety box equipped with a syringe and needle cutter	74	86
7	Knowing how to dispose of sharps and needles	86	95.6
8	Knowing how to collect and dispose of medical waste, such as body organs	55	62.5
9	Getting vaccinated against hepatitis B	81	89
10	Availability of information on the number of injuries related to medical waste	25	28.1
11	Knowing where medical waste is treated	61	67
12	Knowing the correct way to collect disposable plastics	52	57.8

3.6 Investigating the relationship between the KAP of personnel

Based on the data presented in Table 4, statistically significant relationships were identified among all three variables examined. The strongest positive and significant association was observed between staff knowledge and practice ($r = 0.702$, $P < 0.001$). These findings indicate that improvements in staff knowledge and understanding of hospital waste management are closely associated with better practical performance, supporting the effectiveness of targeted training interventions (Mousavi et al., 2020).

This relationship suggests that focused and well-designed educational programs can lead to meaningful improvements in staff behavior and waste management practices (Letho et al., 2021). In contrast, weaker yet statistically significant correlations were identified between knowledge and attitude ($r = 0.294$, $P = 0.004$) and between attitude and practice ($r = 0.28$, $P = 0.007$). These results imply that while knowledge and positive attitudes are necessary prerequisites for appropriate practice, they may not be sufficient on their own. Additional enabling factors, such as managerial support, availability of resources and equipment, and a supportive organizational culture, are likely required to achieve optimal and sustainable practice outcomes. Moreover, knowledge may function as an internal motivating factor influencing individual behavior and practical performance, as previously reported (Banstola et al., 2017). The findings of the present study are largely consistent with, yet also extend, previous research examining the relationships among knowledge, attitude, and practice in hospital waste management. For example, Letho et al. (2021) reported a strong and significant correlation between staff knowledge and practice, reinforcing the role of knowledge as a critical determinant of correct waste management behavior.

Similarly, Dewi et al. (2024) identified weak but significant correlations between knowledge and attitude and between attitude and practice, suggesting that attitude may act as an intermediate variable rather than a direct predictor of

practice. Furthermore, Mousavi et al. (2020) demonstrated a strong, positive, and significant association between knowledge and practice, further confirming that enhancing staff knowledge is a key driver of improved waste management practices across different healthcare settings.

Table 4. The Relationship between KAP using Spearman's Correlation Coefficient

Correlation coefficient (significant value)	knowledge	Attitude	practice
knowledge	-	-	-
Attitude	0.294 (0.004)	-	-
practice	0.702 (<0.001)	0.28 (0.007)	-

3.7 Investigating the relationship between KAP with demographic variables

3.7.1 Age and work experience

As shown in Supplementary Table S5, neither age nor work experience was significantly associated with personnel's knowledge, attitudes, or practices regarding hospital waste management ($P > 0.05$). Age showed negligible correlations with knowledge (r = 0.006, $P = 0.955$), practice (r = 0.133, $P = 0.207$), and attitude (r < 0.001, $P = 0.998$). Similarly, work experience was not significantly correlated with knowledge (r = 0.142, $P = 0.187$), practice (r = 0.153, $P = 0.156$), or attitude (r = 0.080, $P = 0.465$). These findings suggest that older age or longer work experience alone does not necessarily translate into better knowledge, more favorable attitudes, or improved waste management practices. Therefore, continuous education and periodic retraining should be implemented for all personnel, regardless of age or length of service.

3.7.2 Gender

According to the data presented in Table 5, no statistically significant difference was observed between male and female personnel in terms of their scores for KAP related to hospital waste management ($P > 0.05$). These findings suggest that both genders are exposed to similar training conditions and share comparable expectations regarding waste management practices within the hospital. Therefore, the implementation of comprehensive and integrated training programs aimed at improving knowledge, attitude, and practice in waste management for all personnel, irrespective of gender, appears to be both appropriate and effective (Kumar et al., 2015).

3.7.3 Education Level

As shown in Table 5, there was no statistically significant difference in knowledge, attitude, or practice scores across educational levels (diploma or lower, associate degree, bachelor's degree, and master's degree or higher). Among these groups, participants with an associate degree showed the highest knowledge score [11.5 (9.25–13)], while those with a diploma or lower had the highest attitude [42 (39–45)] and practice [11 (7–12)] scores. These findings suggest that academic education level alone may not serve as a decisive determinant of personnel knowledge, attitudes, or practices in hospital waste management. This pattern further implies that in operational and practice-oriented areas, such as waste management, hands-on experience and job-specific in-service training may exert a greater influence than formal academic qualifications. Consequently, these results underscore the importance of designing practical, role-based, and targeted training programs tailored to specific job categories, rather than relying solely on educational background (Desta et al., 2017).

3.7.4 Job Title

Based on the results presented in Table 5, knowledge and practice scores varied significantly across job titles, whereas attitude scores did not show a statistically significant difference. Administrative- financial staff had the lowest knowledge score [9 (7-11)], whereas support staff recorded the highest [12 (10–12.5)]. In terms of practice, nurses achieved the highest score [11 (8–12)], while administrative and financial staff had the lowest [6 (3.5–9)]. Although attitude did not differ significantly by job title, support staff recorded the highest score [42 (38.5–46)]. Post-hoc pairwise comparisons with Bonferroni correction further clarified these findings. For knowledge, administrative and financial staff had significantly lower scores than both nurses (adjusted $P = 0.016$) and support staff (adjusted $P = 0.026$). No other pairwise comparisons for knowledge remained statistically significant after adjustment. For practice, administrative and financial staff had significantly lower scores than nurses (adjusted $P < 0.001$), whereas the comparison between administrative and financial staff and support staff was not statistically significant after Bonferroni correction (adjusted $P = 0.052$). The corresponding average-rank distributions for knowledge and practice are presented in Figures 1 and 2, respectively. The significant differences observed in knowledge and practice levels across job categories appear to be closely aligned with the nature, scope, and operational demands of each professional role. Support staff are often directly involved in waste collection and handling processes, which necessitates a high degree of practical knowledge and compliance with safety measures. Similarly, nurses are required to strictly adhere to waste management standards due to their central role in waste segregation at the point of generation and their frequent contact with potentially contaminated materials (Sehgal et al., 2015).

These findings highlight that effective hospital waste management depends on job-specific and role-oriented training strategies, tailored to the distinct responsibilities of each occupational group (Elsayed et al., 2020). Conversely, the absence of significant differences in attitude across job categories suggests a uniformly positive perception of the importance of waste management among hospital personnel (Akter et al., 2002). The observed variation in knowledge and practice by job title is also consistent with findings from previous studies. For example, Woith et al. (2010) reported significant differences in knowledge levels

across healthcare professions, with physicians demonstrating higher knowledge scores than nurses and support staff, reflecting professional hierarchies that may influence waste management practices and outcomes.

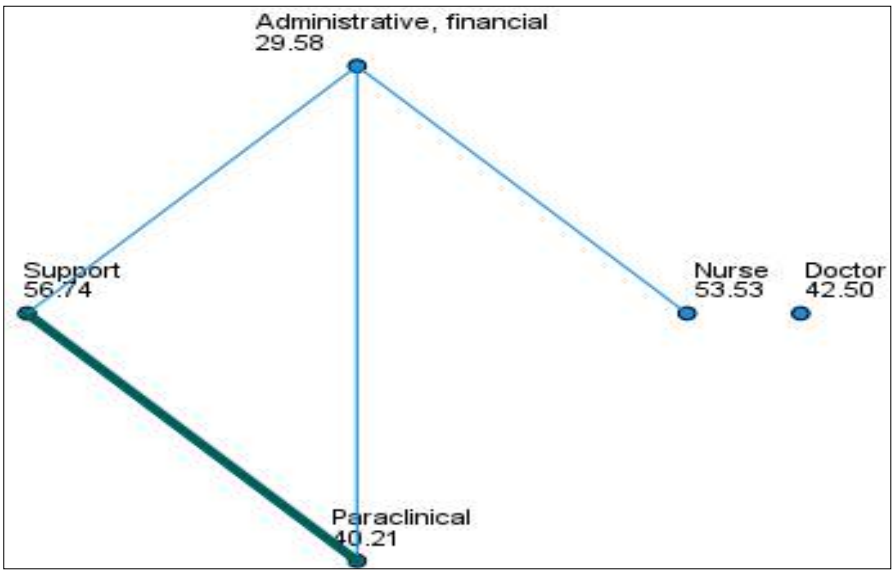


Figure 1. Pairwise comparisons of knowledge scores according to job title based on average ranks

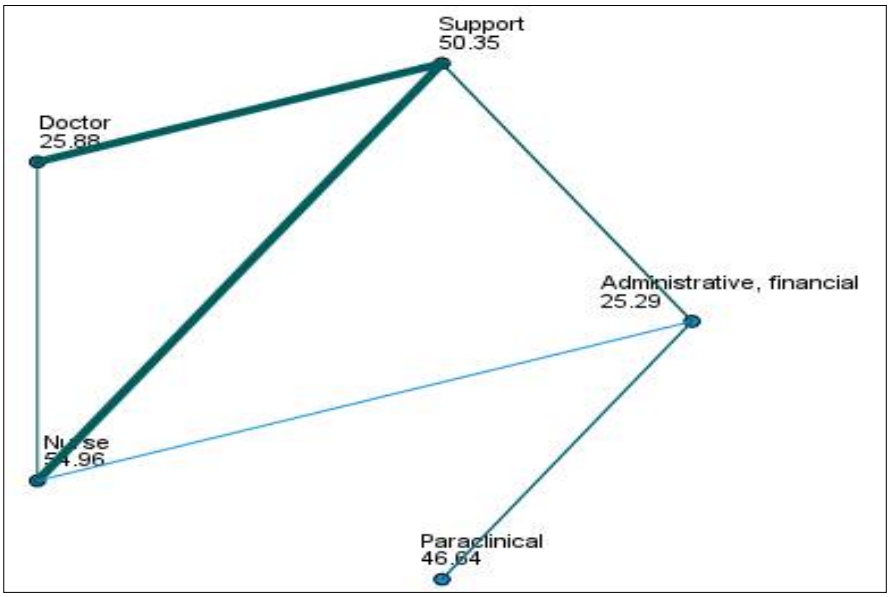


Figure 2. Pairwise comparisons of practice scores according to job title based on average ranks

3.7.5 Effect of Training Courses

The results presented in Table 5 demonstrated a statistically significant positive association between participation in waste management training courses and both knowledge and practice scores. Personnel who had completed the training courses had higher median knowledge [12 (10–13)] and practice [11 (9–12)] scores compared with those who had not received training [9.5 (8–11) and 8 (5.25–9.75), respectively]. In contrast, no statistically significant difference was observed in attitude scores between trained and untrained personnel, with median scores of 39 (36–43) and 39 (35.25–42), respectively. These findings highlight the critical role of regular, practical, and hands-on training in improving hospital waste management performance. The lack of a measurable effect on attitude suggests that attitudinal changes may require more comprehensive or prolonged interventions, rather than short-term theoretical training alone (Kumar et al., 2016). The present results are in line with previous studies confirming the positive impact of education on medical waste management.

For instance, Mousavi et al. (2020) reported that 70.58% of paraclinical staff completed waste management training courses, which led to enhanced knowledge and practice.

Similarly, Kumar et al. (2016) demonstrated statistically significant improvements in knowledge, attitude, and practice of hospital staff following targeted training interventions. These results suggest that fostering positive attitudes through training may help reduce resistance to change and increase active participation in waste management programs. Furthermore, Joseph reported that training workshops significantly improved healthcare workers' knowledge and awareness, with post-training scores showing substantial increases ($p < 0.0001$) (Joseph et al., 2024). Soni et al. (2020) also observed marked improvements in knowledge and practice among participants following biomedical waste management training sessions, underscoring the effectiveness of targeted and role-specific educational programs.

Table 5. Comparison of Knowledge, Attitude, and Practice Scores by Gender, Education Level, Job Title, and Training Course Participation

Variable name	Categories	Knowledge			Attitude			practice		
		Median (Q1–Q3)	Test statistic	*p-value*	Median (Q1–Q3)	Test statistic	p-value	Median (Q1–Q3)	Test statistic	*p-value*
Education level	Diploma or lower	10 (9-12)	1.043	0.791	42 (39-45)	4.933	0.177	11 (7-12)	2.354	0.502
	Associate degree	11.5 (9.25-13)			39 (34.5-48)			10 (6.75-11.75)		
	Bachelor's degree	11 (9-12)			39 (35.75-41.25)			9 (7-11)		
	Master's degree or higher	11.5 (8.75-13)			41.5 (34.5-43.5)			7 (5-11.25)		
Job title	Doctor	10 (9-11.75)	13.535	0.01	38 (31.25-41.75)	8.603	0.072	7 (4.5-8.75)	18.055	0.001
	Nurse	11 (10-13)			39 (35-41)			11 (8-12)		
	Paraclinical	9.5 (7-12.25)			40 (39-41.25)			8.5 (6.75-11.25)		
	Support	12 (10-12.5)			42 (38.5-46)			10 (6.5-11)		
	Administrative-financial	9 (7-11)			38 (33.5-43)			6 (3.5-9)		
Gender	Women	11 (9-12)	-0.242	0.809	39 (36-41)	-0.901	0.368	9 (7-11)	-0.289	0.772
	Men	11 (9-12)			39 (36-43)			9 (6-11)		
Taking a training course	Yes	12 (10-13)	-4.218	0.000	39 (36-43)	-0.594	0.553	11 (9-12)	-4.952	0.000
	No	9.5 (8-11)			39 (35.25-42)			8 (5.25-9.75)		

4. Conclusion

This study assessed the KAP of staff at Imam Ali Hospital in Sarayan concerning hospital waste management. The findings indicate that hospital personnel generally possess an acceptable level of knowledge and maintain a positive attitude toward hospital waste management. Nevertheless, certain operational practices and aspects of legal awareness in the field of hospital waste management still require further strengthening and improvement. Statistically significant correlations among knowledge, attitude, and practice, with the strongest association observed between knowledge and practice, indicate that enhancing staff knowledge may directly contribute to improved waste management performance. Observing the positive effect of completing waste management training courses on raising knowledge and improving personnel practice also confirms the key role of targeted and practical training. This underscores the need to design and implement continuous and comprehensive training programs that are periodically updated and formally evaluated. Such programs should specifically focus on source segregation, strict adherence to safety protocols, and the correct use of personal protective equipment (PPE). Since significant statistical differences were observed in knowledge and practice scores among different job categories, training must be tailored to the specific roles and needs of each group, including nurses, physicians, and support staff. To achieve this, it is recommended to implement continuous and specialized training, alongside studies to evaluate the effectiveness of these interventions. Furthermore, sufficient financial resources must be allocated to ensure the effective operation and maintenance of waste neutralization equipment, the systematic provision of specialized training programs, and the continuous procurement of appropriate safety equipment. In addition, ongoing and rigorous monitoring through routine internal audits and performance indicators is essential to identify, document, and address operational challenges in waste management practices.

Finally, it is suggested to ensure compliance with safety standards in medical waste management by integrating measurable waste management benchmarks into managerial performance reviews; and by developing clear organizational policies. All of these efforts are aimed at improving hospital waste management practice and safeguarding human health and the environment.

Authors' Contributions

Senobar Imanian: Writing-original draft; Writing-review & editing. **Malihe Ram:** Formal analysis; Methodology; Validation; Visualization. **Fatemeh Samiei:** Conceptualization; Methodology. **Farzaneh Fanaei:** Conceptualization; Investigation; Methodology; Project administration; Supervision; Validation; Visualization; Writing-original draft; Writing-review & editing. **Masoumeh Heravi:** Data curation; Investigation. **Mahla Abbasi:** Data curation; Investigation.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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Ethical Considerations

This study was approved by the Ethics Committee of Birjand University of Medical Sciences under the ethical code of IR.BUMS.REC.1404.332.

Using Artificial Intelligence

No artificial intelligence was applied.

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