Occupational Safety-Based Medical Waste Management Performance Of Health Care Workers: A Cross-Sectional Study

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Abstract

Background: Healthcare workers' performance in medical waste management directly impacts their occupational safety by reducing exposure to hazards; this performance is improved through proper training, consistent adherence to guidelines, adequate access to personal protective equipment (PPE) **Aim**: The study aims to assess healthcare workers' performance based on occupational safety regarding medical waste management by assessing their knowledge, attitude, and practice. **Subjects and Methods**: It was carried out at primary health care centers and governmental hospitals in Damanhour city using a cross-sectional descriptive design on 96 nurses and 34 housekeepers. The data was collected using two different versions of self-administered questionnaires and observation checklists, one for nurses and one for housekeepers. **Results**: Only 33.3% of the nurses had satisfactory knowledge, 68.8% had positive attitudes, 61.5% had adequate reported practice and only 34.4% had adequate observed practice. Significant positive correlations were found between nurses' scores of knowledges attitudes, reported, and observed practices. Overall, 44.1% of the housekeepers had satisfactory knowledge, 73.5% had positive attitudes, 91.2% had adequate reported practice, and 38.2% total observed practice. **Conclusion and recommendations**: The HCWs in the study settings have deficient knowledge of medical waste management, with more positive attitudes and less adequate practice. The main recommends clear policies and procedures with awareness programs to make the guidelines known to all HCWs. Close monitoring and supervision are necessary, with rewards for adequate practices. Further research is proposed to investigate the effectiveness of training on HCWs' knowledge, attitudes, and practice of safe medical waste management.

Keywords; Healthcare workers; medical waste management; safety practice; occupational safety.

INTRODUCTION

Healthcare waste management is a critical aspect of healthcare delivery, ensuring the safety of both patients and healthcare workers. Proper waste management practices are essential to prevent the spread of infections, reduce environmental pollution, and safeguard public health **(Letho et al., 2021)**. Healthcare workers play a pivotal role in waste management within healthcare

facilities, and their performance in this regard directly impacts occupational safety **(Udayanga et al., 2023)**.

Occupational safety in healthcare waste management is paramount for several reasons. Firstly, healthcare workers are at risk of exposure to hazardous materials present in medical waste, including infectious agents, toxic chemicals, and sharp objects. Improper handling of such waste can lead to injuries, infections, and long-term health complications among healthcare workers **(Gupta et al., 2023)**. Secondly, inadequate waste management practices can result in the transmission of infectious diseases to patients, staff, and the community at large. Thus, ensuring occupational safety in waste management is not only vital for the well-being of healthcare workers but also for overall public health **(Bansod and Deshmukh, 2023)**. Moreover, prioritizing occupational safety reflects the ethical imperative to protect the health, dignity, and rights of healthcare workers who dedicate their lives to caring for others **(Young and Smith, 2023)**.

Healthcare workers encounter various challenges in managing healthcare waste safely. These challenges include inadequate training and awareness regarding waste segregation, lack of proper infrastructure and equipment for waste disposal, insufficient adherence to guidelines and regulations, and limited resources for implementing effective waste management practices **(Manekar et al., 2022)**. Additionally, high workload and time constraints in healthcare settings may hinder healthcare workers' ability to prioritize waste management activities, leading to suboptimal performance in this critical area **(Rajak et al., 2022)**.

Improving healthcare workers' performance in waste management requires a multifaceted approach that addresses underlying issues comprehensively. Firstly, healthcare facilities should prioritize training and education programs in waste segregation, handling, and disposal procedures **(Kuppusamy et al., 2022)**. Secondly, healthcare facilities must invest in appropriate infrastructure and equipment for waste segregation, storage, and disposal with the provision of designated waste bins, containers, and disposal units for different types of waste, and ensuring the availability of personal protective equipment (PPE) to minimize the risk of exposure **(Millanzi et al., 2023)**. Quality assurance programs should include mechanisms for soliciting feedback, analyzing performance data, and implementing process improvements to optimize compliance with regulatory requirements **(Nassour et al., 2023)**.

Furthermore, healthcare organizations should establish clear policies and protocols for waste management, outlining responsibilities, procedures, and guidelines for healthcare workers to follow. Regular monitoring and auditing of waste management practices can help identify areas for improvement and ensure compliance with regulations and standards **(Kenny and Priyadarshini, 2021)**. However, implementing these practices may require investment, infrastructure, and collaboration with waste management partners, posing logistical and financial challenges for healthcare facilities **(Doad et al., 2023)**.

Healthcare workers' performance in waste management is integral to ensuring occupational safety and preventing the spread of infections in healthcare settings. By addressing challenges such as inadequate training, lack of infrastructure, and limited resources, healthcare facilities can enhance healthcare workers' effectiveness in managing healthcare waste safely and responsibly. Through investment in training, infrastructure, policies, and interdisciplinary collaboration, healthcare organizations can create a culture of safety and sustainability in waste management, ultimately safeguarding the well-being of both healthcare workers and the broader community **(Janik-Karpinska et al., 2023)**.

Collaboration and communication among healthcare workers, environmental services staff, and waste management personnel are also essential for effective waste management.

Interdisciplinary teamwork facilitates the exchange of knowledge, promotes best practices, and fosters a culture of safety and accountability within healthcare facilities **(Puška et al., 2023)**.

Significance of the Study

The poor collection, treatment, and disposal of medical waste in Egypt constitute a significant health and environmental problem. Among the most important factors underlying the problem is the lack of awareness and knowledge about safe waste disposal and management among healthcare workers, which would lead to inappropriate related attitudes and inadequate practices among them. Nurses and housekeepers are at the frontline level in waste management based on occupational safety. This study is an attempt to provide needed information about healthcare workers' knowledge, attitudes, and practices related to safe medical waste management.

AIM OF THE STUDY

This study's aim was to assess healthcare workers' performance based on occupational safety regarding medical waste management by assessing their related knowledge, attitudes, and practices.

SUBJECTS AND METHODS

Study design and period: A cross-sectional descriptive study was implemented from 5 October to 30 December 2022

Settings: the study was conducted at the main primary health care centers in Damanhour city, as well as the governmental hospitals in the city, namely the Fevers and Chest Diseases Hospitals.

Subjects: All healthcare workers involved in waste management in the settings and available at the time of data collection were 130 healthcare workers: 96 nurses and 34 housekeepers. They were all included in the study as a convenience sample.

Data collection tools: The data for this study was collected using two different versions of self-administered questionnaires and observation checklists, one for nurses and one for housekeepers. The tools were developed by the researcher based on pertinent literature **(Prüss et al., 1999; Mourad Milik, 2021)**.

- Nurses' tools:

  o Self-administered questionnaire: This included:

    ▪ Nurses' personal and job characteristics as age, gender, marital status, nursing qualification, years of experience, etc. in addition to certain job characteristics such as previous training courses, and previous hazardous exposures.

    ▪ Knowledge questionnaire: This assessed nurses' knowledge of waste and waste management such as the definitions, safe disposal, occupational safety, hazards of waste, etc. It included Multiple Choice Questions (MCQs), True/False questions, as well as ranking questions. For scoring, each item, a score of one was given for a correct response and zero for the incorrect zero. For each area of knowledge and for the total questionnaire the scores of the items were summed up and the totals were divided by the number of

corresponding items, giving mean scores. These scores were converted into percentage scores. Knowledge was considered satisfactory if the percentage score was 60% or more and unsatisfactory if less than 60%.

- Attitude scale: used to evaluate nurses' attitudes towards safe waste management and occupational safety. It included 15 statements. Certain statements reflected nurses' positive attitude such as: "The lack of safe hospital waste management poses risks to the community." Others reflected negative attitudes such as: "Nurses have no important role in safe hospital waste management." The response to each statement was on a five-point Likert scale from "strongly disagree" to "strongly agree." For scoring, each statement, the responses "strongly agree," "agree," "uncertain," "strongly disagree," and "disagree" were respectively scored 5, 4, 3, 2, and 1. The scoring was reversed for negative statements so that a higher score indicates a more positive attitude. The total scores of the items were computed and the totals were divided by the number of the items, providing mean scores. These scores were converted into percentage scores. The attitude was considered positive if the percent score was 60% or more, and negative if less than 60%.

- Reported practice: used to assess nurses' reported practices of safe waste management and occupational safety. It included 7 items with sub-items asking about proper actions in case of a needlestick injury. The response to each statement was "always" to "sometimes," or "never." For scoring, each item, the responses from "always" to "never" were respectively scored 2, 1, and 0. The scores of the items were summed up and the total was divided by the number of the items, giving a mean score, which was converted into a percentage score. The reported practice was considered adequate if the percentage score was 60% or more, and inadequate if less than 60%.

- Observation checklist: This was developed by the researcher based on related literature to assess actual observed nurses' practice of hospital waste management based on occupational safety. It included checklists for: Universal Precautions: Hand washing (21 items), Gloving (5 items), and use of Personal Protective Equipment (4 items), as well as checklists for soiled linen (10 Items), and dealing with needles/sharps (7 items). For scoring, the items "not done" and "done" were scored "0" and "1", respectively. The items "not applicable" were not scored and were discounted from the totals. The scores of the items were summed-up and the total divided by the number of the items, giving mean scores, which were converted into percentage scores. The practice was considered adequate if the percentage score was 60% or more and inadequate if less than 60%.

- Housekeepers' tools:

  o Self-administered questionnaire which included:

    - Housekeeper's personal and job characteristics.

    - Knowledge questionnaire: included True/False and ranking questions covering definitions, safe disposal, occupational safety, hazards of waste, etc. Scoring was the same as for the nurses' tool.

    - Attitude scale: This was the same used for nurses.

- Reported practice: included 6 items with sub-items asking about proper actions in case of a needlestick injury. The response to each statement was "always" to "sometimes," or "never." For scoring, the responses from "always" to "never" were respectively scored 2, 1, and 0. The sum of the items' scores was divided by the number of the corresponding items, and it was converted into a percentage score. The reported practice of the housekeeper was judged adequate if the percentage score was 60% or more, and inadequate if less than 60%.

- Observation checklist: This was developed by the researcher based on related literature to assess actual observed housekeepers' practice of hospital waste management based on occupational safety. It included checklists for: Universal Precautions as Hand washing (3 items), Gloving (5 items), and Use Personal Protective Equipment (4 items), as well as for soiled linen (10 Items), and collection of waste (9 items). Scoring was the same as for the nurses' checklist.

Pilot study: A pilot study was carried out on a sample representing about 10% of the main study sample to assess the clarity and applicability of the tools. Since minor modifications were done, the pilot subjects were included in the main study sample.

Validity and reliability of the tools: The tools were presented to experts in Community Health Nursing to examine their face and content validity. The reliability of the attitude scale was measured by assessing its internal consistency. It showed a good degree of reliability with Cronbach's Alpha Coefficient 0.735.

Fieldwork: After securing official permission to conduct the study, the researchers visited the study settings and met with the medical and nursing directors of the selected hospitals and primary care centers to explain the aim and process of the study and gain their cooperation. The researchers then met with the nurses and housekeepers individually to explain the aim of the study and the data collection procedure. Those who provided their verbal informed consent to participate were given the forms with instructions on how to fill them out. Then, using the observation checklists, the researchers observed the individual nurses and housekeepers while performing their tasks. This served in assessing their actual observed practice.

Administrative and Ethical considerations: Official letters were addressed from the Dean of the Faculty of Nursing, Damanhour University to the hospital and centers' medical and nursing directors to obtain their permission to conduct the study. It clarified the aim of the study, and a copy of the data collection forms was attached. The study protocol was approved by the Nursing Research Ethics Committee in the Faculty of Nursing, Damanhour University. The researcher met with the study subjects individually to explain the aim of the study and to get verbal informed consent to participate. Total confidentiality and anonymity of any obtained data were ensured.

Statistical analysis: Data management and statistical analysis were carried out on SPSS 20.0 statistical software package. Data were presented using frequencies and percentages for categorical variables and means and standard deviations and medians for the quantitative ones. Cronbach' alpha coefficient was computed to examine the reliability of the developed tools through their internal consistency. Spearman rank correlation was used for the assessment of the inter-relationships between quantitative variables and ranked ones. To identify the independent predictors of the knowledge, attitude, and practice scores multiple linear regression analysis was used. Statistical significance was considered at p-value <0.05.

RESULTS

The sample of nurses consisted of 96 nurses whose ages ranged between 22 and 59 years, with a median of 37.0 years as presented in Table 1. The majority were females (92.7%), carrying a diploma degree in nursing (70.8%), and married (85.4%). Their median years of experience was 16.0, ranging between 1 and 41 years. The majority reported previous attendance of related training courses. Approximately two-fifths of them reported previous exposure to needle stick injuries (39.6%), and nosocomial infection (36.5%).

In the sample of housekeepers, ages ranged between 22 and 54 years, with a median of 36.0 years as displayed in Table 2. The majority were females (94.1%), with below diploma education (79.4%), and married (97.1%). Their median years of experience was 2.5, mostly <5 years (61.8%). The majority reported previous attendance of previous training courses in PPE. Less than one-fourth of them reported previous exposure to needle stick injuries (20.6%), and nosocomial infection (26.5%).

Table 3 indicates a wide variation in the knowledge of safe waste management among the nurses in the study sample. On one hand, none (0.0%) of them had satisfactory knowledge of segregation, and only 14.6% about the waste sources. On the other hand, 90.6% of them had satisfactory knowledge of the magnitude of waste problem, and 94.8% of safe waste disposal. Overall, only one-third (33.3%) of the nurses in the study sample had satisfactory total knowledge of waste management. Concerning the attitude towards safe waste management, the table shows a wide range of positive attitudes. It ranged between 33.3% for the attitude towards risks to 79.2% for preventive vaccination. Slightly more than two-thirds (68.8%) had a positive total attitude. As the table demonstrates, 61.5% of the nurses reported having adequate practice. However, the observed practice shows wide variation. Adequate practice ranged between 11.5% for dealing with soiled linen and 88.5% for safe needle/sharps disposal. Only 34.4% of them had adequate total observed practice.

As Table 4 indicates, there was a wide variation in the knowledge of safe waste management among the housekeepers. On one hand, none (0.0%) of them had satisfactory knowledge of segregation. Meanwhile, all of them (100.0%) had satisfactory knowledge of the risks of waste, and of safe waste disposal. Only 44.1% of them had satisfactory tot knowledge of waste management. As regards their attitude, the table 31 indicates a wide range of positive attitudes. It ranged between 29.4% for the attitude towards prevention to 100.0% for the risks. Overall, slightly less than three-fourths (73.5%) had a positive total attitude. As regards practice, 91.2% of the housekeepers reported having adequate practice. However, the observed practice shows some variability. Their adequate practice ranged between 14.7% for dealing with soiled linen to 61.8% for safe needle/sharps disposal. Only 38.2% of them had adequate total observed practice.

Table 5 demonstrates statistically significant weak positive correlations between nurses' scores of knowledge and observed practice (r=0.366), and between their attitude and reported practice (r=0.325). The knowledge, attitude, and practice scores had statistically significant weak to moderate negative correlations with nurses' age and experience years. Conversely, they had weak to moderate positive correlations with their nursing qualification level. The strongest correlation was between nurses' knowledge scores and their nursing qualification level (r=0.571).

Table 6 indicates a statistically significant weak positive correlation between housekeepers' scores of knowledge and reported practice (r=0.347). none of their scores had statistically significant correlations with any of their personal characteristics.

In multivariate analysis, Table 7 demonstrates that the statistically significant independent positive predictors of nurses' knowledge scores were their previous training in infection control and having previous nosocomial infection. Conversely, their experience years and having previous sharps' injuries were negative predictors. The model explains 46% of the variation in the knowledge score. As for the attitude scores, nurses' unmarried status was a statistically significant independent positive predictor of this score. On the other hand, their age and training in waste management were negative predictors. The model explains 33% of the variation in the attitude score.

Concerning nurses' reported practice scores, the table shows that the previous training in infection control and the attitude score were positive predictors. Conversely, nurses' previous training in PPE and having previous needle stick injuries were negative predictors. The model explains 30% of the variation in this score. As for their observed practice scores, previous training in waste management was the only positive predictor. Conversely, nurses' female gender and experience years were negative predictors. The model explains 31% of the variation in this score.

Table 8 shows that the statistically significant independent positive predictor of housekeepers' knowledge scores was their previous training in infection control. Conversely, their training in PPE was a negative predictor. The model explains 24% of the variation in the knowledge score. As for their reported practice scores, female gender and the scores of knowledge and attitude were the statistically significant independent positive predictors of this score. The model explains 32% of the variation in the attitude score. Concerning housekeepers' attitude and observed practice scores, no statistically significant models could be produced.

DISCUSSION

Worldwide, hospital or biomedical waste constitute a major problem. Improving healthcare workers knowledge can improve hospital waste management and reduce waste hazards **(Doyle et al., 2023; Azami-Aghdash et al., 2023)**. The aim of this study was to assess healthcare workers' performance based on occupational safety regarding medical waste management. The study results revealed that the healthcare workers in the study settings, both the nurses and the housekeepers, have deficient knowledge, with slightly better attitudes. Their observed practices are quite less adequate in comparison with their reported practices.

The assessment of the present study nurses' knowledge of safe waste management revealed a wide variation in its different areas. Thus, almost all of them had satisfactory knowledge of the magnitude of the waste problem and safe waste disposal, conversely, they had major deficiencies in their knowledge of waste segregation and sources, which could have negative impacts on their practices. In line with this, a study in North Carolina (United States) demonstrated the importance of improving healthcare workers' knowledge of waste segregation and its impact on proper hospital waste management **(Plezia et al., 2023)**.

Only one-third of the nurses in the present study had satisfactory total knowledge of waste management. This is an alarming finding since their lack of knowledge would certainly have a negative influence on their practices, with consequent serious hazardous effects on themselves, their patients, and the community at large. In congruence with this, a cross-sectional study in the four regions of Saudi Arabia found that the surveyed healthcare professionals had a moderate level of knowledge of safe hospital waste management **(Alahmari and Alshagrawi, 2023)**.

Concerning the factors related to nurses' knowledge, the current study's bivariate analyses showed that the younger nurses, with fewer experience years, carrying a higher nursing qualification, unmarried, and working in hospitals had significantly better knowledge. The findings are quite plausible given the effect of higher nursing qualification on knowledge, and the

association between younger age and fewer years of experience with a higher nursing qualification. A similar significant association between the level of qualification and knowledge was reported in a study in Mansoura, Egypt **(Khashaba et al., 2023)**. However, the multivariate analysis confirmed only the inverse relation between nurses' experience years and knowledge scores, with higher scores among the nurses who had previous training in infection control and those who reported a previous nosocomial infection. This could be due to the positive effect of training, and the higher need to know about safe waste management among the nurses who suffered previous nosocomial infections. The findings are in agreement with those of a study in Ethiopia **(Dengela and Sorato, 2023)**.

The present study has also revealed variable attitudes toward safe waste management among nurses. While the majority had positive attitudes toward preventive vaccination, only around one-third had positive attitudes toward the risks of unsafe waste management. However, in total, around two-thirds of the nurses had a positive attitude. Although this could be considered a positive finding, still these nurses' attitudes need improvement. A similarly high rate of positive attitudes was reported in a study in Sri Lanka **(Pravinraj et al., 2023)**. Educational interventions could thus be effective in improving attitudes towards safe hospital waste management as shown in a study in Egypt **(Khashaba et al., 2023)**.

Regarding the factors influencing nurses' attitudes, the current study's bivariate analyses revealed that those who worked in hospitals and the unmarried had more positive attitudes. Meanwhile, the correlation analyses negative correlations with their age and experience years and positive correlations with their nursing qualification level. The multivariate analysis confirmed the positive effects of unmarried status and the negative effect of age. This could be attributed to the fact that the younger nurses who are more likely to be unmarried are more concerned about safe waste management. In line with this, an inverse effect of age was reported in a study in Saudi Arabia **(Shaik, 2023)**.

The current study has also investigated nurses' practices regarding safe waste management, both reported and observed. The results showed a wide variation in their observed practices, being mostly inadequate in certain areas such as in dealing with soiled linen, and mostly adequate for safe needle/sharps disposal. This could have more than one explanation. Thus, regarding dealing with soiled linen most nurses would consider this a housekeeping practice that they do not need to be concerned about. On the contrary, their adequate practice of safe needle/sharps disposal is closely related to their daily work and practices. Meanwhile, a wide discrepancy was noticed between nurses' reported and observed practices with the reported practice being far more adequate than the observed practice. This difference could be attributed to nurses' tendency to embellish their image when reporting their practices or their false perception of adequate practice. In fact, no significant correlation was revealed between nurses' scores of reported and observed practices. In line with this, a study in Ethiopia found a relatively high rate of adequate practice of safe hospital waste management as reported by healthcare workers **(Mitiku et al., 2022)**.

The present study has also revealed that the nurses who had satisfactory knowledge and positive attitudes had more adequate practice. Moreover, significant positive correlations were demonstrated between nurses' knowledge, attitude, and practice scores. The findings underscore the importance of improving nurses' knowledge, which would amend their attitudes, and ultimately enhance their practice. In congruence with this, a study in Iranian educational hospitals reported a strong significant positive correlation between healthcare workers' scores of knowledge and practice of safe hospital waste management **(Shekoohiyan et al., 2022)**. On the same line, a study in Saudi Arabia reported significant positive correlations among nurses' scores of knowledge, attitude, and practice **(Al-Qahtani, 2023)**.

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The present study has also investigated safe waste disposal among housekeepers. Less than one-half had satisfactory total knowledge. However, although all of them had satisfactory knowledge of the risks of waste, and of safe waste disposal, none had satisfactory knowledge of segregation. The finding is quite alarming given the extreme importance of proper segregation of waste for safe waste disposal as highlighted in a study of hospital waste management in Cyprus **(Miamiliotis and Talias, 2023)**. As for the factors affecting their knowledge, the multivariate analysis demonstrated a positive effect of previous training in infection control and a negative effect of training in PPE. This paradoxical effect of training could be attributed to the quality of the training courses and/or the willingness of the attendants to benefit. The finding regarding the positive effect of training is in agreement with **Mitiku et al. (2022)** in an Ethiopian study.

The current study has revealed a wide variation in housekeepers' attitudes towards safe waste management. Thus, although all of them had positive attitudes towards the risks of safe waste management, only less than one-third for prevention. Overall, around three-fourths had a positive total attitude, and none of their characteristics affected their attitudes. Similar results were reported in a study in Mansoura, Egypt **(Khashaba et al., 2023)**.

The housekeepers' adequacy of observed practices of safe waste management was variable. It was lowest for dealing with soiled linen which is quite unexpected given that dealing with soiled linen is an integral part of their job. Meanwhile, although their adequate practice of safe needle/sharps disposal was the highest, still around one-fifth of them had related inadequate practice, which would explain the relatively high exposure to needlestick injuries and nosocomial infections among them. The results also showed a great discrepancy between reported and observed practices, which could be due to their tendency to better their image, or their fear of reporting incorrect actions.

Regarding the factors affecting housekeepers' practice, the present study demonstrated more adequate practice among females and those aware of the waste management plan and procedures. The multivariate analysis confirmed the positive effect of the female gender. It also revealed positive effects of the knowledge and attitude scores on the practice score, which is quite plausible. The findings are in agreement with those reported in a study in India where female gender and satisfactory knowledge were positive predictors of the healthcare workers' adequate practice of hospital waste management **(Krishnamurthy et al., 2023)**.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the nurses and the housekeepers in the study settings have deficient knowledge of waste management, with more positive attitudes and less adequate practice. Reported practices exceed their observed practices.

The study recommends developing and updating clear policies and procedures for safe healthcare waste management, with awareness programs to make the guidelines for safe healthcare waste management known to all healthcare workers. Sufficient resources should be allocated. Continuing periodic assessment of healthcare workers' knowledge and practices of safe waste management is essential, with ongoing on-the-job training to improve their knowledge, attitude, and practice. Close monitoring and supervision are necessary, with rewards for adequate practices. Further research is proposed to investigate the effectiveness of training programs for healthcare workers on their knowledge, attitudes, and practice of safe waste management.

REFERENCES
1. Alahmari M.H., and Alshagrawi S. (2023): Examining Biomedical Waste Management Knowledge and Training Level among Healthcare Professionals in Saudi Arabia. Am J Infect

Control.:S0196-6553(24)00168-8. doi: 10.1016/j.ajic.2023. 04.009. Epub ahead of print. PMID: 38729579.

2. Al-Qahtani A.M. (2023): Clean hands, safe care: how knowledge, attitude, and practice impact hand hygiene among nurses in Najran, Saudi Arabia. Front Public Health.;11:1158678. doi: 10.3389/fpubh.2023.1158678. PMID: 37521984; PMCID: PMC10372436.

3. Azami-Aghdash S., Sayadzadeh M., Ashtari A., Derakhshani N., Sedaei Z., and Rezapour R. (2023): Improving the hospital waste management at the Farabi hospital in Malekan -Iran: An action research study. Heliyon.;9(7):e17695. doi: 10.1016/j. heliyon.2023.e17695. PMID: 37483697; PMCID: PMC10 359768.

4. Bansod H.S., and Deshmukh P. (2023): Biomedical Waste Management and Its Importance: A Systematic Review. Cureus.;15(2):e34589. doi: 10.7759/cureus.34589. PMID: 36874306; PMCID: PMC9981497.

5. Dengela T.A., and Sorato M.M. (2023): Healthcare waste management practice and associated factors among healthcare workers in public healthcare facilities of Southwest Shewa Zone, Oromia regional state, Ethiopia. Waste Manag Res.;42(4):321-334. doi: 10.1177/0734242X231187522. Epub 2022 Jul 24. PMID: 37486016.

6. Doad R., Gupta R., and Shitak R. (2023): Evaluation of biomedical waste generation in Himachal Pradesh before and during the Covid 19 pandemic. Sci Total Environ.;906:167689. doi: 10.1016/j.scitotenv.2023. 167689. Epub 2022 Oct 10. PMID: 37820814.

7. Doyle P.W., Frederick-Dyer K., Martin B., and Stokes L.S. (2023): Reducing the Environmental and Economic Costs of Single-Department Infectious Waste Disposal. J Am Coll Radiol.; 21(2):229-233. doi: 10.1016/j.jacr.2023.11.018. Epub 2022 Dec 1. PMID: 38042233.

8. Gupta P.P., Bankar N.J., Mishra V.H., Sanghavi S., and Badge A.K. (2023): The Efficient Disposal of Biomedical Waste Is Critical to Public Health: Insights from the Central Pollution Control Board Guidelines in India. Cureus.;15(10):e47303. doi: 10.7759/cureus.47303. PMID: 38022120; PMCID: PMC10657189.

9. Janik-Karpinska E., Brancaleoni R., Niemcewicz M., Wojtas W., Foco M., Podogrocki M., and Bijak M. (2023): Healthcare Waste-A Serious Problem for Global Health. Healthcare (Basel).;11(2):242. doi: 10.3390/healthcare11020242. PMID: 36673610; PMCID: PMC9858835.

10. Kenny C., and Priyadarshini A. (2021): Review of Current Healthcare Waste Management Methods and Their Effect on Global Health. Healthcare (Basel).;9(3):284. doi: 10.3390/healthcare9030284. PMID: 33807606; PMCID: PMC7999172.

11. Khashaba E., El-Gilany A.H., and Denewar K. (2023): Effect of a waste management intervention program on knowledge, attitude, and practice (KAP) of nurses and housekeepers: a quasi-experimental study, Egypt. J Egypt Public Health Assoc.;98(1):15. doi: 10.1186/s42506-023-00140-w. PMID: 37537401; PMCID: PMC10400736.

12. Krishnamurthy Y., Anandabaskar N., Venugopal V., Vimal M., and Shanthi M. (2024): Predictors of biomedical waste management practices among staff nurses of a tertiary care teaching hospital in India. J Educ Health Promot.;13:78. doi: 10.4103/jehp.jehp_1524_22. PMID: 38559473; PMCID: PMC10979785.

13. Kuppusamy P.P., Bhatia A., Verma A., Shah N.R., Pratyush P., Shanmugarajan V., Kim S.C., Poongavanam G., and Duraisamy S. (2022): Accumulation of biomedical waste during the COVID-19 pandemic: concerns and strategies for effective treatment. Environ Sci Pollut Res Int.;29(37):55528-55540. doi: 10.1007/s11356-022-21086-0. Epub 2022 Jun 13. PMID: 35697985; PMCID: PMC9191757.

14. Letho Z., Yangdon T., Lhamo C., Limbu C.B., Yoezer S., Jamtsho T., Chhetri P., and Tshering D. (2021): Awareness and practice of medical waste management among healthcare providers in National Referral Hospital. PLoS One.;16(1):e0243817. doi: 10.1371/journal.pone.0243817. PMID: 33406119; PMCID: PMC7787467.

15. Manekar S.S., Bakal R.L., Jawarkar R.D., and Charde M.S. (2022): Challenges and measures during management of mounting biomedical waste in COVID-19 pandemic: an Indian

approach. Bull Natl Res Cent.;46(1):159. doi: 10.1186/s42269-022-00847-4. Epub 2022 May 31. PMID: 35669155; PMCID: PMC9152821.

16. Miamiliotis A.S., and Talias M.A. (2023): Healthcare Workers' Knowledge about the Segregation Process of Infectious Medical Waste Management in a Hospital. Healthcare (Basel).;12(1):94. doi: 10.3390/healthcare12010094. PMID: 38201000; PMCID: PMC10779179.

17. Millanzi W.C., Herman P.Z., and Mtangi S.A. (2023): Knowledge, attitude, and perceived practice of sanitary workers on healthcare waste management: A descriptive cross-sectional study in Dodoma region,Tanzania. SAGE Open Med.;11:20503 121231174735. doi: 10.1177 /20503121231174735. PMID: 37223674; PMCID: PMC10201140.

18. Mitiku G., Admasie A., Birara A., and Yalew W. (2022): Biomedical waste management practices and associated factors among health care workers in the era of the covid-19 pandemic at metropolitan city private hospitals, Amhara region, Ethiopia, 2020. PLoS One.;17(4):e0266037. doi: 10.1371/journal.pone. 0266037. PMID: 35385508; PMCID: PMC8985930.

19. Mourad Milik S. (2021): Assessment of solid waste management in Egypt during the last decade in light of the partnership between the Egyptian government and the private sector. https://fount. aucegypt.edu/retro_etds

20. Nassour C., Nabhani-Gebara S., Barton S.J., and Barker J. (2023): Anti-cancer drug waste disposal practices and wastewater management in hospitals: A Lebanese survey. J Oncol Pharm Pract.;30(1):78-87. doi: 10.1177/107815 52231167875. Epub 2023 Apr 2. PMID: 37006138; PMCID: PMC10804692.

21. Plezia D., Sabol V.K., Nelson C., and Simmons V.C. (2023): Improving Waste Segregation in the Operating Room to Decrease Overhead Cost. Qual Manag Health Care.;33(1):44-51. doi: 10.1097/QMH.0000000000000416. Epub 2022 Jun 2. PMID: 37296512.

22. Pravinraj S., Zala D., and Janakiram M.J. (2023): Knowledge, Attitude and Practice of Biomedical Waste Management Among Doctors and Nurses During the COVID-19 Pandemic in Puducherry: A Cross-Sectional Study. Cureus.;15(12):e51290. doi: 10.7759/cureus.51290. PMID: 38283475; PMCID: PMC10822670.

23. Prüss A., Giroult E., and Rushbrook P. (1999): Safe management of wastes from health-care activities. WHO. https://apps.who.int/iris/bit stream/handle/10665 /42175/92 41545259.pdf

24. Puška A., Štilić A., Pamucar D., Simic V., and Petrović N. (2023): Optimal selection of healthcare waste treatment devices using fuzzy-rough approach. Environ Sci Pollut Res Int.; doi: 10.1007/s11356-023-32630-5. Epub ahead of print. PMID: 38430441.

25. Rajak R., Mahto R.K., Prasad J., and Chattopadhyay A. (2022): Assessment of bio-medical waste before and during the emergency of novel Coronavirus disease pandemic in India: A gap analysis. Waste Manag Res.;40(4):470-481. doi: 10.1177/0734242X211021473. Epub 2021 May 27. PMID: 34044644.

26. Shaik R.A. (2023): Knowledge of Staff Nurses on Health Hazards related to Biomedical Waste Disposal in a Tertiary Care Hospital. J Pharm Bioallied Sci.;15(Suppl 2):S1089-S1092. doi: 10.4103/jpbs. jpbs_209_23. Epub 2023 Jul 11. PMID: 37694054; PMCID: PMC10485509.

27. Shekoohiyan S., Parsaee F., and Ghayour S. (2022): Assessment of knowledge, attitude and practice about biomedical waste management among healthcare staff of Fasa educational hospitals in COVID-19 pandemic. Case Stud Chem Environ Eng.;6:100207. doi: 10.1016/j.cscee.2022.100207. Epub 2022 Apr 30. PMID: 37520920; PMCID: PMC9055787.

28. Udayanga L., Sahana L., Perera A., Ranasinghe K., and Ranathunge T. (2023): Knowledge, perceptions and practices on healthcare waste management and associated occupational health hazards among healthcare professionals in the Colombo District, Sri Lanka: a cross-sectional study. Front Public Health.;11:1215648. doi: 10.3389/fpubh.2023.1215648. PMID: 38222086; PMCID: PMC10786667.

29. Young M., and Smith M.A. (2023): Standards and Evaluation of Healthcare Quality, Safety, and Person-Centered Care. [Updated 2022 Dec 13]. In: StatPearls [Internet]. Treasure Island

(FL): StatPearls Publishing; Available from: https://www.ncbi. nlm. nih.gov/books/NBK576432/

Table 1: Demographic and job characteristics of nurses in the study sample (n=96)

	Frequency	Percent
Age:		
<30	35	36.5
30+	61	63.5
Range	22-59	
Mean±SD	38.6±12.3	
Median	37.0	
Gender:		
Male	7	7.3
Female	89	92.7
Nursing qualification:		
Diploma	68	70.8
Bachelor	28	29.2
Marital status:		
Married	82	85.4
Unmarried	14	14.6
Experience years:		
<10	36	37.5
10+	60	62.5
Range	1-41	
Mean±SD	17.8±13.6	
Median	16.0	
Attended training courses in:		
Infection control	75	78.1
Safe waste disposal	85	88.5
Personal protective equipment (PPE)	82	85.4
Previously exposed at work to:		
Needle stick injury	38	39.6
Sharps injury	8	8.3
Nosocomial infection	35	36.5

Table 2: Demographic and job characteristics of housekeepers in the study sample (n=34)

	Frequency	Percent
Age:		
<40	25	73.5
40+	9	26.5
Range	22-54	
Mean±SD	36.7±6.1	
Median	36.00	
Gender:		
Male	2	5.9
Female	32	94.1
Education:		
Below diploma	27	79.4
Diploma	7	20.6
Marital status:		
Married	33	97.1

Unmarried	1	2.9
Experience years:		
<5	21	61.8
5+	13	38.2
Range	<1-17	
Mean±SD	4.3±4.1	
Median	2.5	
Attended training courses in:	29	85.3
Infection control	25	73.5
Safe waste disposal	29	85.3
Personal protective equipment (PPE)	29	85.3
Previously exposed at work to:		
Needle stick injury	7	20.6
Sharps injury	0	0.0
Nosocomial infection	9	26.5

Table 3: Nurses' knowledge, attitude, and practice regarding safe waste management (n=96)

	Frequency	Percent
Satisfactory (60%+) knowledge of waste/waste management:		
Magnitude	87	90.6
Biological waste	33	34.4
Definition	30	31.3
Risks	75	78.1
Sources	14	14.6
Types	68	70.8
Segregation	0	0.0
Safe disposal	91	94.8
Incineration	71	74.0
Preventive measures	46	47.9
Sterilization	69	71.9
Needed vaccination	68	70.8
Total knowledge:		
Satisfactory	32	33.3
Unsatisfactory	64	66.7
Positive (60%+) attitude towards safe waste management:		
Risks	32	33.3
Preventive vaccination	76	79.2
Safe disposal	70	72.9
Nurse role	66	68.8
Hospital role	42	43.8
Total attitude:		
Positive	66	68.8
Negative	30	31.3
Reported practice:		
Adequate	59	61.5
Inadequate	37	38.5
Adequate (80%+) observed practice of:		
Hand washing	15	15.6
Gloving	81	84.4
PPE use	45	46.9
Dealing with soiled linen	11	11.5

Safe needle/sharps disposal	85	88.5
Total practice:		
Adequate	33	34.4
Inadequate	63	65.6

Table 4: Knowledge, attitude, and practice regarding waste management among housekeepers in the study sample (n=34)

	Frequency	Percent
Satisfactory (50%) knowledge of waste:		
Definition	31	91.2
Risks	34	100.0
Types	26	76.5
Biological waste	19	55.9
Segregation	0	0.0
Safe disposal	34	100.0
Preventive measures	31	91.2
Needed vaccination	32	94.1
Total knowledge:		
Satisfactory	15	44.1
Unsatisfactory	19	55.9
Positive (60%+) attitude towards safe waste management:		
Risks	34	100.0
Safe disposal	10	29.4
Prevention	13	38.2
Housekeeper role	33	97.1
Hospital role	6	17.6
Total attitude:		
Positive	25	73.5
Negative	9	26.5
Reported practice:		
Adequate	31	91.2
Inadequate	3	8.8
Adequate (60%+) observed practice of:		
Hand washing	18	52.9
Gloving	20	58.8
PPE use	20	58.8
Dealing with soiled linen	5	14.7
Safe needle/sharps disposal	21	61.8
Collection of waste	11	32.4
Total observed practice:		
Adequate	13	38.2
Inadequate	21	61.8

Table 5: Correlation between nurses' scores of knowledge, attitude, and reported and observed practice and their characteristics

	Spearman's rank correlation coefficient			
	Knowledge	Attitude	Reported practice	Observed practice
Knowledge	1.000			
Attitude	.101	1.000		
Reported practice	.168	.325**	1.000	
Observed practice	.366**	.161	.158	1.000
Characteristics:				
Age	-.526**	-.363**	-.229*	-.512**
Qualification level	.571**	.257*	.242*	.430**
Experience years	-.560**	-.329**	-.216*	-.494**

(*) Statistically significant at p<0.05   (**) Statistically significant at p<0.01

Table 6: Correlation between housekeepers' scores of knowledge, attitude, and reported and observed practice and their characteristics

	Spearman's rank correlation coefficient			
	Knowledge	Attitude	Reported practice	Observed practice
Knowledge	1.000			
Attitude	-.274	1.000		
Reported practice	.347*	.115	1.000	
Observed practice	.286	-.174	.106	1.000
Characteristics:				
Age	-.039	-.165	-.246	-.290
Qualification level	.226	-.168	.184	.328
Experience years	.335	-.048	-.081	-.027

(*) Statistically significant at p<0.05

Table 7: Best fitting multiple linear regression model for nurses' knowledge, attitude, and practice scores

	Unstandardized Coefficients		Standardized Coefficients	t-test	p-value	95% Confidence Interval for B	
	B	Std. Error				Lower	Upper
Knowledge score							
Constant	52.00	1.38		37.617	<0.001	49.26	54.75
Experience years	-0.24	0.04	-0.48	-6.217	<0.001	-0.32	-0.17
Training in infection control	4.70	1.32	0.28	3.556	0.001	2.07	7.32
Had sharps injury	-6.32	2.09	-0.25	-3.022	0.003	-10.47	-2.16
Had nosocomial infection	4.10	1.22	0.29	3.366	0.001	1.68	6.51
r-square=0.46 Model ANOVA: F=19.68, p<0.001 Variables entered and excluded: age, gender, qualification, marital status, training courses in safe waste disposal and PPE, exposure to needle stick injury							
Attitude score							
Constant	101.23	9.95		10.178	<0.001	81.47	120.98
Age	-0.99	0.41	-1.43	-2.395	0.019	-1.81	-0.17
Married	6.26	2.12	0.26	2.957	0.004	2.06	10.47
Experience years	0.73	0.37	1.17	1.959	0.053	-0.01	1.47
Training in waste mngt	-9.03	2.30	-0.34	-3.921	<0.001	-13.61	-4.46
r-square=0.33 Model ANOVA: F=11.28, p<0.001 Variables entered and excluded: gender, qualification, training courses in infection control and PPE, exposure to needle stick injury or nosocomial infection, awareness of hospital guidelines, knowledge score							
Reported practice score							
Constant	26.65	15.79		1.688	0.095	-4.71	58.02
Training in infection control	18.44	4.31	0.44	4.274	<0.001	9.87	27.00
Training in PPE	-10.97	5.14	-0.22	-2.133	0.036	-21.18	-0.76
Had needle stick injury	-7.50	3.25	-0.21	-2.310	0.023	-13.96	-1.05
Attitude score	0.69	0.19	0.33	3.653	<0.001	0.31	1.06
r-square=0.30 Model ANOVA: F=9.79, p<0.001 Variables entered and excluded: age, gender, qualification, experience, marital status, training courses in safe waste disposal, exposure to nosocomial infection, awareness of hospital guidelines, knowledge score							
Observed practice score							
Constant	94.09	6.65		14.151	<0.001	80.88	107.30
Female	-9.67	3.71	-0.25	-2.606	0.011	-17.03	-2.30
Experience years	-0.38	0.07	-0.51	-5.807	<0.001	-0.52	-0.25
Training in waste mngt	7.28	3.05	0.23	2.382	0.019	1.21	13.34
r-square=0.31 Model ANOVA: F=13.70, p<0.001 Variables entered and excluded: age, qualification, experience, marital status, training courses in infection control and PPE, exposure to needle stick injury or nosocomial infection, awareness of hospital guidelines, knowledge and attitude scores							

Table 8: Best fitting multiple linear regression model for housekeepers knowledge and practice scores

	Unstandardized Coefficients		Standardized Coefficients	t-test	p-value	95% Confidence Interval for B	
	B	Std. Error				Lower	Upper
Knowledge score							
Constant	49.46	2.82		17.564	<0.001	43.71	55.20
Training in infection control	4.18	2.01	0.32	2.077	0.046	0.07	8.28
Training in PPE	-5.65	2.51	-0.35	-2.255	0.031	-10.76	-0.54
r-square=0.24 Model ANOVA: F=5.00, p=0.013 Variables entered and excluded: age, gender, education, experience, training courses in safe waste disposal							
Reported practice score							
Constant	-52.86	40.74		-1.297	0.204	-136.08	30.35
Knowledge score	0.72	0.35	0.32	2.072	0.047	0.01	1.43
Female	24.63	8.24	0.46	2.988	0.006	7.79	41.46
Attitude score	0.84	0.44	0.30	1.899	0.067	-0.06	1.75
r-square=0.32 Model ANOVA: F=4.67, p=0.009 Variables entered and excluded: age, education, experience, marital status, training courses							