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Authors' Affiliation:
[1]Preventive Medicine Departments, Armed Forces Hospital, Wadi Aldawasir, Kingdom of Saudi Arabia (KSA).
[2]Infection Prevention and Control Unit, Armed Forces Hospital, Wadi Aldawasir, KSA.
[3]General Surgery Departments, Armed Forces Hospital, Wadi Al Dawasir, KSA.
[4]Quality Improvement and Patient Safety Department, Armed Forces Hospital, Wadi Al Dawasir, KSA.

***Corresponding author:**
Ashraf E Saad,
Preventive Medicine Departments, Armed Forces Hospital, Wadi Aldawasir, KSA; Email: ashrafelghali@hotmail.com, ORCID: 0000-0002-3357-0566

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Understanding and implementation of clinical waste management among healthcare professionals: A cross-sectional survey conducted at a military hospital in central Saudi Arabia

Ashraf E Saad[1]*, Nurrahifah Tajudin[2], Shaqra I Shali[1], Hassan M Aldossary[3], Bashir Ighile[4]

ABSTRACT

Background: The hospitals around the globe diverge in the execution and management of clinical waste and face diverse challenges in launching efficient procedures & practices. This study focuses on the Armed Forces Hospital Wadi Al-Dawaser (AFHWD) in Saudi Arabia. Objectives: To assess the awareness and implementation of clinical waste management practices among healthcare workers (HCW) in the inpatient units of AFHWD. Methodology: A cross-sectional quantitative survey was conducted involving 100 healthcare workers selected via purposive sampling. Data were gathered using an adapted self-administered questionnaire and analyzed using SPSS version 27.0. Result: The survey achieved a 100% response rate. Participants reported a high level of awareness (93%) and adherence to clinical waste management practices (99%). No correlation was found between awareness and practice ($r = 0.488$). However, a significant difference was observed between awareness and practice ($p < 0.001$). Factors such as age, education, job position, department, work experience in healthcare, and training attendance had a significant influence on awareness and practices of clinical waste management ($p < 0.05$). Conclusion: While most healthcare workers demonstrate a high level of awareness and adherence to proper practices regarding clinical waste management, there is a need for ongoing and effective oversight by healthcare management. Strengthening sustainable and systematic practices of clinical waste management systems is more significant to progress safety to unbiased best practices in the management of clinical waste among clinical staff.

Keywords: Management of clinical-wastes, Awareness, Practice, Healthcare Workers, Inpatient Units

1. INTRODUCTION

Clinical waste, known as medical, biomedical, or healthcare waste, refers to waste materials commonly generated in healthcare settings and are also accompanied by the risk of infection or injury to healthcare workers, patients, and the public (Alanazi et al., 2023; Omar et al., 2018). Numerous factors are linked with the rate of generation of clinical-wastes, which include size and category of clinical organizations, number of patients attending healthcare, expansion of the country's economy and progress of the country (Abdulrahman et al., 2022).

Since the COVID-19 pandemic, almost all healthcare facilities around the globe have experienced doubled clinical waste generation (Agamuthu & Barasarathi, 2020). General healthcare waste is the non-infectious waste generated in healthcare facilities, such as paper towels (Omar et al., 2018). Steps involved in waste management include segregation, where the clinical waste will be segregated at the point of generation into appropriate categories using color-coded containers or bags. It is important to prevent contamination and ensure the proper disposal process (Akkajit et al., 2020). In the phase of transportation, through the specialized transport vehicles, the healthcare services transfer the clinical wastes to the treatment and disposal services with the help of trained personnel. The clinical waste will be disposed of properly through various disposal methods, including land-filling, deep burial, and other approved methods (Abdulrahman et al., 2022).

An observational cross-sectional study among 353 HCWs from the teaching hospital found that 74.4% of them were aware of medical waste management (Letho et al., 2021). Then, 98.2% of the HCWs were also aware of the importance of using the proper personal protective equipment while managing clinical waste. Notifying that only 37.6% of them knew how long the medical waste was to be kept in the hospital premises, and it was found that 61.3% of the observed wards, units, or departments correctly segregated the clinical waste based on the national guidelines. It emphasized that employees require regular training to enhance their knowledge and improve clinical waste management practices.

Next, a cross-sectional observational study was conducted in India among 273 HCWs in several public healthcare institutes in Karnataka (Golandaj & Kallihal, 2021). The study revealed that a majority of HCWs require enhanced knowledge and awareness about clinical waste management.

Only 43% knew about categorizing clinical waste and disposing of it in proper, color-coded bins/bags. Poor awareness of clinical waste management was also found among HCWs in the lower age group, male HCWs, lab technicians, pharmacists, and supporting staff. Therefore, we strongly recommend periodic training and regular monitoring for all healthcare workers to enhance their knowledge and practice of clinical waste management.

A hospital-based observational study was conducted among 500 HCWs at a teaching hospital in Uttar Pradesh (Rajani, 2021). It was observed that the ranking of awareness of clinical waste management is high among doctors, followed by nurses and waste handlers. Overall, nurses demonstrated the highest awareness of existing practices at 74.0%, followed by doctors at 70.2% and waste handlers at 53.8%. This study underscored the importance of providing ongoing education and information to HCWs to enhance their awareness about clinical waste management.

A cross-sectional survey conducted among 344 healthcare workers in Thailand (Akkajit et al., 2020). It was found that most of them had good practice in clinical waste management, with an overall score of 92.2%. This study found that most of the HCWs mentioned that they always wash their hands thoroughly after contact with medical waste, and even wear gloves and rubber gloves during medical services, with 95.6% and 93.6%, respectively. The HCWs also practice disposing of sharp medical waste in hard containers, with 95.6% of them doing so. It's addressed that the HCWs are known to have the responsibility for clinical waste management, from the generation of medical wastes to their final disposal. Thus, it is highly recommended that the management of healthcare facilities ensure all HCWs appropriately practice clinical medical waste management by strictly following the related guidelines or protocols available in the clinical area.

A cross-sectional study was conducted among 404 HCWs in India to study the awareness among HCWs of biomedical waste management (Divya et al., 2022). This survey found that all of the HCWs who participated in this study demonstrated a low degree of awareness related to biomedical waste management. Only 7.4% of HCWs are aware of biomedical waste management in the clinical area.

An earlier survey, which was executed among 110 HCWs in Lahore, Pakistan, showed that their awareness of management of hospital wastes was highly influenced by socio-demographic factors. These results exposed that better consciousness and best practices are needed among the HCW system for the sustainable management of clinical wastes. Additionally, the study found a statistically significant relationship between HCWs' awareness and their age, marital status, and qualifications, with p-values of 0.047, 0.024, and

0.01, respectively. This study reported that HCWs who are over 30 years old and single, as well as post-registered nurses, tend to demonstrate good awareness of healthcare waste management.

Next, a cross-sectional survey was conducted in Uganda among 200 HCWs to determine their practice on clinical waste management (Solomon et al., 2019). It found that 148 HCWs had satisfactory practice in clinical waste management. The inferential analysis of the collected data indicated that healthcare workers were more likely to demonstrate sufficient clinical waste management practices if they had a diploma as their highest educational qualification, worked in the teenage corner, had previously attended training on clinical waste management, and believed that clinical waste management was critical, with a significance level of $p<0.001$. It also suggested the need for the management to provide clinical waste management training to improve the clinical waste management practice among HCWs.

It also suggested that the need for the management to provide clinical waste management training to improve the clinical waste management practice among HCWs. A study conducted among 100 healthcare workers from various departments of Biyem-Assi District Hospital revealed that most healthcare workers demonstrated poor clinical waste management practices (Woromogo et al., 2020). It was also found that HCWs with more than 10 years of professional experience were more likely to demonstrate good practice in biomedical waste management, with $p = 0.034$. It also addressed that experiential learning is beneficial in the healthcare field, where the HCWs continuously learn from their experience in the real clinical area and improve their practice on it.

This study aims to investigate the relationship between healthcare workers' (HCWs') awareness of clinical waste management and their actual practice in managing clinical waste. It will identify any association between the HCWs' socio-demographic characteristics and their awareness and practice of clinical waste management. The conceptual framework of this study suggested that the level of awareness of clinical waste management among HCWs plays a significant role in affecting the actual practice of the HCWs in clinical waste management.

2. MATERIALS AND METHODS

Study Design

The Armed Forces Hospital in Wadi Al-Dawaser, Saudi Arabia, was chosen as the study setting. The study population consists of healthcare workers working in the selected inpatient units, such as Male Ward, Female Ward, Intensive Care Unit (ICU), Neonatal Intensive Care Unit (NICU), and Pediatric Ward. The total of healthcare workers working in the selected study setting was 130. A quantitative cross-sectional survey was employed as the study design. Data were collected from the participants using a self-administered questionnaire as the research tool during face-to-face survey sessions.

Sampling Criteria

Krejcie and Morgan's sample size calculation was used in calculating the sample size of the study (Krejcie & Morgan, 1970). Based on the calculation above, the recommended sample size is 92. However, to achieve a 100% response rate, an additional study sample size was recruited, also known as a preventive measure, to prevent any non-response bias. An additional eight participants were added to achieve a sample size of 100 for the study. A total of 20 HCWs were recruited from each selected inpatient unit. Due to the small study population, the non-probability purposive sampling technique was used. Participants were recruited based on the researcher's judgment, in accordance with the study's objective (Serra et al., 2018). Inclusion criteria were permanent healthcare workers: nurses, physicians, and support services staff who passed the probation period and worked in the inpatient area for 12 months or more. They actively participated in patient management and consented to take part in the study. Exclusion criteria were healthcare workers with administrative roles as their primary job scope, regardless of their experience duration, and those who resumed work from extended leave —within a month, such as maternity leave.

Research Instruments

Data collected between March and April 2024 through a self-administered questionnaire, which was adapted from several related previous studies, was used as the research instrument of the study, with three sections developed. Section A: Socio-Demographic Characteristics: This section consists of 11 closed-ended items used to collect the various socio-demographic characteristics of the study participants (Letho et al., 2021). Firstly, to prevent any risk of redundancy among study participants, each participant will have their own unique ID/code. Then, followed by their position, working area, gender, age, nationality, marital status, highest level of education, years of working experience in the healthcare field, years of working experience at the current hospital, and attending any training or

workshop related to clinical waste management in the previous 12 months. Section B: Awareness on Clinical Waste Management: 10 closed-ended items were adapted to measure the awareness level of HCWs on clinical waste management (Sharma et al., 2013). It focuses on the segregation process and handling of the clinical waste in the clinical area. Each item is known as a multiple-choice question with only one correct answer. Each correct answer will be scored as '1', while the incorrect answer will be scored as '0'. The overall score may vary from 0 to 10, and it is categorized into three levels of awareness: excellent, good to average, and poor. The corresponding total scores are 8 to 10, 4 to 7, and less than 4, respectively.

Section C - Practice on Clinical Waste Management: 12 open-ended items were used to measure the practice level of HCWs on clinical waste management (Akkajit et al., 2020). It focuses on the segregation process and handling of the clinical waste in the clinical area. The 3-point Likert scale will be used in the study, known as never (0), sometimes (1), and always (2). Overall scores may range from 0 to 24, and three levels of practice are available, categorized as good, moderate, and poor practice, corresponding to overall scores of 18 to 24, 17 to 10, and less than 10, respectively.

Data Analysis

We used the statistical software Statistical Package for the Social Sciences (SPSS) Version 25.0 for the data analysis. The data distribution had been identified by performing the normality test, which helps in determining the type of tests used in the inferential analysis. We will present all the analysis findings in table form. Descriptive analysis in the form of percentage and frequency was done for demographic data, HCWs' awareness of clinical waste management, and HCWs' practice of clinical waste management. The inferential analysis, which looks at whether the data follows a normal pattern and has a p-value of less than 0.05, is seen as statistically significant and is used to examine the connection between healthcare workers' awareness and practices in clinical waste management, as well as how their socio-demographic characteristics relate to their awareness and practices in this area.

3. RESULTS

The findings show that 100% of respondents participated in this study, and 77% of respondents were female, with an average age between 20 and 30 years old (37%). Table 1 shows that most respondents in this study are single (30%) and non-Saudi (88%). Next, this study has determined that most respondents hold post-basic degrees (40%), followed by 12 respondents with diplomas, 35 respondents with degrees, and 13 respondents with master's degrees. This study found that the majority of respondents were nurses (52%), followed by other healthcare professionals (34%), and doctors/physicians (14%). This study also determined that the majority of respondents who participated in this study were from the nursing department (52%) with experience between 6 to 10 years in AFHWD (38%) and 11 to 15 years of experience in the healthcare field (33%). Moreover, this study has determined that most respondents have received training regarding clinical waste management (52%). Only 48% of respondents have no training in clinical waste management.

Table 1. Sociodemographic Characteristics (N=100)

Sociodemographics	
Gender	Female 77 (77.0%), Male 23 (23.0%); Female: Male 3.35: 1
Age	Mean 37.4 ± 11.3; Range 25.0-55.0
Marital Status	Single 30 (30.0%), Married 46 (46.0%), Divorced 13 (13.0%), Widowed 11 (11.0%)
Nationality	Saudi 12 (12.0%), Non-Saudi 88 (88.0%)
Education	Diploma 12 (12%), Degree 35 (35.0%), Degree with post-basic 40 (40.0%), Master 13 (13.0%)
Position	Physician 14 (14.0%), Nurse 52 (52.0%), Others 34 (34.0%)
Assigned Department	Nursing 52 (52.0%), Medical 14 (14.0%), Allied-health 8 (8.0%), Support Services 26 (26.0%)
Years of Work Experience in AFHWD	Less than 5 years 34 (34.0%), 6-10 years 38 (38.0%), 11-15 years 19 (19.0%), 16-20 years 9 (9.0%), More than 20 years 0 (0.0%)
Years of Work Experience in Healthcare Field	Less than 5 years 14 (14.0%), 6-10 years 23 (23.0%), 11-15 years 33 (33.0%), 16-20 years 30 (30.0%), More than 20 years 0 (0.0%)
Training received	Yes 52 (52.0%), No 48 (48.0%); Ratio 1.08:1

As shown in Table 2, based on the findings, the Kolmogorov-Smirnov test was used to determine the p-value, as the number of respondents in this study exceeds 50. Non-parametric analysis was used in the data analysis since the p-value for awareness ($p < 0.001$) and practice ($p = 0.014$) was less than 0.05.

Table 2. Assessing Normality of Distribution of the Variables

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	p	Statistic	df	p
Awareness	0.421	100	<0.001	0.632	100	<0.001
Practice	0.348	100	<0.001	0.610	100	<0.001

* Significant value, p≥0.05

There were 10 questions to determine the awareness of clinical waste management among healthcare workers. Table 3 shows that 100% of respondents answered *'Yes'* to questions 1, 2, and 3. Next, this study found that most respondents (94%) selected "sharp containers" as the answer for question 4. The majority of respondents then selected "Blue" for question 8 (96%), while "False" (97%) and "Red" (93%) were the answers to questions 5 and 6, respectively. Moreover, this study has determined that most respondents (95%) answered that a pricked finger should be kept in antiseptic lotion for question 9 and that any type of container, including food containers, can be used to contain hazardous waste in question 10 (94%). Moreover, the mean total rank score of the respondents is 9.62, indicating that most respondents have an excellent awareness of clinical waste management.

Table 3. Awareness of Clinical Waste Management among Healthcare Workers by Question (N=100)

Awareness Question	Frequency (N)	Percentage (%)
Do you know about colour-coding segregation of clinical waste?		
Yes	100	100
No	0	0
Not Sure	0	0
Do you follow colour-coding for clinical waste?		
Yes	100	100
No	0	0
Sometimes	0	0
Is the waste disposal practice correct in your hospital?		
Yes	100	100
No	0	0
Cannot Comment	0	0
Objects that may be capable of causing punctures or cuts, that may have been exposed to blood or body fluids including scalpels, needles, glass ampoules, test tubes and slides, are considered biomedical waste. How should these objects be disposed of?		
Black Bags	1	1
Yellow Bags	5	5
Clear Bags	0	0
Sharp Containers	94	94
Documents with confidential patient information are to be disposed of into the paper recycling bins.		
True	3	3
False	97	97
Do not know	0	0
The colour code for the clinical waste to be autoclaved, disinfected is:		
Red	93	93

Awareness Question	Frequency (N)	Percentage (%)
Black	0	0
Yellow	0	0
Blue/White	7	7
The approximate proportion of infectious waste among total waste generated from a health care facility is:		
10%-20%	93	93
30%-40%	4	4
50%-60%	3	3
80%-90%	0	0
The colour code for disposal of normal waste from the college is:		
Red	1	1
Black	3	3
Yellow	0	0
Blue	96	96
All the following steps should be followed after an exposure with infected blood/body fluid and contaminated sharps EXCEPT:		
Exposed parts to be washed with soap and water	2	2
Pricked finger should be kept in antiseptic lotion	95	95
Splashes to eyes should be irrigated with sterile irrigants	2	2
Splashes to skin to be flushed with water	1	1
All of the following statements about hazardous waste containers are true, EXCEPT for:		
Containers must be closed except when removing or adding waste.	2	2
Containers must be clean on the outside	2	2
Contents must be compatible with the type of waste containers	2	2
Any type of container, including food containers, can be used to contain hazardous waste.	94	94

There were 12 questions to determine the practice of clinical waste management among healthcare workers, and most respondents answered *'Always'* for most of the questions, especially for question 2 (97%), question 6 (97%), and question 9 (97%). Unfortunately, there are questions that most respondents answer *'Never*,' which are question 4 (96%), question 10 (94%), and question 12 (96%). Some respondents answered *'Sometimes,'* especially on questions 5 (8%) and 11 (7%), as shown in Table 4. The mean rank total score of the respondents is 23.26, indicating that most respondents have a good practice of managing clinical waste.

Table 4. Practice of Clinical Waste Management among Healthcare Workers by Question (N=100)

Practice Questions	Always (N, %)	Sometimes (N, %)	Never (N, %)
1. How often do you separate clinical waste from general waste?	96 (96)	3 (3)	1 (1)
2. Do you put general waste into a black container and clinical waste into a red container?	97 (97)	3 (3)	0(0)
3. Do you wear rubber gloves during medical services?	93 (93)	5 (5)	2 (2)
4. Do you not put sharp clinical waste into a red	2 (2)	2 (2)	96 (96)

	plastic bag?			
5.	**Do you put sharp clinical waste into a hard container?**	90 (90)	8 (8)	2 (2)
6.	**Do you clean spills of liquid clinical waste immediately with proper procedure?**	97 (97)	3 (3)	0 (0)
7.	**Do you wear rubber glove when pick up trash that falls on the ground?**	95 (95)	4 (4)	1 (1)
8.	**Do you wash your hands thoroughly after contact with clinical waste, even if you had worn gloves?**	95 (95)	3 (3)	2 (2)
9.	**Do you close and seal the clinical waste bag when it is 1/3 to 2/3 full?**	97 (97)	0 (0)	3 (3)
10.	**Do you not reuse the plastic bag for clinical waste?**	0 (0)	6 (6)	94 (94)
11.	**Do you collect clinical waste and disposed by following local regulations and guidelines for biomedical waste management?**	93 (93)	7 (7)	0 (0)
12.	**Do you not flush liquid clinical waste into toilet bowl?**	0 (0)	4 (4)	96 (96)

Based on the results shown in Table 5, there is no significant relationship between awareness and practice, with an r-value of 0.488, which is less than 1. Moreover, there is a substantial difference between awareness and practice, as indicated by a p-value of less than 0.05 ($p < 0.001$).

Table 5. Relationship between Awareness and Practice of Clinical Waste Management

	Mean ± SD	**r-value**	**p-value**
Awareness	9.62±0.62	0.488	<0.001*
Practice	23.26±1.35		

*Significant p-value ≤0.05

Kruskal-Wallis and Mann-Whitney U-tests were used to determine the association between sociodemographic characteristics and awareness of clinical waste management among healthcare workers. According to Table 6, the factors influencing awareness of clinical waste management include age (p=0.020), education (p=0.008), position (p=0.028), assigned department (p=0.045), years of work experience in the healthcare field (p=0.027), and training (p=<0.001), particularly when the p-value is less than 0.05. The effect is evident when there is a significant difference in mean rank between categorical groups, as seen in the comparison between diploma mean rank (29.83) and degree mean rank (50.50). It also shows that for the department, the medical mean rank (52.71) has a significant difference compared to the allied health department (35.00). However, gender (p = 0.434), marital status (p = 0.065), nationality (p = 0.156), and years of work experience in AFHWD (p = 0.777) did not influence awareness of clinical waste management when the p-value was more than 0.05. According to Table 7, factors such as age (p=<0.001), education (p=<0.001), position (p=0.016), assigned department (p=0.039), years of work experience in the healthcare field (p=<0.001), and training (p=<0.001) significantly influence the practice of managing clinical waste when the p-value is less than 0.05. This is proved when there is a high difference in mean rank between categorical groups, such as the age between 20 and 30 years (mean rank 34.59), which has a high difference with the age between 31 and 40 years (mean rank 58.81). It also indicates that the respondent who received training has a mean rank of 62.05, which shows a significant difference compared to the respondent who did not receive training, whose mean rank is 37.99. However, gender (p = 0.698), marital status (p = 0.142), nationality (p = 0.219), and years of work experience in AFHWD (p = 0.083) did not influence the practice of clinical waste management when the p-value was more than 0.05.

Table 6. Association between Sociodemographic Characteristics and Awareness of Clinical Waste Management among Healthcare Workers

Sociodemographic data	Mean Rank	p-value
Gender		
Male	53.87	0.434
Female	49.49	
Age		
20-30 years old	41.28	
31-40 years old	56.40	0.020*
41-50 years old	52.98	
>50 years old	59.62	
Marital Status		
Single	51.02	
Married	45.45	0.065
Widowed	66.00	
Divorced	54.08	
Nationality		
Saudi	41.46	0.156
Non-Saudi	51.73	
Education		
Diploma	29.83	
Degree	50.50	0.008*
Degree with Post Basic	56.31	
Master	51.69	
Position		
Nurse	55.57	
Doctor/Physician	52.71	0.028*
Others	41.84	
Assigned Department		
Nursing	55.57	
Medical	52.71	0.045*
Allied-health	35.00	
Support Serviced	43.94	
Years of work Experience in AFHWD		
Less than 5 years	47.76	
6-10 years	50.50	0.777
11-15 years	52.95	
16-20 years	55.67	
Above 20 years	0	
Years of work Experience in the Healthcare Field		
Less than 5 years	41.64	
6-10 years	41.07	0.027*
11-15 years	57.08	
16-20 years	54.63	
Above 20 years	0	
Training received		
Yes	60.34	<0.001*
No	39.84	

*Significant p-value ≤0.05

Table 7. Association between Sociodemographic Characteristics and Practice of Clinical Waste Management among Healthcare Workers

Sociodemographic data	Mean Rank	p-value
Gender		
Male	52.26	0.698
Female	49.97	
Age		
20-30 years old	34.59	
31-40 years old	58.81	<0.001*
41-50 years old	58.10	
>50 years old	63.68	
Marital Status		
Single	51.13	
Married	45.53	0.142
Widowed	63.50	
Divorced	55.62	
Nationality		
Saudi	42.25	0.219
Non-Saudi	51.63	
Education		
Diploma	24.67	
Degree	45.60	<0.001*
Degree with Post Basic	60.63	
Master	56.38	
Position		
Nurse	55.72	
Doctor/Physician	55.32	0.016*
Others	40.53	
Assigned Department		
Nursing	55.72	
Medical	55.32	0.039*
Allied-health	39.38	
Support Serviced	40.88	
Years of work Experience in AFHWD		
Less than 5 years	46.81	
6-10 years	47.38	0.083
11-15 years	54.82	
16-20 years	68.50	
Above 20 years	0	
Years of work Experience in Healthcare Field		
Less than 5 years	34.36	
6-10 years	34.74	<0.001*
11-15 years	58.18	
16-20 years	61.67	
Above 20 years	0	
Training received		
Yes	62.05	<0.001*
No	37.99	

*Significant p-value ≤0.05

4. DISCUSSION

Awareness of Clinical Waste Management among Healthcare Workers

This study found a high level of awareness among HCWs on clinical waste management. However, there is a need for improvement in the understanding of clinical waste containers. This is because only 2% of the HCWs correctly answered all statements related to the clinical waste containers. A previous study conducted in northern Saudi Arabia yielded similar results, indicating that most healthcare workers (HCWs) demonstrated a high awareness of clinical waste management in clinical areas, particularly in hospital settings (Thirunavukkarasu et al., 2022). However, the finding is different from the findings of the previous study conducted in Uganda, where a majority of the HCWs are aware of the clinical waste containers and the right color codes for clinical waste containers for the different waste forms, with 89.5% of them (Solomon et al., 2019). It might be challenging for the nurses, not only non-Saudi nurses but Saudi nurses too, as it's difficult for them to keep up with all the nuances and details, especially if they are not regularly updated or communicated with effectively within the healthcare facility (Alharbi et al., 2021; Thirunavukkarasu et al., 2022). The HCWs who do not frequently encounter the clinical waste container or handle the container directly are at high risk of not retaining detailed knowledge about the characteristics or requirements of each clinical waste container according to its color code (Alqassab et al., 2024). Finally, the HCWs are also more vulnerable to prioritizing the knowledge that is directly relevant to their immediate patient care responsibilities rather than the information related to the clinical waste containers and their management.

The Practice of Clinical Waste Management among Healthcare Workers

The findings of this survey found that most of the HCWs demonstrate good practice in clinical waste management, with 99% of them. Then, 1% of them demonstrate moderate practice in clinical waste management. Nonetheless, the survey did identify specific areas that needed improvement. The management of sharp clinical waste is one noteworthy issue; just 2% of HCWs consistently dispose of sharp clinical waste in red plastic bags, whereas 90% dispose of it in hard containers. This raises the possibility that improper treatment of sharp clinical waste protocols needs to be followed, which could put healthcare personnel and other waste management personnel at risk. Furthermore, just 4% of HCWs need to consistently flush liquid clinical waste down the toilet, indicating that there is an opportunity for improvement in this area. To reduce environmental risks and avoid contaminating water sources, liquid clinical waste must be disposed of properly. The previous studies conducted in northern Saudi Arabia also found a similar finding that most of the HCWs in Saudi Arabia demonstrated a high level of practice related to clinical waste handling and management in the clinical area (Thirunavukkarasu et al., 2022). Inadequate training or education provided on waste management protocols in the clinical area is more vulnerable to contributing to this lack of awareness and has been reflected in poor practice (Akkajit et al., 2020). Also, without good access to the necessary equipment and infrastructure related to excellent or proper clinical waste management, the HCWs tend to implement alternative methods, which commonly do not align with the best practice of clinical waste management (Woromogo et al., 2020). A rush to attend to the patient's needs and fulfill their responsibilities in patient care might cause the HCWs to prioritize providing patient care rather than strictly adhering to the proper disposal protocols (Solomon et al., 2019). The inconvenience of disposal bins or inadequate signage significantly contributes to poor waste disposal or errors in clinical waste management (Divya et al., 2022).

Relationship between Awareness and Practice of Clinical Waste Management among Healthcare Workers

This study showed that when the r-value is 0.488, which is less than 1, there is no relationship between awareness and practice. However, when the p-value is smaller than 0.05 ($p=<0.001$), there is a substantial difference between awareness and practice. It also addressed that the awareness level of HCWs towards clinical waste management is independent of the practice of HCWs towards clinical waste management. A study conducted in Karnataka mentioned that even though an individual's awareness of a specific area may not guarantee an individual's optimal practice in that area, awareness is recognized as the cornerstone for behavior change (Ahmad, 2021).

HCWs might possess a distinct awareness of the risks that really exist when it comes to inappropriate waste management. HCWs may need more motivation to prioritize appropriate waste management techniques if they clearly grasp how their activities will directly affect the possible consequences of their actions (Leonard et al., 2022). Lastly, although HCWs may receive waste management education or training, these programs may or may not need to be more successful in putting awareness into practice. To enable long-lasting behavior change, adequate training should be customized to the unique demands and difficulties faced by HCWs and include continuing support and feedback methods (Dhole et al., 2024).

Association between Healthcare Workers' Socio-demographic Characteristics with Awareness and Practice of Clinical Waste Management among Healthcare Workers

This survey found that several socio-demographic characteristics of healthcare workers (HCWs) influenced their awareness and practices regarding clinical waste management. *Age***:** The findings of the inferential analysis indicated that healthcare workers (HCWs) older than 50 years were more likely to demonstrate excellent awareness and good practices in clinical waste management, with $p=0.20$ and $p<0.001$, respectively. This is because HCWs older than 50 years are more likely to have gained extensive experience in their field. Over the years, HCWs tend to have the opportunity to encounter various scenarios and learn from them, which enhances the HCWs' awareness and practice of clinical management (Divya et al., 2022). Then, as the understanding of best practices evolves, the older HCWs are more likely to have the opportunity to update their knowledge and skills in clinical waste management through continuous in-service training (Alqassab et al., 2024). Besides that, compared to their younger colleagues who could not have had as much exposure to changes in rules, older healthcare professionals may have witnessed and adapted to these developments throughout their careers, resulting in greater awareness and compliance with current standards (Ahmad, 2021). Finally, because of personal experience or observation of the consequences on patients or colleagues, older healthcare professionals may have a deeper awareness of the medical issues associated with improper clinical waste management. Due to this deeper awareness, they might be more likely to prioritize implementing proper clinical waste disposal procedures (Leonard et al., 2022).

*Highest Educational Status***:**

Healthcare workers (HCWs) with a post-basic degree as their highest educational qualification are more likely to demonstrate excellent awareness and good practices in clinical waste management, as indicated by $p=0.008$ and $p<0.001$, respectively. HCWs with post-basic degrees underwent specialized training in their respective fields, and this may encourage the HCWs to have better awareness and training on clinical waste management (Hattingh & Downing, 2020; Solomon et al., 2019). This advanced knowledge may develop a further understanding of the proper clinical waste management and handling and enhance the HCWs ability to effectively implement the best practices related to clinical waste management (Chang et al., 2023; Connor et al., 2023).

Working Department:

Those working in the nursing department are more likely to demonstrate excellent awareness and good practice of clinical waste management with $p=0.045$ and $p=0.016$, respectively. A majority of the HCWs working in the nursing department are nurses. Then, nurses are identified as one of the healthcare professional groups that demonstrate extensive hands-on clinical experience working in the healthcare setting. Also, in their daily and continuous interaction with patients, especially while providing bedside nursing care services, the nurses witnessed firsthand the consequences of inadequate waste management practices on patient health and safety. This practical experience strengthened the nurses' awareness of the importance of proper clinical waste disposal, and it also motivated them to implement the best clinical waste management practice effectively in the clinical area (Woromogo et al., 2020). The direct involvement of the nurses in patient care may enhance the nurse's proper implementation of the clinical waste management practice (Solomon et al., 2019). Maintaining a clean and safe healthcare setting depends on efficient waste management, which is consistent with the ethical principles of nursing practice (Thirunavukkarasu et al., 2022).

Years of work experience in the healthcare field:

The HCWs with 16 to 20 years of working experience in the healthcare field were identified to demonstrate excellent awareness and good practice in clinical waste management with $p=0.027$ and $p<0.001$, respectively. Firstly, it's related to the accumulation of knowledge and expertise. The HCWs with 16 to 20 years of working experience are more likely to have accumulated significant knowledge and expertise in their respective roles. This accumulated knowledge and skill also encourage them to have the capability to identify potential risks and implement effective waste management strategies (Alharbi et al., 2021). Moreover, with years of working experience in healthcare, the HCWs have become familiar with clinical waste management guidelines and protocols. This familiarity increases their ability to effectively adhere to regulations and processes (Leonard et al., 2022). Lastly, experienced healthcare workers recognize the importance of professional accountability in maintaining the highest standards of patient care. As a result of this sense of accountability, they continuously exhibit excellent awareness and best practices in their approach to clinical waste management (Divya et al., 2022).

Limitations

This study involved a small sample size, which was collected from only one study setting. This could potentially lead to the sample's inaccurate representation of the wider population, thereby limiting the generalizability of the findings. This is because the adapted questionnaire was originally designed for different contexts or populations. Also, the differences in the cultural norms, values, or the way the questions are framed may increase the risk of the introduction of response bias. The self-administered questionnaire used for data collection was also accompanied by several biases, which impaired the accuracy of the findings. Also, the cross-sectional survey is unable to capture the changes in variables over time, and it is unable to offer suggestions for changes or trends.

5. CONCLUSION

To conclude, a majority of AFHWD HCWs demonstrated excellent awareness and adherence to clinical waste management practices. Unfortunately, no relationship was found between the HCWs' awareness of clinical waste management and their practice of clinical waste management. The age, highest educational level, position, department, work experience, and attendance at related training influence the HCWs' awareness and practice of clinical waste management. The management of healthcare organizations must ensure their HCWs continuously receive the latest knowledge and skills on how to handle clinical waste effectively. The purpose is to provide the HCWs with the newest guidelines, protocols, and procedures for clinical waste management. Furthermore, it's highly recommended that healthcare institutions implement quality assurance and monitoring systems. It is essential to ensure the HCWs' compliance with the clinical waste management procedures and protocols available in the clinical area. Additionally, regular inspections, audits, and performance evaluations can help identify errors, gaps, or deviations in clinical waste management practices among healthcare workers in the clinical area. Keeping a close watch on how well HCWs follow the guidelines for clinical waste management in different areas can help the healthcare organization ensure that these practices are consistent across departments, reduce the chances of not following the rules, and enhance the overall quality of care. Comparative studies are recommended to evaluate the clinical waste management practices across various healthcare settings, including private versus public hospitals, urban versus rural areas, or different regions or countries. Future research should focus on determining targeted interventions and further investigating their effectiveness.

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Author's Contribution

Author A.E.S. set the study design and methodology, shared the preparation of the study instrument, data display, discussion guidelines, manuscript preparation. H.M.D. and B.I. set recommendations, and final write-up. Author N.J. and S.I.S. set research proposal and concept, conducted statistical analysis, data display, report review, ethical approvals, study instrument validation, supervised data collection, data entry, manuscript preparation, and study progress. All authors read and approved the final manuscript.

Informed consent

Written and oral informed consent was obtained from all individuals participating in the study.

Ethical approval

The study was approved by the Research and Ethics Committee of AFHWD (Ethical approval code: 0024 March 10, 2024).

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Conflict of interest

The authors declare that there is no conflict of interest.

Data and materials availability

All data associated with this work are present in the paper.

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