Assessment of Nurse's Knowledge and Practices Regarding Barriers to Green Practice in Operating Rooms

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Abstract

Background; Nurses are at a higher risk of exposure to medical waste hazards due to their extended presence with patients in hospital wards. Green operating rooms can foster a healthier and more comfortable environment for both healthcare staff and patients. **The aim of the study was** to assess nursing knowledge and practice regarding barriers to green practice in operating rooms. **Research design;** A descriptive research design was used. **Sample;** A convenience sample of 91 nurses of both genders who agreed to participate in the study. **Setting;** The study was conducted in the operating rooms at Sohag University Hospital. **Tools**; Three tools were utilized for data collection. Tool (1) Structured Interview Questionnaire: was included two parts, Tool (II): Barriers to green practice and waste management ,Tool (III): Observational check list for practices. **Results**; The present study revealed that more than half of the nurses (58.2 %) had satisfactory knowledge about barriers to green practice, more than half of the nurses (83.5 %) had adequate and competent practice level about waste management in operating rooms. More than the half of nurses (79.1%) had lack of awareness and about (68.1%) had barriers due to lack of government support. **Conclusion;** Based on the findings, most of the studied nurses had satisfactory knowledge and adequate practices concerning green practices and waste management in operating rooms. **Recommendations;** It was recommended to organize educational programs that address nurses' information needs regarding green practices. These should include applicable procedures and steps to reduce waste.

Keywords: Barriers, Green practice, Waste management, Nurses knowledge, Operating room.

Introduction

Over the past three decades, the volume of medical waste has escalated significantly. Healthcare facilities worldwide are now generating more waste than ever before. This surge is driven by several factors, including global population growth, the expansion and diversification of medical services, and the widespread dependence on disposable medical supplies. Compounding the issue is a general lack of awareness regarding the health risks associated with healthcare waste (HCW), inadequate staff training in proper waste handling, limited human resources, and the tendency to deprioritize waste management in institutional policies **(Wu & Cerceo, 2021).**

Improper handling of healthcare waste poses serious threats to the well-being of healthcare workers, patients, and surrounding communities. Effective medical waste management requires cooperation from all hospital personnel; however, nurses play a particularly critical role due to their constant and direct contact with patients. Their involvement in handling and disposing of medical waste means that they must be well-trained and knowledgeable in best practices **(Azouz et al., 2020).**

Healthcare waste is broadly defined as all types of waste produced by healthcare facilities (HCFs), regardless of whether the material is hazardous or non-hazardous, infectious or chemical in nature (Janik-Karpinska et al., 2023). This waste is typically categorized into several main types: infectious waste, sharps, pathological waste, pharmaceutical waste, genotoxic waste, radioactive waste, chemical waste, and general non-hazardous waste. Each category requires specific handling and disposal procedures to minimize risk **(Rizul et al., 2023).**

A green operating room (OR) is one that integrates environmentally sustainable practices while maintaining high standards of patient care. These practices include waste reduction, energy efficiency, water conservation, and the adoption of eco-friendly materials and equipment. For example, replacing disposable items with durable, reusable surgical tools can reduce both environmental impact and long-term operational costs **(Singh et al., 2020).**

Green practices in the OR extend to proper waste segregation and recycling, the repurposing or donation of medical supplies, and the installation of energy-saving infrastructure such as LED lighting and efficient ventilation ,and air conditioning (HVAC) systems. Furthermore, sustainable procurement practices—such as purchasing biodegradable cleaning supplies—and water-saving technologies like low-flow faucets help reduce environmental strain. Staff education is equally vital; training programs focused on green principles and proper waste handling protocols are essential for effective implementation **(Hanssen et al., 2020).**

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Monitoring environmental impact through regular audits and assessments ensures continued compliance with sustainability standards. Additionally, designing ORs with green building principles—such as optimizing natural lighting, enhancing ventilation, and selecting non-toxic materials—further contributes to improved outcomes. These efforts not only reduce a hospital's carbon footprint but also foster healthier environments for staff and patients **(González-Viralta et al., 2023).**

Limitation for implementing green practice in operating rooms; Financial limitations often challenge operating rooms, making it difficult to adopt sustainable alternatives like reusable instruments or eco-friendly supplies, which may have higher initial costs. Furthermore, there may be a lack of training and education on these sustainable practices **(Johnson, et al .,2024**).

Significance of the study

Among all healthcare professionals, nurses are at the greatest risk of exposure to medical waste hazards. Their prolonged and frequent interaction with patients increases their vulnerability to risks associated with improper waste management **(Health-care Waste, 2020).**

Healthcare waste generation in the United States has seen a dramatic rise—from 5 million tons per year prior to 2023 to approximately 2.5 million tons per month in 2023 **(Janik-Karpinska et al., 2023).** Similarly, Egypt faces its own challenges. According to the Ministry of Health and Population (2020), healthcare facilities across Egypt collectively generate an average of 300 tonnes of medical waste daily. Within Sohag University Hospital alone, approximately 365 tonnes of medical waste are produced annually **(Sohag University Hospital Record, 2024).**

The objective of this paper is to provide a comprehensive overview of medical waste-related issues, outline the fundamental principles of effective waste management, and highlight the potential risks to human health and the environment resulting from improper disposal practices **.**

Aim of the study

The current study aims to assess nursing knowledge and practice regarding barriers to green practice in operating rooms.

Research Questions

To achieve the objectives of this study, the following research questions have been formulated:

1. What is the level of nurse's knowledge and practice regarding green practices in operating rooms?
2. What is the level of nurse's knowledge regarding barriers to the green practices in operating room?

Subjects and Methods

Research design

A descriptive, research design was utilized to conduct this study.

Research setting

The study was carried out in five operating rooms at Sohag University Hospital, Egypt. These operating rooms provide a variety of healthcare services to a large number of surgical patients and include general surgery, orthopedic surgery, neurosurgery, urology, and cardiac/thoracic surgery departments.

Sampling

A convenience sample consisting of all available nurses (n = 91) working in the operating rooms, both male and female, who were willing to participate in the study with age (20-60) years old was included.

Data Collection Tools

Three tools were used for data collection:

Tool I: Structured Interview Questionnaire: This tool was developed by the researcher based on national and international literature **(Lee, et al., 2022).** To assess demographic data and nurses'

knowledge regarding green practice; it consists of two parts:

Part 1: - Demographic Data: This part includes information about nurse's code, gender, age, years of experience, level of education and previous training related to green practices.

Part 2: - Knowledge Assessment Tool: To assess nurses' knowledge about green practice. This part was designed by the researcher after reviewing relevant literature and includes 13 multiple-choice questions aimed at assessing nurses' knowledge about green practice. The questions cover the definition of green practice, its benefits, waste product definitions, waste classification, and waste segregation.

Scoring system: Each question was scored as follows: correct answers received 1 point, and incorrect answers received 0 points. Scores were converted into percentages, where less than 70% indicated unsatisfactory knowledge, 70% and more indicated satisfactory knowledge **(Lee et al., 2022).**

Tool II: Barriers to Green Practice and Waste Management: This tool was designed by the researcher after reviewing related literature. It includes 3 multiple choice questions to assess nurse's knowledge related to barriers to green practice and waste management such as (human barriers ,training) .

Scoring system: The scoring system : correct answers scored 1, incorrect answers scored 0, with scores converted to percentages. A score below 70% was considered unsatisfactory knowledge, while 70% or above was deemed satisfactory **(Lee, et al., 2022).**

Tool III: Observational Check list for Nurses Practices Regarding Green practice : This checklist was developed based on literature and expert consultation to assess nurses' practices related to waste management. It contains 3 items focusing on the "3Rs": Reduce, Reuse, and Recycle. The checklist evaluates practices such as reducing costs through proper waste segregation using a color-coding system, conserving energy, reusing surgical linens, and recycling clean plastics and paper.

Scoring System: Each item is scored from 0 to 1, where 0 indicates incomplete or incorrect practice and 1 indicates complete and correct practice. The total score ranges from 0 to 10. A total score of 60% or higher is considered adequate practice, while scores below 60% indicate inadequate practice **(Arab-Zozani et al., 2021).**

Content validity

The content validity of the data collection tools was evaluated by a panel of five experts in the field of Medical-Surgical Nursing. This panel included two assistant professors from the Critical Nursing Department, two lecturers from the Medical-Surgical Nursing Department, and one professor from the Administration Department, all affiliated with the Faculty of Nursing, Sohag University. The experts reviewed the tools for clarity, relevance, comprehensiveness, comprehensibility, applicability, and ease of use. Based on their feedback, necessary corrections, additions, and omissions were made to improve the tools.

Reliability

The reliability of the tools was assessed using Cronbach's alpha coefficient, which yielded a reliability score of 95%, indicating high internal consistency.

Pilot study

A pilot study was conducted on 10% of the sample size (9 nurses) to test the feasibility of the study, evaluate the application of the tools, assess content validity, and estimate the time required to complete the questionnaires. No modifications were necessary after the pilot study; thus, these nurses were included in the main study sample. The pilot study aimed to ensure the relevance of the tools, identify any issues affecting statement clarity, and estimate the time needed to complete the interview schedule.

Field work

Data collection was conducted one day per week (Sunday) during the morning shift over a six-month period from June 2024 to November 2024. The researcher introduced herself to the nurses, explained the study's objectives and procedures, and provided instructions on completing the self-administered questionnaires. Each participant required approximately 30 minutes to complete the (study tools), which was collected on the same day.

Administrative design

Official permission to conduct the study was obtained from the Dean of the Faculty of Nursing and the head of the Operating Rooms Unit at Sohag University Hospital. The study's objectives were clearly explained to gain their cooperation, and data collection was facilitated accordingly.

Ethical considerations

Ethical approval was granted by the Ethical Committee of the Faculty of Nursing, Sohag University, under code (166) dated 17/3/2024. Participation was voluntary, and signed informed consent and all participants were informed about the study's nature, procedures, and expected

outcomes. Participants retained the right to withdraw at any time without any adverse consequences. They were also informed that they could receive the study results after its completion. Confidentiality was strictly maintained by coding data using initials or numbers. Access to data was restricted and required participant permission. Data were used exclusively for research purposes

Statistical design

The collected data were coded, entered into a computer, scored, tabulated, and analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 23. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize data. Inferential statistics, such as Pearson's correlation coefficient, were employed to examine relationships between variables.

Results

Table 1: illustrates that more than half of the participating nurses (54.9%) were between 25 and 35 years old. The majority were female (70.3%). Regarding educational level, half of the nurses (50.5%) held a technical diploma, while 28.6% had other qualifications. In terms of professional experience, approximately half of the sample (49.5%) had between 5 and 10 years of experience. The majority (64.8%) were married. Notably, most of the nurses (74.7%) had not received any training related to green practices or waste management.

Table 2: shows that a significant proportion of nurses (91.2%) lacked knowledge about the definition of green practice, and more than half (51.6%) were unaware of its benefits. In contrast, 56.0% of the nurses were knowledgeable about the meaning of waste management. Additionally, 76.9% were aware of composting methods for waste disposal, the waste management hierarchy, and the concept of recycling. However, 71.4% reported having no information about hazardous waste products. On a more positive note, 89.0% of the nurses were familiar with the color-coding system used in waste handling.

Figure 1: shows that 58.2% of the nurses demonstrated satisfactory knowledge regarding the barriers to implementing green practices in operating rooms, while 41.8% had unsatisfactory knowledge in this area.

Table 3: highlights that 94.5% of nurses had adequate knowledge about waste segregation using the color-coding system, and an equal percentage reported knowledge of how to reuse sharps containers. However, 65.9% lacked knowledge about energy conservation measures, and none of the nurses (100%) had knowledge of how to recycle clean plastic and paper.

Figure 2: indicates that 83.5% of the nurses demonstrated competent and adequate levels of practice regarding waste management in the operating rooms, whereas 16.5% were rated as having in adequate and incompetent practices.

Table 4: presents the mean and standard deviation of nurses' knowledge and practice scores. The mean score for knowledge about green practices and waste management was 7.87 ± 3.53, and the mean practice score for waste management was 9.35 ± 2.46.

Table 5: reveals a positive correlation between nurses' knowledge of green practices and their practical implementation of medical waste disposal measures in operating rooms.

Table 6: shows that there was no statistically significant relationship between nurses' knowledge or practices regarding waste management and their demographic characteristics such as age, gender, educational level, marital status, or years of experience.

Table 7: identifies key barriers to green practices as perceived by the nurses. More than two-thirds (72.5%) reported poor waste segregation practices. A majority (79.1%) cited lack of awareness, and 68.1% identified insufficient government support—manifested through low salaries and limited resources—as the main obstacle to implementing green practices. Additionally, 17.6% mentioned a lack of commitment from hospital management.

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Results

Table 1: Distribution of the studied nurses according to their demographic characteristics (N = 91).

Variables		No.	percent%
Age	18< 25	19	20.9
	25-35	**50**	**54.9**
	> 35	22	24.2
Sex	Male	27	29.7
	Female	64	70.3
Educational level	Three-year nursing school	14	15.4
	Technical diploma	46	50.5
	Bachelor's degree	5	5.5
	Other	26	28.6
Marital status	Married	59	64.8
	Single	32	35.2
Years of experience	< 5 years	23	25.3
	5 -10 years	**45**	**49.5**
	>10 years	23	25.3
Attending training courses related to green practice and waste management	Yes	23	25.3
	No	**68**	**74.7**
Number of courses attended	One course	23	25.3

Table 2: Distribution of the nurse's knowledge about green practice and waste management (N = 91)

Green practice waste management Knowledge	Incorrect		Correct	
	No.	%	No.	%
• Definition of green practice.	83	**91.2**	8	8.8
• Benefits of the green practices and waste management.	47	**51.6**	44	48.4
• Definition of waste management.	51	**56.0**	40	44.0
• Waste management hierarchy.	39	42.9	52	57.1
• Meaning of recycling.	42	46.2	49	53.8
• Methods of composting for waste disposal.	21	23.1	70	**76.9**
• Classifications of the medical waste.	37	40.7	54	**59.3**
• Meaning of hazardous waste product.	65	**71.4**	26	28.6
• Knowledge about infectious medical waste and handling precautions	27	29.7	64	70.3
• Definition of Radioactive medical waste.	47	51.6	44	48.4
• Definition of medical waste segregation.	58	63.7	33	36.3
• Classification of the color-coded waste segregation	10	11.0	81	**89.0**

Figure (1): Percentage of the nurse's knowledge level about barriers to green practice in operating rooms (N=91).

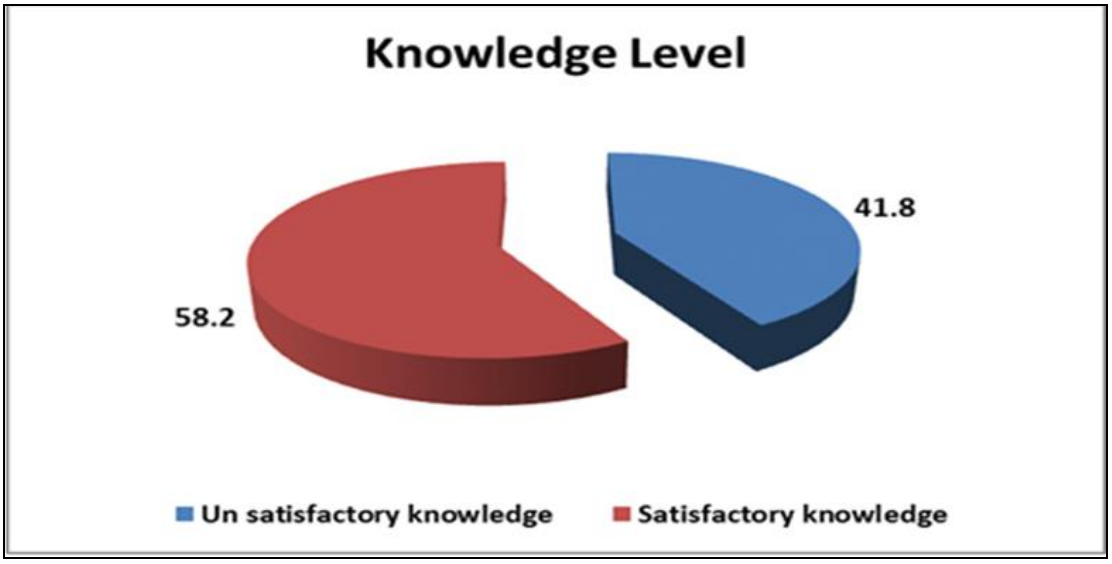

Table 3: Distribution of nurse's practices regarding waste management (N =91).

Practice category	Practice items	Incomplete and incorrect done		Complete and correct done	
		No	%	No.	%
Reduce	Reduce cost through proper waste segregation, through the color cod system as the following:	5	5.5	86	**94.5**
	1-Proper waste segregation (Yellow: blood-contaminated dressings)	5	5.5	86	94.5
	2- Proper waste segregation (Red: anatomical waste) 3- Proper waste segregation (Blue: medicinal waste)	5	5.5	86	94.5
	Fluid waste management.	15	16.5	76	83.5
	Energy conservation.	60	**65.9**	31	34.1
	Greener equipment packaging.	10	11.0	81	89.0
	Use of LED surgical lamps.	15	16.5	76	83.5
Reuse	Use of reusable surgical linens.	10	11.0	81	89.0
	Use of reusable sharp containers.	5	5.5	86	94.5
	Reprocessing of used medical devices.	10	11.0	81	**89.0**
	Use of reusable hard cases (e.g., sphygmomanometer cuff, pulse oximeter	10	11.0	81	89.0
Recycle	Recycling of clean plastic and paper	91	**100.**	0	0.0

Figure 2: Percentage of the nurse's practice level regarding waste management (n=91).

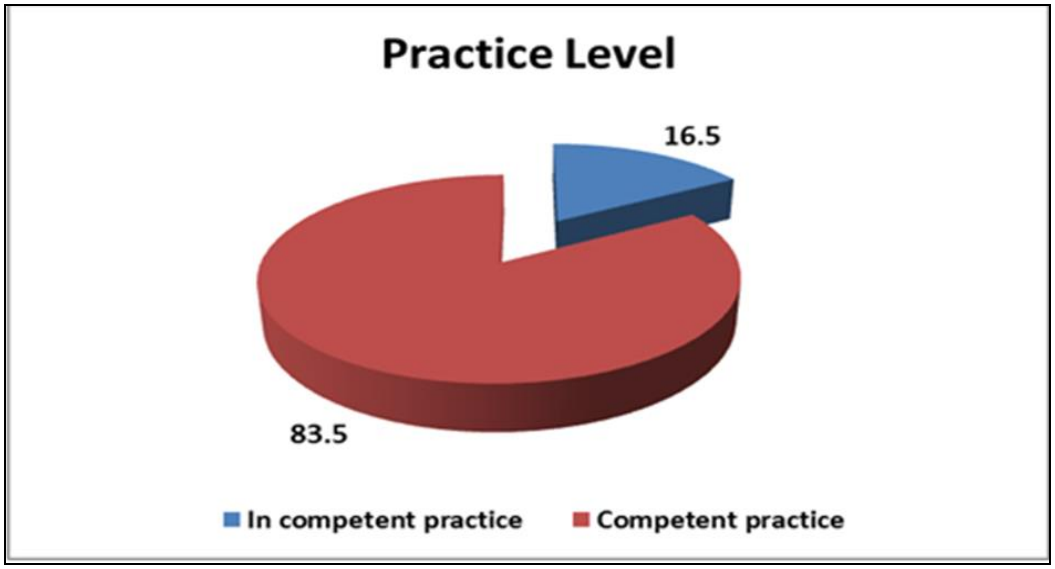

Table 4: Mean and standard deviation of the nurse's knowledge about green practice and waste management; and practices about waste management (N=91).

Variables	Mean ±Std. Deviation
Knowledge about green practice and waste management	7.87±3.53
Practices about waste management	9.35±2.46

Table 5: Best fitting multiple linear regression model for practices about waste management in relation to knowledge about green practice (n=91).

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
Practices about waste management	5.368	.435		12.330	000**
Knowledge about green practice	.506	.051	.728	10.018	000**

Significant at P. value < 0.01

Table 6: Pearson correlations between nurse's personal data, knowledge about green practice and waste management practice (N=91).

Variables		1	2	3	4	5	6	7	8
Age	**r.**	1	.391**	029	-.379**	.553**	-.122	.375**	.443**
	p.	1	.000	782	.000	.000	.248	.000	.000
Sex	**r.**	.391**	1	002	-.882**	.778**	-.101	-.244*	-.054
	p.	.000	1	986	.000	.000	.341	.020	.610
Educational level	**r.**	-.029	-.002	1	.069	.039	.109	-.066	.025
	p.	.782	.986	1	.515	.712	.306	.532	.815
Marital status	**r.**	-.379**	-.882**	069	1	-.745**	.164	-.025	-.247*
	p.	.000	.000	515	1	.000	.121	.816	.018
Years of experience	**r.**	.553**	.778**	039	-.745**	1	-.142	.180	.190
	p.	.000	.000	712	.000	1	.179	.087	.071
Have training courses	**r.**	-.122	-.101	109	.164	-.142	1	-.101	.063
	p.	.248	.341	306	.121	.179	1	.341	.553
Knowledge about green practice	**r.**	.375**	-.244*	066	-.025	.180	-.101	1	.728**
	p.	.000	.020	532	.816	.087	.341	1	.000
Practice	r.	.443**	-.054	025	-.247*	.190	.063	.728**	1
	p.	.000	.610	815	.018	.071	.553	.000	1

*** Significant at P. value < 0.05** **Significant at P. value < 0.01**

(1- Age, 2-Sex ,3- Educational level,4- Marital status,5- Years of experience,6- Have training courses,7- Knowledge,8- practice).

Table 7: Distribution of the studied nurses' barriers to the application of green practice regarding waste management in the operating rooms (N=91).

Items	No.	%
- Human and training barriers		
lack of awareness	**72**	79.1
Time required to obtain training, cost of certification, and lack of clarity on long-term benefits	**13**	**14.3**
- Administrative Barriers		
Insufficient support from government agencies	**62**	**68.1**
Lack of management commitment	**16**	**17.6**
- Infrastructure Barrier		
lack of waste segregation practices	**66**	**72.5**

Discussion

Medical waste amount has increased dramatically over the last 30 years, and health facilities around the world are producing more waste than ever before. The amount of health care waste generation is rising with the increase in the world's population, medical facilities' multitude and with the widespread propensity to use disposable medical equipment. Further problems include a lack of health risk awareness associated with HCW, insufficient training in proper waste management, inadequate human resources and the low priority given to this matter (**Wu and Cerceo, 2021).**

Based on the result of the current study regarding age, the participants age ranged from 25 to 35 years,. This result is consistent with the findings of (**Faltas et al. 2022),** who reported that the majority of studied nurses were aged between 30 and less than 40 years, with a mean age of 39.58 ± 8.69 years. It is believed that surgical nurses tend to be within the 25 to 35 age group due to the demanding nature of operating room shifts, which may last from one hour to 12 hours or more.

Regarding the gender, the majority of nurses were female, and more than half were married. These findings are consistent with those reported by **(Faltas et al. 2022).** Concerning the level of education, it was found that about half of the nurses held a technical nursing diploma. This finding disagrees with Faltas et al. (2022), who reported that the majority of studied nurses held either a diploma or a bachelor's degree. However, it aligns with the results of **(Khedre et al. 2020),** who conducted a study titled "Assessment of Healthcare Waste Management at Egyptian Hospitals: Case Study at Qotour General Hospital" and reported that 60% of nurses had a nursing diploma. In my opinion, nursing college graduates typically work as supervisors, but in cases of severe nursing shortages, they also work as staff nurses. Therefore, the vast majority of nurses are holders of a technical

Regarding the level of experience, half of the nurses had between 5 to 10 years of experience. This finding disagrees with **(González-Viralta et al. 2023),** who reported that about one-third of the nurses had less than 5 years of experience. Additionally, two-thirds of the nurses had not attended any training courses related to green practices. This result is consistent with **(Johnson et al. 2024),** who found that the majority of participants had not received any training in green practices. I believe that nurses have not received such training due to barriers such as limited time availability for courses and the financial costs associated with them.

Regarding the studied nurses' knowledge about green practices (reduce, reuse and recycle) in the operating room, the present study showed that the majority of nurses had satisfactory level knowledge about green practices in this setting. This result disagrees with **(Khedre et al. 2020),** who conducted a study titled "Knowledge and Practice of Biomedical Waste Management and Awareness of 3 'R's Concept Among Staff Nurses in the Hospital—A Cross-sectional Study" and reported inadequate awareness of the 3 'R's concept (reduce, reuse and recycle) and its implementation. According to their findings, most nurses focused only on biomedical or hazardous waste components, neglecting the solid waste generated in the hospital.

Regarding the studied nurses' knowledge about medical waste classification, the present study showed that the majority of nurses had satisfactory knowledge in this area. This result disagrees with (**Mohammed , 2019),** who conducted a study titled "Knowledge, Attitude and Practice of Health Care Personnel about Medical Waste Management in Selected Family Health Centers in Mansoura, Egypt," and reported that less than one-quarter of the participants had correct knowledge about medical waste classification and types.

Regarding knowledge about barriers to green practice in operating rooms, more than half of the nurses demonstrated satisfactory knowledge in this area. This finding aligns with Faltas et al. (2022), who reported that the majority of studied nurses had satisfactory knowledge and practice regarding medical waste management and green practices in operating rooms. However, this result disagrees with Taha et al. (2024), who found that the majority of nurses had unsatisfactory overall knowledge and practice related to medical waste management and green practices in operating rooms. In my opinion, nurses' satisfactory knowledge about barriers to green practice and medical waste management in operating rooms may be attributed to frequent visits from the infection control team, periodic follow-ups by the green practice team, and the personal interest of some nurses in self-development and updating their knowledge about modern, environmentally friendly waste disposal methods.

Regarding the relationship between knowledge about green practice, waste management, and nurses' educational level, the study found no statistically significant difference between knowledge of green practice and waste management and nurses' educational level, training, or years of experience. This finding is consistent with Taha et al. (2024), who reported no statistically significant relationship between nurses' knowledge and their participation in training courses or their years of experience.

Regarding the relationship between waste management practices and nurses' educational level, the study found a statistically significant difference related to years of experience and having training courses. This result disagrees with Taha et al. (2024), who reported no statistically significant relationship between nurses' practice and their educational level, training courses, or years of experience.

Regarding nurses' knowledge about barriers to green practice in the operating room, the study found that lack of awareness and insufficient government support were the main obstacles to implementing green practices. This result aligns with Faltas et al. (2022), who reported that administrative and human barriers are the primary challenges in adopting green practices in operating rooms. In my opinion, low wages contribute to nurses' job dissatisfaction, while the shortage of essential supplies—such as designated containers for different types of waste—makes it difficult for nurses to effectively apply green practices. Additionally, lack of awareness hinders nurses from correctly implementing green practices in the operating rooms

Conclusion

Based on the result of the present study concluded that the present study findings showed that the highest percentage of the studied nurses their age ranged from twenty-five to thirty-five years old. The majority of nurses were female more than half of the nurses had satisfactory knowledge about barriers to green practice in operating rooms. More than half of the nurses had satisfactory waste management practice in operating rooms. The majority of nurses had not had any training courses about green practice. The majority of nurses had technical diploma. The lack of government support was the main obstacle to implementing green practices in operating rooms.

Recommendations

The following recommendations were reached in the light of the study results:

1- Nurses should receive specific training regarding the new concept of sustainability and green practice and waste management.
2- Policy makers should be encouraged to purchase environmentally friendly supplies and materials used in operating rooms.
3- Activating the color code system to dispose of all types of waste generated inside the operating rooms.
4- Operating room nurses should be encouraged to prevent waste generation and to decrease surplus materials, and reusable materials should be given preference over disposable materials.
5- Efforts should be made to build environment – friendly teams "green team" in the operating rooms to follow green practices and applications.
6- Availability of relevant written and visual information in Operating room to facilitate educating nurses about proper operating waste management.
7- Further studies on larger samples from different geographical areas in Egypt to generalize the results.
8- Improve the government support to hospitals especially operating rooms

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