

Effect of Green Management Training Program for Nurses on Organizational Innovation at Hafar Al-Batin Hospital, Saudi Arabia

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Abstract:

Background: Integrating green management into nursing practice can promote sustainable healthcare through waste reduction, efficient resource utilization, energy conservation, and environmentally responsible healthcare operations. In addition, organizational innovation is essential for improving healthcare quality, reducing errors, and enhancing organizational performance. **Aim:** This study aimed to determine the effect of a green management program for nurses on organizational innovation at Hafar Al-Batin Central Hospital, Saudi Arabia. **Method:** A quasi-experimental design with repeated measurements (before, immediate after, and three-month follow-up) was conducted among 100 nurses from different departments at Hafar Al-Batin Central Hospital. Data were collected using three tools: the Green Management Knowledge Questionnaire, Green Management Practices Questionnaire, and Siegel Scale of Support for Innovation. **Results:** The findings revealed significant improvements in nurses' green management knowledge, practices, and perceptions of organizational innovation following the program's implementation. The proportion of nurses with high knowledge levels increased from 34.0% before training to 99.0% immediately after training and remained 92.0% after three months ($\chi^2=138.271$, $p<0.0001$). High-level green management practices increased from 17.0% before training to 60.0% immediately after training, then remained at 56.0% after three months. Furthermore, high perceptions of innovation support increased from 0% before training to 93.0% immediately after training and remained at 79.0% after three months ($\chi^2=223.012$, $p<0.0001$). **Conclusion:** The green management program was effective in improving nurses' green management knowledge, practices, and perceptions of organizational innovation, with sustained improvements after three months at Hafar-Al-Batin Central Hospital. **Recommendation:** Healthcare organizations should implement continuous green management training programs and evaluate their impact on environmental outcomes, including healthcare waste reduction, energy conservation, and sustainable resource utilization.

Keywords: Green Management, Training Program, Nurses, Organizational Innovation, Sustainability

Introduction

In recent years, increasing global awareness of environmental sustainability has encouraged organizations, including healthcare institutions, to adopt environmentally responsible management approaches. Healthcare organizations are increasingly integrating green initiatives to reduce environmental impact, improve sustainability, and enhance operational efficiency. Green management (GM) has emerged as an important organizational approach that promotes sustainability by developing environmentally responsible practices and managing sustainability-related initiatives (Gazi et al., 2024). Integrating GM into nursing practices can enhance innovation through approaches such as waste reduction, energy-efficient healthcare operations, and digital healthcare solutions that minimize resource consumption (Lee & Lee, 2022).

Green management refers to the implementation of environmentally friendly policies, sustainable practices, and resource-efficient strategies within organizations. In healthcare settings, GM focuses on reducing medical waste, conserving energy and water resources, adopting eco-friendly operational practices, and promoting sustainable healthcare delivery (Lee & Lee, 2022). In nursing practice, GM involves incorporating environmentally sustainable behaviors into daily nursing activities while maintaining safe and high-quality patient care. These practices include responsible resource utilization, waste reduction, energy conservation, and compliance with environmentally responsible healthcare policies (Saleh et al., 2023).

Healthcare organizations are important settings for implementing GM due to their high consumption of resources and generation of healthcare waste. Applying green practices can contribute to reducing operational costs, improving workplace safety, minimizing exposure to hazardous materials, and supporting environmental conservation. Moreover, sustainable nursing practices can create healthier work environments for healthcare professionals and patients by reducing environmental risks associated with healthcare activities (Shaban et al., 2024).

Successful implementation of GM in nursing requires organizational commitment, leadership support, and continuous education. Healthcare institutions can enhance green practices through structured training programs, environmental policies, staff engagement, green committees, and recognition systems that encourage nurses' participation in sustainability initiatives. Integrating practices such as proper waste segregation, reducing unnecessary use of materials, energy conservation, electronic documentation, and responsible

use of healthcare supplies into routine nursing activities can strengthen sustainable healthcare practices (Shaban et al., 2024). However, the adoption of GM may be influenced by several factors, including organizational policies, leadership commitment, availability of resources, environmental education, financial limitations, and institutional culture toward sustainability (Aly Abd-Elhamid & Gaber, 2023).

The principles of GM in nursing include implementing recycling programs, reducing single-use materials, promoting energy-efficient equipment, minimizing paper consumption through electronic systems, ensuring safe pharmaceutical disposal, reducing chemical exposure, and empowering nurses to support environmentally sustainable healthcare practices (Abd-elmonem et al., 2022). Therefore, improving nurses' knowledge and competencies through educational interventions is essential for integrating GM into healthcare organizations.

Alongside environmental sustainability, organizational innovation has become a key factor in improving healthcare systems. Innovation in nursing contributes to enhancing healthcare quality, reducing medical errors, improving patient outcomes, and optimizing available resources. It enables nurses to adopt effective practices, improve workflow efficiency, and provide patient-centered care. Organizational innovation refers to the adoption of new ideas, processes, technologies, and strategies that improve organizational efficiency, productivity, and service quality (Honda et al., 2023).

The successful adoption of innovation in nursing organizations depends on several factors, including leadership support, technological advancement, staff education, organizational culture, and resource availability. Supportive leadership and continuous professional development encourage nurses to participate in innovative activities and adapt to changing healthcare requirements. Furthermore, evidence-based practice, teamwork, flexibility, and sustainability represent important principles that support organizational innovation in healthcare settings (Eichelzer et al., 2025).

Healthcare institutions can promote organizational innovation by creating supportive work environments, providing continuous education, investing in healthcare technologies, encouraging research and quality improvement activities, and recognizing nurses who contribute innovative ideas. Empowering nurses to participate in organizational improvement initiatives can enhance creativity and strengthen innovation capacity (Eichelzer et al., 2025).

The integration of GM and organizational innovation provides an opportunity for healthcare organizations to achieve sustainable improvement. Green management supports the development of organizational cultures that encourage environmental responsibility, resource optimization, and innovative thinking. Green managers play an important role in establishing strategies, allocating resources, and creating supportive environments that facilitate innovation within healthcare organizations (Lin et al., 2024).

Healthcare institutions need to adapt to sustainability challenges to maintain effective and high-quality services. A successful green organization requires appropriate training programs, supportive policies, and effective systems that encourage employees to adopt environmentally responsible behaviors. Green management practices, including staff development, performance improvement, and organizational support, facilitate the integration of sustainability into healthcare culture (Shaban et al., 2024). However, limited evidence exists regarding the effect of structured GM training programs on nurses' organizational innovation, particularly within Saudi healthcare settings. Therefore, this study was conducted to determine the effect of a GM program for nurses on organizational innovation at Hafar-Al Batin Central Hospital, Saudi Arabia.

Aim of the Study

The study aimed to determine the effect of a green management program for nurses on organizational innovation at Hafar-Al Batin Central Hospital, Saudi Arabia.

Research Hypotheses

The study tested the following hypotheses:

H1: Nurses' knowledge of green management will improve after implementing the green management training program.

H2: Nurses' green management practices will improve after implementing the green management training program.

H3: Organizational innovation will improve after the implementation of the green management training program.

Methods

Research Design

A quasi-experimental design with repeated measurements (before the intervention, immediately after the intervention, and at a three-month follow-up) was used to assess the effect of a GM program for nurses on organizational innovation at Hafar Al-Batin Central Hospital, Saudi Arabia.

Setting

The study was conducted at Hafar Al-Batin Central Hospital, Saudi Arabia. The hospital is one of the leading healthcare facilities in the Eastern Province of the Kingdom of Saudi Arabia. The study was conducted among nurses working in different hospital departments who were involved in providing direct patient care..

Participants and Sample

A convenience sample was used in the present study. The study included 100 nurses from different hospital departments. Participants were eligible if they were responsible for direct patient care, had at least one year of work experience, were available during the data collection period, and agreed to participate in the study.

Tools of Data Collection

Three tools were used for data collection: the Green Management Knowledge Questionnaire, Green Management Practices Questionnaire, and Siegel Scale of Support for Innovation.

Tool I: Green Management Knowledge Questionnaire

The Green Management Knowledge Questionnaire was developed by the researcher based on a review of relevant literature (Aftab et al., 2023; Bahuguna et al., 2023; Tanova & Bayighomog, 2022; Kodua, 2022). The tool aimed to assess nurses' knowledge regarding GM during the different phases of the training program. The questionnaire consisted of two parts. The first part assessed nurses' personal characteristics, including age, gender, marital status, educational qualification, years of work experience, and previous attendance at training courses related to the study topic. The second part consisted of 20 questions related to GM concepts, including its definition, benefits, components, categories, advantages, and strategies. The questions were presented as true/false and multiple-choice. Each correct answer was assigned a score of 1, while incorrect answers received a score of 0.

Scoring System

The total knowledge score was classified according to predetermined cut-off points as follows:

- Low level: <60% of the total score.
- Moderate level: 60–75% of the total score.
- High level: >75% of the total score.

Tool II: Green Management Practices Questionnaire

The Green Management Practices Questionnaire was developed by Mukherjee et al. (2020) to measure GM practices among nurses. The questionnaire consisted of 40 items distributed across seven dimensions: green recruitment and selection (6 items), green training and development (6 items), green performance appraisal management (6 items), green pay and reward management (7 items), green employee participation and empowerment (6 items), management of green organizational culture (5 items), and green exit (4 items). Responses were measured using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

Scoring System

The total practice score was classified according to predetermined cut-off points as follows:

- Low level: <60% of the total score.
- Moderate level: 60–75% of the total score.
- High level: >75% of the total score.

Tool III: Siegel Scale of Support for Innovation

The Siegel Scale of Support for Innovation was developed by Siegel and Kaemmerer (1978). It was used to assess nurses' perceived support for innovation within the organization. The scale consisted of 61 items categorized into five dimensions: leadership (19 items), ownership (16 items), norms for diversity (9 items), continuous development (10 items), and consistency (7 items). Responses were measured using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

Scoring System

The total score of organizational innovation support was classified according to predetermined cut-off points as follows:

- Low level: <60% of the total score.
- Moderate level: 60–75% of the total score.
- High level: >75% of the total score.

Validity and Reliability

The study tools were tested for face and content validity by five experts in the fields of nursing administration, healthcare management, and the study topic. Necessary modifications were made based on the experts' feedback. The reliability of the study tools was assessed using Cronbach's alpha coefficient. The reliability coefficients were 0.89 for the GM Knowledge Questionnaire, 0.79 for the GM Practices Questionnaire, and 0.93 for the Siegel Scale of Support for Innovation, indicating acceptable internal consistency. The Green Management Knowledge Questionnaire was translated into Arabic by the researcher.

Pilot Study

A pilot study was conducted among 10 nurses (10% of the total sample) to evaluate the clarity, feasibility, and applicability of the study tools. The pilot participants were randomly selected and excluded from the final study sample. Necessary modifications were performed based on the findings of the pilot study. Participants in the pilot study were not included in the main study.

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Nursing, Mansoura University. Official permission to conduct the study was obtained from the administration of Hafar Al-Batin Central Hospital after explaining the purpose and procedures of the study. All participants were informed about the nature and objectives of the study. Participation was voluntary, and participants were assured of their right to withdraw from the study at any time without any consequences. Confidentiality and privacy of the collected data were maintained throughout all stages of the study. Written informed consent was obtained from all participants who agreed to participate.

Data Collection Procedure

Data collection was conducted through several phases. Initially, official approval was obtained from the Faculty of Nursing, Mansoura University, and Hafar Al-Batin Central Hospital administration. The researcher met the participants individually, explained the aim and procedures of the study, and obtained their written informed consent. During the first phase, baseline data were collected before implementing the training program using the Green Management Knowledge Questionnaire, Green Management Practices Questionnaire, and

Siegel Scale of Support for Innovation. This assessment represented the pre-intervention measurement.

Based on the baseline findings and a review of relevant literature, the researcher developed a GM training program for nurses. The program aimed to improve nurses' knowledge and practices regarding GM and to enhance organizational innovation. The training program was implemented through small-group sessions according to nurses' availability and workload. Various teaching strategies were used, including lectures, brainstorming, group discussions, educational videos, and researcher-prepared educational materials and handouts.

The GM training program was conducted from December 2024 to June 2025. Nurses were divided into small groups, and training sessions were conducted during morning and evening shifts three days per week. The program consisted of four sessions for each group, with each session lasting two hours, resulting in a total duration of eight training hours. Immediately after completion of the training program, the same study tools were administered to evaluate the immediate effect of the intervention. A follow-up assessment was conducted three months after program implementation using the same tools to evaluate the sustainability of the program outcomes.

Results

Table (1): Personal Characteristics of the Studied Nurses at Hafar Al-Batin Central Hospital, Saudi Arabia

Personal characteristics	The studied nurses (n=100)	
	n	%
■Age years		
20-<35	65	65.0
35-40	35	35.0
Range	21-40	
Mean±SD	32.19±5.62	
■Sex		
Male	17	17.0
Female	83	83.0
■Experience years		
< 1	3	3.0

1-5	11	11.0
>5-10	44	44.0
>10	42	42.0
Mean±SD	10.52±5.14	
■ Educational level		
Bachelor	74	74.0
Master	10	10.0
PHD	8	8.0
Other	8	8.0
■Previous training		
Yes	70	70.0
No	30	30.0

Table (1) presents the personal characteristics of the studied nurses at Hafar Al-Batin Central Hospital, Saudi Arabia. The findings revealed that 65.0% of the nurses were aged between 20 and less than 35 years, with a mean age of 32.19 ± 5.62 years. The majority of participants were female (83.0%). Regarding years of experience, 44.0% of nurses had more than 5 to 10 years of experience, with a mean experience of 10.52 ± 5.14 years. Concerning educational level, 74.0% of participants held a Bachelor's degree. Additionally, 70.0% of the nurses studied reported having attended training programs previously.

Table (2): Level of Green Management Knowledge among the Studied Nurses at Hafar Al-Batin Central Hospital, Saudi Arabia, Before, Immediately After, and Three Months After the Training Program

Green Management Knowledge level (Each item was scored 0-1)	Green Management Knowledge of the studied nurses before and after training program (n=100)						x ² test P value
	Before		Immediate after		After 3 months follow up		
	n	%	n	%	n	%	
A-True/False knowledge questions level							
Low level (0-4)	28	28.0	1	1.0	2	2.0	60.990 0.0001*
Moderate level (5-6)	9	0.9	1	1.0	4	4.0	
High level (7-8)	63	63.0	98	98.0	94	94.0	

B-Multiple choice questions (MCQs) level							
Low level (0-6)	33	33.0	0	0	4	4.0	103.857
Moderate level (7-9)	29	29.0	3	3.0	11	11.0	0.0001*
High level (10-12)	38	37.0	97	97.0	85	85.0	
Total Green Management Knowledge level							
Low level (0-11)	32	32.0	0	0	1	1.0	138.271
Moderate level (12-15)	34	34.0	1	1.0	7	7.0	0.0001*
High level (16-20)	34	34.0	99	99.0	92	92.0	

N.B. Knowledge level was classified as Low (<60% of total scores), Moderate (60-75% of total scores), and High (>75% of total scores).

Table (2) illustrates the level of GM knowledge among the studied nurses before, immediately after, and three months after the implementation of the training program. Regarding true/false knowledge questions, the proportion of nurses with high knowledge levels increased from 63.0% before the program to 98.0% immediately after the program and remained 94.0% after three months of follow-up ($\chi^2=60.990$, $p<0.0001$).

Concerning multiple-choice questions, the proportion of nurses with high knowledge levels increased from 37.0% before the program to 97.0% immediately after the program and remained 85.0% after three months of follow-up ($\chi^2=103.857$, $p<0.0001$). Regarding the total GM knowledge level, the percentage of nurses with high knowledge levels increased from 34.0% before the program to 99.0% immediately after the program and remained 92.0% after three months of follow-up ($\chi^2=138.271$, $p<0.0001$).

Table (3): Total Green Management Practices Score and Level among the Studied Nurses at Hafar Al-Batin Central Hospital, Saudi Arabia, Before, Immediately After, and Three Months After the Training Program

Total Green Management Practices	Total Green Management Practices of the studied nurses before and after training program (n=100)	χ^2 test P value
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(Each item was scored 1-5)	Before		Immediate after		After 3 months follow up		
	n	%	n	%	n	%	
•Total Green Management Practices level							
Low level (40-119)	47	47.0	22	22.0	1	1.0	81.204
Moderate level (120-180)	36	36.0	18	18.0	43	43.0	0.0001*
High level (181-200)	17	17.0	60	60.0	56	56.0	
•Total Green Management Practices scores (40-200)							
Range	45-200		112-200		46-200		
Mean±SD	131.94±44.07		176.00±23.03		163.36±46.44		
x ² value	42.697						
P value	0.0001*						

*Statistically significant (P<0.05)

Table (3) presents the total GM practices score and level among the studied nurses before, immediately after, and three months after the implementation of the training program. The findings revealed that the mean total GM practices score increased from 131.94±44.07 before the program to 176.00±23.03 immediately after the program and decreased to 163.36±46.44 after three months of follow-up ($\chi^2=42.697$, $p<0.0001$). Regarding the level of GM practices, the proportion of nurses with high-level practices increased from 17.0% before the program to 60.0% immediately after the program and remained 56.0% after three months of follow-up.

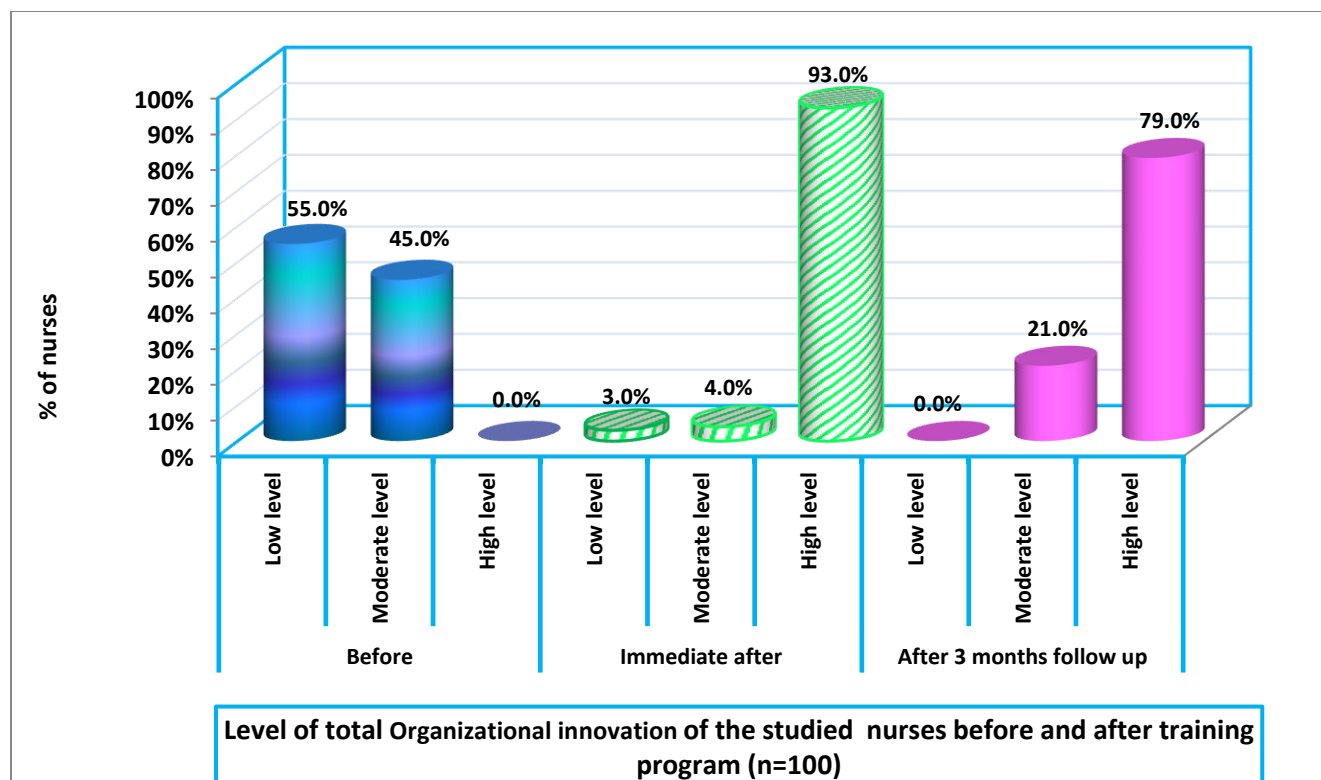


Figure (1): Level of Total Organizational Innovation among the Studied Nurses at Hafar-Al Batin Central Hospital, Saudi Arabia, Before, Immediately After, and Three Months After the Training Program

Figure (1) presents the total organizational innovation scores and levels among the studied nurses before, immediately after, and three months after the implementation of the training program. The mean total organizational innovation score increased from 173.80 ± 28.69 before the program to 256.16 ± 23.37 immediately after the program and remained 249.01 ± 22.15 after three months of follow-up ($\chi^2=191.387$, $p<0.0001$). Regarding the level of organizational innovation support, the proportion of nurses with high-level perceptions increased from 0% before the program to 93.0% immediately after the program and remained 79.0% after three months of follow-up ($\chi^2=223.012$, $p<0.0001$).

Table (4): Correlation between Total Green Management Knowledge, Green Management Practices, and Organizational Innovation Scores among the Studied Nurses at Hafar Al-Batin Central Hospital, Saudi Arabia, Before, Immediately After, and Three Months After the Training Program

Variables	Total Green Management Knowledge scores of the studied nurses pre and post program (n=100)					
	Before		Immediate after		After 3 months follow up	
	r	P value	r	P value	r	P value
Total Green Management Practices scores	0.506	0.0001*	0.840	0.0001*	0.894	0.0001*
Total Organizational innovation scores	0.510	0.0001*	0.811	0.0001*	0.862	0.0001*

***Statistically significant (P<0.05)**

r=Correlation Coefficient

Table (4) presents the correlation between total GM knowledge scores and GM practices and organizational innovation scores among the studied nurses before, immediately after, and three months after the implementation of the training program. A statistically significant positive correlation was found between total GM knowledge scores and total GM practices scores at all assessment phases. The correlation coefficient increased from $r=0.506$ before the program to $r=0.840$ immediately after the program and to $r=0.894$ after a 3-month follow-up ($p<0.0001$). Similarly, a statistically significant positive correlation was found between total GM knowledge scores and organizational innovation scores. The correlation coefficient increased from $r=0.510$ before the program to $r=0.811$ immediately after the program and $r=0.862$ after three months follow-up ($p<0.0001$).

Discussion

Green management in nursing involves integrating environmentally sustainable practices into nursing roles, clinical processes, and daily healthcare activities while maintaining safe and high-quality patient care. It includes efficient resource utilization, reduction of healthcare waste, energy conservation, environmentally responsible disposal practices, and nurses' participation in

sustainability initiatives. Implementing GM within healthcare organizations supports environmental responsibility and promotes sustainable healthcare practices while encouraging organizational improvement and innovation. Therefore, the present study aimed to determine the effect of a GM program for nurses on organizational innovation at Hafar-Al Batin Central Hospital, Saudi Arabia.

Green Management Knowledge among the Studied Nurses Before, Immediately After, and Three Months After the Training Program

The present study revealed a statistically significant improvement in nurses' GM knowledge following implementation of the training program. The proportion of nurses with high total GM knowledge increased from 34.0% before the program to 99.0% immediately after the program and remained 92.0% after three months of follow-up ($\chi^2=138.271$, $p<0.0001$). Similarly, high knowledge levels in both true/false and multiple-choice questions showed significant improvement after the intervention, with this improvement maintained at follow-up.

The improvement in nurses' knowledge may be attributed to the structured educational content of the GM program, which provided nurses with comprehensive information regarding environmental sustainability, waste reduction, resource conservation, and green healthcare practices. Before the intervention, limited exposure to formal GM education may have contributed to lower knowledge levels among some nurses. The combination of theoretical sessions, practical examples, discussions, and educational materials may have enhanced nurses' understanding and supported knowledge retention over time. The maintained level of knowledge after three months suggests that the program had a sustainable educational effect rather than producing only short-term improvement.

These findings are consistent with Aly Abd-Elhamid and Gaber (2023), who reported significant improvements in nurses' sustainability management knowledge after implementing a GM educational program. Their findings demonstrated that structured educational interventions effectively improve nurses' awareness and understanding of environmental sustainability concepts, supporting the current study results. Similarly, Saleh et al. (2023) found that a GM training program significantly improved nursing managers' perception and understanding of GM concepts. This supports the present findings, indicating that targeted educational programs can enhance environmental knowledge among nursing professionals.

Furthermore, Elksas et al. (2024) reported a significant improvement in nursing staff knowledge following the implementation of a GM program, with sustained improvement relative to baseline measurements. These findings support the current study by highlighting the effectiveness of continuous educational approaches in strengthening nurses' GM knowledge. The current results are also supported by Ahmad et al. (2021), who emphasized that environmental knowledge is an important factor in promoting environmentally responsible behaviors. Increased knowledge enables employees to better understand sustainability principles and facilitates the adoption of green practices.

Similarly, Zhang et al. (2021) highlighted that environmental knowledge management contributes to improving employees' environmental awareness and sustainable behaviors, supporting the role of educational interventions in achieving long-term knowledge improvement. Additionally, Cai et al. (2024) emphasized the importance of workplace learning mechanisms and green knowledge management in developing employees' environmental competencies. This finding further supports the current study by indicating that structured learning environments are essential for improving and maintaining GM knowledge.

Green Management Practices among the Studied Nurses Before, Immediately After, and Three Months After the Training Program

The present study demonstrated a statistically significant improvement in nurses' GM practices following implementation of the training program. The mean total GM practices score increased from 131.94 ± 44.07 before the program to 176.00 ± 23.03 immediately after the program and remained 163.36 ± 46.44 after three months of follow-up ($p < 0.0001$). Regarding practice levels, the proportion of nurses with high-level GM practices increased from 17.0% before the program to 60.0% immediately after implementation, then remained at 56.0% after three months of follow-up.

The improvement in GM practices may be attributed to the training program's role in translating nurses' acquired knowledge into practical applications. The program provided nurses with guidance on sustainable healthcare practices, including appropriate resource use, waste reduction, environmental responsibility, and the adoption of green practices in daily nursing activities. The increase in practice levels immediately after training indicates that nurses were able to apply the acquired concepts effectively. The maintained improvement at the three-month follow-up suggests that the intervention supported the

integration of green practices into routine nursing activities and contributed to sustained behavioral change.

These findings are consistent with Atalla, El-Ashry, and Khattab (2025), who reported that implementing green human resource practices enhanced nurses' engagement in environmentally responsible behaviors and improved organizational environmental performance. Their findings support the current study by demonstrating that structured green initiatives can positively influence nurses' adoption of green practices. Similarly, Paillé et al. (2020) emphasized that systematic green human resource practices contribute to improving employees' environmental behaviors and sustainability performance. This supports the present findings, as nurses who received structured GM training demonstrated significant improvement in their GM practices.

In agreement with the current results, Yusoff et al. (2020) found that green initiatives and employee training positively influenced environmentally responsible behaviors and sustainable practices. Their findings highlight the importance of organizational support and educational interventions in achieving behavioral improvements. Furthermore, Ercantan and Eyupoglu (2022) reported that green human resource management practices encourage employees to engage in environmentally responsible behaviors. This supports the current study findings, indicating that planned GM interventions can enhance nurses' commitment to sustainable practices.

Additionally, Huo et al. (2022) found that structured GM practices improved employees' green performance by promoting environmental awareness and sustainable behaviors. Similarly, Lee and Lee (2022) emphasized the importance of continuous education and organizational support in improving healthcare workers' environmental practices, particularly in areas related to sustainable healthcare and medical waste management. Overall, the findings of the current study indicate that a structured GM training program can effectively improve nurses' GM practices and maintain these improvements over time.

Organizational Innovation among the Studied Nurses Before, Immediately After, and Three Months After the Training Program

The current study revealed a statistically significant improvement in nurses' perceptions of organizational innovation following implementation of the GM training program. The mean total organizational innovation score increased from 173.80 ± 28.69 before the program to 256.16 ± 23.37 immediately after the program and remained 249.01 ± 22.15 after three months of follow-up ($p < 0.0001$).

Furthermore, the proportion of nurses with high-level perceptions of innovation support increased from 0% before the intervention to 93.0% immediately after the program and remained 79.0% after three months of follow-up.

The improvement in perceptions of organizational innovation may be attributed to the training program's role in enhancing nurses' awareness of innovation processes, encouraging participation, and strengthening their understanding of organizational support mechanisms. Green management initiatives require problem-solving, teamwork, creativity, and continuous improvement, which may contribute to developing a supportive environment for innovation. In addition, the interactive educational approaches used during the program may have encouraged communication, knowledge exchange, and collaborative thinking among nurses, contributing to improved innovation perceptions.

The sustained improvement after three months indicates that the training program may have contributed to lasting changes in nurses' attitudes toward innovation and increased recognition of opportunities for improvement within the healthcare organization. The present findings are supported by Sun et al. (2024), who reported that nurses' perceptions of organizational innovation climate significantly influenced innovative behaviors and workplace attitudes. Their findings support the current results by demonstrating that innovation-related perceptions among nurses can be improved through supportive organizational interventions.

Similarly, Gao et al. (2022) found that nursing innovation workshops significantly improved nurses' innovation abilities following an educational intervention, with sustained effects over time. This finding is consistent with the current study, where organizational innovation scores improved immediately after training and remained elevated at three-month follow-up. Furthermore, Emiralioglu and Sönmez (2021) reported that supportive organizational environments and empowerment strategies enhanced nurses' innovative behaviors. This supports the current findings, suggesting that improving organizational support perceptions is an important factor in promoting nursing innovation. In agreement with these findings, Emiralioglu and Sönmez (2021) found that supportive nursing work environments and innovation support were positively associated with nurses' innovative behaviors and outcomes. These findings reinforce the importance of organizational support in facilitating innovation among nursing staff.

Relationship between Green Management Knowledge, Green Management Practices, and Organizational Innovation among the Studied Nurses

The present study revealed statistically significant positive correlations between nurses' GM knowledge, GM practices, and organizational innovation across all assessment periods. A significant positive correlation was observed between total GM knowledge scores and total GM practices scores before the program ($r=0.506$, $p<0.0001$), which became stronger immediately after the intervention ($r=0.840$, $p<0.0001$) and remained very strong after three months of follow-up ($r=0.894$, $p<0.0001$).

The positive relationship between knowledge and practices may be explained by the important role of knowledge in supporting behavioral change. Nurses who have a better understanding of GM concepts are more capable of applying sustainable practices in their daily activities. The training program provided nurses with both theoretical knowledge and practical guidance, which may have facilitated the translation of acquired knowledge into effective GM behaviors. The stronger correlation observed after the intervention and at follow-up indicates that improved knowledge was associated with more consistent application of green practices over time.

These findings are supported by Bresciani et al. (2023), who reported that environmental knowledge management contributes to improving environmental performance by facilitating the application of sustainable practices. Their findings support the current study by highlighting the role of knowledge development in promoting environmentally responsible behaviors. Similarly, Polas et al. (2023) emphasized that knowledge management practices enhance environmental awareness and encourage the adoption of sustainable behaviors. This aligns with the present findings, where improvement in GM knowledge was associated with improved GM practices among nurses. In agreement with the current results, Malik et al. (2023) found that green knowledge acquisition positively influenced the implementation of green project management practices and sustainability outcomes. This supports the current findings by demonstrating that increasing environmental knowledge can enhance the practical application of sustainability principles.

Furthermore, Shahzad et al. (2021) reported that the interaction between knowledge management processes and sustainable development practices contributes to improved green innovation outcomes. This reinforces the current finding that strengthening nurses' GM knowledge can support the development and maintenance of sustainable practices. The present study also demonstrated

a statistically significant positive correlation between total GM knowledge scores and organizational innovation scores at all measurement periods. The correlation increased from $r=0.510$ before the program to $r=0.811$ immediately after the program and remained strong at three months follow-up ($r=0.862$), with statistically significant associations ($p<0.0001$).

This relationship may be attributed to the fact that enhanced environmental knowledge can increase nurses' awareness of improvement opportunities and encourage creative approaches to solving healthcare-related challenges. Green management knowledge may promote critical thinking, problem-solving abilities, and active participation in organizational improvement initiatives. Therefore, improving nurses' knowledge through structured training may contribute not only to sustainability awareness but also to strengthening innovation-related perceptions within healthcare organizations.

These findings are consistent with previous research emphasizing the relationship between knowledge development and innovation. Green knowledge provides employees with the ability to identify environmental challenges, generate solutions, and participate in improvement activities. Therefore, educational interventions focusing on GM may represent an effective strategy for supporting both sustainability and innovation within healthcare settings. Additionally, the current findings revealed a statistically significant positive correlation between total GM practices scores and organizational innovation scores across all measurement periods. The correlation between these variables increased from $r=0.506$ before the program to $r=0.840$ immediately after the program and remained high at three months follow-up ($r=0.894$, $p<0.0001$).

The observed relationship may be explained by the fact that GM practices encourage teamwork, employee engagement, continuous improvement, and efficient resource utilization, which are essential elements of organizational innovation. Implementing environmentally sustainable practices requires nurses to identify problems, develop practical solutions, and participate in organizational changes, thereby creating a supportive environment for innovation. The current findings are supported by Abd-elmonem et al. (2022), who found a significant positive relationship between green human resource management strategies and organizational innovativeness among head nurses. Their findings support the current study by indicating that green-oriented management approaches can enhance innovation within nursing organizations.

Similarly, Atalla et al. (2025) reported that green human resource practices positively influenced organizational environmental performance among nurses, supporting the relationship between sustainable practices and organizational improvement. In addition, Skubis et al. (2023) highlighted that green initiatives within healthcare organizations contribute to innovation development by encouraging sustainable solutions and organizational change.

Overall Discussion Summary

Overall, the findings of the present study demonstrate that the GM training program was effective in improving nurses' GM knowledge, enhancing GM practices, and strengthening perceptions of organizational innovation. The significant improvements observed immediately after the intervention and maintained after three months of follow-up indicate the sustainability of the program outcomes. Furthermore, the positive correlations between knowledge, practices, and organizational innovation highlight the interconnected role of environmental knowledge and sustainable practices in promoting innovation within healthcare organizations.

These findings support the study hypotheses:

- **H1:** Nurses' knowledge of green management improved after the implementation of the green management training program.
- **H2:** Nurses' green management practices improved after implementing the green management training program.
- **H3:** Organizational innovation improved after implementing the green management training program.

Conclusion

Based on the findings of the present study, it was concluded that the GM training program was effective in improving nurses' GM knowledge, practices, and perceptions of organizational innovation at Hafar Al-Batin Hospital, Saudi Arabia. Significant improvements were observed immediately after the intervention and were maintained at the three-month follow-up assessment. Furthermore, significant positive correlations were identified between GM knowledge, GM practices, and organizational innovation, indicating the importance of strengthening nurses' environmental knowledge and sustainable practices to support organizational improvement.

Recommendations

For Hospital Administration

1. Develop and integrate structured GM training programs into continuous professional development activities for nurses to promote sustainable healthcare practices.
2. Establish organizational policies and monitoring systems that support the implementation of GM practices, including waste reduction, resource conservation, and environmentally responsible healthcare activities.
3. Encourage innovation initiatives related to sustainability by providing supportive environments, resources, and recognition for nurses who contribute to green healthcare improvements.

For Head Nurses

1. Conduct regular refresher training sessions and educational activities to reinforce nurses' GM knowledge and maintain sustainable practices.
2. Monitor the implementation of GM practices within nursing units through regular audits, observation checklists, and feedback mechanisms.
3. Encourage nurses' participation in sustainability projects and quality improvement initiatives that promote environmental responsibility and organizational innovation.

For Staff Nurses

1. Participate actively in GM education programs and continuous learning opportunities to enhance knowledge and competency in sustainable healthcare practices.
2. Apply GM principles in daily nursing practice, including appropriate waste segregation, reduction of unnecessary resource use, energy conservation, and responsible utilization of healthcare supplies.
3. Participate in innovation and improvement activities aimed at developing sustainable solutions within healthcare settings.

For Future Research

1. Conduct longitudinal studies with extended follow-up periods to evaluate the long-term sustainability of GM knowledge, practices, and organizational innovation outcomes.

2. Investigate the impact of nurses' GM practices on measurable environmental indicators, including healthcare waste reduction, energy consumption, water usage, and carbon footprint.
3. Conduct multicenter studies involving different healthcare organizations to enhance the generalizability of findings regarding GM interventions in nursing practice..

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Conflict of interest

The authors declare no conflict of interest in the preparation of this study.

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