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Cultural and social dimensions of nurses' awareness of sustainable healthcare practices in hospital settings: A humanistic perspective toward advancing SDG 3

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ABSTRACT

This study examines the cultural and social dimensions shaping hospital nurses' awareness of sustainable healthcare practice principles within the Saudi Arabian context, adopting a humanistic lens aligned with SDG 3 (Good Health and Well-Being). Using a cross-sectional design, data were collected from 256 nurses (mean age = 38.12 years; 63.7% female; 56.6% holding a bachelor's degree) representing diverse hospital environments. The psychometrically validated Nurses' Awareness of Sustainable Healthcare Practice Principles Questionnaire (NASHPP-Q) assessed five domains: climate change knowledge, perceived links between nursing practice and the environment, barriers to implementation, education and training, and leadership and advocacy. Findings revealed moderate awareness of climate change impacts (M = 2.90), alongside low understanding of climate-smart healthcare strategies (M = 2.58). A notable theory–practice gap emerged, where high recognition of environmental stewardship values (M = 3.65) contrasted with limited application of waste-reduction practices (M = 3.09). Major structural and cultural barriers included time constraints (M = 4.28), limited institutional support (M = 4.01), and inadequate resource availability (M = 3.76). Only 28.5% of participants reported having received training related to sustainability. Socially, nurses expressed stronger trust in informal peer leadership networks (M = 3.96) than in formal sustainability committees (M = 2.23). These results underscore the need to integrate sustainability competencies into nursing education, redesign organizational workflows, and reinforce institutional support systems. Leveraging peer networks and addressing sociocultural barriers may enhance the adoption of sustainable healthcare practices, contributing to national and global progress toward SDG 3.

KEYWORDS: cultural dimensions, social context, climate-smart care, environmental awareness, healthcare sustainability, SDG 3, sustainable healthcare practices, sustainability barriers, nursing workforce

Introduction

Sustainable healthcare represents a comprehensive approach to delivering high-quality, accessible, and affordable medical care while minimizing adverse environmental impacts, promoting social equity, and ensuring long-term economic viability for current and future generations (Osorio-González et al., 2020; Tamer, 2018). This paradigm is structured around three interconnected pillars that define its scope and implementation. The environmental pillar focuses on reducing the healthcare sector's ecological footprint through minimizing waste generation, decreasing greenhouse gas emissions, and promoting resource conservation practices that safeguard planetary health (Hussain et al., 2024; Rahat et al., 2023; Soares et al., 2023). The social sustainability pillar emphasizes ensuring equitable access to healthcare services, addressing health disparities across diverse populations, supporting healthcare workforce well-being, and fostering community engagement and social justice initiatives (De Hoop et al., 2022; Gupta et al., 2023; Hussain et al., 2024). The economic sustainability pillar centers on maintaining healthcare affordability, optimizing resource utilization efficiency, and ensuring the long-term financial viability of healthcare systems to guarantee continued delivery of quality care (De Hoop et al., 2022; Hussain et al., 2024). These three pillars are inherently interdependent, as neglecting one dimension can significantly undermine the effectiveness and sustainability of the others (Gupta et al., 2023; Rahat et al., 2023).

The global healthcare sector has emerged as a significant contributor to environmental degradation, accounting for approximately 4-5% of total global carbon emissions, positioning it as the fifth-largest emitter worldwide if considered as a single country (Karliner et al., 2020; Lenzen et al., 2020; Pichler et al., 2019; RodríguezJiménez et al., 2023). Most of these emissions, up to 71%, originate from healthcare supply chains, including pharmaceutical production, medical equipment manufacturing, and procurement processes (Pichler et al., 2019; MacNeill et al., 2017). Additionally, hospitals are particularly resource-intensive environments, with operating rooms alone consuming three to six times more energy than other hospital areas and generating up to 30% of total hospital waste (MacNeill et al., 2017; Wu & Cerceo, 2021). Medical waste generation presents another critical environmental challenge, with hospitals producing up to 29 pounds of waste per patient daily, predominantly consisting of single-use plastics and hazardous materials (Soares et al., 2023; Singh et al., 2021). Alarmingly, only 39% of medical waste globally is properly segregated, and less than half of healthcare workers receive adequate training in waste management practices (Chisholm et al., 2021; Lee & Lee, 2022; Singh et al., 2021). This growing environmental impact has prompted increased emphasis on environmental responsibility and sustainability within healthcare delivery systems (Cristiano et al., 2024; Filho et al., 2024; Lee & Lee, 2022; Soares et al., 2023).

Within hospital settings, sustainable healthcare practices manifest through specific operational strategies that simultaneously address all three sustainability pillars. Waste segregation and management systems enable hospitals to differentiate between hazardous and non-hazardous materials, facilitating recycling initiatives, reducing landfill burden, and minimizing environmental and occupational health risks (Anract et al., 2024; Soares et al., 2023; Wu & Cerceo, 2021). Energy efficiency measures, including upgrades to heating, ventilation, and air conditioning systems, implementation of smart lighting technologies, and integration of renewable energy sources, significantly reduce energy consumption and greenhouse gas emissions while lowering operational costs (De Oliveira et al., 2021; Doulabi, 2024; Schwab et al., 2025). Resource conservation strategies promote the rational use of water and materials, reduce unnecessary consumption patterns, and advance circular economy principles that simultaneously conserve natural resources and decrease operational expenses (Mostepaniuk et al., 2023; Soares et al., 2023; Vaishnavi & Suresh, 2022). Green procurement policies involve sourcing environmentally friendly products, prioritizing reusable over single-use disposable items, and considering the full lifecycle environmental impact of medical supplies and equipment, thereby supporting both environmental protection and economic sustainability objectives (Mostepaniuk et al., 2023; Schwab et al., 2025; Soares et al., 2023).

Despite increasing recognition of environmental sustainability in healthcare, a persistent gap exists between policy formulation and practical implementation in hospital settings due to workforce shortages, inadequate funding, and insufficient leadership commitment (Luque-Alcaraz et al., 2024; Schwab et al., 2025). Nurses, comprising the largest healthcare workforce segment, represent critical agents for achieving sustainable health systems, yet evidence suggests significant knowledge gaps and limited integration of sustainability

principles in practice (Anåker & Elf, 2025; Luque-Alcaraz et al., 2022). While nurses often exhibit moderate awareness and positive attitudes toward sustainability, these do not consistently translate into sustainable behaviors due to lack of time, resources, and institutional support (Álvarez-Nieto et al., 2021; Aronsson et al., 2020; Richardson et al., 2017). Insufficient evidence exists regarding nurses' actual knowledge of sustainable healthcare principles, creating uncertainty about educational needs and intervention priorities (Aronsson et al., 2023; López-Medina et al., 2019). This implementation gap highlights the critical need to assess nurses' current awareness levels and identify specific knowledge deficits that must be addressed through targeted educational interventions and institutional support mechanisms.

A comprehensive literature review reveals that knowledge and awareness of climate change constitute a fundamental principle shaping nurses' engagement with sustainable healthcare practices. Contemporary research demonstrates that nurses increasingly recognize the profound impact of climate change on health outcomes and acknowledge the healthcare sector's significant contribution to environmental degradation (Álvarez-Nieto et al., 2021; Anåker et al., 2015; Yeboah et al., 2023). Although awareness levels vary across healthcare settings and geographical regions, empirical evidence indicates a growing understanding among nursing professionals of the urgent need for climate-smart healthcare interventions. This recognition extends beyond general environmental concerns to encompass specific understanding of how climate-related health impacts, including heat-related illnesses, respiratory conditions from air pollution, and vector-borne diseases, directly affect patient populations and healthcare delivery systems (Álvarez-Nieto et al., 2021; Yeboah et al., 2023).

The literature further establishes the connection between nursing practice and environmental sustainability as a critical principle reflecting a paradigm shift in professional identity. Evidence suggests that contemporary nurses increasingly perceive environmental stewardship as an integral component of their professional responsibilities rather than an auxiliary concern (Álvarez-Nieto et al., 2021; Luque-Alcaraz et al., 2024; Salmela et al., 2017; Shaban et al., 2024). This expanded professional identity encompasses practical interventions such as waste reduction, energy conservation, sustainable resource utilization, and promoting eco-conscious practices in clinical settings. Research indicates that nurses recognize sustainable healthcare practices as aligned with fundamental nursing values of patient advocacy and community health promotion, particularly as environmental degradation poses direct threats to population health and well-being (Álvarez-Nieto et al., 2021; Luque-Alcaraz et al., 2024; Salmela et al., 2017). However, adequate knowledge, skills, and institutional frameworks must support this emerging professional consciousness to translate awareness into meaningful practice changes.

Examining the existing literature identifies barriers to sustainable practice and the critical role of education and training as interconnected principles that significantly influence nurses' capacity to implement sustainable healthcare interventions. Multiple studies document that nurses consistently encounter barriers impeding the implementation of sustainable healthcare practices, including insufficient time, limited resources, lack of confidence in advocating for change, and inadequate institutional support (Anåker et al., 2015; Aronsson et al., 2023; Leppänen et al., 2021; Yeboah et al., 2023). Hierarchical organizational structures frequently limit nurses' ability to challenge unsustainable practices, while insufficient training leaves professionals ill-equipped to identify and implement sustainable alternatives. However, empirical research demonstrates that integrating sustainability into nursing curricula and providing ongoing professional development significantly enhances nurses' awareness, confidence, and capacity to implement sustainable practices in clinical settings (Álvarez-Nieto et al., 2021; Álvarez-Nieto et al., 2024; López-Medina et al., 2022; Richardson et al., 2017; Richardson et al., 2019; Saleh & Elsabahy, 2022). Educational interventions employing scenario-based learning and practical skill development have proven particularly effective in translating theoretical knowledge into actionable practice changes (López-Medina et al., 2022; Richardson et al., 2017; Saleh & Elsabahy, 2022).

The scholarly literature consistently emphasizes leadership and advocacy as essential catalysts for promoting a culture of sustainability within healthcare organizations. Research evidence demonstrates that both formal leadership structures, such as nurse managers and Green Teams, and informal peer influence play pivotal roles in driving sustainable healthcare initiatives (Cruz et al., 2024; Luque-Alcaraz et al., 2024; Rosa et al., 2019; Shaban et al., 2024; Yakusheva et al., 2022). Studies indicate that nurse leaders who model sustainable behaviors and advocate for policy changes create organizational environments conducive to sustainable practice adoption. Furthermore, the literature highlights nurses' unique position at the interface of patient care,

organizational operations, and community health, positioning them as powerful advocates for systemic change toward environmental sustainability (Cruz et al., 2024; Fields et al., 2024; Ismail et al., 2025; Rosa et al., 2019; Rosa et al., 2021). Effective leadership in this domain requires commitment to sustainability principles, the competence to challenge established practices, and the skills to navigate organizational resistance to change.

Research on nurses' sustainability awareness in Saudi Arabia remains markedly limited, with existing studies predominantly addressing policy frameworks and institutional preparedness rather than directly evaluating frontline healthcare workers' knowledge and attitudes (Ajoud & Ibrahim, 2024; AlDulijand et al., 2023; Huraysi et al., 2023). While recent literature reviews have identified essential competencies for Saudi nurses in climate change response, emphasizing advocacy and capacity building (Mani et al., 2024), systematic measurement of practicing nurses' sustainability awareness remains absent. The only direct assessment conducted in Saudi Arabia focused exclusively on nursing students, revealing moderate pro-environment attitudes but leaving a significant gap regarding practicing nurses (Cruz et al., 2018). Furthermore, despite the availability of validated international instruments such as the Nurses' Environmental Awareness Tool (NEAT) and Sustainability Attitudes in Nursing Survey-2 (SANS-2) (Chung et al., 2024; Conti et al., 2025; Luque-Alcaraz et al., 2024), no evidence exists of their systematic application among Saudi nursing populations, highlighting the critical need for direct, validated assessment of frontline nurses' sustainability awareness in healthcare settings.

Given the critical gaps identified in the literature regarding nurses' sustainability awareness in Saudi Arabia and the absence of validated assessment tools applied to practicing nurses in the region, this study aimed to assess hospital nurses' awareness of sustainable healthcare practice principles across five key dimensions: knowledge and awareness of climate change, nursing-environment link, barriers to practice, education and training, and leadership and advocacy. Additionally, this research sought to validate the Nurses' Awareness of Sustainable Healthcare Practice Principles Questionnaire (NASHPP-Q) for use within the Saudi Arabian nursing context. By systematically evaluating nurses' current awareness levels and identifying specific knowledge deficits and implementation barriers, this study provides empirical evidence to inform targeted educational interventions, organizational policy development, and strategic initiatives necessary for advancing sustainable healthcare practices aligned with SDG 3 objectives in hospital settings.

Method
Study Design and Setting
This cross-sectional descriptive study was conducted in Saudi Arabia to assess nurses' awareness of sustainable healthcare practices in hospital settings. Data was collected using an online survey administered through Google Forms, which allowed for efficient distribution and collection of responses from nursing professionals across various healthcare facilities within the Kingdom.

Instrument Development
The study utilized the Nurses' Awareness of Sustainable Healthcare Practice Principles Questionnaire (NASHPP-Q), a newly developed instrument designed to comprehensively assess nurses' knowledge and attitudes toward sustainable healthcare practices. The questionnaire consisted of two main sections: Section A collected demographic information including age, gender, educational qualification, years of nursing experience, current position, department, hospital type, employment status, work shift, marital status, prior training in sustainable healthcare practices, membership in environmental committees, and geographic location. Section B initially comprised 27 items across five subscales measuring different dimensions of sustainability awareness. However, following confirmatory factor analysis, items 19 and 21 were removed due to poor factor loadings, resulting in a final instrument with 23 items distributed across five subscales: Knowledge and Awareness of Climate Change (5 items), Nursing-Environment Link (5 items), Barriers to Practice (5 items), Education and Training (4 items), and Leadership and Advocacy (4 items). All items in the knowledge and awareness domains were rated on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), except the Barriers to Practice subscale, which employed reverse scoring with 1 indicating Strongly Agree and 5 indicating Strongly Disagree to capture impediments to sustainable practice implementation appropriately.

Psychometric Validation Sample

Prior to the main study, the NASHPP-Q underwent rigorous psychometric evaluation using a validation sample of 213 nurses recruited from various hospital settings across Saudi Arabia. The sample represented diverse demographic and professional characteristics as detailed in Table 1. Participants' ages ranged from 25 to 54 years (M = 40.35, SD = 8.463), with the majority being female (65.7%). The sample included nurses with varying levels of education, from diploma to doctoral degrees, and professional experience ranging from less than one year to more than 20 years. Participants represented multiple clinical departments and hospital types, with the majority working rotating shifts in government hospitals. Notably, only 39.9% of participants had received prior training in sustainable healthcare practices, and only 16.4% were members of environmental or sustainability committees in their hospitals.

Table 1 Demographic Characteristics of Psychometric Validation Sample (N = 213)

Variable	Category	Frequency	Percentage
Gender	Male	73	34.3
	Female	140	65.7
Educational Qualification	Diploma in Nursing	57	26.8
	Bachelor of Science in Nursing	87	40.8
	Master of Science in Nursing	48	22.5
	Doctor of Nursing Practice	11	5.2
	PhD in Nursing	10	4.7
Years of Experience	Less than 1 year	34	16.0
	1-5 years	39	18.3
	6-10 years	41	19.2
	11-15 years	21	9.9
	16-20 years	34	16.0
	More than 20 years	44	20.7
Current Position	Staff Nurse	116	54.5
	Charge Nurse	46	21.6
	Nurse Manager	15	7.0
	Clinical Nurse Specialist	11	5.2
	Advanced Practice Nurse	16	7.5
	Health Educator	9	4.2
Department	Medical Ward	36	16.9
	Surgical Ward	38	17.8
	Intensive Care Unit	26	12.2
	Emergency Department	44	20.7
	Pediatrics	24	11.3
	Obstetrics/Gynecology	19	8.9
	Operating Room	19	8.9
	Outpatient Department	7	3.3
Type of Hospital	Government Hospital	94	44.1
	Private Hospital	59	27.7
	Teaching/Academic Hospital	25	11.7
	Community Hospital	12	5.6
	Specialty Hospital	23	10.8
Employment Status	Full-time Permanent	106	49.8
	Full-time Contract	66	31.0
	Part-time	31	14.6
	Casual/Per diem	10	4.7

Work Shift	Day shift only	49	23.0
	Night shift only	25	11.7
	Rotating shifts	139	65.3
Marital Status	Single	72	33.8
	Married	98	46.0
	Divorced	26	12.2
	Widowed	17	8.0
Prior Training in Sustainable Healthcare	Yes	85	39.9
	No	128	60.1
Membership in Environmental Committees	Yes	35	16.4
	No	178	83.6
Geographic Location	Urban	135	63.4
	Suburban	54	25.4
	Rural	24	11.3

Confirmatory factor analysis conducted using AMOS 26 demonstrated acceptable model fit indices for the five-factor structure of the NASHPP-Q. The chi-square statistic was significant (χ^2 = 472.828, df = 220, p < .001) with a chi-square to degrees of freedom ratio (CMIN/DF) of 2.149, indicating reasonable model fit. Additional fit indices supported the model's adequacy: the Goodness of Fit Index (GFI = .853), Adjusted Goodness of Fit Index (AGFI = .815), Normed Fit Index (NFI = .909), Relative Fit Index (RFI = .895), Incremental Fit Index (IFI = .949), Tucker-Lewis Index (TLI = .941), and Comparative Fit Index (CFI = .949) all exceeded acceptable thresholds. The Root Mean Square Error of Approximation (RMSEA = .074) fell within the acceptable range, and the Root Mean Square Residual (RMR = .057) indicated good model fit. Convergent validity was established through examination of composite reliability (CR), average variance extracted (AVE), and maximum reliability (MaxR[H]) values. All five factors demonstrated excellent composite reliability: Knowledge and Awareness of Climate Change (CR = 0.960, AVE = 0.826, MaxR[H] = 0.960), Nursing-Environment Link (CR = 0.959, AVE = 0.825, MaxR[H] = 0.959), Barriers to Practice (CR = 0.939, AVE = 0.754, MaxR[H] = 0.940), Education and Training (CR = 0.919, AVE = 0.745, MaxR[H] = 0.950), and Leadership and Advocacy (CR = 0.857, AVE = 0.613, MaxR[H] = 0.939). All AVE values exceeded the recommended threshold of 0.50, confirming adequate convergent validity. Discriminant validity was confirmed as the square root of AVE for each construct exceeded its correlations with other constructs, and the maximum shared variance (MSV) values were lower than the corresponding AVE values for all factors. Inter-factor correlations ranged from moderate to strong (r = 0.310 to r = 0.661, p < .001), indicating that while the constructs were related, they remained distinct.

Internal consistency reliability was assessed through multiple coefficients for each subscale. The Knowledge and Awareness of Climate Change subscale demonstrated excellent reliability (ω = 0.960, α = 0.959). The Nursing-Environment Link subscale similarly showed exceptional internal consistency (ω = 0.959, α = 0.959). The Barriers to Practice subscale exhibited strong reliability (ω = 0.939, α = 0.939). The Education and Training subscale showed excellent internal consistency (ω = 0.921, α = 0.912). The Leadership and Advocacy subscale, while demonstrating the lowest reliability coefficients among the five factors, still maintained acceptable internal consistency (ω = 0.849, α = 0.849). Correlations between the five subscales and the overall questionnaire total score ranged from strong to very strong (r = 0.650 to r = 0.799, p < .001), with Knowledge and Awareness of Climate Change (r = 0.786), Nursing-Environment Link (r = 0.799), Barriers to Practice (r = 0.650), Education and Training (r = 0.707), and Leadership and Advocacy (r = 0.786) all demonstrating significant positive correlations with the total scale. These psychometric findings supported the validity and reliability of the NASHPP-Q for assessing nurses' awareness of sustainable healthcare practice principles.

Main Study Sample
Following successful validation of the instrument, the main study was conducted with a sample of 256 nurses working in hospital settings across Saudi Arabia. Participants ranged in age from 23 to 52 years (M = 38.12, SD = 8.626), representing a diverse cross-section of the nursing workforce in terms of experience, education, and clinical specialization.

Data Collection Procedure

Data collection was conducted electronically through a structured Google Form containing the NASHPP-Q. The online format facilitated widespread distribution and ensured standardized questionnaire administration across different hospitals and geographic regions within Saudi Arabia.

Data Analysis

All statistical analyses were performed using SPSS version 27 and AMOS version 26. Descriptive statistics were calculated to characterize participants' demographic profile and assess mean awareness levels across different sustainability domains. Confirmatory factor analysis was employed to validate the factorial structure of the NASHPP-Q. Reliability analyses included calculation of Cronbach's alpha (α), and omega coefficients (ω) to establish internal consistency of the subscales. Pearson correlation coefficients were computed to examine relationships between subscales and the overall questionnaire score. Model fit indices including chi-square, CMIN/DF, GFI, AGFI, CFI, TLI, NFI, RFI, IFI, RMSEA, and RMR were evaluated to assess the adequacy of the measurement model.

Results

The study sample comprised 256 nurses employed in hospital settings across Saudi Arabia, with a mean age of 38.12 years (SD = 8.626, range = 23-52 years). Table 2 presents the comprehensive demographic characteristics stratified by gender and chi-square analyses examining potential associations between demographic variables and gender distribution.

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able 2 *Baseline characteristics across the study population(N = 256)*

Variable	Category	Male N (%)	Female N (%)	Total N (%)	χ^2
Educational Qualification	Diploma in Nursing	21 (22.6)	42 (25.8)	63 (24.6)	
	Bachelor of Science in Nursing	55 (59.1)	90 (55.2)	145 (56.6)	
	Master of Science in Nursing	13 (14.0)	22 (13.5)	35 (13.7)	0.621
	Doctor of Nursing Practice	2 (2.2)	5 (3.1)	7 (2.7)	
	PhD in Nursing	2 (2.2)	4 (2.5)	6 (2.3)	
Years of Experience	Less than 1 year	7 (7.5)	6 (3.7)	13 (5.1)	
	1-5 years	27 (29.0)	49 (30.1)	76 (29.7)	
	6-10 years	27 (29.0)	53 (32.5)	80 (31.3)	5.253
	11-15 years	14 (15.1)	35 (21.5)	49 (19.1)	
	16-20 years	9 (9.7)	10 (6.1)	19 (7.4)	
	More than 20 years	9 (9.7)	10 (6.1)	19 (7.4)	
Current Position	Staff Nurse	63 (67.7)	108 (66.3)	171 (66.8)	
	Charge Nurse	15 (16.1)	27 (16.6)	42 (16.4)	
	Nurse Manager	3 (3.2)	6 (3.7)	9 (3.5)	0.177
	Clinical Nurse Specialist	7 (7.5)	14 (8.6)	21 (8.2)	
	Advanced Practice Nurse	2 (2.2)	3 (1.8)	5 (2.0)	
	Health Educator	3 (3.2)	5 (3.1)	8 (3.1)	
Department	Medical Ward	12 (12.9)	20 (12.3)	32 (12.5)	
	Surgical Ward	13 (14.0)	19 (11.7)	32 (12.5)	
	Intensive Care Unit	16 (17.2)	24 (14.7)	40 (15.6)	
	Emergency Department	6 (6.5)	20 (12.3)	26 (10.2)	7.485
	Pediatrics	3 (3.2)	15 (9.2)	18 (7.0)	
	Obstetrics/Gynecology	17 (18.3)	20 (12.3)	37 (14.5)	
	Operating Room	15 (16.1)	22 (13.5)	37 (14.5)	
	Outpatient Department	11 (11.8)	23 (14.1)	34 (13.3)	

Variable	Category	Male N (%)	Female N (%)	Total N (%)	χ^2
Type of Hospital	Government Hospital	40 (43.0)	77 (47.2)	117 (45.7)	
	Private Hospital	22 (23.7)	34 (20.9)	56 (21.9)	
	Teaching/Academic Hospital	9 (9.7)	27 (16.6)	36 (14.1)	5.370
	Community Hospital	8 (8.6)	12 (7.4)	20 (7.8)	
	Specialty Hospital	14 (15.1)	13 (8.0)	27 (10.5)	
Employment Status	Full-time Permanent	60 (64.5)	113 (69.3)	173 (67.6)	
	Full-time Contract	22 (23.7)	34 (20.9)	56 (21.9)	2.171
	Part-time	6 (6.5)	5 (3.1)	11 (4.3)	
	Casual/Per diem	5 (5.4)	11 (6.7)	16 (6.3)	
Work Shift	Day shift only	23 (24.7)	44 (27.0)	67 (26.2)	
	Night shift only	5 (5.4)	12 (7.4)	17 (6.6)	0.626
	Rotating shifts	65 (69.9)	107 (65.6)	172 (67.2)	
Marital Status	Single	19 (20.4)	57 (35.0)	76 (29.7)	
	Married	63 (67.7)	98 (60.1)	161 (62.9)	10.331*
	Divorced	5 (5.4)	6 (3.7)	11 (4.3)	
	Widowed	6 (6.5)	2 (1.2)	8 (3.1)	
Sustainable Healthcare Prior Training	Yes	23 (24.7)	50 (30.7)	73 (28.5)	1.026
	No	70 (75.3)	113 (69.3)	183 (71.5)	
Committee Membership	Yes	11 (11.8)	21 (12.9)	32 (12.5)	0.060
	No	82 (88.2)	142 (87.1)	224 (87.5)	
Geographic Location	Urban	69 (74.2)	111 (68.1)	180 (70.3)	
	Suburban	14 (15.1)	35 (21.5)	49 (19.1)	1.593
	Rural	10 (10.8)	17 (10.4)	27 (10.5)	

Note. *p < .05

The sample consisted of 93 males (36.3%) and 163 females (63.7%). The majority of participants held bachelor's degrees in nursing (56.6%), had 6-10 years of professional experience (31.3%), and were employed as staff nurses (66.8%) in government hospitals (45.7%). Most participants worked rotating shifts (67.2%) and held full-time permanent positions (67.6%). With regard to marital status, 62.9% were married, 29.7% were single, 4.3% were divorced, and 3.1% were widowed. Geographic distribution showed that 70.3% of participants worked in urban areas, 19.1% in suburban locations, and 10.5% in rural settings. Notably, only 73 participants (28.5%) reported having received prior training in sustainable healthcare practices, and merely 32 (12.5%) held membership in environmental or sustainability committees within their institutions.

Chi-square analyses revealed that gender was not significantly associated with educational qualification ($\chi^2 = 0.621$, df = 4, p = .961), years of experience ($\chi^2 = 5.253$, df = 5, p = .386), current position ($\chi^2 = 0.177$, df = 5, p = .999), department ($\chi^2 = 7.485$, df = 7, p = .380), type of hospital ($\chi^2 = 5.370$, df = 4, p = .251), employment status ($\chi^2 = 2.171$, df = 3, p = .538), work shift ($\chi^2 = 0.626$, df = 2, p = .731), prior training ($\chi^2 = 1.026$, df = 1, p = .311), committee membership ($\chi^2 = 0.060$, df = 1, p = .806), or geographic location ($\chi^2 = 1.593$, df = 2, p = .451). However, a statistically significant association emerged between gender and marital status ($\chi^2 = 10.331$, df = 3, p = .016), with male nurses demonstrating a higher proportion of widowed status (6.5%) compared to female nurses (1.2%), while female nurses showed a higher proportion of single status (35.0%) relative to male nurses (20.4%).

Table 3 presents the descriptive statistics for the five subscales of the Nurses' Awareness of Sustainable Healthcare Practice Principles Questionnaire (NASHPP-Q), including means, standard deviations, hierarchical rankings, and classification levels based on the established interpretation criteria (1.00-1.79 = Very Low; 1.80-2.59 = Low; 2.60-3.39 = Medium; 3.40-4.19 = High; 4.20-5.00 = Very High).

Table 3 *Descriptive Statistics for NASHPP-Q Subscales (N = 256)*

Subscale	M	SD	Rank	Level
Barriers to Practice	3.76	0.778	1	High
Education and Training	3.64	0.736	2	High
Nursing-Environment Link	3.49	0.338	3	High
Leadership and Advocacy	3.37	0.778	4	Medium
Knowledge and Awareness of Climate Change	2.90	0.242	5	Medium

Note. Barriers to Practice subscale employed reverse scoring; higher scores indicate greater perceived barriers. The highest mean score was observed for the Barriers to Practice subscale (M = 3.76, SD = 0.778), indicating that nurses perceived substantial systemic and organizational impediments to implementing sustainable healthcare practices. The Education and Training subscale ranked second (M = 3.64, SD = 0.736), followed by the Nursing-Environment Link subscale (M = 3.49, SD = 0.338), both demonstrating high awareness levels. The Leadership and Advocacy subscale showed medium awareness (M = 3.37, SD = 0.778), while the Knowledge and Awareness of Climate Change subscale yielded the lowest mean score (M = 2.90, SD = 0.242), remaining within the medium awareness range but notably lower than all other domains. Table 4 presents item-level analysis for the Knowledge and Awareness of Climate Change subscale, displaying means, standard deviations, within-subscale rankings, and awareness classifications.

Table 4 *Item-Level Analysis: Knowledge and Awareness of Climate Change (N = 256)*

Item	Statement	M	SD	Rank	Level
3	I recognize the link between environmental factors and the emergence of diseases	3.20	0.736	1	Medium
2	I am aware that healthcare facilities contribute significantly to carbon emissions and environmental degradation	3.07	0.679	2	Medium
1	I understand how climate change affects patient health outcomes	2.88	0.744	3	Medium
4	I am knowledgeable about how extreme weather events impact health-care delivery	2.78	0.704	4	Medium
5	I understand the concept of "climate-smart healthcare" and its importance	2.58	0.827	5	Medium
Subscale Total		2.90	0.242		**Medium**

All items within this subscale demonstrated medium awareness levels. The highest-rated item concerned recognizing the link between environmental factors and disease emergence (M = 3.20, SD = 0.736), approaching the threshold for high awareness. Nurses also showed moderate awareness of healthcare facilities' contribution to carbon emissions (M = 3.07, SD = 0.679) and climate change's impact on patient health outcomes (M = 2.88, SD = 0.744). Lower scores were observed for knowledge regarding extreme weather events' impact on healthcare delivery (M = 2.78, SD = 0.704) and understanding of climate-smart healthcare concepts (M = 2.58, SD = 0.827), with the latter representing the lowest-rated item across the entire subscale. Table 5 presents the detailed item-level analysis for the Nursing-Environment Link subscale, which assessed nurses' perceptions of their professional responsibility toward environmental stewardship and their reported engagement in sustainable practices.

Table 5 *Item-Level Analysis: Nursing-Environment Link (N = 256)*

Item	Statement	M	SD	Rank	Level
8	I make conscious efforts to conserve energy (e.g., turning off lights and equipment when not in use) in the workplace	3.82	0.634	1	High

Item	Statement	M	SD	Rank	Level
10	I see the connection between protecting the environment and protecting patient health	3.75	0.669	2	High
6	I believe that environmental stewardship is part of my professional nursing responsibility	3.65	0.640	3	High
9	I practice sustainable resource use by avoiding unnecessary consumption of medical supplies	3.18	0.681	4	Medium
7	I actively consider waste reduction strategies in my daily nursing practice	3.09	0.751	5	Medium
Subscale Total		3.49	0.338		High

The Nursing-Environment Link subscale achieved an overall high awareness level (M = 3.49, SD = 0.338). Three of the five items demonstrated high awareness levels, with energy conservation efforts receiving the highest rating (M = 3.82, SD = 0.634). Nurses strongly endorsed recognizing the environment-health connection (M = 3.75, SD = 0.669) and viewing environmental stewardship as integral to professional nursing responsibility (M = 3.65, SD = 0.640). However, medium awareness levels characterized items addressing sustainable resource use (M = 3.18, SD = 0.681) and active consideration of waste reduction strategies (M = 3.09, SD = 0.751), suggesting a gap between conceptual understanding and operational implementation of resource conservation practices. Table 6 displays the analysis of perceived barriers to implementing sustainable healthcare practices. This subscale employed reverse scoring, whereby higher scores indicate greater perceived barriers.

Table 6 *Item-Level Analysis: Barriers to Practice (N = 256)*

Item	Statement	M	SD	Rank	Level
11	Lack of time during my shift prevents me from implementing sustainable practices	4.28	0.449	1	Very High
15	My hospital does not provide adequate institutional support for sustainability initiatives	4.01	0.610	2	High
12	Insufficient resources and infrastructure limit my ability to practice sustainably	3.76	0.562	3	High
14	The hierarchical structure in my hospital makes it difficult to challenge unsustainable practices	3.50	0.501	4	High
13	I lack confidence in my knowledge and skills to implement sustainable healthcare practices	3.27	0.575	5	Medium
Subscale Total		3.76	0.778		High

Note. Higher scores indicate greater perceived barriers (reverse scored items).

The Barriers to Practice subscale yielded the highest overall mean score among all domains (M = 3.76, SD = 0.778), indicating substantial impediments to sustainable practice implementation. Time constraints emerged as the most significant barrier, with nurses rating lack of time during shifts at a very high level (M = 4.28, SD = 0.449). Inadequate institutional support represented another major obstacle (M = 4.01, SD = 0.610), followed by insufficient resources and infrastructure (M = 3.76, SD = 0.562) and hierarchical organizational structures that inhibit challenging unsustainable practices (M = 3.50, SD = 0.501). Lack of confidence in knowledge and skills to implement sustainable practices showed the lowest rating within this subscale (M = 3.27, SD = 0.575), though still reflecting a medium-level barrier. Table 7 presents the item-level analysis for the Education and Training subscale, examining nurses' perceptions of educational adequacy and institutional training provision.

Table 7 *Item-Level Analysis: Education and Training (N = 256)*

Item	Statement	M	SD	Rank	Level
19	My hospital provides regular workshops or seminars on environmental sustainability	4.32	0.469	1	Very High

Item	Statement	M	SD	Rank	Level
18	Education and training would increase my awareness of sustainable practices	4.24	0.429	2	Very High
16	Sustainability topics were adequately covered in my nursing education program	3.02	0.187	3	Medium
17	I have access to continuing professional development opportunities on sustainable healthcare practices	2.99	0.153	4	Medium
Sub-scale Total		3.64	0.736		**High**

The Education and Training subscale demonstrated high overall awareness (M = 3.64, SD = 0.736). Nurses strongly agreed that their hospitals provide regular workshops or seminars on environmental sustainability (M = 4.32, SD = 0.469) and recognized that education and training would enhance their awareness of sustainable practices (M = 4.24, SD = 0.429), with both items achieving very high ratings. However, medium awareness characterized perceptions of sustainability coverage in nursing education programs (M = 3.02, SD = 0.187) and access to continuing professional development opportunities (M = 2.99, SD = 0.153), revealing a discrepancy between current institutional training offerings and foundational educational preparation as well as ongoing professional development access. Table 8 presents the detailed analysis for the Leadership and Advocacy subscale, examining nurses' perceptions of leadership effectiveness and their own advocacy roles in promoting sustainable healthcare practices.

Table 8 *Item-Level Analysis: Leadership and Advocacy (N = 256)*

Item	Statement	M	SD	Rank	Level
21	Peer influence and informal leadership play an important role in encouraging sustainable behaviors	3.96	0.562	1	High
23	I actively model sustainable behaviors to influence my colleagues and create a culture of sustainability	3.68	0.466	2	High
22	I feel empowered to advocate for policy changes that support sustainable healthcare practices	3.64	0.481	3	Medium
20	Green Teams or sustainability committees are effective in driving environmental initiatives in hospitals	2.23	0.645	4	Medium
Subscale Total		**3.37**	**0.778**		**High**

The Leadership and Advocacy subscale yielded a medium overall awareness level (M = 3.37, SD = 0.778). Nurses highly valued peer influence and informal leadership in encouraging sustainable behaviors (M = 3.96, SD = 0.562) and reported actively modeling sustainable behaviors to influence colleagues (M = 3.68, SD = 0.466). They felt empowered to advocate for policy changes supporting sustainable healthcare practices (M = 3.64, SD = 0.481). However, a markedly low rating characterized perceptions of Green Teams or sustainability committees' effectiveness in driving environmental initiatives (M = 2.23, SD = 0.645), indicating limited confidence in formal organizational structures for sustainability governance. This substantial disparity between informal peer-based leadership (M = 3.96) and formal committee effectiveness (M = 2.23) suggests that nurses perceive grassroots approaches as more influential than institutionalized mechanisms for promoting sustainable healthcare practices.

Discussion

The current study revealed that nurses demonstrated substantially higher awareness of barriers to sustainable practice (M = 3.76) and education needs (M = 3.64) compared to their actual knowledge of climate change concepts (M = 2.90). This pattern aligns with previous research indicating that nurses frequently recognize implementation barriers—such as lack of time, resources, and organizational support—while possessing only

moderate conceptual knowledge (Álvarez-Nieto et al., 2021; Anåker et al., 2021; Yeboah et al., 2023). This discrepancy primarily stems from insufficient curricular integration of climate change content in nursing programs and structural workplace hierarchies that limit nurses' confidence and self-efficacy in addressing sustainability issues (Aronsson et al., 2023; Leffers et al., 2017).

The significant disparity between nurses' high ratings of informal peer leadership (M = 3.96) and low confidence in formal Green Teams/sustainability committees (M = 2.23) can be attributed to differential trust mechanisms and cultural alignment. Consistent with prior research, nurses demonstrate stronger trust in peer networks than in institutional structures (Pan et al., 2021; Walls & Berrone, 2015), viewing informal leaders as more authentic and responsive to frontline challenges. This finding aligns with Nguyen-Van et al. (2021), who emphasized that social influence within peer networks more effectively shapes pro-environmental behaviors than formal mechanisms. Additionally, formal committees may be perceived as symbolic rather than substantive (Velte & Stawinoga, 2020), while informal leadership integrates seamlessly with nursing's clan culture, where relational dynamics drive environmental engagement (Mohamed et al., 2025).

The significant gap between nurses' conceptual understanding of environmental stewardship (M = 3.65) and their actual waste reduction practices (M = 3.09) can be addressed through multifaceted interventions. This discrepancy aligns with previous research identifying knowledge deficits, resource limitations, and time constraints as primary barriers (Kallio et al., 2020; Luque-Alcaraz et al., 2024). Effective strategies include implementing targeted education programs on sustainable practices (Shaban et al., 2024), enhancing organizational infrastructure with adequate recycling facilities (Hassan et al., 2024), and fostering active leadership engagement through "Green Teams" (Schenk & Johnson, 2022). Additionally, integrating waste reduction protocols into daily workflows and providing incentives for environmental efforts can transform stewardship ideals into consistent practice (Levett-Jones et al., 2024).

The finding that only 28.5% of participants received prior training in sustainable healthcare underscores a significant gap in professional development, contributing to moderate knowledge levels in this area. Nurses recognize the need for education to enhance their sustainability awareness (M = 4.24), highlighting systemic curriculum and professional development deficiencies. The low score for understanding climate-smart healthcare concepts (M = 2.58) reveals a lack of specialized knowledge for implementing sustainability initiatives, exacerbating the disconnect between expressed values and practical application. Time constraints (M = 4.28) are identified as the primary barrier to implementing sustainable practices, indicating that sustainability is often viewed as an additional responsibility rather than integrated into nursing practice. This calls for a systemic redesign to embed sustainability within routine care.

The study findings highlight crucial implications for nursing education, healthcare policy, and organizational practices in Saudi Arabia and similar regions. Nursing students have a moderate understanding of climate change and sustainability principles, accompanied by a high awareness of existing barriers, indicating an urgent need for significant curricular reforms. Nursing education should incorporate sustainability competencies at all levels, making environmental stewardship a core value rather than an elective aspect. The gap between theory and practical implementation of sustainable practices calls for experiential learning approaches, including simulation-based training and clinical experiences focused on waste reduction and resource optimization in real healthcare contexts. Healthcare organizations must acknowledge the identified barriers, particularly time constraints, which suggest that sustainability cannot simply be an added responsibility for nurses. Administrators need to redesign workflows and policies to integrate sustainable practices into standard care delivery, supported by dedicated resources such as sustainability coordinators and infrastructure for effective waste management. The lack of confidence in formal Green Teams indicates the need for restructuring governance to enhance frontline nursing participation and improve decision-making transparency regarding sustainability initiatives. The contrasting levels of trust in peer leadership versus formal institutional structures emphasize the importance of leveraging peer influence in sustainability efforts. Nurse leaders should empower sustainability champions within nursing teams who can model best practices and facilitate communication between staff and leadership. Finally, policymakers should strengthen regulatory frameworks to include environmental performance metrics in hospital licensing and quality assessments, underscoring the essential role of sustainability in quality healthcare delivery and incentivizing systematic improvements.

Several methodological limitations impact the interpretation of this study's findings. The cross-sectional

design hinders causal inferences between awareness levels, demographics, and sustainability behaviors, raising questions about whether knowledge deficits lead to practice gaps or if barriers hinder knowledge acquisition. Self-report measures may introduce social desirability bias, causing participants to overstate their sustainability engagement due to societal pressures. The convenience sampling limited participant diversity, potentially excluding nurses with less digital access, and skewing results towards those with higher education or technological skills. The study lacks objective measures of sustainability behaviors, relying on perceived awareness and self-reported practices, which may not align with observable actions. Focusing solely on hospital-based nurses restricts generalizability to other healthcare settings, and cultural factors specific to Saudi Arabia may affect the applicability of findings in different regions or healthcare contexts.

Future research should focus on longitudinal study designs to monitor nurses' sustainability awareness and practices, especially after educational interventions or policy changes. Prospective cohort studies are recommended to assess the connections between knowledge, attitudes, and behavior changes, highlighting effective sustainability strategies. Mixed-methods approaches should combine quantitative awareness assessments with qualitative insights into contextual factors affecting engagement with sustainable practices. Ethnographic and participatory action research can reveal barriers and facilitators often missed by quantitative methods, reflecting the influence of organizational dynamics on sustainability efforts. Intervention research must shift towards evidence-based practices, utilizing randomized controlled trials to determine the efficacy of various educational techniques and organizational interventions to enhance sustainability competencies. Additionally, refining measurement tools to validate sustainability assessments, develop objective behavioral metrics, and create environmental impact metrics is crucial. Investigating the links between nurses' sustainability awareness and patient outcomes and organizational performance will support the case for investment in sustainable healthcare. Lastly, international research is needed to identify common principles and necessary adaptations for advancing sustainable healthcare globally.

Conclusion

This study assesses Saudi Arabian nurses' awareness of sustainable healthcare practices, revealing moderate knowledge and significant implementation gaps. While nurses acknowledge the importance of environmental stewardship and education, they lack a deep understanding of climate-smart practices and face systemic barriers such as time constraints and inadequate support. The disparity between their confidence in informal leadership versus skepticism towards formal structures indicates a need for grassroots and institutional efforts to drive sustainability transformation. The study also validates the NASHPP-Q tool for evaluating nursing sustainability competencies, enabling improvements in education and policy. It emphasizes the necessity for a fundamental shift in educational and organizational practices to integrate environmental stewardship into the nursing profession, underscoring the critical role of nurses in achieving sustainable healthcare amidst growing public and environmental pressures.

Conflicts of Interest:
The authors declare no conflict of interest.

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Authorship and Level of Contribution
All authors contributed to the literature research, data collection, analysis, and interpretation of the collected data.

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