

Exploring Knowledge, Attitudes, and Behaviours Towards Sustainable and Green Healthcare Systems: A Scoping Review

ABSTRACT

This scoping review explores the knowledge, attitudes, behaviours, and perspectives of healthcare professionals and students regarding resilient, sustainable, and green healthcare systems. The importance of integrating sustainability into healthcare settings has become increasingly evident due to the sector's significant environmental footprint. The World Health Organization (WHO) defines health not only as the absence of disease but as a holistic concept encompassing physical, mental, and social well-being, thus highlighting the need for green healthcare practices supporting individual and environmental health. Awareness of sustainability issues in healthcare has significantly increased; however, a gap persists between knowledge and practical implementation. Studies indicate that healthcare workers and students are aware of the environmental impacts of healthcare practices but face barriers such as insufficient resources, lack of institutional support, and competing priorities. Attitudes toward sustainability, when fostered through leadership and education, are shown to influence behaviour positively. In particular, educational interventions that promote green practices can enhance knowledge and facilitate behavioural change. Challenges such as financial constraints and systemic barriers remain, but opportunities like the adoption of telemedicine and renewable energy offer promising solutions. The scoping review emphasizes the need for integrated education, policy frameworks, and cross-sector collaboration to overcome these barriers and promote sustainable healthcare practices. Future efforts should focus on reducing environmental impacts while improving health outcomes, contributing to both ecological sustainability and better quality of life for individuals.

Keywords: Sustainable healthcare, healthcare sustainability, green hospitals, climate-resilient healthcare systems, healthcare education, healthcare professionals, environmental health, environmental sustainability

1. INTRODUCTION

Health is a fundamental element of individual and societal well-being, serving as a cornerstone for development and sustainability. The World Health Organization (WHO) defines health not merely as the absence of disease or infirmity but as a state of complete physical, mental, and social well-being (WHO, 1948). This inclusive definition emphasizes the multifaceted nature of health and underscores the need for holistic approaches in healthcare delivery, integrating preventive, curative, and promotive aspects to achieve equitable outcomes.

In recent decades, global environmental challenges such as climate change, pollution, and resource depletion have raised concerns about the resilience and sustainability of healthcare systems. Hospitals and healthcare facilities, as resource-intensive institutions, contribute significantly to environmental degradation through energy consumption, waste generation, and greenhouse gas emissions (Brown et al., 2012; Eckelman et al., 2020; Tee et al., 2024). Consequently, the concept of

"green healthcare" has gained prominence, advocating for practices that minimize environmental impact while maintaining high standards of care. This approach aligns with the broader goals of sustainable development, as outlined in the United Nations' Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being) and SDG 13 (Climate Action) (United Nations, 2015).

The transition towards resilient and sustainable healthcare systems necessitates active engagement from all stakeholders, including healthcare professionals, administrators, and students. Healthcare workers, being at the forefront of service delivery, play a pivotal role in adopting and promoting environmentally conscious practices. Similarly, students in health-related disciplines represent the future workforce and are crucial for embedding sustainability principles into professional practices. Understanding their knowledge, attitudes, behaviours, and perceptions towards sustainable and green healthcare is essential for designing effective educational and policy interventions.

1.1 Importance of Sustainable and Green Healthcare

Sustainable healthcare is defined as the delivery of health services that meet current needs without compromising the ability of future generations to meet theirs. This concept encompasses various dimensions, including reducing the environmental footprint of healthcare facilities, promoting resource efficiency, and integrating sustainability into clinical and administrative practices (Berniak-Woźny et al., 2023; Shaban et al., 2024). Green hospitals, a key component of this approach, adopt strategies such as energy-efficient building designs, renewable energy use, waste reduction, and sustainable procurement to minimize their ecological impact.

While awareness of the environmental challenges linked to healthcare has increased, significant variability remains in how effectively healthcare workers and students understand and adopt green practices. For example, studies have shown that while healthcare professionals recognize the importance of sustainability, practical knowledge and institutional support for implementing green initiatives are often limited (Aboueid et al., 2023). This knowledge gap underscores the need for targeted education and training programs that equip healthcare workers and students with the skills and knowledge necessary to advocate for and implement sustainable practices (Tiitta et al., 2024).

1.2 The Role of Education in Promoting Green Practices

Education is a powerful tool for fostering a culture of sustainability in the healthcare sector. Integrating sustainability concepts into medical and health sciences curricula can enhance awareness and inspire proactive behaviour among students. Educational initiatives should focus on the intersection of health and environmental science, emphasizing topics such as the health impacts of climate change, waste management in healthcare, and the principles of sustainable design (Gandhi et al., 2020; Gupta et al., 2022). Additionally, experiential learning opportunities, such as internships and community projects, can reinforce theoretical knowledge and enable students to apply sustainability principles in real-world settings.

For practising professionals, continuing education programs and workshops can provide updated knowledge and skills related to sustainable healthcare. Organizational support is also crucial; healthcare institutions should foster an environment that encourages innovation, collaboration, and accountability in implementing green practices. Leadership commitment, adequate resources, and clear policies are essential for translating sustainability principles into action at the institutional level.

1.3 Barriers to Green and Sustainable Healthcare

Despite its potential benefits, the adoption of sustainable practices in healthcare faces several challenges. Financial constraints, lack of awareness, and resistance to change are among the most cited barriers. For instance, transitioning to renewable energy sources or implementing waste management programs often requires significant initial investment, which may be perceived as a burden by resource-limited healthcare facilities. Furthermore, a lack of standardized guidelines and

metrics for measuring sustainability performance can hinder efforts to evaluate and improve green practices.

Another critical challenge is the perception of sustainability as a secondary priority compared to immediate clinical and operational demands. Healthcare workers, particularly in high-stress environments, may prioritize patient care over environmental considerations, viewing sustainability as an additional responsibility rather than an integral component of their professional roles. To overcome these barriers, a comprehensive strategy is needed, involving strong policy frameworks, financial incentives, and awareness initiatives that emphasize the long-term advantages of sustainable healthcare.

1.4 Relevance of This Study

This scoping review investigates the knowledge, attitudes, and behaviours of healthcare professionals and students towards sustainable and green healthcare. By synthesizing evidence from various studies, the review aims to identify gaps in understanding and highlights effective strategies to promote sustainability within healthcare systems. The findings will contribute to the growing literature on sustainable healthcare and inform the development of educational and policy interventions tailored to healthcare workers and students. The World Health Organization's (WHO) definition of health, which emphasizes the interconnectedness of health, environmental sustainability, and societal well-being, provides the framework for this study. Through exploring the perspectives of healthcare professionals and students, this review aims to bridge the gap between theory and practice, ensuring that sustainability principles are understood and effectively implemented in healthcare settings.

2. MATERIAL AND METHODS

2.1 Protocol

This scoping review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist and was guided by Arksey and O'Malley's five-stage framework. The framework includes the following stages: (1) formulating research questions, (2) identifying relevant studies, (3) selecting studies, (4) synthesizing and interpreting essential information (referred to as "charting the data"), and (5) compiling, summarizing, and presenting the results. This methodological choice ensures transparency, replicability, and comprehensiveness, as PRISMA-ScR is specifically designed for scoping reviews, and Arksey and O'Malley's framework provides a systematic approach for synthesizing diverse data sources.

2.2 Searching Criteria

A literature search was conducted on October 15, 2024, using Web of Science for publications from the past five years (2019-2024). Web of Science was selected for its broad coverage of peer-reviewed journals across multiple disciplines, ensuring access to high-quality and relevant studies.

The following keywords and combinations were used in the search within Web of Science:

"green hospital" OR "sustainable hospital" OR "eco-friendly hospital" OR "resilient hospital" OR "green healthcare" OR "resilient healthcare" OR "low-carbon healthcare."

These keywords were chosen based on their prevalence in the literature and their alignment with the primary themes of the review. However, it is acknowledged that studies using alternative terminologies or regional variations might not have been captured, potentially limiting the scope of the findings.

2.3 Inclusion and Screening Criteria

Only English-language publications from the last five years (2019-2024) were included in the scoping review. The inclusion criteria did not impose restrictions on the type of research or publication to ensure a comprehensive scoping review of available evidence. However, proceedings papers (n = 9), preprints (n = 9), meeting abstracts (n = 8), editorial materials (n = 15), letters (n = 2), dissertations/theses (n = 7), awarded grants (n = 6), and book reviews (n = 2) were excluded as they do not typically provide peer-reviewed, detailed, or finalized findings essential for the robustness and reliability of the analysis.

In the initial screening phase, the title and abstract of each article were reviewed. Articles that met the following exclusion criteria were excluded from the review:

- Publications not written in English
- Publications for which the full text was not accessible
- Publications evaluating different outcomes

2.4 Data Extraction

The selected articles were reviewed and documented for the following information: first author(s), publication year, type of study, location (country), setting, participants, outcome instruments, results, and limitations.

2.5 Data Analysis

A qualitative analysis of the full-text articles was conducted, and the data were systematically tabulated in Excel. The analysis focused on extracting and organizing information related to the first author, publication year, type of study, location (country), setting, participants, outcome instruments, results, and limitations.

Figure 1. Flow chart showing study protocol

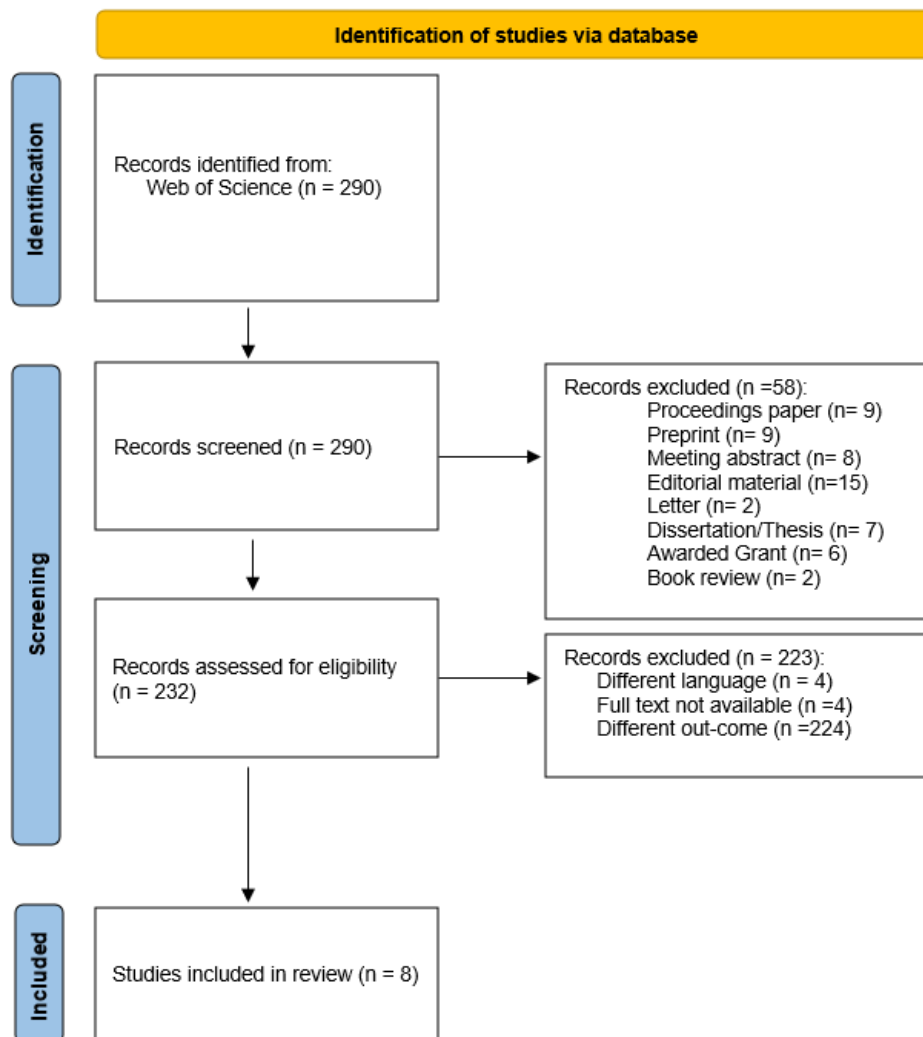


Table 1. Table of study characteristics

#	Authors & Publication Year	Country	Design	Setting	Participants	Outcome Instrument	Results	Limitations
1	Eman Salman Taie (2022)	Egypt	Quasi-experimental study	Two private internationally accredited hospitals (El-Salam International Hospital and Dar El-Fouad Hospital)	<p>Managers (n=112): Top, middle, and first-line managers from El-Salam International Hospital (68) and Dar El-Fouad Hospital (44), representing roles in general management, medical, nursing (head nurses, supervisors, directors), quality, infection control, HR, finance, health & safety, and housekeeping. Included both genders with ≥2 years of experience.</p> <p>Expert Panel (n=45): Professors/assistant professors from Cairo, Ain Shams, and Alexandria universities, and American University in Cairo (AUC) experts from the Office of Sustainability and Center for Applied Research on the Environment and Sustainability.</p>	Three tools were used for collecting data (Managers' knowledge about green hospital questionnaire, Green Hospital Checklist, and opinionnaire).	<p>Attitudes Towards Climate and Sustainability: High awareness of environment-health link (99.7%) and importance of sustainability at home (92.5%) and work (92.2%). Strong acknowledgment of climate-health link (98.6%) and climate's moderate/significant impact on Queensland health (72.9%). Fewer perceived impacts on health services (60.4%) or organizations (49.4%). Anticipation of increased healthcare impact over a decade (77.8%). Support for urgent climate action (90.4%) and health services leadership (87%). Need for public awareness of climate change's health impacts (91.9%). Varied self-reported understanding: uninformed (24.4%), somewhat informed (46%), well-informed (29.4%).</p> <p>Sustainable Practices: Common at home (e.g., recycling, conserving water/energy) but limited at work. Climate discussions mostly with family/friends (64%), less with colleagues (36%), managers (10%), officials (6%).</p> <p>Organizational Support: Environmental protection valued (74.5%), but personal commitment to environmental values exceeds employers' (53.3%). Low awareness of sustainability policies (19%) and HHS Strategy (26.8%). Organizational climate action largely unknown (57.1%). Some support for sustainability (68.8%), but leadership-driven initiatives lacking.</p> <p>Barriers and Challenges: Limited awareness of organizational environmental policies, inadequate integration of sustainability strategies, and a lack of institutional commitment. Minimal preparedness for future climate impacts (Only 2.1% of participants considering their organization well-prepared).</p> <p>Conclusion: Strong individual commitment not reflected organizationally. Need for leadership, clear strategies, and effective communication to align individual and systemic sustainability initiatives in healthcare.</p>	<p>Sample Size: Limited to two hospitals, reducing generalizability.</p> <p>Time Frame: One-year fieldwork lacks long-term effect analysis.</p> <p>Self-Reported Data: Potential bias in managers' self-reported questionnaires.</p>
#	Authors &	Country	Design	Setting	Participants	Outcome Instrument	Results	Limitations

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2	Ferguson, Adele et2023)	Taiwan	Cross-sectional study	A regional teaching hospital in Taiwan	<p>Hospital staff from a regional teaching hospital in Taiwan, divided into five stakeholder groups:</p> <ol style="list-style-type: none"> 1) Medical administrators (n = 45), 2) Doctors (n = 32), 3) Nursing staff (n = 196), 4) Medical examination and medical personnel (pharmacists, laboratory technicians, radiologists, etc.) (n = 35) 5) Outsourced personnel (e.g., waste disposal, catering services, security personnel) (n = 31). 	<p>Behavioural intention to promote green healthcare, measured by a 7-point Likert scale (+3: strongly agree, -3: strongly disagree). Independent variables based on the TPB model:</p> <ol style="list-style-type: none"> (1) Attitude (5 items constructed by PES [8 items] and PU [6 items]) (2) Subjective Norms (4 items constructed by MSN [4 items] and SSN [4 items]) (3) Perceived Behavioural Control (4 items constructed by ICF [4 items] and ECF [4 items]) 	<p>Critical Stakeholders: Medical administrators (M1) and nursing staff (M3) were the most influential groups in implementing green hospital policies.</p> <p>Theory of Planned Behaviour (TPB): Attitudes (AT), Subjective Norms (SN), and Perceived Behavioural Control (PBC) positively influence green behaviours; PBC has the strongest effect.</p> <p>Perceived Behavioural Control (PBC): Internal control factors (ICFs, $\beta = 0.347^{***}$) outweigh external control factors (ECFs, $\beta = 0.184^*$); resources and training are critical to fostering green behaviours.</p> <p>Subjective Norms (SN): The hospital's promotion department (PG) had a stronger effect ($\beta = 0.396^{***}$) than external entities such as government agencies (SG) ($\beta = 0.217^{**}$). This highlights the importance of internal green policy promotion within hospitals.</p> <p>Attitudes and Perceived Usefulness: Perceived usefulness of green hospitals (PU, $\beta = 0.423^{***}$) is a stronger motivator than perceived ease of use (PEOU, $\beta = 0.21^{**}$). Emphasizing the practical benefits of green healthcare initiatives is key to driving adoption among hospital staff.</p> <p>Stakeholder Roles: Medical administrators (M1) focused on improving the ease of use (PEOU) and managing internal control factors; nursing staff (M3) prioritized the perceived usefulness (PU) and the effectiveness of green policy promotion (PG). Bridging these perspectives is critical for the successful implementation of green healthcare policies.</p> <p>Policy Recommendations: Encourage collaboration, enhance environmental education, implement incentives, and strengthen green infrastructure and support for sustainability initiatives.</p> <p>Conclusion: Engaging stakeholders, improving internal conditions, and highlighting practical benefits of green hospital policies are vital for sustainable and green healthcare practices.</p>	<p>TPB framework: Excludes emotional factors, limiting explanation of responsibility for green hospital performance.</p> <p>Single hospital: Limited to a regional hospital, affecting generalizability to other hospitals in Taiwan or different healthcare levels.</p>

3	Year A.L. Soares et al. (2023)	31 countries	Cross-sectional study	<p>Project: SAFE EUROPE</p> <p>Period: October 2021 - February 2022</p> <p>Project Purpose: Address educational gaps for European Therapeutic Radiographers (TRs) and Radiation Therapists (RTTs) via free webinars.</p> <p>Partner organizations:</p> <ol style="list-style-type: none"> 1)Ulster University (UK), 2)University of Malta (Malta), 3)Associação Portuguesa de Radioterapeutas (Portugal), 4)Polskie Towarzystwo Elekroradiologii (Poland), 5)Society of Medical Radiographers (Malta), 6)Instituto Português de Oncologia Porto (Portugal), 7)European Federation of Radiography Societies (EFRS, Europe-wide). 	190 respondents	<p>Survey: Validated, self-designed</p> <p>Format: Mostly Likert scales, supplemented with closed- and open-ended questions</p> <p>Sections:</p> <ol style="list-style-type: none"> 1) Demographics 2) Knowledge of Circular Economy (CE) and Green Skills (GS) 3) Personal attitudes 4) TR/RTTs professional attitudes towards CE 5) Importance of CE 6) Education <p>Structure: 3 parts, 6 sections</p> <p>-Part 1: <i>Section I - Socio-demographic details</i></p> <p>-Part 2: <i>Section II - Knowledge of CE and GS</i></p> <p><i>Section III - Personal/individual attitudes towards CE</i></p> <p><i>Section IV - TR/RTTs professional group attitudes towards CE in workplace</i></p> <p><i>Section V - Perception of importance of CE</i></p> <p>-Part 3: <i>Section VI - TR/RTTs perception regarding educational needs for CE and GS</i></p>	<p>Awareness: 31%-42% of participants aware of national and departmental policies on Circular Economy (CE) and Green Sustainability (GS).</p> <p>Circular Economy (CE) Advocacy: Half of participants viewed themselves as advocates and practitioners of CE, revealed a predominant focus on waste management, overlooking other critical dimensions of CE in healthcare.</p> <p>Attitudes and Lifestyles: Participants attitudes and lifestyles did not align with CE principles.</p> <p>Therapists and Radiation Therapy Technologists (TR/RTTs) Opinions: TR/RTTs acknowledged importance of CE and GS in their field. Divergence on ideal academic stage for CE skill development: 44% suggested high school, 32% recommended bachelor's level.</p> <p>Conclusion: There is a pressing need to enhance TR/RTTs' awareness of the multifaceted applications of CE in healthcare. Key areas include "green transportation," "environment-friendly procurement," "hospital building design," "food process optimization," "water reduction," "energy efficiency," and "waste management."</p>	<p>Representation: Representation was limited to 31 out of 44 European countries.</p> <p>Response Rate: The response rate was low, with only 190 valid responses collected.</p> <p>Awareness: Many TR/RTTs may have been unaware of the relevance of CE and GS to their practice, which may have reduced their participation.</p> <p>Access: Not all TR/RTTs had access to the survey, despite efforts to distribute the survey through SAFE EUROPE partners and social media.</p> <p>Response Distribution: Responses were unevenly distributed across countries, with Portugal over-represented (71 respondents, 37.4%), which could have influenced the results.</p> <p>Sampling: Convenience sampling limited to members of professional organizations and those via SAFE EUROPE media channels.</p> <p>Bias: Respondent bias may have occurred as individuals interested in CE and GS were more likely to participate.</p> <p>Survey Reliability: While the survey tool was tested for reliability within this population, revalidation would be necessary for use in other groups.</p>
#	Authors & Publication Year	Country	Design	Setting	Participants	Outcome Instrument	Results	Limitations

4	Helen Dion et al. (2023)	Middle East and North Africa (MENA) region	Qualitative case study	Ten case studies of both public and private hospitals in the Middle East and North Africa (MENA) region	<p>29 executives and leaders responsible for energy management across ten case studies.</p> <p>Participants included senior management, lead executives, senior physicians, and lead engineers.</p> <p>All individuals were involved in overseeing energy management systems.</p>	<p>Method: Semi-structured in-depth interviews.</p> <p>Interview Content: 10 to 15 questions, adapted based on responses, with a focus on gaining knowledge about the sustainability trends of the hospitals across various areas.</p> <p>Data Analysis: Transcribed and categorized into three primary areas:</p> <ol style="list-style-type: none"> (1) Energy consumption management (2) Adoption of green technologies (3) Hospital facility management. 	<p>The study investigated energy management, green technology adoption, and hospital building envelope practices within healthcare systems.</p> <p>Energy Management: Analysis focused on energy management goals, Key Performance Indicators (KPIs), monitoring and control mechanisms, employee awareness programs, reductions in energy consumption, and anticipated cost savings. Senior management demonstrated strong dedication to achieving Sustainable Development Goals (SDGs), but staff attitudes towards energy efficiency were inconsistent.</p> <p>Green Technologies: This category explored the implementation of energy-efficient equipment and the use of renewable energy sources. Financial investment and available funding were critical factors influencing adoption. However, some stakeholders showed low motivation, and responses regarding investment in energy-efficient technologies varied significantly.</p> <p>Hospital Building Envelopes: Key considerations included ventilation, natural lighting, and the incorporation of green hospital concepts in design, procurement, construction, and maintenance. Evaluations highlighted the need for enhanced building envelope practices to meet SDG requirements, but stakeholder awareness of comparative energy costs remained limited.</p> <p>Key Insights: Aligning attitudes, increasing stakeholder motivation, and improving awareness are crucial for supporting sustainable and resilient healthcare systems.</p>	<p>The study is confined to the initiatives and experiences of healthcare facilities in the Middle East and North Africa (MENA) region, which may limit the generalizability of the findings to other regions. The cultural and socioeconomic context specific to the MENA region might influence the strategies and outcomes of green hospital initiatives.</p>
#	Authors & Publication Year	Country	Design	Setting	Participants	Outcome Instrument	Results	Limitations

5	Huang, Andrea et al. (2024)	Australia	Cross-sectional study	Staff members at Sunshine Coast Hospital and Health Service (SCHHS), Queensland, Australia	<p>Medical</p> <ul style="list-style-type: none"> n=17 (5.6%) <p>Nursing and Midwifery</p> <ul style="list-style-type: none"> n=119 (39.6%) <p>Allied Health and Dental</p> <ul style="list-style-type: none"> n=57 (18.9%) <p>Administration and Building and Engineering Officers, Professional, Technical and Operational Officers</p> <ul style="list-style-type: none"> n=104 (34.5%) <p>Prefer not to say, Other</p> <ul style="list-style-type: none"> n=4 (1.3%) 	The study utilized an anonymous, online survey co-developed by research partners from the Hospital and Health Services (HHS), Griffith University, and the Climate and Health Alliance (CAHA). The survey comprised 25 closed-ended questions and 5 open-ended questions, allowing for more detailed responses. The questions addressed several key areas: (1) Demographics, (2) Attitudes towards sustainable and climate-resilient healthcare, (3) Practices at home and at work, and (4) Organizational support for sustainable practices, climate-resilient behaviours, and suggestions for further organizational support in these areas.	<p>Attitudes:</p> <p>Environmental Importance: 99.7% recognized the environment as crucial for health, with strong support for sustainable practices at home (92.5%) and work (92.2%).</p> <p>Climate Change and Health Awareness: High awareness of the climate change-health link (98.6%); 72.9% reported moderate to significant effect on health in Queensland.</p> <p>Health Services Impact: 60.4% noted climate change's impact on health services; 49.4% on their organizations; 77.8% expected the impact on healthcare services to escalate over the next decade.</p> <p>Call to Action: Urgent action on climate change was deemed necessary by 90.4%, and 87% believed health services should lead these efforts.</p> <p>Awareness Disparities: Awareness about the health effects of climate change was uneven; 24.4% felt uninformed; 46% felt somewhat informed, 29.4% considered themselves well-informed.</p> <p>91.9% believed public understanding of climate-related health issues requires improvement.</p> <p>Practices:</p> <p>Sustainable practices were more common at home than in the workplace.</p> <p>Conversations on climate and health were more frequent with family and friends (64%) than with colleagues (36%), managers (10%), or officials (6%).</p> <p>Organizational Support:</p> <p>Although 74.5% highlighted the importance of environmental protection within their organizations, only 19% were familiar with their organization's sustainability policies.</p> <p>68.8% reported organizational support for sustainability, though 27.7% felt there was no support.</p> <p>The Health and Human Services (HHS) Sustainability Strategy: Recognized by 26.8%, while 57.1% were unaware of any climate-focused initiatives in their organizations.</p> <p>Staff-driven initiatives were more common than those led by the organization.</p> <p>Barriers and Challenges:</p> <p>Only 2.1% believed their organization was adequately prepared for future climate impacts.</p> <p>Lack of robust organizational commitment and integration of sustainability into practice.</p>	<p>Selection Bias:</p> <p>The higher participation of individuals already interested in environmental sustainability may have introduced selection bias, affecting the representativeness of the sample.</p> <p>Sample Size and Survey Timing:</p> <p>The survey's length (15-20 minutes) and its timing during the COVID-19 pandemic likely contributed to a smaller sample size than ideal, limiting statistical power.</p> <p>Generalizability:</p> <p>Findings are based on a single health service in Queensland, limiting applicability to other regions, particularly rural and remote areas.</p> <p>Study Design:</p> <p>Cross-sectional design prevents establishing causal relationships, requiring longitudinal studies for understanding long-term trends and effective health system transitions.</p>
#	Authors & Publication Year	Country	Design	Setting	Participants	Outcome Instrument	Results	Limitations

6	Sascha Hammer et al. (2024)	Austria	A Qualitative Interview Study	Medical University of Graz	The study sample consisted of experts in sustainable anaesthesia who were members of the Platform for Sustainable Anaesthesia and Intensive Care Medicine under the Austrian Society for Anaesthesiology, Resuscitation, and Intensive Care Medicine (ÖGARI). At the time of the interviews, the platform had 26 members, comprising physicians from various hospitals across Austria. One member from each of Austria's nine states (n = 9) was invited to participate.	Data collection was conducted through interviews lasting 25–70 minutes, with strict confidentiality and anonymization ensured.	<p>Green Team Support: Strong support for the establishment of green teams in hospitals, with unanimous agreement (100%) among participants.</p> <p>Anaesthesiology Representation: Approximately two-thirds (66%) reported that anaesthesiology departments were represented within their hospital's green team, emphasizing their role in promoting sustainability.</p> <p>Standardization Support: 83% of participants supported the idea of standardizing green team structures across hospitals in Austria to enhance information exchange and collaboration.</p> <p>Attitudes Toward Sustainability: Generational differences in attitudes toward sustainability measures were noted, with 33% of participants observing that younger anaesthetists were more proactive in adopting sustainable practices compared to their older counterparts. This generational gap underscores the need for targeted strategies to engage diverse age groups in implementing green healthcare initiatives effectively.</p> <p>Conclusion: Emphasizes structured and inclusive approaches to advancing sustainability within healthcare, particularly through well-supported and standardized green teams.</p>	<p>Sample Size: The study involved only six experts, which may limit the generalizability of the findings to a broader population of anaesthetists.</p> <p>Lack of Clinical Data: The absence of clinical data and ethical approval may restrict the depth of insights regarding the practical implementation of sustainability measures.</p> <p>Subjectivity in Interviews: The qualitative nature of the interviews may introduce bias, as responses are based on personal opinions and experiences rather than standardized metrics.</p>
7	Nagihan İlaslan et al. (2024)	Türkiye	A descriptive and cross-sectional study	The Nursing Department of the Faculty of Health Sciences at a state university in the fall semester of the 2022–2023 academic year."	<p>Study Population: 822 students</p> <p>Academic Year Distribution: 1st Year: 206 students 2nd Year: 219 students 3rd Year: 212 students 4th Year: 185 students</p>	Global Climate Change Awareness Scale (GCCAS) Climate Change Anxiety Scale (CCAS) Sustainability Attitudes in Nursing Survey 2 (SANS 2)	<p>Nursing students' climate change awareness was at a moderate level, while their climate change anxiety and sustainability attitudes in nursing were found to be above average.</p> <p>A positive moderate relationship was identified between climate change awareness, climate change anxiety, and sustainability attitudes in nursing.</p> <p>Climate change awareness had a stronger impact on sustainability attitudes compared to climate change anxiety, increasing sustainability attitudes six-fold in the regression model.</p> <p>Variables such as gender, prior knowledge of climate change and sustainability concepts, and education on these topics influenced the students' awareness, anxiety, and attitudes.</p> <p>Students' awareness of global climate change causes and feelings of helplessness negatively affected their sustainability attitudes.</p>	<p>Generalizability: The study was conducted at a single center limiting the ability to generalize the findings to all nursing students.</p> <p>Study Design: As a correlational study, the study did not establish causal relationships.</p> <p>Other Factors: Climate change and sustainability policies differ by country, which may influence the study's variables in future research.</p>
#	Authors & Publication Year	Country	Design	Setting	Participants	Outcome Instrument	Results	Limitations
8	Fredrika Sundberg et	Sweden	Qualitative research	The study was conducted across four	24 postgraduate intensive care nursing students	The outcome instrument is a	Climate Change Awareness and Sustainability Attitudes:	Generalizability: The study captures the

	al. (2024)			universities located in the southern and western regions of Sweden, between September 2021 and January 2023.		<p>qualitative questionnaire focused on ICU students' experiences with sustainability in ICUs. It includes open-ended questions on: Sustainability observations in the ICU and patient rooms. Suggestions for sustainability improvements and areas of focus. Views on key sustainability issues, such as pharmaceutical management, waste, equipment, staffing, and working environment. Preparedness of the ICU education for sustainable practice. Gaps in education regarding sustainability. Additional thoughts on sustainable healthcare in ICUs.</p>	<p>Nursing students demonstrated moderate levels of climate change awareness, while their climate change anxiety and sustainability attitudes were above average. A moderate positive relationship was identified among these variables, with awareness exerting a stronger influence on sustainability attitudes than anxiety. Increased awareness led to a six-fold increase in sustainability attitudes. Factors such as gender, prior knowledge of climate change, and education on sustainability concepts significantly influenced students' awareness, anxiety, and attitudes. Interestingly, students who reported feelings of helplessness or limited understanding of global climate change causes exhibited lower sustainability attitudes.</p> <p>Environmental Sustainability in Intensive Care Settings:</p> <p>Postgraduate intensive care nursing students identified five subthemes regarding their environmental sustainability experiences in Intensive Care Units (ICUs):</p> <ol style="list-style-type: none"> 1. Recognizing good and bad sustainability habits among staff. 2. Concerns over unsustainable packaging of clinical supplies and the need for better alternatives. 3. The necessity for increased knowledge and education on sustainable practices. 4. Emphasizing a holistic approach to sustainability throughout the patient care pathway. 5. Highlighting the prerequisites for maintaining a sustainable work life. <p>The ICU environment, where saving lives is the top priority, often complicates the adoption of sustainable practices. Students noted that improving awareness among staff and addressing systemic issues could significantly enhance sustainability efforts. Education and training were emphasized as critical tools for advancing sustainable healthcare practices.</p> <p>Conclusion:</p> <p>The study highlights the need for targeted educational interventions, systemic improvements, and a holistic approach to integrating sustainability into healthcare, particularly in high-pressure environments like ICUs.</p>	<p>perspectives of postgraduate intensive care nursing students in Sweden, which may not be applicable to other countries with different approaches to procurement, waste management, and sustainability.</p>
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TPB: Theory of Planned Behaviour, **PES:** Perceived Environmental Sustainability, **PU:** Perceived Usefulness, **MSN:** Main Social Norms, **SSN:** Secondary Social Norms, **ICF:** Internal Control Factors, **ECF:** External Control Factors, **AT:** Attitudes, **SN:** Subjective Norms, **PBC:** Perceived Behavioural Control, **PEOU:** Perceived Ease of Use, **PG:** Promotion Department, **SG:** Government Agencies, **β :** Beta Coefficient, *: Denotes statistical significance at a lower level (p -value < 0.05), **: Denotes statistical significance at a moderate level (p -value < 0.01), ***: Denotes statistical significance at a high level (p -value < 0.001).

3. RESULTS

This comprehensive scoping review synthesizes insights from studies conducted between 2022 and 2024, examining the attitudes, knowledge, and practices of healthcare professionals, students, and managers toward sustainable and resilient healthcare systems. The selected articles encompass a diverse range of methodologies, including quantitative, qualitative, and quasi-experimental designs, and cover various populations and geographical contexts, including Australia, Europe, the Middle East and North Africa (MENA), and Asia, with a specific focus on countries such as Egypt, Türkiye, and Sweden. Each study provides valuable perspectives on green healthcare practices, offering a thorough understanding of the challenges and opportunities for promoting sustainability in healthcare settings.

Geographically, the studies span continents, with Huang et al. (2024) exploring sustainable practices in Australian hospitals, while Ferguson et al. (2023) analysed green behaviours in a Taiwanese hospital. In Europe, research included sustainability in anaesthesiology (Hammer et al., 2024) and circular economy practices among radiographers (Soares et al., 2023). MENA-based case studies (Dion et al., 2023) assessed energy-efficient hospital strategies, while studies in Egypt (Taie, 2022) and Türkiye (İlaslan et al., 2024) focused on managerial and student perspectives, respectively. Sundberg et al. (2024) provided insights from Swedish ICUs.

- Huang et al. (2024) conducted a cross-sectional study in Australia, focusing on healthcare staff's perceptions of climate-resilient and sustainable practices. Despite high individual awareness of climate change's health impacts, the study revealed limited organizational support and engagement with sustainability strategies. Similarly, Ferguson et al. (2023) explored the behavioural intentions of hospital staff in Taiwan using the Theory of Planned Behaviour (TPB). The findings emphasized the importance of perceived behavioural control and organizational strategies in promoting green healthcare policies.
- In Egypt, Taie (2022) implemented a quasi-experimental design to assess the impact of awareness sessions on hospital managers' knowledge and practices regarding green hospitals. Results highlighted significant improvements post-intervention, although initial levels of knowledge and implementation were notably low. Hammer et al. (2024) provided qualitative insights into sustainable anaesthesia practices in Austria, emphasizing the importance of establishing standardized green teams across hospitals for effective collaboration.
- İlaslan et al. (2024) evaluated the relationship between climate change awareness, anxiety, and sustainability attitudes among nursing students in Turkey. The study identified positive correlations, with awareness playing a more substantial role in shaping sustainability attitudes. Similarly, Sundberg et al. (2024) explored postgraduate nursing students' experiences with environmental sustainability in Swedish intensive care units (ICUs). The findings underscored the challenges of implementing sustainable practices in resource-intensive environments.
- Soares et al. (2023) assessed the knowledge of circular economy concepts among European therapeutic radiographers. The results revealed a narrow focus on waste management, highlighting significant educational gaps in other dimensions of green healthcare, such as procurement and energy efficiency. Finally, Dion et al. (2023) analysed energy management and sustainability strategies in hospitals across the Middle East and North Africa (MENA) region. This qualitative case study identified variability in organizational commitment and the adoption of green technologies, influenced by cultural and financial barriers.

Across these studies, common themes emerged: individual awareness of sustainability is high, but organizational support and integration of green practices remain inconsistent. Education and training were repeatedly identified as critical for bridging knowledge gaps and improving sustainable behaviours, while financial, cultural, and structural barriers were highlighted as key challenges to implementing resilient and sustainable healthcare systems globally. These findings collectively underscore the interplay between individual commitment, organizational support, and systemic challenges in advancing sustainable healthcare. Addressing gaps in education, policy implementation, and resource allocation can help healthcare systems more effectively transition toward resilience and sustainability.

Developing Green Hospital Protocols (Egypt)

Taie (2022) explored managers' knowledge and implementation of green hospital practices in two private hospitals. Awareness sessions led to significant improvements, with 86.6% of participants achieving satisfactory knowledge levels post-intervention compared to 2.68% pre-intervention. Despite this, only 11.6% perceived current practices as satisfactory, emphasizing the necessity of institutional alignment with green protocols.

Resilient Healthcare in Natural Disasters (Taiwan)

Ferguson et al. (2023) used the Theory of Planned Behaviour to evaluate the willingness of hospital staff in Taiwan to adopt green hospital policies. Findings showed that attitudes, subjective norms, and perceived behavioural control were significant predictors of pro-environmental intentions, with internal control factors being the strongest influencer. Hospital management was identified as pivotal in fostering green initiatives through internal strategies and improved education.

Circular Economy in Radiation Therapy (Europe)

Soares et al. (2023) evaluated the knowledge and attitudes of therapeutic radiographers towards circular economy (CE) practices across 31 European countries. Although 50% of respondents claimed to practice CE, their focus was predominantly on waste management, neglecting other aspects like energy efficiency or green procurement. Educational gaps were evident, with respondents advocating for CE integration at the high school or undergraduate levels.

Energy Management in Hospitals (MENA Region)

Dion et al. (2023) assessed sustainability and energy efficiency in hospitals across the Middle East and North Africa. Hospitals exhibited varied levels of commitment to energy management and green technologies. Cultural and financial barriers, coupled with inconsistent stakeholder motivation, were identified as challenges. Recommendations included enhancing staff awareness and incorporating sustainable design in hospital infrastructure.

Transitioning to Climate-Resilient Healthcare (Australia)

A cross-sectional study by Huang et al. (2024) surveyed healthcare staff in Queensland to assess attitudes and practices towards sustainable healthcare. The majority (99.7%) recognized the importance of the environment to health, and 92% supported sustainable practices both at home and work. However, only 19% of participants were familiar with their organization's sustainability strategies, and 57.1% were unaware of specific climate-related actions undertaken. Organizational support was perceived as limited, with most environmental actions initiated by staff rather than institutional leadership. This highlights a critical need for organizational engagement to complement individual commitment to environmental sustainability.

Sustainable Anaesthesia Practices (Austria)

Hammer et al. (2024) conducted qualitative interviews with Austrian anaesthesiologists to explore sustainability in aesthetic practices. Participants unanimously supported establishing green teams in hospitals and emphasized standardizing these teams for better inter-hospital collaboration. Despite a small sample size, the study highlighted generational differences in adopting sustainability measures, with younger anaesthetists showing greater enthusiasm.

Nursing Students' Climate Awareness (Turkey)

Ilaslan et al. (2024) examined the interplay between climate change awareness, anxiety, and sustainability attitudes among nursing students. While awareness was moderate, both climate anxiety and sustainability attitudes were above average. Regression analyses revealed that awareness had a stronger influence on sustainability attitudes compared to anxiety. Gender, prior knowledge, and educational exposure were significant factors influencing these variables.

Environmental Sustainability in Intensive Care Units (Sweden)

A thematic analysis by Sundberg et al. (2024) revealed postgraduate intensive care nursing students' experiences with sustainability in ICUs. Five subthemes emerged, including the need for awareness of sustainable practices, unsustainable packaging, and gaps in education. The ICU was identified as a particularly challenging environment for implementing sustainability due to the prioritization of life-saving measures.

4. DISCUSSION

The adoption of resilient, sustainable, and green healthcare practices is a pressing global challenge, particularly as the healthcare sector grapples with its substantial environmental footprint. Understanding the knowledge, attitudes, behaviours, and perceptions of healthcare professionals and students is critical to ensuring successful transitions toward sustainability.

4.1 Knowledge and Awareness: Foundations for Change

Knowledge forms the cornerstone of sustainable healthcare practices. Awareness of concepts like carbon footprints, energy efficiency, and waste management equips healthcare workers and students to address environmental challenges within their professional roles. Research shows that while many healthcare workers recognize the importance of sustainability, gaps in detailed knowledge of green practices persist. For example, life cycle assessments, which evaluate the environmental impact of medical products and services from production to disposal, are underutilized due to a lack of training and awareness (Mang et al., 2023).

Educational efforts targeting these gaps are vital. Curricula should incorporate hands-on training and theoretical knowledge on sustainability. Students exposed to green practices during their education are more likely to view them as integral to their professional duties. Collaborative frameworks can standardize such educational efforts globally (Gupta et al., 2022).

4.2 Attitudes Toward Sustainable Healthcare

Attitudes significantly influence the willingness of healthcare professionals to adopt green practices. Positive attitudes are often linked to an understanding of the broader benefits of sustainability, such as improved public health outcomes and institutional efficiency. However, in many healthcare settings, attitudes remain ambivalent, with sustainability perceived as secondary to clinical responsibilities (Lister et al., 2022).

Hospitals that actively promote sustainability, such as by reducing single-use plastics or employing renewable energy, often foster greater employee engagement in green initiatives. Moreover, framing sustainability as an ethical responsibility, aligned with the Hippocratic Oath to "do no harm," can further strengthen positive attitudes among healthcare workers and students.

4.3 Translating Knowledge and Attitudes into Behaviour

Behavioural change in healthcare settings is a significant challenge when implementing sustainable practices. While knowledge and attitudes form the foundation, they are insufficient on their own; systemic factors, resources, and clear guidelines also play a crucial role. Studies have shown that healthcare professionals recognize the importance of sustainability but struggle to consistently apply this knowledge in their daily practices (Mostepaniuk, et al., 2023; Aliohani et. al., 2023; Shaban et al.,

2024). For instance, waste segregation and energy-saving measures are widely recognized but inconsistently practised (Mostepaniuk, et al., 2023; Werlang et al., 2023; Aliohani et. al., 2023; Soares et al., 2023; Shaban et al., 2024).

To bridge this gap, interventions that provide real-time feedback and tangible incentives have proven effective in encouraging sustainable behaviours (Dowding et al., 2018; Schembre et al., 2018; Batcup et al., 2023; Rajagopalan et al., 2023; Soares et al., 2023). These approaches help healthcare workers understand their environmental impact and motivate them to integrate green practices into their routines (Almukhtar et al., 2024; Shaban et al., 2024). Additionally, green certification programs and training on sustainability in healthcare institutions can institutionalize sustainable practices and provide a clear framework for staff (Rajagopalan et al., 2023). Furthermore, involving students in sustainability projects during their education can enhance their commitment to green behaviours throughout their careers (Yusuf, et al., 2022; Abo-Khalil, 2024; Phillips-Wilson et al., 2024).

4.4 Barriers to Sustainable Practices

Systemic challenges, such as limited financial resources and insufficient policy support, create major obstacles to adopting green healthcare practices. Building energy-efficient facilities and installing advanced waste management systems require high initial investments, which many resource-constrained institutions cannot afford (Aboueid et al., 2023; Zurynski et al., 2023).

Additionally, the absence of standardized metrics and guidelines for assessing sustainability slows progress. Clear benchmarks to evaluate environmental performance are essential. These benchmarks can help institutions identify weaknesses and prioritize necessary actions. Resistance to change among staff, especially those who are used to traditional workflows, adds another layer of difficulty to implementing sustainable practices (Zurynski et al., 2023).

4.5 Opportunities and Future Directions

Despite these challenges, there are many opportunities to improve sustainability in healthcare. Integrating sustainability into health policies, guided by frameworks like the United Nations Sustainable Development Goals (SDGs), can drive systemic change (United Nations, 2015).

Technological advancements also offer promising solutions. Tools such as telemedicine, electronic medical records, and energy monitoring systems can help reduce resource use while improving efficiency. Additionally, adopting green building designs and using renewable energy sources in healthcare facilities can significantly lower their environmental impact (Allen et al., 2015).

4.6 The Role of Healthcare Students

Students, as the forthcoming leaders in healthcare, play a pivotal role in fostering long-term transformations within the field. The integration of environmental health into medical and nursing curricula is imperative for equipping them with the requisite competencies and perspectives essential for advancing sustainable healthcare practices. Engaging students in experiential learning opportunities, such as internships in environmentally sustainable hospitals or involvement in community health initiatives focused on sustainability, serves as an effective means of reinforcing these principles and preparing future healthcare professionals to drive meaningful change in this domain.

5. CONCLUSION

The transition toward resilient, sustainable, and green healthcare systems is a multifaceted challenge that requires a unified approach from healthcare professionals, students, policymakers, and institutions. Drawing upon the World Health Organization's (WHO) holistic definition of health, which emphasizes physical, mental, and social well-being, sustainable healthcare practices are essential not only for environmental preservation but also for improving public health outcomes (WHO, 1948).

5.1 Knowledge as a Cornerstone of Sustainable Practices

The review highlights a significant need for enhanced education and training among healthcare workers and students regarding green practices, such as energy conservation and waste management (Yusuf et al., 2022; Shaban et al., 2024). While awareness of sustainability concepts is growing, actionable knowledge remains inconsistent. Bridging this gap requires embedding sustainability into health education curricula, ensuring that students understand its importance as part of their professional roles.

5.2 Attitudes and Perceptions: Shifting the Paradigm

Positive attitudes toward sustainable healthcare are pivotal for systemic change. Findings indicate that many healthcare professionals are supportive of green initiatives but often view them as secondary to clinical responsibilities. Addressing this requires reframing sustainability as integral to patient care and institutional efficiency. For instance, sustainable practices not only reduce environmental impacts but also create healthier workplaces, benefiting both staff and patients (Mortimer et al., 2018).

Institutional leadership plays a critical role in fostering these attitudes. Policies and initiatives promoting sustainability, such as renewable energy use and waste reduction, encourage healthcare workers to adopt these practices more readily. However, resistance to change remains a barrier, particularly among professionals accustomed to traditional workflows (Zurynski et al., 2023).

5.3 Behaviour and Systemic Barriers

Behavioural change continues to be one of the most significant challenges in integrating sustainability into healthcare (Batcup et al., 2023). Although awareness of sustainable practices is increasing, the implementation of daily practices, such as effective waste segregation, energy conservation, and the adoption of telemedicine, remains inconsistent (Fragão-Marques et al., 2023; Zurynski et al., 2023; Savoldelli et al., 2023; Savoldelli et al., 2024).

Systemic barriers, including insufficient funding, the absence of standardized guidelines, and inadequate institutional support, further hinder the adoption of sustainable practices (Cowie et al., 2020; McArthur et al., 2021; Aboueid et al., 2023; Zurynski et al., 2023). While green building designs and the integration of renewable energy in healthcare facilities often require substantial initial investment (Aboueid et al., 2023), they result in significant reductions in long-term environmental impacts (Allen et al., 2015). Furthermore, international collaborations and policy reforms focused on standardizing sustainability metrics have the potential to address systemic barriers and advance sustainable healthcare globally (European Parliament, 2018; United Nations, 2019; Hensher & McGain, 2020; King et al., 2023).

5.4 Students: Drivers of Change

Healthcare students represent a unique opportunity for embedding sustainability into the sector's future. Experiential learning through internships, projects, and green hospital initiatives equips students with practical skills and a sense of responsibility for environmental stewardship. Their fresh perspective and openness to innovation make them ideal advocates for integrating green practices into healthcare systems (Phillips-Wilson, T. et al., 2024).

5.5 Interdisciplinary and Collaborative Efforts

Achieving sustainable healthcare systems requires interdisciplinary approaches and global collaborations. Efforts such as the United Nations' Sustainable Development Goals (SDGs) and WHO's environmental health initiatives provide frameworks for guiding institutional and individual actions (United Nations, 2015; WHO, 2018). Integrating public health expertise with environmental sciences, technology, and economics can address the multifaceted nature of sustainability challenges.

This scoping review emphasizes that the path toward resilient, sustainable, and green healthcare systems depends on the effective dissemination of knowledge, shifts in attitudes, behavioural adaptation, and robust systemic support. By aligning education, institutional leadership, and global policy frameworks, the healthcare sector can significantly contribute to mitigating environmental

impacts while improving health outcomes. The review's findings highlight the importance of addressing knowledge gaps, promoting sustainability education, and offering organizational support to advance green practices in healthcare. Although individual awareness of sustainability is high, systemic and institutional changes are essential to fully integrate these practices into global healthcare systems. Enhanced educational initiatives, strong policies, and financial investments are crucial to realizing the vision of resilient, sustainable healthcare systems.

LIMITATIONS

This scoping review has several notable limitations that must be acknowledged. First, the scope of the review was limited to English-language articles, which may have resulted in the exclusion of relevant studies published in other languages. This language restriction could introduce language bias and limit the diversity of perspectives on sustainable healthcare practices. The search was conducted using keywords such as "green hospital," "sustainable hospital," "eco-friendly hospital," "resilient hospital," and "low-carbon healthcare," which may also have led to the exclusion of studies that used alternative terminologies or regional variations. Second, the search was restricted to articles available through Web of Science, and although this is a comprehensive database, it may not encompass all potential sources of relevant information, particularly grey literature (e.g., reports, policy documents, and unpublished studies). This exclusion could result in an incomplete representation of the available evidence, particularly as the concepts of "green healthcare" and "resilient healthcare" may appear in various non-peer-reviewed sources not indexed in Web of Science, thereby limiting the broader understanding of green healthcare practices. Third, there is a lack of standardized definitions and metrics for sustainability across the included studies. This inconsistency makes it challenging to compare findings effectively and draw generalized conclusions regarding the effectiveness of specific interventions or strategies in sustainable healthcare. Additionally, this review does not assess the methodological quality of the included studies, which is typical of scoping reviews. This limitation could affect the robustness of the synthesized evidence, as the inclusion of studies with varying degrees of methodological rigor might influence the reliability of the conclusions. Another limitation lies in the heterogeneity of the studies included. Due to the diverse range of healthcare settings, geographic locations, and study designs, synthesizing results across these studies may not fully capture the contextual factors influencing sustainability in healthcare. Furthermore, the geographical diversity of studies included in the review may be limited, as the selection process may have overlooked relevant studies from certain regions or countries, particularly those where sustainable healthcare practices are emerging. Incorporating a more detailed analysis of literature from diverse geographical settings would provide a broader understanding and enhance the qualitative depth of the review. Lastly, the timeframe of the included studies (2019-2024) may also limit the inclusion of older but still relevant studies or emerging trends in sustainable healthcare that could have provided additional insights into the evolving nature of the field. These limitations highlight the need for future research to address these gaps by incorporating a wider range of studies, adopting standardized sustainability metrics, and evaluating the quality of evidence more rigorously. Expanding the scope of future reviews to include grey literature, diverse study designs, and multilingual publications will provide a more comprehensive understanding of sustainable healthcare practices.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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