

Exploring Knowledge, Attitudes, and Behaviours of Healthcare Professionals and Students Towards Resilient, 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 that support both individual and environmental health. Despite growing awareness of sustainability issues in healthcare, a gap exists between knowledge and actual behaviour. 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.

Despite growing awareness of the environmental challenges associated with healthcare, there is variability in how well healthcare workers and students understand and implement 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 aims to examine the knowledge, attitudes, behaviours, and perceptions of healthcare professionals and students regarding green and sustainable healthcare. By synthesizing evidence from various studies, the review seeks to identify gaps in understanding, highlight best practices, and provide recommendations for fostering a culture of sustainability in the healthcare sector. The findings will contribute to the growing body of literature on sustainable healthcare and inform the development of educational and policy interventions tailored to the needs of healthcare workers and students.

The WHO's comprehensive definition of health provides a foundational framework for this inquiry, emphasizing the interconnectedness of health, environmental sustainability, and societal well-being. By exploring the perspectives of those directly involved in healthcare delivery, this study aims to bridge the gap between theory and practice, ensuring that sustainability principles are not only understood but also 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.

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).

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."

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.

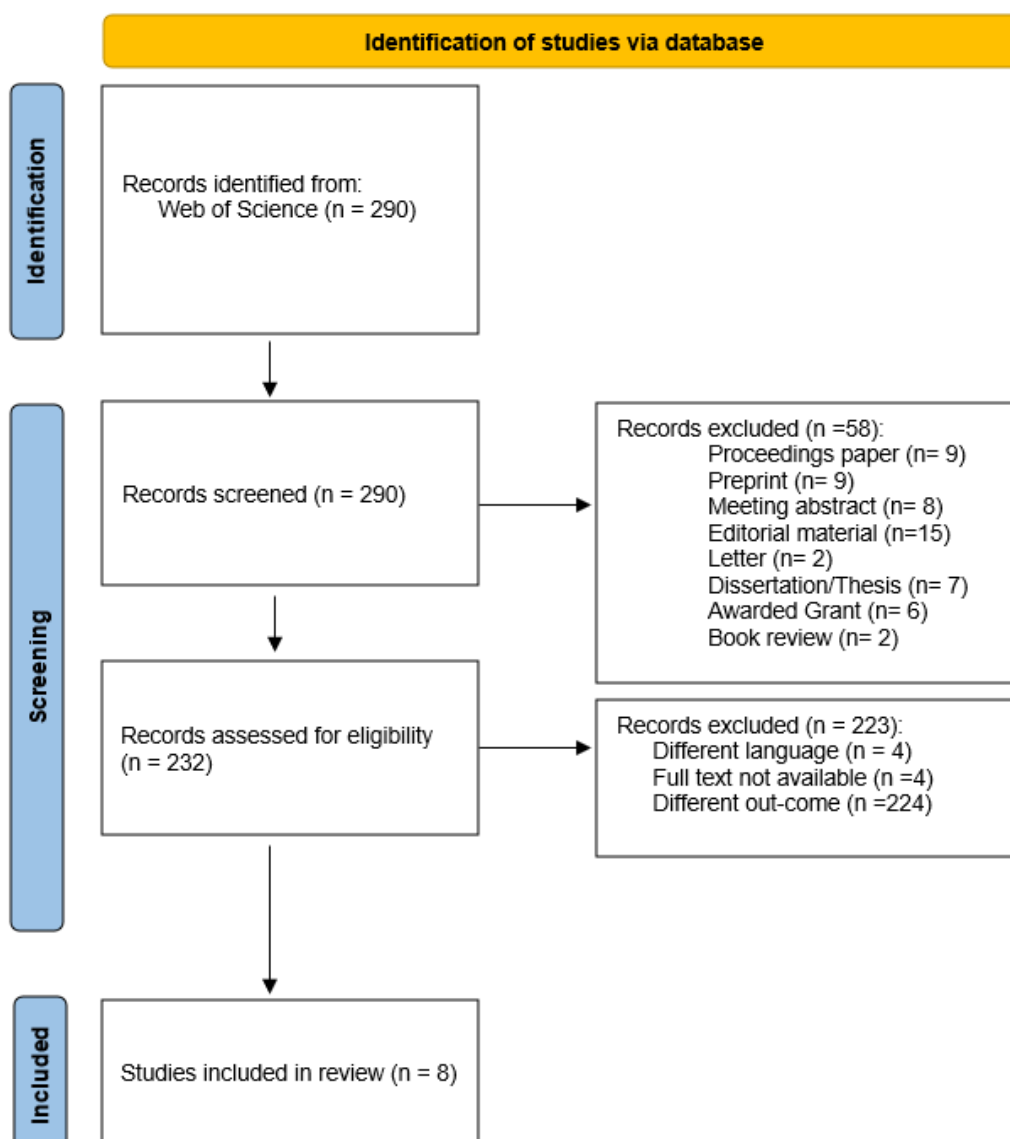


Fig. 1 Flow chart showing study protocol

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)	The study involved two groups of participants: 1) Managers (112): This group included all managerial levels (top, middle, and first-line managers) from two selected hospitals: El-Salam International Hospital (68 managers) and Dar El-Fouad Hospital (44 managers). The managers represented diverse roles such as general managers, medical managers, nursing managers (head nurses, supervisors, and nursing directors), and managers from departments like quality, infection control, human resources, finance, health and safety, and housekeeping. Both male and female managers with at least two years of professional experience were included. 2) Expert Panel (45): This group consisted of professors	Three tools were used for collecting data (Managers' knowledge about green hospital questionnaire, Green Hospital Checklist, and opinionnaire).	Attitudes Towards Climate and Sustainability Nearly all participants (99.7%) recognized the critical role of the environment in health, and the majority considered sustainable practices important both at home (92.5%) and at work (92.2%). Awareness of the connection between climate change and health was high, with 98.6% acknowledging the link, and 72.9% perceiving climate change as already having a moderate to significant impact on health in Queensland. However, fewer participants believed climate change directly impacted health services (60.4%) or their organization (49.4%). Many (77.8%) anticipated that the impacts of climate change on healthcare would intensify over the next decade. Urgent action to address climate change was supported by 90.4%, with 87% agreeing that health services	Sample Size: The study was conducted in only two hospitals, which may limit the generalizability of the findings to other healthcare settings. Time Frame: The fieldwork spanned over a year, which may not capture long-term effects of the implemented protocol. Self-Reported Data: Managers' knowledge and practices were assessed through self-reported questionnaires, which may introduce bias.

				<p>and assistant professors from nursing faculties at Cairo, Ain Shams, and Alexandria universities, as well as experts from the American University in Cairo (AUC). The AUC experts were affiliated with the Office of Sustainability and the Center for Applied Research on the Environment and Sustainability .</p>		<p>should lead these efforts. Furthermore, 91.9% identified the need for improved public awareness about climate change's health implications. Despite this, participants' self-reported understanding of climate change's health impacts varied, with 24.4% feeling uninformed, 46% somewhat informed, and only 29.4% well-informed. Sustainable Practices Sustainable behaviours were more commonly reported in personal settings compared to professional environments. Actions such as recycling and conserving water and energy were more prevalent at home. Communication about climate change and its health effects was primarily with family and friends (64%), while professional discussions were limited, involving colleagues (36%), managers (10%), or officials (6%). Organizational Support While 74.5% of participants valued environmental protection in their workplaces, 53.3% believed their personal commitment to environmental</p>	
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							<p>values exceeded that of their employers. Awareness of organizational sustainability policies was notably low, with only 19% familiar with such strategies and just 26.8% aware of the HHS Sustainability Strategy introduced in 2021. A significant portion (57.1%) reported being unaware of their organization's climate-related actions. While 68.8% reported some level of organizational support for sustainability, 27.7% perceived no support at all. Environmental initiatives were often driven by staff rather than organizational leadership.</p> <p>Barriers and Challenges Key challenges included limited awareness of organizational environmental policies, inadequate integration of sustainability strategies into everyday practices, and a lack of institutional commitment. Preparedness for future climate impacts was minimal, with only 2.1% of participants considering their organization well-prepared to address such challenges.</p> <p>Conclusion</p>	
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							While participants demonstrated a strong individual commitment to environmental sustainability and acknowledged the pressing health impacts of climate change, these efforts were not consistently mirrored at the organizational level. The lack of awareness, engagement, and preparedness among institutions underscores the need for stronger leadership, clearer strategies, and effective communication to align individual and systemic sustainability initiatives in healthcare.	
2	Ferguson, Adele et al. (2023)	Taiwan	Cross-sectional study	A regional teaching hospital in Taiwan	Hospital staff from a regional teaching hospital in Taiwan, divided into five stakeholder groups: 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	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: (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]	Critical Stakeholders: •Medical administrators (M1) and nursing staff (M3) were the most influential groups in implementing green hospital policies. •These stakeholders had the highest proportion of significant effects across all hypotheses, underscoring their importance in the success of green healthcare initiatives. Theory of Planned Behaviour (TPB): •The TPB framework effectively explained the	The TPB framework focuses on rational reasoning and excludes emotional factors, potentially limiting its explanation of hospital employees' responsibility for green hospital performance. The study is limited to a single regional hospital, restricting generalizability to all hospitals in Taiwan or different healthcare levels

					services, security personnel) (n = 31).	and ECF [4 items])	<p>behavioural intentions of hospital staff toward green practices.</p> <ul style="list-style-type: none"> •Three core dimensions—Attitudes (AT), Subjective Norms (SN), and Perceived Behavioural Control (PBC)—positively influenced green behaviours, with PBC showing the strongest impact. <p>Perceived Behavioural Control (PBC):</p> <ul style="list-style-type: none"> •Internal control factors (ICFs, $\beta = 0.347^{***}$) had a greater influence than external control factors (ECFs, $\beta = 0.184^*$). •This finding suggests that enhancing internal conditions, such as providing resources and training, is critical to fostering green behaviours. <p>Subjective Norms (SN):</p> <ul style="list-style-type: none"> •Among subjective norms, 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>Attitudes and Perceived Usefulness:</p> <ul style="list-style-type: none"> •The perceived usefulness (PU) of green 	
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						<p>hospitals had a significant impact on staff behaviour ($\beta = 0.423^{***}$), surpassing the perceived ease of use (PEOU, $\beta = 0.21^{**}$).</p> <ul style="list-style-type: none"> •Emphasizing the practical benefits of green healthcare initiatives is key to driving adoption among hospital staff. <p>Roles of Medical Administrators and Nursing Staff:</p> <ul style="list-style-type: none"> •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>Policy Recommendations:</p> <ul style="list-style-type: none"> •Foster cross-departmental collaboration to align priorities and resources. •Enhance environmental education to raise awareness and skills related to green practices. •Introduce incentive systems to motivate staff and reinforce sustainable behaviours. •Strengthen internal green management 	
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							to improve infrastructure, resources, and support for sustainability initiatives. This review demonstrates that engaging key stakeholders, addressing internal conditions, and highlighting the practical advantages of green hospital policies are essential to driving systemic adoption of sustainable healthcare practices.	
3	A.L. Soares et al. (2023)	31 countries	Cross-sectional study	<p>Data collection took place as part of the SAFE EUROPE project, a European-funded initiative conducted between October 2021 and February 2022. The project aimed to address educational gaps among European Therapeutic Radiographers (TRs) and Radiation Therapists (RTTs) by providing free webinars.</p> <p>The study involved seven partner organizations across Europe, including: 1)Ulster University (UK, project leader), 2)University of Malta (Malta),</p>	190 respondents	<p>The validated self-designed survey was divided into six sections: (i) demographics, (ii) knowledge of Circular Economy (CE) and Green Skills (GS), (iii) personal attitudes, (iv) TR/RTTs attitudes, (v) the importance of CE, and (vi) education.</p> <p>Questions consisted of mostly Likert scales complemented with other closed- and open-ended questions.</p> <p>The questionnaire is divided into three parts and six sections.</p> <p>1st part <i>Section I-</i> Socio-demographic details</p> <p>2nd part <i>Section II-</i> Knowledge of CE and GS</p>	<p>Awareness levels among participants regarding national and departmental policies related to Circular Economy (CE) and Green Sustainability (GS) concepts were reported as 31%-42%. Despite half of the participants perceiving themselves as advocates and practitioners of CE, responses to open-ended questions revealed a predominant focus on waste management, overlooking other critical dimensions of CE in healthcare. Furthermore, participants' personal attitudes and lifestyles did not align with CE principles.</p> <p>Therapists and Radiation Therapy Technologists (TR/RTTs) acknowledged the importance of CE practices</p>	<p>The study faced several limitations. Only 31 out of 44 European countries were represented, and the response rate was low, with only 190 valid responses collected. Many TR/RTTs may have been unaware of the relevance of CE and GS to their practice, reducing their inclination to participate. Despite efforts to distribute the survey widely through SAFE EUROPE partners, including EFRS, and social media, not all TR/RTTs had access to it. Additionally, online surveys typically have low response rates but were used here for their efficiency in covering a large geographical area.</p>

				<p>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).</p>	<p><i>Section III - Personal/Individual attitudes towards CE practices</i> <i>Section IV- TR/RTTs professional group attitudes towards CE practices within the working environment</i> <i>Section V- TR/RTTs perception of the importance of CE</i></p> <p>3rd part <i>Section VI- TR/RTTs perception regarding educational needs on CE and GS</i></p>	<p>and GS development in their field. However, opinions diverged on the most suitable academic stage for developing these skills, with 44% suggesting high school and 32% recommending the bachelor's level.</p> <p>In 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>The responses were unevenly distributed across countries, with Portugal being over-represented (71 respondents, 37.4%), potentially influencing the results. This imbalance, common in international studies, highlights the need for more equitable response distribution in future research. Convenience sampling was employed, limiting participation to members of professional organizations or those reached via SAFE EUROPE media channels. Despite this, the survey's broad reach across 31 countries provides confidence in its generalizability to European TR/RTTs. Respondent bias was another challenge, as those interested in the topic were more likely to participate. However, the survey still captured responses from individuals less familiar with CE and GS, as only 36%-42% of participants reported knowledge of these concepts. Finally, while the survey tool was tested for</p>
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								reliability within this population, it would need revalidation for use in other groups.
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.	The participants included 29 executives and leaders responsible for energy management across ten case studies. This group comprised senior management, lead executives, senior physicians, and lead engineers, all involved in overseeing energy management systems.	Semi-structured in-depth interview. The interviews included 10 to 15 questions, adjusted based on the interviewees' responses, with a focus on gaining knowledge about the sustainability trends of the hospitals across various areas. The collected data was transcribed and categorized into three primary areas: (1) energy consumption management, (2) adoption of green technologies, and (3) hospital facility management.	The study investigated energy management, green technology adoption, and hospital building envelope practices within healthcare systems. Energy Management: Analysis focused on energy management goals, 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. 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	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>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>These findings emphasize the importance of aligning attitudes, increasing stakeholder motivation, and improving awareness to support sustainable and resilient healthcare systems.</p>	
5	Huang, Andrea et al. (2024)	Australia	Cross-sectional study	Staff members at Sunshine Coast Hospital and Health Service (SCHHS), Queensland, Australia	Medical n=17 (5.6%) Nursing and Midwifery n=119 (39.6%) Allied Health and Dental n=57 (18.9%) Administration and Building and Engineering Officers, Professional,	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	<p>Attitudes:</p> <ul style="list-style-type: none"> •A vast majority (99.7%) recognized the environment as vital for health, with strong support for sustainable practices at home (92.5%) and work (92.2%). 	This study has several limitations. First, the higher participation of individuals already interested in environmental sustainability may have introduced selection bias, affecting the

				<p>Technical and Operational Officers n=104 (34.5%) Prefer not to say, Other n=4 (1.3%)</p>	<p>(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>	<p>•Awareness of the link between climate change and health was high (98.6%), with 72.9% believing it already has a moderate to significant effect on health in Queensland. •Fewer participants perceived impacts of climate change on health services (60.4%) or their organizations (49.4%). •77.8% expected the impact on healthcare services to escalate over the next decade. •Urgent action on climate change was deemed necessary by 90.4%, and 87% believed health services should lead these efforts. •Awareness about the health effects of climate change was uneven: o24.4% felt uninformed. o46% felt somewhat informed. o29.4% considered themselves well-informed. •Most participants (91.9%) believed public understanding of climate-related health issues needs improvement. Practices: •Sustainable practices, like recycling and conserving resources, were more common at home than in the workplace.</p>	<p>representative ness of the sample. Additionally, 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. The findings are also based on a single health service in Queensland, which may not be generalizable to other regions, particularly rural and remote areas with distinct challenges. Furthermore, the cross-sectional design of the study prevents establishing causal relationships, and longitudinal studies would be valuable for understanding long-term trends and effective health system transitions.</p>
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						<ul style="list-style-type: none"> •Conversations on climate and health were more frequent with family and friends (64%) than with colleagues (36%), managers (10%), or officials (6%). Organizational Support: •Although 74.5% highlighted the importance of environmental protection within their organizations, only 19% were familiar with their organization's sustainability policies. •The HHS Sustainability Strategy (launched in 2021) was recognized by 26.8% of participants. •57.1% were unaware of any climate-focused initiatives in their organizations. •Organizational support for sustainability was reported by 68.8%, though 27.7% felt there was no support. •Staff-driven initiatives were more common than those led by the organization. Barriers and Challenges: •Limited communication and engagement with organizational environmental strategies. •Lack of robust organizational commitment and integration of sustainability into practice. •Only 2.1% believed their organization 	
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							<p>was adequately prepared for future climate impacts.</p> <p>Opportunities:</p> <ul style="list-style-type: none"> •The high level of individual awareness and commitment among staff could be a foundation for enhanced sustainability if better supported by institutional leadership and clear strategies. <p>Conclusion:</p> <p>Healthcare professionals and students demonstrated strong individual commitment to sustainability and an understanding of the health implications of climate change. However, institutional shortcomings in leadership, preparedness, and communication limit the effectiveness of sustainability efforts. Addressing these gaps could enable healthcare organizations to align more closely with the values and actions of their staff, fostering resilient and sustainable healthcare systems.</p>	
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	Data collection was conducted through interviews lasting 25–70 minutes, with strict confidentiality and anonymization ensured.	The findings highlight strong support for the establishment of green teams in hospitals, with unanimous agreement (100%) among participants on their necessity.	Sample Size: The study involved only six experts, which may limit the generalizability of the findings to a broader population of anaesthetists.

				<p>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</p>		<p>Approximately two-thirds (66%) reported that anaesthesiology departments were represented within their hospital's green team, emphasizing their role in promoting sustainability. Additionally, 83% of participants supported the idea of standardizing green team structures across hospitals in Austria to enhance information exchange and collaboration. 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. These findings underscore the importance of structured and inclusive approaches to advancing sustainability within healthcare, particularly through well-</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. 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>
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							supported and standardized green teams.	
7	Nagihan İlaslan et al. (2024)	Türkiye	A descriptive and cross-sectional study	Nursing department of the faculty of health sciences of a state university in the fall semester of the 2022–2023 academic year	The study population included 822 students, distributed across four academic years: 206 in the first year, 219 in the second year, 212 in the third year, and 185 in the fourth year.	Global Climate Change Awareness Scale (GCCAS) Climate Change Anxiety Scale (CCAS) Sustainability Attitudes In Nursing Survey 2 (SANS 2)	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. A positive moderate relationship was identified between climate change awareness, climate change anxiety, and sustainability attitudes in nursing. Climate change awareness had a stronger impact on sustainability attitudes compared to climate change anxiety, increasing sustainability attitudes six-fold in the regression model. Variables such as gender, prior knowledge of climate change and sustainability concepts, and education on these topics influenced the students' awareness, anxiety, and attitudes. Students' awareness of global climate change causes and feelings of helplessness negatively affected their sustainability attitudes.	The study was conducted at a single center, limiting the ability to generalize the findings to all nursing students. Climate change and sustainability policies differ by country, which may influence the study's variables in future research. As a correlational study, it did not establish causal relationships. Awareness and anxiety explained at least 25.1% of the variance in nursing students' sustainability attitudes.

8	Fredrika Sundberg et al. (2024)	Sweden	Qualitative research	The study was conducted across four universities located in the southern and western regions of Sweden, between September 2021 and January 2023.	24 postgraduate intensive care nursing students	<p>The outcome instrument is a qualitative questionnaire focused on ICU students' experiences with sustainability in ICUs. It includes open-ended questions on:</p> <p>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>Climate Change Awareness and Sustainability Attitudes in Nursing Nursing students displayed moderate levels of climate change awareness, while their climate change anxiety and sustainability attitudes were above average. A moderate positive relationship was identified between these variables, with awareness exerting a stronger influence on sustainability attitudes than anxiety. Regression analysis revealed that increased awareness boosted sustainability attitudes six-fold. Factors such as gender, prior knowledge of climate change, and education on sustainability concepts significantly shaped students' awareness, anxiety, and attitudes. Interestingly, students who reported feelings of helplessness or limited understanding of global climate change causes tended to exhibit lower sustainability attitudes. Environmental Sustainability in Intensive Care Settings Postgraduate intensive care</p>	<p>A limitation of the study is that it captures the 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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						<p>nursing students shared their environmental sustainability experiences within one overarching theme: the ICU as a challenging context for sustainability. Five subthemes emerged from their perspectives:</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, such as packaging inefficiencies, could significantly enhance sustainability efforts. Education and</p>	
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							training were repeatedly mentioned as critical tools for advancing sustainable healthcare practices. These findings underscore the importance of targeted educational interventions, systemic improvements, and a holistic approach to integrating sustainability into healthcare, particularly in high-pressure environments like ICUs.	
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TPB: Theory of Planned Behavior, PES: Perceived Environmental Sustainability, PU: Perceived Usefulness, MSN: Main Social Norms, SSN: Secondary Social Norms, ICF: Internal Control Factors, ECF: External Control Factors

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 complex process influenced by systemic factors, such as institutional support, resources, and clear guidelines. Despite general awareness, healthcare professionals often struggle to integrate sustainability into their daily routines. For instance, waste segregation and energy-saving measures are widely recognized but inconsistently practised (Mostepaniuk et al., 2023).

Behavioural interventions that provide real-time feedback and tangible incentives have shown promise in bridging this gap. For example, green certification programs for hospitals, coupled with staff training, can institutionalize sustainable practices. Additionally, students who participate in sustainability initiatives, such as environmental audits or waste reduction projects, are more likely to carry these behaviours into their professional lives (Yusuf et al., 2022).

4.4 Barriers to Sustainable Practices

Systemic challenges, such as financial constraints and insufficient policy support, remain significant obstacles to implementing green healthcare practices. Investments in green infrastructure, such as energy-efficient buildings and advanced waste management systems, require substantial upfront costs, which are often prohibitive for resource-limited institutions (Aboueid et al., 2023; Zurynski et al., 2023).

Moreover, a lack of standardized metrics and guidelines for evaluating sustainability hinders progress. Scholars emphasize the need for clear benchmarks to measure environmental performance, which can help institutions identify gaps and prioritize interventions. Resistance to change, particularly among staff accustomed to traditional workflows, further complicates these efforts (Zurynski et al., 2023).

4.5 Opportunities and Future Directions

Despite these challenges, numerous opportunities exist to enhance sustainability in healthcare. Integrating sustainability into health policies, supported by national and international frameworks like the United Nations Sustainable Development Goals (SDGs), can provide a robust foundation for systemic change (United Nations, 2015).

Technological innovations also offer significant potential. Tools such as telemedicine, electronic medical records, and energy monitoring systems can reduce resource consumption while improving efficiency. Incorporating green building designs and renewable energy sources into healthcare infrastructure can further reduce environmental impacts (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 is the most challenging aspect of integrating sustainability into healthcare. Despite increasing awareness, daily practices like proper waste segregation, energy conservation, and adopting telemedicine are inconsistently implemented. Research suggests that providing feedback on environmental impact and offering incentives can motivate healthcare workers to adopt sustainable behaviours (Batcup et al., 2023).

Systemic barriers such as insufficient funding, lack of resources, and absence of standardized guidelines exacerbate this issue. Green infrastructure, though beneficial in the long term, often demands high upfront investments, which are particularly challenging for resource-constrained institutions (Aboueid 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 limitations that should be acknowledged. First, the review is limited to English-language articles, which may exclude relevant studies published in other languages, potentially leading to a language bias. Second, the databases searched may not encompass all possible sources of information on sustainable healthcare practices, particularly grey literature, which could result in an incomplete representation of the available evidence. Third, the lack of standardized definitions and metrics for sustainability across the included studies poses a challenge in comparing findings and drawing generalized conclusions. Finally, this review does not assess the quality of the included studies, as is typical of scoping reviews, which may affect the robustness of the synthesized evidence. These limitations highlight the need for future research to address these gaps and provide more comprehensive insights into sustainable healthcare practices.

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UNDER PEER REVIEW