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Bridging the gap in sustainable radiography: insights from five countries in Asia and Africa

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Abstract

Introduction Sustainability in healthcare, particularly in medical imaging, is increasingly important as healthcare operations contribute significantly to global emissions. Radiographers, as integral members of imaging departments, play a vital role in implementing sustainable practices. This study examines radiographers' perceptions, practices, and barriers to sustainability across five countries: the United Arab Emirates, Saudi Arabia, Palestine, Sudan, and Ghana, highlighting regional differences and factors influencing engagement.

Methods A cross-sectional survey was conducted among 441 radiographers using an online platform. The survey included questions on demographic information, sustainability perceptions, practices, and barriers. Data were analyzed using descriptive statistics and the Kruskal-Wallis H test to evaluate regional variations in sustainability engagement.

Results Results revealed moderate sustainability knowledge among participants, with 45.1% ($n=199$) understanding the concept and 46.7% ($n=206$) recognizing its benefits. Common practices included digital documentation (34.6%, $n=289$) and daily energy reduction efforts (32.2%, $n=142$). However, advanced practices such as recycling residual contrast media or adopting energy-efficient equipment were limited. Key barriers included lack of training (39.2%, $n=173$), financial constraints (44.7%, $n=197$), and insufficient managerial support (39.2%, $n=173$). Regional variations were evident, with Ghana showing the highest engagement across knowledge, attitudes, and practices, while Saudi Arabia scored the lowest. Statistical analysis indicated significant differences in sustainability engagement by region ($p<0.05$), with Ghana benefiting from targeted educational initiatives and international collaborations. In contrast, resource limitations and insufficient institutional support hindered progress in other regions.

Conclusion The findings emphasize the need for tailored strategies to promote sustainability in radiography. Recommendations include integrating sustainability into radiography curricula, providing targeted training, enhancing leadership support, and adopting region-specific interventions. Addressing these challenges can empower radiographers to contribute to environmentally sustainable healthcare systems.

Keywords Sustainability, Radiography, Environmental impact, Healthcare systems, Regional differences, Barriers, Sustainable practices, Developing countries

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Introduction

Sustainability in healthcare, particularly in medical imaging, has gained importance as clinical practices increasingly affect the environment. Given the energy-intensive nature of imaging equipment and the growing global focus on environmentally friendly healthcare, radiography provides a unique opportunity to integrate sustainable solutions. In radiography, sustainability efforts focus on reducing energy consumption, minimizing waste, and adopting eco-friendly practices, given the healthcare sector's notable contribution to global emissions [1–3].

Studies indicate that while many radiographers understand sustainability's importance, their knowledge often remains limited to waste management, with less awareness of broader sustainable practices [4, 5]. Several sustainable practices are emerging, such as using energy-efficient equipment, reducing single-use items, and enhancing waste management [6]. However, practices vary widely by region, with developed countries often leading in integrating sustainability due to better resources and institutional support. In low-resource settings, radiographers face unique challenges, emphasizing the need for context-specific strategies to advance sustainability across diverse environments [5].

While radiographers generally express positive attitudes toward sustainability, barriers such as limited institutional support, lack of training, and resource constraints prevent widespread implementation. Furthermore, radiographers face personal barriers, as many work in environments that do not actively promote or facilitate sustainable practices [6]. This disconnect stresses the need for more targeted training and resources to bridge the gap between motivation and actionable practices [7]. Addressing these challenges requires a comprehensive approach that includes institutional support, enhanced training on sustainability frameworks, and policy adjustments to encourage sustainable practices within radiography practice.

Advancing sustainability in radiography requires strategies that encompass education, policy support, collaboration, and ongoing research. Integrating sustainability into radiography curricula and enhancing institutional support can empower radiographers to implement eco-friendly practices. Additionally, fostering collaboration among radiographers, healthcare leaders, and policymakers can strengthen commitment to sustainable healthcare. As climate change and environmental degradation challenge the healthcare sector, radiographers' role in promoting sustainability becomes increasingly critical for a more resilient and sustainable future in healthcare.

Medical imaging significantly contributes to healthcare's environmental footprint, with radiography playing a key role in energy consumption, electronic waste, and medical disposables. Studies estimate that diagnostic imaging accounts for a substantial proportion of hospital energy use, with magnetic resonance imaging and computed tomography scanners consuming up to 10 times more energy than standard medical equipment. Additionally, improper disposal of contrast agents and imaging-related waste can have long-term ecological consequences. Without proactive sustainability measures, the growing demand for medical imaging could exacerbate environmental harm. Addressing these challenges through sustainable radiography practices is essential to reducing the sector's carbon footprint while maintaining high-quality patient care [3, 8–12].

This study explores radiographers' knowledge, attitudes, and practices regarding sustainability, identifying barriers and opportunities for improvement. It seeks to investigate the role of institutional support, policy, and personal demographics in shaping sustainability practices. Additionally, the research aims to identify innovative approaches that radiographers employ to overcome sustainability challenges in low-resource settings and explore strategies to integrate sustainability principles effectively within radiography practice.

Methods

This study examines radiographers' perceptions, practices, and barriers to sustainability in five countries: the UAE, Saudi Arabia, Palestine, Sudan, and Ghana. It explores how institutional support, policy, and demographics influence sustainability, highlighting differences between low-resource and well-resourced settings. The study also investigates strategies radiographers use to overcome challenges and integrate sustainable practices. The study focused on the UAE, Saudi Arabia, Palestine, Sudan, and Ghana to capture sustainability challenges across diverse healthcare settings, ranging from well-resourced to low-resource environments. This selection enabled a comparative analysis of how institutional, economic, and policy differences influence sustainability in radiography. Additionally, these countries were chosen based on the research team's professional networks and active involvement in these regions, ensuring effective data collection and contextual relevance.

Study design and data collection

A cross-sectional design was chosen to capture diverse perspectives across multiple regions and professional settings. The survey was developed and distributed online in a digital platform between August and October 2024 among radiographers working in five countries. All responses were anonymous, and submissions were stored in an encrypted form and access-controlled by the principal investigator.

Study sample

The study targeted practising radiographers in five countries: the United Arab Emirates, Saudi Arabia, Palestine, Sudan, and Ghana. To enhance the sample's diversity, a convenient sampling method was used to recruit participants through professional networks, social media groups, and collaborations with local radiography societies. Eligibility criteria included current employment in radiography, voluntary participation, and proficiency in English to complete the survey. Data collection aims at a diverse representation of radiographers from various healthcare settings (e.g., public hospitals, private clinics, and educational institutions) across the selected countries.

Survey design

The survey, guided by the WHO Sustainability Framework, was developed from a comprehensive literature review and adapted for cultural and practice differences across participating countries. It comprised four sections: demographics, perceptions, sustainability practices, and barriers, using Likert-scale, multiple-choice, and ranking questions to assess radiographers' attitudes and challenges. To ensure validity, experts in radiography and sustainability reviewed the survey for clarity, relevance, and comprehensiveness. Pilot testing with 25 radiographers refined wording and cultural suitability, aligning with recommended pilot study sizes. Reliability was assessed using Cronbach's alpha (≥ 0.7) for internal consistency, and test-retest reliability was evaluated by re-administering the survey to a subset after two weeks to ensure response stability.

Table 1 Demographic and professional profile of radiographer respondents

	n (%)
Gender	
Male	228 (51.7)
Female	213 (48.3)
Age group	
0–30	245 (55.7)
31–40	140 (31.8)
41–50	45 (10.2)
51+	10 (2.3)
Years of experience	
0–10 years	315 (72.9)
11–20 years	97 (22.5)
21+	20 (4.6)
Facility	
Hospital	316 (71.5)
Clinic	82 (18.5)
Educational Institution	31 (7.0)
Research Institution	6 (1.3)
Other	30 (6.8)
Modality working in	
General Radiography	310 (29.1)
CT	196 (18.4)
MRI	119 (11.2)
Dental Radiography	81 (7.6)
Ultrasonography	79 (7.5)
Mammography	43 (4.1)
Other	16 (1.6)

Statistical analysis

Data analysis was conducted using SPSS version 27.0, with both descriptive and inferential statistical tests applied to examine the study variables. Descriptive statistics (frequencies, means, and standard deviations) summarised demographic characteristics, sustainability perceptions, practices, and barriers. Sustainability engagement scores for knowledge, attitudes, practices, and barriers (KAPB) were computed by summing responses from Likert-scale items, creating composite scores where higher values indicated stronger engagement or greater barriers. The Kruskal-Wallis H test was conducted to compare KAPB scores across the five countries due to the non-normal distribution of the data. Statistically significant differences were reported at $p < 0.05$.

Ethics approval

This study received approval from the Research Ethics Committee at the University of Sharjah (REC-24-05-27-01-F). Informed consent was obtained from all participants who engaged voluntarily and could withdraw. The study adhered to the principles of the Declaration of Helsinki and complied with applicable national ethical guidelines.

Results

Demographic characteristics and professional background of respondents

A total of 441 responses from radiographers across five countries. The UAE represented the largest group (22.9%, $n = 101$), followed by Saudi Arabia (22.7%, $n = 100$), Palestine (21.8%, $n = 96$), Ghana (18.6%, $n = 82$), and Sudan (14.1%, $n = 62$). Males comprised the majority (51.7%, $n = 228$), and most respondents (55.7%, $n = 245$) were 30 or younger. Most respondents had limited professional experience (72.9%, $n = 315$) reporting 0–10 years. 71.5% ($n = 316$) of respondents worked in hospitals, followed by 18.5% ($n = 82$) in clinics. Regarding imaging modalities, general radiography was the most practised (29.1%, $n = 310$), followed by Computed Tomography (CT) (18.4%, $n = 196$), and Magnetic Resonance Imaging (MRI) (11.2%, $n = 119$) (see Table 1).

Sustainability awareness, practices, and barriers among radiographers

Responses revealed that 46.9% ($n = 207$) of participants identified reducing the environmental impact of healthcare operations as the best description of sustainability, while 33.6% ($n = 148$) posterized enhancing patient comfort. Most (87.1%, $n = 384$) identified waste management, energy efficiency, and water conservation as key focus areas. Sustainability was a primary clinical decision factor for 45.6% ($n = 201$) and secondary to patient care for 32.7% ($n = 144$). The main barrier reported was a lack of awareness and training (25.1%, $n = 304$). With familiarity with waste disposal methods, the highest was recycling (28.5%, $n = 208$), followed by incineration (23.8%, $n = 173$). Regarding energy reduction practices, 32.2% ($n = 142$) engaged daily, while 30.6% ($n = 135$) rarely engaged. Digital documentation to reduce paper use was the most common sustainable practice (34.6%, $n = 289$) (see Table 2).

Table 2 Radiographers' perceptions and practices on sustainability in healthcare

	n (%)
Best describes sustainability in healthcare?	
Reducing the environmental impact of healthcare operations	207 (46.9)
Enhancing patient comfort regardless of environmental cost	148 (33.6)
Increasing the financial profits of healthcare facilities	51 (11.6)
None of the above	35 (7.9)
Key Areas of Focus in Sustainable Healthcare	
Energy efficiency	29 (6.6)
Waste management	22 (5)
Water conservation	6 (1.4)
All of the above	384 (87.1)
How Sustainability is Prioritized in Clinical Decisions	
It's a primary consideration	201 (45.6)
It's of some importance but secondary to patient care	144 (32.7)
I consider it when it's convenient	69 (15.6)
I do not consider it at all	27 (6.1)
Biggest Barrier to Implementing Sustainable Practices	
Lack of awareness and training	304 (25.1)
Financial constraints	209 (17.4)
Insufficient Managerial support	188 (15.6)
Busy schedule and lack of time	150 (12.4)
Perceived impact on patient care	88 (7.4)
Waste Disposal Methods Familiarity	
Recycling	208 (28.5)
Incineration	173 (23.8)
Chemical treatment	101 (13.9)
Composting	63 (8.6)
Frequency of Engaging in Energy Reduction Practices	
Never	56 (12.7)
Rarely	135 (30.6)
Daily	142 (32.2)
Weekly	56 (12.7)
Monthly	52 (11.8)
Sustainable Practices Incorporated into Daily Routine	
Digital documentation to reduce paper use	289 (34.6)
Energy-efficient lighting	154 (18.5)
Using reusable materials	134 (16)
Water-saving fixtures	74 (8.9)

Sustainability engagement: knowledge, attitudes, practices, and perceived barriers

The analysis of participants' engagement with sustainability encompassed four main areas: knowledge, attitude, practice, and barriers, assessed on a 5-point Likert scale from "Strongly Disagree" to "Strongly Agree."

Knowledge

Participants demonstrated moderate knowledge of sustainability concepts, with 45.1% ($n = 199$) agreeing that they understand the concept and 46.7% ($n = 206$) recognizing the benefits of sustainable practices in healthcare. 42.9% ($n = 189$) reported awareness of the environmental impact of healthcare waste, and 44% ($n = 194$) agreed that they understand energy conservation within healthcare. However, only 34.5% ($n = 152$) reported regularly updating their sustainability knowledge.

Attitude

Attitudinal responses indicated a positive outlook towards sustainability, with 45.1% ($n = 199$) affirming its importance in healthcare and 41% ($n = 181$) supporting the integration of sustainability into professional training programs. Nearly half of the participants (48.8%, $n = 215$) were motivated to learn more about sustainable practices, and 49.2% ($n = 217$) believed that the healthcare sector has the potential to reduce its environmental impact.

Practice

Regarding practical engagement, 39.2% ($n = 173$) actively worked to reduce waste, and nearly half (49.7%, $n = 219$) encouraged others to adopt sustainable practices. 39.7% ($n = 175$) reported adhering to disposal procedures, and 48.5% ($n = 214$) of respondents stated that they make suggestions for improving sustainability. Participation in sustainability training was observed in 38.5% ($n = 170$) of participants.

Barriers

The major barriers to sustainable practices included a lack of training (39.2%, $n = 173$) and insufficient financial support, with 44.7% ($n = 197$) agreeing that it posed a challenge. Workload and staff shortages were also significant, with 39.9% ($n = 176$) indicating these as obstacles,

and 39.2% ($n = 173$) cited a lack of leadership commitment to sustainability as a barrier (see Table 3).

Sustainability engagement scores across knowledge, attitude, practice, and barriers

Scores for sustainability engagement across knowledge, attitude, practice, and perceived barriers were evaluated on a 5-point scale (1 = "Strongly Disagree" to 5 = "Strongly Agree"). In the knowledge category, 4.5% ($n = 20$) had the lowest score of 7, indicating minimal understanding, while 3.2% ($n = 14$) achieved the highest score of 35, reflecting strong engagement.

For attitudes, 4.1% ($n = 18$) recorded the lowest score of 7, suggesting weaker agreement with sustainable values, whereas 3.9% ($n = 17$) achieved the highest score of 34, indicating strong positive attitudes. In practice, 2.7% ($n = 12$) reported the lowest score of 14, reflecting limited engagement in sustainable practices, while 1.6% ($n = 7$) scored the highest at 69, indicating extensive participation. For barriers, higher scores corresponded to greater challenges in implementing sustainability. 4.1% ($n = 18$) scored the lowest of 5, while 2.0% ($n = 9$) scored the highest of 25, indicating significant obstacles.

Figure 1 illustrates the mean ranks of sustainability engagement across countries of employment based on knowledge, attitude, practice, and perceived barriers. A Kruskal-Wallis H test assessed statistically significant differences among these categories across the five

Table 3 Levels of sustainability engagement in knowledge, attitudes, practices, and barriers among radiographers

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	n (%)				
Knowledge					
Understand sustainability concept	31 (7.0)	16 (3.6)	127 (28.8)	199 (45.1)	68 (15.4)
Aware of sustainability impact on patient care	26 (5.9)	35 (7.9)	143 (32.4)	186 (42.2)	51 (11.6)
Familiar with workplace sustainability policies	35 (7.9)	50 (11.3)	163 (37)	154 (34.9)	39 (8.8)
Identify benefits of sustainable practices in healthcare	28 (6.3)	21 (4.8)	123 (27.9)	206 (46.7)	63 (14.3)
Regularly update knowledge of sustainability	35 (7.9)	73 (16.6)	138 (31.3)	152 (34.5)	43 (9.8)
Aware of the environmental impact of healthcare waste	28 (6.3)	25 (5.7)	107 (24.3)	189 (42.9)	92 (20.9)
Understand energy conservation in a healthcare setting	33 (7.5)	34 (7.7)	103 (23.4)	194 (44)	77 (17.5)
Attitude					
Sustainability is important in healthcare	31 (7.0)	16 (3.6)	127 (28.8)	199 (45.1)	68 (15.4)
Sustainability is essential for improving patient outcomes.	27 (6.1)	16 (3.6)	87 (19.7)	200 (45.4)	111 (25.2)
Sustainability is prioritized in the workplace.	28 (6.3)	73 (16.6)	162 (36.7)	121 (27.4)	57 (12.9)
Integrate sustainability into all health professional training programs.	23 (5.2)	19 (4.3)	78 (17.7)	181 (41)	140 (31.7)
Motivated to learn more about Sustainability	23 (5.2)	14 (3.2)	80 (18.1)	215 (48.8)	109 (24.7)
Every health professional can promote sustainability.	23 (5.2)	12 (2.7)	71 (16.1)	217 (49.2)	118 (26.8)
The healthcare sector can reduce its environmental impact.	25 (5.7)	14 (3.2)	75 (17)	217 (49.2)	110 (24.9)
Practice					
Follow guidelines	18 (4.1)	117 (26.5)	152 (34.5)	138 (31.3)	16 (3.6)
Reduce waste	26 (5.9)	41 (9.3)	145 (32.9)	173 (39.2)	56 (12.7)
Encourage others	35 (7.9)	35 (7.9)	96 (21.8)	219 (49.7)	56 (12.7)
Participate in training	41 (9.3)	59 (13.4)	129 (29.3)	170 (38.5)	42 (9.5)
Use resources responsibly	36 (8.1)	65 (14.7)	165 (37.4)	137 (31.1)	38 (8.6)
Consider the impact of decisions	27 (6.1)	36 (8.2)	136 (30.8)	190 (43.1)	52 (11.8)
Support energy initiatives	31 (7)	29 (6.6)	116 (26.3)	200 (45.4)	65 (14.7)
Make suggestions	30 (6.8)	30 (6.8)	109 (24.7)	214 (48.5)	58 (13.2)
Follow disposal procedures	32 (7.3)	47 (10.7)	140 (31.7)	175 (39.7)	47 (10.6)
Engage in discussions	32 (7.3)	61 (13.8)	117 (26.5)	171 (38.8)	60 (13.6)
Seek product alternatives	35 (7.9)	74 (16.8)	171 (38.8)	115 (26.1)	46 (10.4)
Implement practices	28 (6.3)	56 (12.7)	176 (39.9)	133 (30.2)	48 (10.9)
Contribute to feedback	40 (9.1)	61 (13.8)	114 (25.9)	177 (40.1)	49 (11.1)
Evaluate effectiveness	41 (9.3)	61 (13.8)	165 (37.4)	140 (31.7)	34 (7.7)
Barriers					
Lack of training	22 (5)	52 (11.8)	130 (29.5)	173 (39.2)	64 (14.5)
Financial support	24 (5.4)	15 (3.4)	96 (21.8)	197 (44.7)	109 (24.7)
Workload and staff shortages	23 (5.2)	26 (5.9)	101 (22.9)	176 (39.9)	115 (26.1)
Leadership commitment	23 (5.2)	28 (6.3)	96 (21.8)	173 (39.2)	121 (27.4)
Benefits communication	22 (5)	30 (6.8)	124 (28.1)	174 (39.5)	91 (20.6)

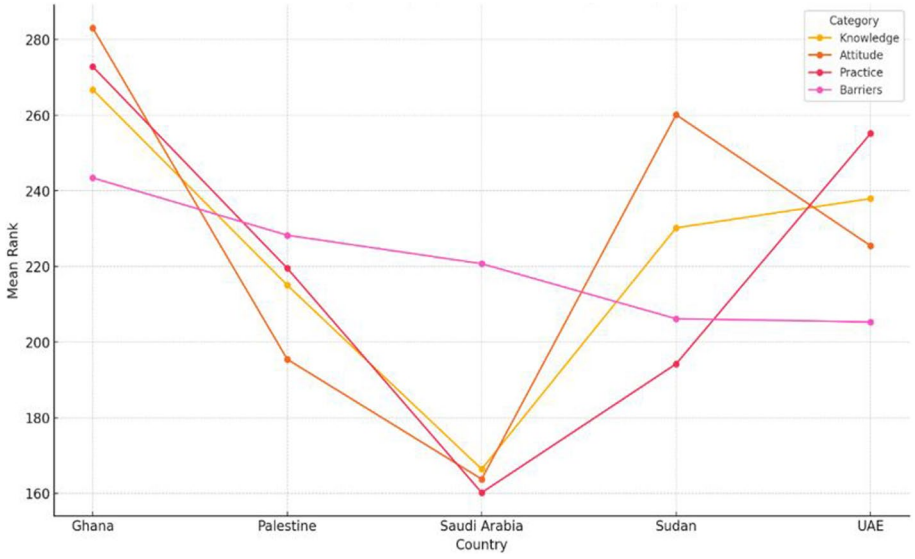

Fig. 1 Mean Ranks of Sustainability Engagement Across Countries: Figure 1 presents the mean ranks of knowledge, attitudes, practices, and perceived barriers to sustainability among radiographers in the five study countries, based on the Kruskal-Wallis H test

countries. The Kruskal-Wallis H test indicated a significant difference in knowledge scores between countries (H (4) = 31.413, $p = 0.000$). Ghana had the highest mean rank (266.73), suggesting that participants from this country perceived themselves as having greater awareness and knowledge of sustainability-related concepts. In contrast, Saudi Arabia had the lowest mean rank (166.42), indicating comparatively lower perceived awareness among participants.

There was a significant difference in attitudes towards sustainability among countries (H (4) = 49.917, $p = 0.000$). The highest mean rank was found in Ghana (283.01), reflecting a more positive attitude toward sustainability. In contrast, Saudi Arabia recorded the lowest mean rank (163.78). Similarly, the test revealed a significant difference in sustainable practices among countries (H (4) = 46.530, $p = 0.000$). Ghana again had the highest mean rank (272.80), demonstrating more active engagement in sustainable practices, while Saudi Arabia had the lowest mean rank (160.20). No significant difference was found in perceived barriers across the countries (H (4) = 5.265, $p = 0.261$). The highest mean rank was recorded in Ghana (243.40), suggesting a higher perception of barriers, while the UAE had the lowest mean rank (205.32).

Discussion

The data illustrate a clear gap between radiographers' positive attitudes toward sustainability and implementing sustainable workplace practices. While 45.1% ($n = 199$) agreed on the importance of sustainability in healthcare and 48.8% ($n = 215$) were motivated to learn more, actual implementation remained limited, with only 39.2% ($n = 173$) actively working to reduce waste and 38.5% ($n = 170$) participating in sustainability training. While radiographers are generally motivated and recognize the importance of sustainability, institutional barriers, such as resource constraints and lack of support from leadership, limit their ability to translate this motivation into action. Addressing these barriers through targeted policies, increased training opportunities and enhanced institutional commitment could help bridge the gap and foster a more sustainable culture in radiography.

More papers and studies on sustainability in radiography are available. The existing literature provides valuable insights into radiographers' perceptions, practices, and barriers to implementing sustainable practices across diverse geographic and economic contexts. A comparative table synthesizes findings from these studies, including those conducted in regions such as Europe, Zimbabwe, Zambia, and multiple countries in Asia and Africa, Table 4. While these studies collectively emphasize the importance of sustainability in radiography, they reveal significant differences in implementation due to varying institutional support, resource availability, and training opportunities. By examining the current study alongside prior research, this comparison underscores both the common challenges and unique regional obstacles that radiographers face in adopting sustainable practices, offering a foundation for targeted recommendations.

1. Knowledge and awareness

The current study revealed a moderate understanding of sustainability concepts among radiographers, with 45.1% recognizing its importance and 46.7% acknowledging its benefits. These findings align with studies by

Table 4 Comparative insights into sustainability practices and barriers in radiology and radiography: A review of key studies

Study	Sample Characteristics	Key Findings on Perceptions	Sustainability Practices	Barriers Identified	Unique Insights
Current Study	441 radiographers from 5 countries	Moderate understanding, focus on reducing environmental impact	Digital documentation commonly practiced	Training gaps, financial constraints, leadership issues	Gender and regional differences in engagement
Rawashdeh et al.	104 radiographers across 14 countries	Confident in climate knowledge and eco-friendly practices	Energy-efficient systems, power monitoring, green transport	Leadership limits, cost and time constraints	Public hospitals show greater engagement than private
Bwanga et al.	19 radiographers from Zimbabwe, Zambia	Awareness of sustainability's importance	Eco-friendly equipment, recycling, energy-saving protocols	Limited awareness, siloed efforts, startup-time issues	Willingness to improve sustainability despite barriers
Roletto et al.	253 responses from 27 European countries	High concern for climate change and sustainability importance	Energy conservation, basic waste reduction	Lack of training, poor recycling systems	Sustainability awareness increases with age
Chinene et al.	96 students in Zimbabwe	Most agreed radiographers should consider the environmental impact	Sustainability taught to majority	Resource shortages, curriculum gaps	Advocates interdisciplinary teaching and innovative methods
Ramlaul & Khine	Narrative review	Curricula inconsistently address sustainability	Critical thinking and ecological literacy emphasized	Overloaded curricula, limited faculty expertise	Collaboration enhances sustainability education
Currie et al.	Review on nuclear medicine	Awareness but lack of cohesive sustainability frameworks	Efficient radionuclide use, energy savings	Funding shortages, high energy use	Five-pillar framework proposed for nuclear medicine
Ghotra et al.	41 studies globally	Stakeholder awareness critical to sustainable practices	Implementation of 3Rs, optimized protocols	High costs, lack of leadership support	Tailored strategies for varied settings
Chau (2024) [13]	Review of safety culture in radiology	Leadership pivotal for sustainability	Leadership walkarounds, safety huddles	Resistance, insufficient leadership training	Leadership bridges strategies and sustainability efforts
Rastrick et al.	2000 UK Allied Health Professionals	Awareness of NHS net-zero goals	Standardized sustainability in training	High energy use, gaps in education	Cultural shift needed for sustainability integration
Vasquez et al.	Case studies from healthcare settings	Growing awareness among radiologists	Low-dose imaging, carbon footprint calculators	Energy use variability, collaboration gaps	Community-focused sustainability via carbon calculators
Ohene-Botwe et al.	Resource-limited settings review	Importance of modernizing equipment	Telemedicine, refurbished equipment	High costs, infrastructure issues	Collaboration and second-hand devices as interim solutions
D'Helft & Daly	Discussion letter	Imaging is crucial for monitoring across the One Health framework	Non-invasive, eco-friendly imaging	Limited sustainability research	Imaging's role in ecological health highlighted
Akudjedu et al.	Editorial on sustainability themes	Sustainability is essential to addressing environmental challenges	Paperless radiography, remote services	Healthcare priorities, policy gaps	Global approaches require tailored strategies
Debnath et al.	1339 stakeholders in India	Overwhelming belief in sustainability's importance	Lead-free aprons, sustainable packaging	Recycling gaps, lack of education	Policy-driven eco-friendly initiatives emphasized

Roletto et al. (2023) [14], who similarly reported strong sustainability awareness but highlighted challenges in translating this into practical action. A key observation from the current study is that younger radiographers, who constitute the majority of participants, demonstrate moderate awareness but limited advanced knowledge of sustainability practices. Roletto et al. (2023) suggested that sustainability awareness increases with professional experience, stressing the importance of embedding sustainability education early in radiography education and training. Ramlaul and Khine (2024) supported this, identifying gaps in curricula that fail to emphasize critical thinking and ecological literacy [15].

Regional differences in sustainability awareness were evident in the current study. Ghana's higher knowledge scores may reflect the influence of targeted educational initiatives and international collaborations, as highlighted by Ohene-Botwe et al. (2024) [16]. In contrast, Saudi Arabia's lower scores underscore the challenges of insufficient institutional emphasis and training, aligning with Vasquez et al. (2024), who stressed the critical role of leadership and policy frameworks in fostering awareness [17].

The study also highlighted varying attitudes among stakeholders, with 45.1% affirming the importance of sustainability in healthcare but only 41% supporting its integration into training programs. This discrepancy may reflect resistance to change or a lack of clarity on sustainability benefits, a trend also observed by Ghotra et al. (2024) [5]. Chau (2024) emphasized the role of leadership-driven awareness campaigns in addressing these gaps and promoting a collective organizational commitment to sustainability [13]. These findings collectively indicate that while sustainability awareness among radiographers is present, its depth and practical application require further enhancement through education, policy, and leadership.

2. Sustainability practices

The current study identified varied engagement in sustainable practices, with digital documentation to reduce paper use (34.6%) being the most common. This finding is consistent with the works of Akudjedu et al. (2024) and Chinene et al. (2024) [18, 19], who similarly reported an emphasis on paper reduction. However, limited engagement in advanced practices, such as energy-saving measures (32.2%), highlights an improvement area. This contrasts with Roletto et al. (2024), which reported a broader array of practices, including energy conservation and waste recycling, likely enabled by greater resource availability in European settings [14].

Previous studies highlighted progressive sustainability practices, such as adopting lead-free aprons (77%) and recycling residual contrast media, which surpass those reported in the current study. These findings emphasize the crucial role of institutional support and infrastructure in facilitating diverse and impactful sustainability efforts [10, 11, 20]. Additionally, strategies such as power monitoring and renewable energy systems have been proposed; however, their implementation remains challenging in low-resource settings, reflecting the infrastructure limitations identified in this study.

Despite these challenges, targeted interventions can still be effective in resource-limited settings. For example, energy-saving protocols, such as shorter MRI sequences, have proven beneficial, while optimizing radionuclide use in nuclear medicine offers insights that could inform sustainable practices in diagnostic radiography. However, comprehensive frameworks like the 3Rs (Reduce, Reuse, Recycle) and standardized sustainability guidelines, which have been widely advocated, remain underutilized in this study, highlighting missed opportunities for enhancing sustainability efforts [4, 5, 7, 9, 16, 21].

Vasquez et al. (2024) also identified remote diagnostics as a promising tool for reducing emissions, notably absent from the practices reported in the current study [17]. This gap highlights the need to integrate technological solutions into sustainability strategies better. While basic practices are prevalent, advancing to more sophisticated and scalable approaches requires enhanced institutional support, infrastructure investment, and tailored strategies for resource-limited settings.

3. Barriers to sustainability

The current study identified key barriers to sustainability, including lack of training (39.2%), financial constraints (44.7%), and insufficient managerial support (39.2%). These findings reflect global trends, underscoring the systemic nature of these challenges across regions. A recurring theme in the literature highlights the critical role of institutional and resource limitations in obstructing sustainability efforts, particularly in low-resource settings, where inadequate funding and support further hinder progress [6, 11, 14].

Financial constraints, driven by the high costs of eco-friendly technologies and outdated infrastructure, remain a major challenge in resource-limited settings like Ghana and Sudan. Operational barriers, such as reluctance to power down equipment due to startup delays, further hinder sustainability efforts, highlighting the need for cost-effective, energy-efficient solutions. Leadership resistance and the lack of cohesive policies also pose significant challenges. Structured protocols and leadership-driven initiatives are essential to overcoming systemic inertia and fostering sustainable practices. Addressing these barriers requires a coordinated approach involving education, leadership engagement, and adaptable solutions for diverse settings [7, 13].

4. Unique insights and regional differences

Table 4 The table provides a comparative overview of studies on sustainability in radiography, summarising sample characteristics, perceptions, practices, barriers, and unique insights. The current study provides novel insights into gender differences and regional variations, adding a new dimension to the sustainability discourse. Male radiographers exhibited slightly higher engagement levels. Understanding these variations could offer actionable insights for tailoring sustainability initiatives to different demographics and regions.

The higher engagement levels observed in Ghana underscore the importance of cultural and contextual factors in driving sustainability efforts. Targeted initiatives such as international collaborations and the use of second-hand equipment have facilitated sustainability practices in Ghana, serving as a potential model for other resource-limited settings. Policymaking is also a critical driver of sustainability, particularly in fostering investment in eco-friendly technologies and recycling programs. The study also highlights the willingness of radiographers to adopt sustainability measures despite significant barriers. This intrinsic motivation, observed in the current study, suggests an opportunity to foster a stronger sustainability culture through targeted support and training. Moreover, the underutilization of technological solutions, such as remote diagnostics, remains a missed opportunity [14, 17]. By exploring these unique insights, including gender dynamics, regional variations, and the role of policy and technology, the current study provides a comprehensive foundation for developing targeted sustainability strategies that address the needs and challenges of diverse economies and healthcare systems.

In conclusion, the comparative analysis reveals common challenges in institutional support, resource constraints, and the need for region-specific strategies. While radiographers generally acknowledge the importance of sustainability, real-world implementation remains limited by structural and operational barriers. The current study contributes uniquely by highlighting regional and demographic variations in engagement, emphasizing the need for adaptable, context-sensitive approaches to promote sustainable practices in radiography. This discussion section can underline how addressing these multifaceted barriers through institutional support, enhanced training, and regional collaboration may foster sustainable practices.

Study limitations

The study's convenience sampling may introduce selection bias and limit generalizability. Participants were recruited from diverse healthcare settings across the five countries to mitigate this. Self-reported data may also introduce response bias, and the study's focus on five countries may not fully capture broader sustainability challenges. Future research should use probability sampling, longitudinal data, and qualitative methods to improve representativeness and deepen insights.

Recommendations for clinical practice and education

To enhance sustainability in radiography, clinical settings should integrate institutional policies that promote eco-friendly practices, such as optimizing energy-efficient imaging protocols and reducing medical waste. Leadership engagement is crucial in fostering a culture of sustainability. Sustainability should be embedded into radiography curricula through structured training on waste management, energy conservation, and sustainable imaging practices in education. Continuing professional development (CPD) programs should also include sustainability education to bridge knowledge gaps among practising radiographers.

Conclusion

This study highlights the gap between radiographers' positive attitudes and implementing sustainable practices, emphasizing barriers such as lack of training, financial constraints, and limited institutional support. While radiographers are motivated to adopt sustainability, practical challenges hinder widespread adoption. Addressing these barriers through targeted education, leadership commitment, and institutional policies is essential to advancing sustainability in radiography. Radiographers can play a key role in promoting environmentally responsible healthcare practices by fostering greater awareness and structural support.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

M.A. conceptualized and designed the study. N.A., C.V.E., and W.E. contributed to developing and validating the survey instrument. M.I. and M.A. coordinated data collection and analysis. M.A., W.E., and M.A.J. conducted the statistical analysis and interpreted the results. N.A. and Z.H. drafted sections of the manuscript, with significant input and revisions from M.A., C.V.E., and W.E. N.A. and Z.H. prepared the figures and tables. M.M.A. and N.A. led the final manuscript preparation and submission process. All authors critically reviewed, edited, and approved the final manuscript, ensuring the accuracy and integrity of the work. *Corresponding author: Mohamed Abuzaid.

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Data availability
The data of this study is available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
This research received approval from the University of Sharjah Research Ethics Committee, under Reference number REC-24-05-27-01-F. We obtained consent from all participants before initiating the survey, ensuring they were informed of their right to withdraw from the study at any point before the final submission.

Consent for publication
NA.

Competing interests
The authors declare no competing interests.

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References

1. Hanneman K, Szava-Kovats A, Burbridge B, Leswick D, Nadeau B, Islam O, et al. Canadian association of radiologists statement on environmental sustainability in medical imaging. Canadian association of radiologists journal. SAGE Publications Inc.; 2024.
2. Sarchosoglou A, Couto JG, Khine R, O'Donovan T, Pisoni V, Bajinskis A, et al. A European Federation of Radiographer Societies (EFRS) position statement on sustainability for the radiography profession. Vol. 30, Radiography. W.B. Saunders Ltd; 2024. pp. 19–22.
3. Martin MF, Maturen KE. On green radiology. Vol. 27, academic radiology. Elsevier Inc.; 2020. pp. 1601–2.
4. Currie GM, Hawk KE, Rohren EM. Challenges confronting sustainability in nuclear medicine practice. Radiography. 2024;30:1–8.
5. Ghotra SS, Champendal M, Flaction L, Ribeiro RT, Sá dos Reis C. Approaches to reduce medical imaging departments' environmental impact: A scoping review. Vol. 30, Radiography. W.B. Saunders Ltd; 2024. pp. 108–16.
6. Rawashdeh M, Ali MA, McEntee M, El-Sayed M, Saade C, Kashabash D, et al. Green radiography: exploring perceptions, practices, and barriers to sustainability. Radiography. 2024;30:62–73.
7. Bwanga O, Chinene B, Mudadi L, Kafwimbi S, Nyawani P, Matika W, et al. Environmental sustainability in radiography in low-resource settings: A qualitative study of awareness, practices, and challenges among Zimbabwean and Zambian radiographers. Radiography. 2024;30:35–42.
8. Ain HQU, Tahir MJ, Waheed S, Ahmad S, Ullah I, Yousaf Z. Teleradiology in COVID-19: A sustainable innovative solution. Academic Radiology. Volume 28. Elsevier Inc.; 2021. pp. 1325–6.
9. Currie GM, Hawk KE, Rohren EM. The potential role of artificial intelligence in sustainability of nuclear medicine. Radiography. 2024;30:S119eS124.
10. Natembeya MC, Anudjo MNK, Ackah JA, Osei MB, Akudjedu TN. The environmental sustainability implications of contrast media supply chain disruptions during the COVID-19 pandemic: A document analysis of international practice guidelines. Radiography. 2024;30:43–54.
11. England A, Rawashdeh M, Moore N, Young R, Curran G, McEntee MF. More sustainable use of iodinated contrast media– Why? Vol. 30, radiography. W.B. Saunders Ltd; 2024. pp. 74–80.
12. Mariampillai J, Rockall A. The green and sustainable radiology department. Volume 63. Radiologie. Springer Medizin; 2023. pp. 21–6.
13. Chau M. Enhancing safety culture in radiology: Key practices and recommendations for sustainable excellence. Vol. 30, Radiography. W.B. Saunders Ltd; 2024. pp. 9–16.
14. Roletto A, Catania D, Rainford L, Savio A, Zanardo M, Bonfitto GR, et al. Sustainable radiology departments: A European survey to explore radiographers' perceptions of environmental and energy sustainability issues. Radiography. 2024;30:81–90.
15. Ramlaul A, Khine R. HOW TO… Incorporating education for sustainable development within a radiography curriculum: A narrative review. Vol. 30, Radiography. W.B. Saunders Ltd; 2024. pp. 102–7.
16. Ohene-Botwe B, Amedu C, Antwi WK, Abdul-Razak W, Kyei KA, Arkoh S et al. Promoting sustainability activities in clinical radiography practice and education in resource-limited countries: A discussion paper. Vol. 30, Radiography. W.B. Saunders Ltd; 2024. pp. 56–61.
17. Vasquez A, Puentes G, Olarte Bermúdez LM, Cifuentes GK. Inspiring healthcare transformation toward a sustainable, low-carbon future: A growing discipline. 30, Radiography. W.B. Saunders Ltd; 2024. pp. 92–3.
18. Akudjedu TN, Toomey R, Precht H. Sustainability in radiography: Securing the future through greener clinical practice and education. Vol. 30, radiography. W.B. Saunders Ltd; 2024. pp. 117–8.
19. Chinene B, Mudadi LS, Mushosho EY. Sustainability in radiography education: A case study of a tertiary institution in Zimbabwe. Radiography. 2024;30:23–9.
20. Palanisami S, Jayachandran VGK, Godlaveeti ME, Sangaraju SKS. Lead-free X-Ray shielding aprons using Zn-doped SnO2 epoxy nanocomposite: A promising alternative to traditional heavy and lead-based materials. Opt Mater (Amst). 2023;145:114496.
21. Rastrick S, Hindle L, Frost J, Madden V, Cooper S, St John-Matthews J. From mission to action: Greener Allied Health Professions (AHPs). Vol. 30, Radiography. W.B. Saunders Ltd; 2024. pp. 17–8.

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