Environmental sustainability in radiography in low-resource settings: a qualitative study of awareness, practices, and challenges among Zimbabwean and Zambian radiographers

Abstract

Introduction: Evidence suggests that radiography activities have a significant impact on the environment. With growing awareness of the negative environmental consequences of radiography services, there is an increasing call for radiographers to adopt sustainable practices. However, little is known about the levels of awareness, current practices, and challenges faced by radiographers working in low-resource settings on this subject. Therefore, this study aimed to explore the awareness, practices, and challenges among Zimbabwean and Zambian radiographers about environmental sustainability in radiography.

M**ethods:** An exploratory descriptive qualitative research design was used in this study. Two focus group discussions (FGDs) were conducted with 19 purposively sampled participants (N=8 and N=11) in Zimbabwe and Zambia, respectively. The audio recordings were transcribed verbatim and analysed using Braun and Clarke's thematic analysis six-phase framework.

Results: Following thematic data analysis three main themes emerged: awareness of the concept of sustainability among radiographers, sustainability practices in radiography, and challenges of implementing sustainability in radiography. The study found that some radiology departments continue to rely on film-screen imaging systems due to insufficient financial resources to transition to digital imaging systems. Consequently, this constraint emerged as the central obstacle thwarting the implementation of sustainable practices in radiography.

Conclusion: Most radiographers understood the concept of sustainability in radiography; however, they were concerned about the negative impact of radiography practices on the environment and wanted more training and financial support to mitigate this impact.

Implications for practice: Environmental sustainability should be integrated into the radiography curriculum and provision of continuing professional development (CPD) to impart radiographers with knowledge and the best practices. Periodical audits should be conducted to monitor sustainable practices and reward deserving radiology departments.

Keywords: Climate change, environmental sustainability, radiography, awareness, practice, challenge

Introduction

Environmental sustainability first emerged in non-healthcare industries and has since developed and evolved over the last 50 years.[1] Recently, it has become a significant topic in healthcare. The United Nations Brundtland Commission (UNBC) defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs".[2] In the last decade, there has been clear evidence that health system activities harm the environment.[1,3,4] The United States of America (USA) healthcare sector generates approximately 10% of the nation's carbon emissions, [5] and an amount of the proportion is attributed to imaging examinations.[6] To address this, health systems in many countries are actively engaging in sustainable development efforts.[1,3] The actions reported in the literature to establish a sustainable health system include promoting awareness among health professionals, energy efficiency, minimising water consumption, waste prevention, green procurement, and ensuring the development of sustainable facilities. [1,3]

Medical imaging is a top contributor to healthcare carbon emissions due to high energy-consuming equipment.[4,5,7] Computed tomography (CT) and magnetic resonance imaging (MRI) scanners account for significant carbon emissions.[5,7] At one hospital in Switzerland, three CT and four MRI scanners were attributed to 4% of total energy consumption.[8] In addition, iodinated-based and gadolinium-based contrast media for CT and MRI respectively, contaminate the aquatic environment. [6] These chemicals end up in water bodies via patients voiding following the examination. [5] Radiographers, as the primary operators of imaging equipment and responsible for its use and optimisation are uniquely positioned to lead efforts and make significant contributions to reducing carbon emissions. Sustainable practices reported in the literature include reducing unjustified examinations and requesting low-impact examinations (general radiography or ultrasound when clinically appropriate). [9] Other strategies include decreasing energy consumption by shutting down imaging equipment and computers during non-working hours, cycling or walking to work, and establishing sustainability as a quality measure.[1,5,8]

There are almost 140 developing countries in the world seeking ways of meeting their

development needs and at the same time taking action to combat climate change. [2] Among these developing countries are Zimbabwe and Zambia. This has resulted in the establishment of the Ministry of Environment, Water and Climate and the Ministry of Green Economy and Environment in Zimbabwe and Zambia, respectively to oversee the impact of global climate change. Although the transition from film-screen and digital radiography was driven by technological advancement, it happened when radiographers were going to green practices. The X-ray film and processing chemicals associated with film-screen imaging are toxic to the environment.[10,11] Although CT and MRI, account for significant carbon emissions in developed countries, [7] there are few in our study settings: 21 CT and 10 MRI scanners in Zimbabwe and 40 CT and 8 MRI scanners in Zambia. This is against the population of 14.4 and 19.5 million for Zimbabwe and Zambia, respectively.[12]

Education and training have been reported as effective strategies for improving knowledge, awareness, and practices among healthcare professionals.[1,13] Developed countries are the main (79%) emitters of carbon emissions because of being highly industrialised.[14] However, the effect of carbon emissions on climate change is disproportionately felt by low-income countries such as Zimbabwe and Zambia.[8] In our study settings, the main reported challenge of the promotion of sustainability practices is a lack of financial resources to implement and plan sustainable development.[15] In addition, literature is scarce on this subject in our settings, making it difficult to base policy decisions. Therefore, this study aimed to explore the awareness, practices, and challenges among Zimbabwean and Zambian radiographers on environmental sustainability in radiography. The study findings could serve as a framework for developing sustainability strategies in radiography in our and similar settings.

Methods

Study design and settings

This study forms part of a larger research concerning sustainability in radiography in low-resource settings. Particularly, a qualitative approach with an explorative and descriptive research design was used to explore the awareness, practices, and challenges among Zimbabwean and Zambian radiographers about sustainability in radiography. This design facilitated a deeper understanding of sustainability in radiography in low-resource settings. [16,17]

Zimbabwe and Zambia are two neighbouring countries in Southern Africa separated by the Zambezi River. Zambia has a larger population, standing at approximately 19.5 million people as compared to Zimbabwe's 14.4 million. [12] In both countries, the Ministry of Health is responsible for the coordination and management of the health sector. A range of imaging services are offered such as general radiography, fluoroscopy, ultrasonography, CT, MRI, nuclear medicine, and mammography. However, advanced imaging services are mostly available in urban areas.

Population and sampling

The study population consisted of 1238 registered radiographers in both countries (N=330 for Zimbabwe; N=908 for Zambia). A purposive sample of 19 diagnostic radiographers was recruited to participate in the FGDs from both countries (Tables 3 and 4). Participants were recruited via radiography social media platforms and approached individually during a conference held in February 2024 in Zimbabwe. The study triangulated the participants, work experiences, and locations to demonstrate variations as well as patterns in the findings.[16,17]

Data collection tool and procedure

Using the interview guide, FGDs were conducted in February 2024. The following were the main questions:

1. *What do you understand about the concept of environmental sustainability in radiography?*
2. *What environmental sustainability practices are currently being implemented in your department?*
3. *What challenges are you currently experiencing in the implementation of environmental sustainability practices in your department?*
4. *What suggestions do you have to overcome the stated challenges to environmental sustainability in Radiography?*

FGDs were used to gain a large amount of information in a short time. [18] The discussions were led by moderators, the first and second authors who are radiography lecturers. Each moderator introduced the topic, asked specific questions using the interview guide, controlled digressions,

and stopped break-away conversations.[17,19] The moderators were skilled in active listening and adept at steering conversations back on track if they veered off-topic and ensured that no participant dominated the discussion while trying to ensure that each of the members contributed.[17] Two FGDs were conducted physically and virtually in Zimbabwe and Zambia, respectively. Each participant received information about the study before signing an informed consent. For virtual participants, a consent form was sent by e-mail to participants who agreed to take part in the FGD. Permission was also obtained to record the discussions. The first FGD consisted of eight Zimbabwean radiographers who attended the conference. The second FGD was held virtually (via Zoom) with 11 Zambian radiographers. The online FGD was cost-effective and removed the geographical limitations as participants were recruited across the country. [20] Both FGDs were conducted in English the official language and lasted from 50 to 70 minutes. The discussions stopped after reaching a data saturation point. The discussions were digitally recorded and transcribed verbatim using Otter software (https://get.otter.ai).

Data analysis

Data was managed in NVivo 14 (Lumivero), a qualitative data analysis software. Data analysis was performed by the first (O.B) and second (B.C) authors at the end of each FGD session using Braun and Clarke's thematic analysis six-phase framework. [21,22] Table 1 shows the phases involved in data analysis: familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and reporting study findings.

Table 1: Braun and Clarke's thematic analysis six-phase framework

	Phase	Activity
1	Familiarisation with the data	• The first and second authors read and reread the transcripts to familiarise themselves with the data.
2	Generating initial codes	• Coding was performed using NVivo software.
3	Searching for themes	• Similar codes were combined to generate themes. A table was used to cluster codes into themes.
4	Reviewing themes	• The first and second authors reviewed, modified, and developed the preliminary themes that were identified in Phase 3.
5	Defining and naming themes	• The first and second authors performed a final refinement of the themes. Questions asked were: What is the theme saying? Do sub-themes interact and relate to the main theme? How do the themes relate to each other? [22]A thematic map was used to aid in answering these questions.
6	Reporting of study findings	• The second author drafted the result section which was later reviewed by all co-authors until the final version was finalised.

Data integration

The data from the two sites were integrated through a thematic analysis, synthesising key findings from both FGDs into a single comprehensive analysis. The integration allowed the researchers to build stronger conclusions, initiate new understandings, and gain a more complete picture of underlying mechanisms. [23] This revealed common themes across both settings, while also highlighting some context-specific differences.

Ethical considerations

Institutional review board approval was obtained from the Harare Institute of Technology Institutional Research Ethics Committee (Ref: SAHS/DR0003/24). The research adhered to the four ethical principles of autonomy, beneficence, non-maleficence, and justice. [16,19,21] Signed informed consent and permission to record the FGDs were obtained from each participant. In this study, confidentiality and anonymity have been maintained. The study aimed to understand sustainability in radiography that would benefit radiographers without causing harm. All participants in both countries were subjected to the same questions.

Trustworthiness

This study was guided by Lincoln and Guba's model of trustworthiness and authenticity [17] to establish the quality of the research (Table 2).

Table 2: Strategies used to enhance trustworthiness and authenticity

Criteria	Strategy	Explanation of the strategy
Credibility	Member checking	• Transcripts were sent to participants for validation of the information. This allowed participants to correct errors.
Dependability	Audit trail	• Complete records have been kept for all stages of this study: problem formation, field notes, focus group transcripts, and data analysis in an accessible manner.
Transferability	Thick description	• Findings on awareness, practices, and challenges among radiographers about sustainability in radiography have been described in sufficient detail.
Confirmability	Triangulation	• Data sources were obtained from Zimbabwean and Zambian radiographers to produce a good understanding.
Authenticity	Impact of research	• Descriptions of the findings would help radiographers arrive at a better understanding of sustainability in radiography. • Implication for practice has been provided.

Results

Demographics

Nineteen participants took part in this study. Two FGDs were conducted, one in Zambia and one in Zimbabwe. Tables 3 and 4 outline the demographic characteristics of the participants.

Table 3: Focus group participants' demographic data from the Zambia cohort (N=11)

Code	Gender	Highest radiography qualification	Work experience	Province
P1	Male	BSc diagnostic radiography	15	Eastern
P2	Female	BSc diagnostic radiography	20	North-western
P3	Male	MSc diagnostic radiography	14	Copperbelt
P4	Female	BSc diagnostic radiography	10	Lusaka
P5	Female	BSc diagnostic radiography	9	Lusaka
P6	Male	Diploma in diagnostic radiography	8	Copperbelt
P7	Male	BSc diagnostic radiography	11	Copperbelt
P8	Male	BSc diagnostic radiography	22	Copperbelt
P9	Female	MSc diagnostic radiography	12	Lusaka
P10	Male	MSc diagnostic radiography	24	Lusaka
P11	Female	BSc diagnostic radiography	9	Southern

Table 4: Focus group participants' demographic data from the Zimbabwean cohort (N=8)

Code	Gender	Highest radiography qualification	Work experience	Province
P1	Male	BSc diagnostic radiography	8	Harare Metropolitan
P2	Male	BSc diagnostic radiography	10	Manicaland
P3	Female	BSc diagnostic radiography	13	Bulawayo Metropolitan
P4	Female	BSc diagnostic radiography	5	Midlands
P5	Female	BSc diagnostic radiography	4	Masvingo
P6	Male	MSc diagnostic radiography	15	Matabeleland North
P7	Female	MSc diagnostic radiography	24	Mashonaland East
P8	Female	MSc diagnostic radiography	19	Mashonaland West

Awareness, practices, and challenges to sustainability in radiography

Three main themes emerged from the data analysis: awareness of the concept of sustainability among radiographers, sustainability practices in radiography, and challenges of implementing sustainability in radiography (Table 5)

Table 5: Summary of the themes, subthemes, and exemplary quotes

Theme	Subtheme	Exemplary quote
Theme 1: Awareness of the concept of sustainability among radiographers	i. Environmental consciousness and ensuring continuity	*"The application of environmentally conscious practices and principles within the field of medical imaging. This may involve taking steps to avoid negative impacts of radiographic procedures on the environment, while also maintaining high-quality patient care"*
	ii. Being deliberate about sustainability	*"But sustainability is something that is often overlooked. People don't want to focus more on it"*
Theme 2: Sustainability practices in radiography	i. Environmentally friendly equipment	*"I remember as a student at XXX, the department used wet processing, i.e., we used a darkroom. So I think the transition from that system to digital imaging is a huge step towards sustainability"*
	ii. Justification of examinations and radiographic techniques	*"For MRI we have moved to shorter and faster sequences to reduce the amount of energy used for each examination. For example, multiple sequences can be run at the same time"*
	iii. Non-radiographic practices	*"We also have separation of waste, where the waste that can be recycled is put in its container and the other that cannot be put in a different container"*
Theme 3: Challenges of implementing sustainability in radiography	i. Lack of awareness	*"Another barrier is ignorance, the practices that we are doing that we do not know are unsustainable because we were not intentionally taught these things"*
	ii. Siloed approach to sustainability	*"I was also thinking of disagreements between professions as far as sustainability is concerned. As professionals, we never agree generally on one thing. It takes a lot of energy to get people to agree on one thing."*
	iii. Limited resources and reluctance to switch off equipment	*"Though they're most people then start thinking of the start-up time, and they neglect the energy consumption saving because they think it's going to take us too long to run up the machine again"*
	iv. Lack of funding and incentives	*"We do not have enough funding as a country to fully drive the sustainability agenda"*

Theme 1: Awareness of the concept of sustainability among radiographers

This theme focuses on the radiographers' comprehension, awareness, and knowledge regarding the environmental, social, and economic consequences of their actions and choices on the environment. The theme comprises two subthemes: environmental consciousness and ensuring continuity and being deliberate about sustainability.

Sub-theme 1: Environmental consciousness and ensuring continuity

Participants emphasised the need to be environmentally conscious while performing their duties as radiographers. The participants also considered maintaining high-quality patient care.

"Being mindful of the way we use resources, making sure we don't deplete them and deprive the next generation of the same resources." (**Zambia FGD/P8)**

"Involves taking steps to avoid negative impacts of radiographic procedures on the environment, while also maintaining high-quality patient care." (**Zambia FGD/P1)**

Some participants stressed the importance of meeting current needs while allowing for continuity. They also emphasised the importance of going green by reducing energy waste, minimising environmental impact, and maintaining high-quality care affordably.

"It's making sure that practices we have satisfy the current needs, but also leave room for improvement and a continuous system in the future." (**Zimbabwe FGD/P5)**

It was interesting to note that some participants recognised the importance of sustainability in other aspects of radiographers' lives, including their daily practices at home.

"Sustainability is not limited to the radiography department but also habits at home. We need to cut off driving to work, people need to cycle to work…even using diapers at home. " (**Zimbabwe FGD/P1)**

Sub-theme 2: Being deliberate about sustainability

Despite the apparent knowledge of sustainability concepts, the participants highlighted the crucial role of education and continuous professional development (CPDs) in raising awareness.

"Awareness can come through education and CPDs." (**Zimbabwe FGD/P3)**

The participants also discussed the importance of instilling sustainability as a fundamental aspect of radiography education, similar to the emphasis placed on technical skills and radiation protection. This will help create a culture where sustainable practices are prioritised and integrated into everyday professional routines.

"I would also suggest the inclusion of this topic in the curriculum." (**Zambia**

FGD/P6)

"Sustainability should be emphasised during training like radiation protection and radiographic technique." (**Zimbabwe FGD/P7)**

Theme 2: Sustainability practices in radiography

This theme encompasses the daily practices and experiences of radiographers within their departments, focusing on the strategies they implement to minimise the environmental impact of radiographic examinations and procedures. When participants were asked what sustainability practices are currently being implemented in their department, three subthemes emerged: environmentally-friendly equipment, justification of examinations and radiographic techniques, and non-radiographic practices.

Sub-theme 1: Environmentally friendly equipment

Some participants highlighted the transition from analogue to digital radiography as a key sustainability practice in their departments. Radiographers specifically noted the role of digital imaging in reducing the use of hazardous chemicals and minimising environmental impact.

"In my department, the move from film screen to digital radiography is a huge step toward sustainability." (**Zimbabwe FGD/P6)**

Some participants testified on the adoption of digital imaging systems: Radiology Information Systems (RIS) and Picture Archiving and Communication Systems (PACS) in reducing radiation exposure, paper usage, and overall resource consumption.

"In my department, we have gone filmless: RIS and PACS. This means reducing the cutting down of trees to make paper." (**Zambia FGD/P7)**

Sub-theme 2: Justification of examinations and radiographic techniques

Participants discussed ensuring the right indication for each radiological examination to protect the patient by confirming the justification of radiology request forms.

"We should be able, to ensure that we have the right indication for the examination, thereby protecting the patient…We validate request forms." (**Zambia FGD/P2)**

"Clinicians would request a CT scan for a thyroid cyst instead of an ultrasound which has low energy consumption." (**Zambia FGD/P10)**

Most participants reported implementing practices like intermittent exposures during long exposure examinations like fluoroscopy, reducing the number of repeat examinations, using reusable instruments, and optimising MRI sequences for energy efficiency to reduce radiation exposure and energy consumption.

"To reduce the amount of radiation produced for examinations that have long exposure times like fluoroscopy, we do not expose continuously but, we use intermittent exposures." (**Zimbabwe FGD/P3)**

"For MRI we have moved to shorter and faster sequences to reduce the amount of energy used for each examination. For example, multiple sequences can be run at the same time." (**Zimbabwe FGD/P2)**

Sub-theme 3: Non-radiographic practices

Participants emphasised other practices that were not exactly related to radiographic examinations like waste segregation, using separate bins for sharps, non-hazardous waste, and recyclable materials.

"We separate the waste, where the waste that can be recycled is put in its container and the other that cannot be put in a different container." (**Zimbabwe FGD/P5)**

Additionally, radiographers discussed the practice of conserving energy by switching off machines during lunch breaks to optimise energy usage.

"If we were going for lunch for an hour, we switch off the scanner." (**Zimbabwe FGD/P8)**

Theme 3: Challenges of implementing sustainability in radiography

This theme focuses on the obstacles seen concerning the implementation of sustainability practices by radiographers. Four subthemes emerged: lack of awareness, a siloed approach to sustainability, limited resources and reluctance to switch off equipment, and a lack of funding and incentives.

Sub-theme 1: Lack of awareness

Some participants reported a lack of training and awareness regarding sustainable practices, especially for the older generation of radiographers. Participants expressed the need for education on aspects like energy conservation, waste disposal, and equipment maintenance to foster a culture of sustainability in radiography.

> *"Another barrier is ignorance, the practices that we are doing that we do not know are unsustainable because we were not intentionally taught these things."* **(Zimbabwe FGD/P8)**

Participants underscored the power of knowledge and training in promoting sustainable behaviours, pointing out that even small practices such as waste separation for recycling can have a substantial positive impact on the environment when individuals are informed and empowered to act sustainably.

> *"I think the moment we become knowledgeable about this, we become more empowered to be sustainable."* **(Zambia FGD/P11)**

Sub-theme 2- Siloed approach to sustainability

Participants emphasised interprofessional disagreements as a significant barrier to sustainability efforts in radiography due to challenges in reaching a consensus on sustainable practices. According to the participants, the interprofessional disagreements underscore the need for a systemic approach to achieve sustainability goals.

> *"I was also thinking of disagreements between professions as far as sustainability is concerned. As professionals, we never agree generally on one thing. It takes a lot of energy to get people to agree on one thing."* (**Zimbabwe FGD/P4)**

Participants also emphasised the collective responsibility of all healthcare professionals, including cleaners, radiographers, and equipment purchasers, to ensure a sustainable future by integrating sustainability considerations into departmental practices and policies.

> *"This means for us to succeed in sustainable healthcare we need to have everyone on board."* (**Zimbabwe FGD/P7)**

Sub-theme 3: Limited resources and reluctance to switch off equipment

The main challenge to sustainability in radiography in low-resource settings reported by participants is that some hospitals were still using film-screen radiography.

> *"I can talk about our department where we use a film-screen radiography system which has negative effects on the environment."* (**Zambia FGD/P3)**

Participants discussed the potential benefits of adopting PACS to enhance sustainability by reducing paper usage and film printing but noted challenges such as limited digital infrastructure and high internet costs as barriers to implementation.

> *"I wanted to add on PACS, I think if we adopt it in our settings, we can go a long way in being sustainable because we eliminate the use of paper and printing of films. However, the internet in Zimbabwe is expensive."* (**Zimbabwe FGD/P6)**

Concerns were raised about the operational challenges that impact sustainability efforts, including the reluctance to switch off machines due to start-up times, economic constraints affecting the repair of critical equipment like CT machines, and unjustified examinations, leading to potential wastage and patient referrals.

"Most people start thinking of the start-up time, and they neglect the energy saving because they think it's going to take us too long to run up the machine again." (**Zimbabwe FGD/P1)**

"In our department, engineers come from South Africa to service and repair equipment. This involves flying to Zambia which contributes to climate change." (**Zambia FGD/P10)**

Sub-theme 4: A lack of funding and incentives

All participants averred that limited funding and resources hinder sustainable practices, leading to compromises in quality and efficiency.

"We do not have enough funding as a country to fully drive the sustainability agenda." (**Zambia FGD/P9)**

Few participants claimed that with adequate funding, most departments would transition to eco-friendly technologies like digital radiography and PACS.

'If we had the money, most departments would transition from film-screen to digital imaging system which is generally more sustainable." (**Zambia FGD/P4)**

However, it was reported that some departments that have implemented digital imaging still lack RIS and PACS resulting in printing images. This was reported due to lack of funds.

"Despite moving to DR, we do not have a PACS. We still print hard-copy films." (**Zimbabwe FGD/P5)**

A lack of a reward system for deserving individuals and departments was also reported as a barrier to sustainability in radiography.

"I wanted to say even from our regulatory bodies should be rewarding those departments that top on sustainable practices." (**Zimbabwe FGD/P2)**

Discussion

This study was aimed at exploring the awareness levels, practices, and challenges among radiographers working in Zimbabwe and Zambia about sustainability in radiography. The benefits of promoting sustainability practices in radiography identified in this study were similar to those reported in the literature. There is cost-saving for more efficient use of energy and other resources. [6,7] For example, Burke and Stowe [24] conducted research in Ireland and found estimated annual savings between €1,095 and €4,533 if equipment and lights were turned off during off hours. Cost savings also can arise by recycling and reuse of equipment parts and the use of paperless practices. [25] It can also result in patient satisfaction as found in the UK study, where most (92%) patients reported the importance of sustainable healthcare.[8]

Awareness of the concept of sustainability among radiographers

Literature reports that awareness among healthcare professionals about the concept of sustainability is a facilitating factor to sustainable practices in healthcare. [1,13] In our study, most of the radiographers were aware of the concept of sustainability in radiography and showed comprehension of its meaning. Radiographers highlighted sustainable radiographic practices for current needs while ensuring resource preservation and continuity for future generations. Although our study used a qualitative research design with a small sample, the findings contradict those of a European survey conducted by Soares et al., [25] where most (57.9%) of the therapeutic radiographers did not know about the concept of environmental sustainability. In our study, radiographers also were concerned about the effect of radiography practices on the environment. This agrees with the UK study, where 92% of the radiology staff were also concerned about climate change. [26] In our study, radiographers suggested the inclusion of this subject in the curriculum and the offering of CPDs. Literature suggests that environmental sustainability training needs to be lifelong, starting during basic school education and continuing after graduation. [1,25] This therefore warrants further exploration of the integration of sustainability issues in the radiography curriculum.

Sustainability practices in radiography

There are several sustainability healthcare practices reported in the literature from developed countries. [1,5,8] However, there is limited literature from low-resource settings such as

Zimbabwe and Zambia. Our study found two categories of sustainability practices performed in radiology departments: radiographic and non-radiographic practices.

Regarding radiographic practices, some radiographers in the current study reported using digital imaging systems, which are environmentally friendly. Digital imaging exhibits a number of advantages related to environmental sustainability when compared with film-screen imaging. These include no handling of toxic processing chemicals, less paper use, and a reduction in patient radiation doses and repeat images.[27,28] Another reported practice performed by radiographers in our study was shutting down imaging equipment during lunch hours. This practice was acknowledged to save energy consumption and money spent on paying electricity bills. Literature also reports that leftover contrast media can be collected and returned to manufacturers for recycling. [13] One of the most important radiation protection principles is the justification of radiographic examinations. In our study, radiographers reported that the justification principle also applies to environmental sustainability. If clinically justified, an ultrasound scan which has low energy consumption can be performed rather than a CT or MRI scan. [7] To fully implement sustainable practices, radiographers in our study suggested the involvement of all healthcare professionals and policymakers.

Our study also found non-radiographic sustainability practices carried out by radiographers. This includes daily practices in the radiology department related to waste separation and recycling. These environmentally friendly practices were also found among radiographers working in Europe. [25] In the current study, some Zimbabwean radiographers also reported using active transport to work such as cycling. However, the literature reports that very few radiographers walk or cycle to work. [25,26] Active travel provides health and environmental benefits simultaneously by reducing cardiovascular and other non-communicable diseases while also helping to reduce carbon emissions from motorised transport. [1]

Challenges of implementing sustainability in radiography

Challenges in implementing sustainability in low-resource settings were identified and reported by radiographers in the current study. These include a lack of awareness, a siloed approach to sustainability, servicing, and limited resources, and a lack of funding and rewards. Literature reports a lack of knowledge or awareness among healthcare professionals of sustainable practices as a challenge in achieving environmentally friendly practices. [1,13] The major

challenge reported in the current study was a lack of financial resources resulting in slow progress in the replacement of traditional film screens with digital imaging systems. A lack of a reward system was also reported as a challenge in implementing sustainability practices in our settings. Financial incentives such as low-interest financing, and tax incentives have been reported to encourage environmental sustainability.[1] Other challenges reported in the literature include a lack of time to release staff for sustainability training,[29] and a lack of training.[25]

Limitations of the study

The study sample was small to generalise the findings of this study. However, the researchers were interested in getting a deep understanding of awareness, practices, and challenges among radiographers about environmental sustainability in radiography which this study has achieved. The data was collected through FGDs only. Information from previous studies has been used to discuss our findings. This triangulation of data has provided rigour to the study.

Conclusion

The overall findings of this study were appealing as most radiographers were aware of and practiced sustainability practices in their respective radiology departments. The main challenge found was the slow progress in the replacement of film screens with digital imaging systems due to a lack of financial resources. Although most radiographers in our study were aware of environmentally friendly practices, they recommended the inclusion of this subject in the radiography curriculum. The implementation of sustainable practices should be part of quality assurance programmes and be audited. These measures should help radiographers protect the environment and at the same time provide high-quality radiography services.

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Conflict of interest statement

There is nothing to declare.

References

1. World Health Organization (WHO). Environmentally sustainable health systems : a strategic document: WHO; 2017.
2. United Nations. Sustainability; 2024. From https://www.un.org/en/ academic-impact/sustainability# (Accessed 26 February 2024)
3. Health Service Executive. Sustainability Strategy for Health. Dublin: HSE, 2017.
4. Alshqaqeeq F, McGuire C, Overcash M, Ali K, Twomey J. Choosing radiology imaging modalities to meet patient needs with lower environmental impact. *Resour Conserv Recycl.* 2020. From https://doi.org/10.1016/j.resconrec.2019.104657
5. Woolen SA, Becker AE, Martin AJ, Knoerl R, Lam V, Folsom J, Eusemann C, Hess CP, Deshpande V. Ecodesign and operational strategies to reduce the carbon footprint of MRI for energy cost savings. *Radiology.* 2023; 307:e230441. https://doi.org/ 10.1148/radiol.230441
6. Anudjo MNK, Vitale C, Elshami W, et al. Considerations for environmental sustainability in clinical radiology and radiotherapy practice: A systematic literature review and recommendations for a greener practice. *Radiography*. 2023;29 (6):1077-1092. doi:10.1016/j.radi.2023.09.006
7. Mariampillai J, Rockall A, Manuellian C, Cartwright S, Taylor S, Deng M, Sheard S. The green and sustainable radiology department. *Radiologie.* 2023:63 (Suppl 2): S21–S26
8. Schoen J, McGinty GB, Quirk C. Radiology in our changing climate: a call to action. *J Am Coll Radiol*. 2021;18(7):1041-1043. doi:10.1016/j.jacr.2021.02.009
9. McAlister S, McGain F, Petersen M, Story D, Charlesworth K, Ison G, *et al.* The carbon footprint of hospital diagnostic imaging in Australia. *Lancet Reg Health West Pac,* 24 (2022 May 3), Article 100459
10. International Atomic Energy Agency. Worldwide implementation of digital imaging in radiology. Vienna: IAEA; 2015.
11. Ardelean E, Ardelean M, Galfi C, Socalici A, Josan A. Radiographic film waste management and recovery. Journal of Physics: Conference Series. 2023; doi:10.1088 /1742-6596/2540/1/01204.
12. World Bank. Population total- Zimbabwe and Zambia. From https://data.worldbank. org/indicator/SP.POP.TOTL?locations=ZW-ZM (Accessed 25 February 2024)
13. Aljohani E, Albarrak A, Akkasi H, et al. Awareness of healthcare providers on

environment-friendly practices in operating rooms in selected hospitals in Riyadh, Saudi Arabia. *Medicine (Baltimore)*.2023;102(34): e34584. doi:10.1097/MD.0000000000034584

14. Center for Global Development. Developed countries are responsible for 79 percent of historical carbon emissions; 2024. From https://www.cgdev.org/media/who-caused-climate-change-historically (Accessed 20 February 2024)
15. International Young Naturefriends. Sustainable development and its challenges in developing countries; 2024. From www.iynf.org/2018/08/a-guide-to-sustainable-development-and-its-challenges-in-developing-countries/ (Accessed 20 February 2024)
16. Lobiondo-Wood G, Haber J. Nursing research- methods and critical appraisal for evidence-based practice (9th ed.). St Louis: Elsevier; 2018.
17. Clark T, Foster L, Sloan L, Bryman A. Bryman's social research methods (6th edition). Oxford: University Press; 2021.
18. Dawson C. Introduction to research methods: A practical guide for anyone undertaking a research project (2nd ed.). Oxford: How to Books Ltd; 2019.
19. Boswell C, Cannon S. Introduction to nursing research: incorporating evidence-based practice (5th edition). Burlington: Jones & Bartlett Learning; 2021.
20. Flayelle M, Brevers D, Billieux J. The advantages and downsides of online focus groups for conducting research on addictive online behaviours. *Addiction*. 2022;117 (8):2142-2144. doi:10.1111/add.15944
21. Clarke V, Braun V. Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. *The Psychologist*. 2013; 26(2): 120-123.
22. Maguire M, Delahunt B. Doing a thematic analysis: a practical, step-by-step guide for learning and teaching scholars. *All Ireland Journal of Teaching and Learning in Higher Education*. 2017; 8 (3): 3351-3354.
23. Love H R, Corr C. Integrating Without Quantitizing: Two Examples of Deductive Analysis Strategies Within Qualitatively Driven Mixed Methods Research. *Journal of Mixed Methods Research*. 2021. https://doi.org/10.1177/1558689821989833
24. Burke NP, Stowe J. Energy efficiency in the radiography department: An Irish perspective. *Radiography.* 2015; 21(2):150-153. doi:101016/jradi201409004
25. Soares AL, Buttigieg SC, Couto JG, et al. An evaluation of knowledge of circular economy among Therapeutic Radiographers/Radiation Therapists (TR/RTTs): Results of a European survey to inform curriculum design. *Radiography*. 2023;29(2):274-283.

doi:10.1016/j.radi.2022.12.006

26. Gendy D, Walters H, O'Mahony E, Zaman S. The scope for radiology to contribute to the NHS net zero target: findings from a survey of radiology staff in the UK. *Clin Radiol*. 2022;77(8):e667-e672. doi:10.1016/j.crad.2022.05.002.
27. Whitley AS, Jefferson G, Sloane KHC, Anderson G, Hoadley G. Clark's positioning in radiography. 13th ed. London: CRC Press Ltd; 2015.
28. Bwanga O. Causes of reject and repeat of digital radiographic images: a literature review to guide the practice of radiography in Zambia. *Medical Journal of Zambia,* 2021; 48(1):38 - 45. https://doi.org/https://doi.org/10.55320/mjz.48.1.766
29. Arepally A, Omary RA, Vandenbergh MP. Scanning the Planet: Radiology's Grand Opportunity to Address Climate Change. *J Am Coll Radiol*. 2022;19(1 Pt B):217-219. doi:10.1016/j.jacr.2021.08.031