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Using a digital transformation framework to explore the experiences of radiographers in the use of digital radiography in a low-resource setting

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Abstract

Introduction: Digital radiography (DR) systems have revolutionised radiographers' experiences, particularly those accustomed to analogue methods. Despite the advantages, DR poses challenges due to its cost and technical requirements, especially in low-resource settings. Zambia, predominantly reliant on analogue systems, is gradually transitioning to DR. Understanding radiographers' experiences with DR is crucial for leveraging its benefits. Therefore, this study aimed to explore the experiences of Zambian radiographers with DR using the digital transformation framework (DTF).

Methods: This qualitative method employed a descriptive phenomenological approach to interview 14 radiographers from five governmental hospitals in the Copperbelt province of Zambia. Interviews were conducted face-to-face, digitally audio-recorded, transcribed, and analysed using Colaizzi's (1978) phenomenological framework and Natural Language Processing (NLP).

Results: Following data analysis, three main themes were developed: education and training in DR, departmental workflow in DR, and challenges of DR. The findings revealed predominantly positive experiences among radiographers using DR, with improved patient waiting times, image quality, workflow efficiency, and job satisfaction. However, challenges such as technological adaptation and system breakdowns were identified.

Conclusion: The study highlighted the positive experiences of radiographers during the initial implementation of DR in Zambian medical facilities. Although challenges exist, the findings suggest that they can be overcome by improving infrastructure and training, thereby maximising the benefits of DR.

Implication of practice: The positive experiences demonstrated by radiographers in implementing DR in Zambian medical facilities indicate that targeted training and infrastructure improvements can enhance workflow efficiency, image quality, and overall patient care.

Keywords: Analogue, Challenges, Digital radiography, Digital transformation, Experience, Radiographer

Introduction

Digital radiography (DR) has revolutionised imaging technology by replacing conventional film-based radiography. DR is an imaging acquisition process that produces an electronic image that can be viewed and manipulated on a computer.¹ Computed tomography (CT) and magnetic resonance imaging (MRI) were among the first modalities to incorporate computer technology, with CT emerging in the early 1970s and MRI following in the late 1970s.¹ In the 1990s, the transition from conventional film-based radiography to DR imaging systems began.^{1,2} This shift led to the introduction of radiology information systems (RIS) and picture archiving and communication systems (PACS) for electronically managing data and images. While radiology departments in developed countries have widely adopted digital systems, some resource-limited settings still rely heavily on conventional film-based radiography.²

The shift to DR offers several advantages over conventional film-based imaging methods. A major advantage is the reduced radiation exposure to patients largely due to the higher sensitivity of digital detectors.^{2,3} Digital systems offer superior image quality, which can be adjusted and enhanced without repeated exposures, thus optimising patient outcomes and reducing the necessity for additional imaging examinations.^{1,3} It also enables the simultaneous transmission and display of images to multiple locations.² Additionally, it eliminates the need for X-ray films and processing chemicals, which lowers operational costs.³ Furthermore, DR contributes to environmental sustainability by eliminating toxic waste associated with film development and processing chemicals^{4,5}, which is crucial in mitigating the healthcare industry's impact on climate change.

Globally, the experiences of radiographers with DR have been documented in the literature.^{6,7} Previous studies indicate that adopting DR technology has generally improved workflow efficiency and image quality but also necessitates significant changes in radiographic technique and workflow management.^{6,7} Radiographers must adapt to new skills, such as managing digital imaging parameters and mastering new software systems.⁸ Moreover, the shift to digital platforms has increased the need for ongoing professional development and training to keep up with technological advancements. Despite these challenges, radiographers have responded positively, particularly appreciating the enhancements in diagnostic imaging capabilities and patient care.⁹ However, there is a lack of published studies on the experiences of radiographers with DR in Zambia.

In Zambia, the transition from film-based radiography to DR began in the mid-2000s with the installation of a CT machine at SINOZAM, a private hospital in the Copperbelt province.

However, the first reported computer radiography (CR) system was installed in 2012 at Chitokoloki Mission Hospital of the North Western Province ^{10,11}, followed by the DR X-ray machine at the University Teaching Hospital (UTH) in 2015.¹¹ About four years later, 13 CR X-ray machines were distributed nationwide.¹² Since then, the country has been trying to implement DR with all the systems that come with it, including RIS and PACS. To support and enhance this implementation process, it is crucial to understand the experiences of radiographers who have encountered these digital systems in the initial phases. Therefore, this study aimed to explore the experiences of Zambian radiographers with DR using the digital transformation framework (DTF).

The DTF consists of three stages of digital transformation describing the advancement of imaging technologies.^{13,14} The first stage, digitisation, involves transitioning from analogue to digital imaging, replacing film-based radiography with digital X-ray machines and digitising older analogue images for easier storage and transmission. The second stage, digitalisation of workflow/optimisation, focuses on improving workflows through systems like PACS and RIS to enhance patient data management. The final stage, transformation and innovation, leverages advanced technologies like artificial intelligence (AI), machine learning (ML), and telemedicine to automate processes, enhance diagnostics, and encourage continuous innovation in imaging practices. These stages may overlap, with progression depending on the facility's infrastructure and goals.^{13,14}

Methods

Research design

This study employed a qualitative descriptive phenomenological research design, adopting the principles of Husserlian methodology, to explore the experiences of radiographers with DR. This approach facilitated a deeper understanding of the opportunities and challenges encountered by radiographers in transitioning from film-based radiography to DR, aligning with the specific methodological and theoretical frameworks associated with descriptive phenomenology.^{15, 16} Descriptive phenomenology was chosen for its emphasis on capturing the essence of lived experiences as they are perceived by individuals, focusing on detailed descriptions without imposing researcher interpretations, which distinguishes it from interpretive phenomenology which seeks to understand the meanings behind those experiences.

^{15, 16}

Research setting

Zambia is a landlocked country in Southern Africa. It is divided into ten provinces, and the Copperbelt province is one of them. The province has 22 hospitals offering imaging services, but only five have DR X-ray machines.¹² This study was conducted at five hospitals with DR X-ray machines, including one Level 3 (Teaching) hospital, three Level 2 (General) hospitals, and one Level 1 (District) hospital.

Population and sampling

The targeted population for the study (N=58) consisted of radiographers working at the study sites, from which 14 were purposefully selected through criterion sampling based on their experience with DR. The sample included radiographers trained in film-based radiography, identified by codes ending with A (e.g., P1-A), and those trained in DR, identified by codes ending with D (e.g., P14-D). Inclusion criteria required participants to be registered with the Health Professions Council of Zambia and possess over six months of work experience. This sample size was deemed sufficient for achieving data saturation in qualitative research, particularly in homogeneous groups, as supported by existing literature on similar studies.^{15, 17}

Data collection tool and procedures

In the study, DTF was applied through the interview guide, which included six open-ended questions designed to elicit detailed responses about the stages of digital transformation:

- **Digitisation:** The questions were structured to gather insights on the current state of education and training in DR. This helped identify gaps and areas for development, aligning with the digitisation stage by focusing on foundational training and curriculum improvements.
- **Digitalisation of workflow/optimisation:** Probing questions explored participants' experiences with workflow efficiency, image quality, and departmental communication. These responses were used to assess and refine strategies to optimise workflow and enhance the DR department's operational processes.
- **Transformation and innovation:** The guide included questions about broader challenges and advanced solutions, such as technological adaptation, radiation safety,

equipment costs, and data management. This approach ensured that the study addressed transformation and innovation, promoting comprehensive digital integration and improvement strategies.

Probing questions were asked depending on the participant's responses. The following were the main questions.

1. How did you acquire education and training in DR?
2. How have you experienced the transition from conventional film-based radiography to DR?
3. How has digital radiography affected the departmental workflow at your hospital?
4. Briefly explain what challenges you have faced with the use of DR compared to conventional film-based radiography.
5. In which aspects would you like training schools offering radiography to improve concerning training students in DR and why?
6. What suggestions would you give to improve the implementation of DR in Zambia?

After obtaining ethical approval and permissions, contact was established with the heads of the radiology departments at the study sites in October 2023. A pilot study was conducted at one of the level 2 hospitals, involving four participants, to assess the interview guide, researcher interviewing skills, data analysis, and the overall study plan before the main research. No further changes were made to the interview guide after the pilot study. To prevent data contamination, the pilot participants and data collected during this phase were excluded from the main results.

Participants were recruited through the heads of radiology departments and provided with the necessary information, including a study information sheet, consent forms and ethical approval. After voluntarily agreeing to participate, they received interview schedules and guides, and face-to-face interviews were conducted in November and December 2023, with consent forms collected and recording permissions obtained before each session. Interviews were conducted in English during working hours in private meeting rooms at each site. This setup ensured convenience and confidentiality, allowing for in-depth probing and detailed responses about radiographers' experiences with DR.¹⁵ The average duration of each interview was 35 minutes, with the shortest lasting 20 minutes and the longest 50 minutes, and all were digitally audio-

recorded. Data saturation was achieved with 11 participants. However, the researchers interviewed all 14 participants.¹⁶

Data management and analysis

The first researcher (NK) transcribed the data verbatim after each interview. The first (NK) and second (OB) researchers then analysed the data thematically using Colaizzi's (1978) phenomenological seven-step framework (Table 1).^{18,19}

Table 1: Colaizzi's (1978) phenomenological framework and activities undertaken at each stage

Stage	Strategy	Activity
1	Transcription and familiarisation	- The researchers familiarised themselves with the collected data by listening to interviews and reading transcripts. - Key ideas and themes were noted in a field notebook.
2	Identifying and extracting statements	- Relevant statements from transcripts concerning radiographers' experiences with DR were manually identified and extracted. - Two researchers undertook this coding process
3	Formulating meanings	- Identified meanings from significant statements. - Pre-suppositions were 'bracketed' to stay close to the experience of radiographers to DR. This was achieved by identifying and setting aside pre-existing assumptions through practices like reflexive journaling, structured interview techniques, and independent coding to ensure the researchers remained focused on the radiographers' actual experiences with Digital Radiography.
4	Clustering themes	- Identified meanings were grouped into common themes while bracketing pre-suppositions. - A systematic table facilitated organisation and analysis.
5	Developing an exhaustive description	A comprehensive description of radiographers' experiences with DR was created, addressing all themes.
6	Producing the fundamental structure	The exhaustive description was condensed into a concise statement capturing vital aspects of the experiences.
7	Seeking verification of the fundamental structure	- The condensed statement was verified with all participants to ensure accuracy. - Adjustments were made based on feedback, reflecting the iterative nature of the process.

The NLP tool enhanced the phenomenological research process by complementing manual analysis from steps 2 to 5. Through automation that minimised human error and bias, it

improved data analysis accuracy, consistency, and depth, thereby allowing researchers to efficiently identify patterns and themes while better-interpreting participants' experiences.

Trustworthiness

Trustworthiness criteria, following Lincoln and Guba's framework, were employed to ensure rigour in this study, encompassing credibility, dependability, conformability, and transferability (Table 3).^{20, 21}

Table 2: The strategies used to ensure trustworthiness

Criteria	Strategy employed
Credibility	• Purposeful selection of participants from different backgrounds (trained during the analogue and digital era). • Triangulation of data sources from five hospitals provided diverse perspectives, enhancing credibility. • There was prolonged engagement with participants from recruitment to member checking. • Post-transcription verification with participants ensured the accuracy of the data collected.
Dependability	• Peer debriefing with other researchers reviewing sub-themes and generating themes, contributing to the dependability of the study. • Meticulous documentation-maintained dependability through transparency in the research process • The NLP tool complemented manual analysis of the data
Conformability	• Direct participant quotes are incorporated in the results section to support findings, ensuring conformability by providing evidence for the interpretations made.
Transferability	• A detailed description of the research process has been provided, facilitating broader applicability of the study's outcomes and enhancing transferability. • By including diverse perspectives and transparent documentation, the study's findings can be applied to various contexts.

Ethical Considerations

Ethical approval was granted by the University of Zambia Biomedical Research Ethics Committee (Ref: 4065-2023). The study adhered to ethical principles: autonomy through informed consent, beneficence by protecting anonymity and data security, non-maleficence by avoiding harm, and justice by ensuring equitable treatment and minimising bias.^{15,22}

Results

Participants demographic data

Demographic and professional details of the study participants (Table 3).

Table 3: Represents the participants' demographic data

Participant code	Biological sex	Highest radiography qualification	Work experience (Years)	Study site
P1-A	Female	Diploma in radiography	8	1
P2-A	Female	Diploma in radiography	9	1
P3-A	Male	Diploma in radiography	9	1
P4-A	Female	Diploma in radiography	12	2
P5-A	Female	Diploma in radiography	10	2
P6-D	Male	Bachelor of Science in radiography	17	2
P7-A	Female	Diploma in radiography	10	3
P8-A	Female	Diploma in radiography	7	3
P9-D	Male	Bachelor of Science in radiography	13	3
P10-A	Female	Diploma in radiography	3	4
P11-D	Male	Bachelor of Science in radiography	13	4
P12-A	Male	Diploma in radiography	7	4
P13-A	Female	Diploma in radiography	3	5
P14-D	Male	Bachelor of Science in radiography	12	1

Themes

Following data analysis, three main themes and 10 sub-themes were developed (Table 4).

Table 4: Main theme and sub-themes

Main themes	Sub-themes
Theme 1: Education and training in digital radiography	- Curriculum development - On-site training and continuous professional development (CPD)
Theme 2: Digital radiography departmental workflow	- Workflow and efficiency - Image quality and evaluation - Communication and collaboration - Emotional and psychological aspects/ user satisfaction
	Technological adaptation

Theme 3: Challenges in the implementation of digital radiography	• Radiation safety • Equipment costs and maintenance • Data management, storage, and interoperability
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Theme 1: Education and training in digital radiography

This first theme focused on the experiences of radiographers with education and training in DR. It consists of two sub-themes: curriculum development, and on-site training and CPD.

Sub-theme 1: Curriculum development

Participants trained during the analogue era indicated that their educational background significantly shaped their experiences. Most radiographers expressed a strong interest in enhancing the curriculum to include DR.

“They should include DR in the curriculum as a course on its own.” (P3-A)

“Looking at the curriculum, we need to change it to incorporate DR.” (P11-A)

“We were just taught the theory part, but the practical part I learned where I did my attachments. The training institutions should consider teaching the practical aspect as well.” (P7-A)

Participants trained in the digital era were concerned about the inadequate DR practical part of the curriculum. They suggested balancing theory and practicals.

“I acquired the experience here where I am working from, but whilst I was at school mostly, we did more theory with less practical, but the job has been done here.” (P8-A)

“Looking at the curriculum, we need to change it.” (P11-D)

Sub-theme 2: On-site training and CPD

Throughout the interviews, on-site training emerged as one of the effective ways of training radiographers in DR. Participants also appreciated the role CPD played in updating their knowledge and skills needed to perform the job effectively.

“Let's encourage CPD in DR because it is here to stay and effectively help the patients.” (P6-D)

Most participants trained in analogue methods emphasised the importance of learning from departmental resources and individuals skilled in operating specific X-ray machines within the radiography field.

“I learnt about DR from the departmental resources and radiographers who were trained to use the machine.” (P1-A)

Theme 2: Digital radiography departmental workflow

The second main theme focused on the departmental workflow of DR. It consists of four sub-themes: workflow and efficiency, image quality and interpretation, communication and collaboration, and emotional and psychological aspects/ user satisfaction.

Sub-theme 1: Workflow and efficiency

All participants with analogue training reported that DR improves image processing efficiency. They noted that eliminating darkroom processing and enabling immediate retrieval of digital images enhanced workflow, which they described as a positive experience.

“It's faster in dispensing images; we are no longer using darkroom processing; we are using image receptors, so we just process them, and you get the image.” (P3-A)

Participants trained in the analogue era emphasised the time-saving benefits of DR in patient interactions. They noted improvements in queue management and overall positive experiences for clinicians and patients, in contrast to the analogue era.

“We spend less time with patients and the clinicians are having a good time when it comes to images. We are also able to manage the queues better than the analogue.” (P2-A)

“ We see quite many patients therefore, there is reduced patient waiting time, no long queues.” (P4-A)

A participant trained during the analogue era noted that DR enhances patient safety and satisfaction by reducing radiation doses. This decrease leads to fewer repeat imaging sessions, improving the patient experience and minimising unnecessary radiation exposure.

“And we have fewer repeats hence, there is reduced radiation dose.” (P4-A)

Sub-theme 2: Image quality and evaluation

All participants provided valuable insights into their experiences with digital image quality and evaluation, noting the clarity, accuracy, and overall effectiveness of digital imaging systems compared to traditional analogue methods.

“The images are good and clear as compared to the films we used to use.” (P7-A)

One participant trained in the digital era emphasised the significant impact of diagnosing various patient conditions, noting that this experience showcased the positive influence of technology on healthcare outcomes.

“It has been very positive because even looking at the quality of images, they are excellent as compared to images produced from analogue. This transition has been very good and has helped a lot in diagnosing various conditions.” (P11-D)

Sub-theme 3: Communication and collaboration

Another issue raised during the interviews was the significant improvement in interdisciplinary interactions following the implementation of DR. One participant specifically noted enhanced communication and collaboration between radiographers and referring clinicians.

“So, we have about 3 local area networks [LAN] where we share images, we have an out-patient department (OPD), national health insurance management authority [NHIMA] and intensive care unit [ICU] so clinicians will just check for images and sometimes will ask for suggestions from the radiographers.” (P8-A)

A digitally trained participant noted that referring clinicians visiting the radiology department to view images fosters real-time discussions and consultations. This practice enhances patient care efficiency, promotes interdisciplinary teamwork, and improves patient outcomes and care quality.

“But some clinicians within the hospital just come to view on the monitor.” (Participant 14-D)

Sub-theme 4: Emotional and psychological aspects/user satisfaction

One participant trained in analogue radiography shared the emotional and psychological experiences during the transition to DR. The participant expressed anticipation, apprehension, and excitement about adopting new technologies and workflows.

“The experience with computers typing names, you need to be accurate and fast, but since you don’t have that training, you end up being slow.” (P7-A)

Theme 3: Challenges in the implementation of digital radiography.

The third main theme focused on challenges related to implementing DR. It consists of four sub-themes: technological adaptation, radiation safety, equipment costs and maintenance, and data management, storage, and interoperability.

Sub-theme 1: Technological adaptation

Participants noted the challenge of adapting to new digital equipment, software, and workflow processes, especially among those trained in analogue methods. They expressed difficulties becoming familiar with unfamiliar technology and adjusting to different operational procedures.

“Some of us had to start learning computer skills, so adaptation took long.” (P4-A)

There was resistance to adopting new technology, especially among the analogue-trained radiographers. This reluctance arose from a preference for traditional methods, concerns about the learning curve, and fears of disrupting established workflows.

“I found it difficult initially, but now I enjoy the experience. It's proven to be very easy and simple, with no darkroom or chemicals, especially for some of us with eye problems, using blue or red light was a problem. Some of us were used to select exposure factors and process films. Not this. It's time-consuming to crop, adjust contrast, and label.” (P7-A)

Sub-theme 2: Radiation safety

Participants observed that DR introduced variability in exposure settings, risking patient safety and diagnostic accuracy due to potential overexposure or underexposure. They emphasised the need for radiographers to uphold strict radiation safety standards and protocols.

“We had to teach others about exposure settings when using DR. It’s crucial to understand how to set exposure factors correctly to ensure patient safety.” (P9-D)

Another participant indicated that:

“Others are not familiar even with the setting of exposure factors.” (P13-A)

Sub-theme 3: Equipment costs and maintenance

Participants noted that implementing DR requires significant initial investments, emphasising the need for strategic budgeting and resource allocation to ensure the purchase of quality equipment with a long-term servicing plan.

“It is expensive to service and maintain these types of equipment; therefore, there should be an active service plan by the government.” (P2-A)

“I think the initial cost of acquiring these DR imaging systems is high,” (P14-D)

Two digitally trained participants acknowledged that DR enhances workflow but noted that maintenance issues can disrupt operations. They suggested proactive maintenance, access to technical support and training, contingency plans, and backup systems.

“For analogue, it will take time to have a fault, but for digital, from time to time, there is a system breakdown. Luckily, we have biomedical engineers now available at the hospital, so most of the time, they will be here to work on it.” (P14-D)

“The only challenge that I have faced is the aspect of the internet. Once we don’t have internet, you won’t be able to send images to the clinicians.” (P11-D)

Sub-theme 4: Data management, storage, interoperability and integration

Participants pointed out the challenge of managing large data volumes from DR due to inadequate strategies and infrastructure. They emphasised the need for robust data management systems to handle digital data efficiently.

“The other issue is the wiping out of data once the computer is full, so we lose images; we need computers with big storage capacity.” (P6-D)

“Some departments don’t have computers, so they just get the images using a phone. Again, phones have different resolutions and might distort the information.” (P9-D)

“We see a lot of patients, so we put on their phones and we use WhatsApp.” (P12-A)

“I think they need to improve on data protection by implementing LAN so that the images go directly to the referring clinician.” (P13-A)

Participants recommended improving data management in DR by investing in PACS, providing computers with larger storage capacities, and ensuring all departments have computer access. They suggested implementing secure data transfer protocols like LAN to enable direct and secure image transfers and avoid insecure platforms like WhatsApp.

Discussion

This research was the first in Zambia to explore radiographers' experiences and recommendations regarding integrating DR. The study used the DTF to gather diverse insights from radiographers and found that on-site training was crucial in bridging the gap between theoretical knowledge and application of DR. On-site training helped radiographers integrate theoretical understanding with real-world use of digital imaging equipment, supporting findings from previous research.²³ The study highlighted the importance of practical skill development, equipment familiarity, workflow integration, patient interaction, and collaboration with medical and IT personnel.²⁴⁻²⁶

The study emphasised the crucial role of CPD for radiographers to keep up with advancements in DR. It supported previous findings on the importance of CPD programs in areas like advanced imaging techniques, technology trends, and ethics. CPD helps radiographers maintain their competence and adaptability in a rapidly evolving field.²⁷⁻²⁹ The study also highlighted the proactive role of professional bodies, such as the Radiological Society of Zambia (RSZ), in offering CPD opportunities and promoting lifelong learning

The research highlights the urgent need to revamp radiography curricula to include advanced digital imaging techniques, data management, ethical considerations, and patient care psychology. A revised curriculum should address the evolving technological demands of DR by emphasising digital imaging principles, practical skills, quality assurance, interdisciplinary collaboration, and effective communication through digital platforms.²⁷ This comprehensive approach will better prepare students for modern imaging practices, enhance healthcare delivery, and improve patient outcomes.

This study also highlighted the profound influence of DR on workflow efficiency, such as the efficiency of DR in image processing, time-saving, queue management, positive patient and staff experience, and radiation dose reduction, aligning with the insights put forth by Mulla.³⁰ Numerous studies corroborate this perspective, emphasising the positive impact of DR on workflow optimisation, image quality enhancement, and overall efficiency in patient care.^{6,31-34} The literature consistently stresses the importance of mastering workflow management and continuous quality improvement to maximise the benefits of DR, further echoed by other studies.³⁵⁻³⁸ Effective communication, technological integration, and collaboration among healthcare professionals are fundamental to enhancing workflow efficiency.³⁹⁻⁴²

Beyond the technical aspects, the study illuminated the significance of emotional and psychological well-being in shaping workflow standards within DR settings by influencing staff productivity, decision-making, and overall job satisfaction. A supportive and stress-free work environment can lead to better collaboration, reduced errors, and a more efficient workflow, ultimately enhancing the quality of patient care. The findings underscored the necessity for supportive work environments and the inclusion of emotional factors in healthcare service delivery.⁴³⁻⁴⁶ Studies reinforce the collaborative commitment to advance DR and improve workflow practices, underscoring the holistic approach necessary for enhancing professional and patient satisfaction.⁴⁷⁻⁵⁰

Radiographers in this study highlighted financial challenges in acquiring and maintaining DR technology in Zambia, where healthcare budgets are limited. The high costs of purchasing, maintaining, and training for DR systems hinder widespread adoption.⁵¹ This delay in integrating DR limits diagnostic advancements, keeping traditional methods in use. Overcoming these financial barriers is essential, as DR can improve efficiency, reduce film-based costs, and enhance patient outcomes, potentially transforming healthcare delivery in the long term.

Radiographers grapple with countless challenges in acclimating to the diverse array of digital technologies inherent in DR. Challenges encompass mastering new equipment, navigating complex software interfaces, and optimising workflow processes. Another study underscores the significance of acquiring proficiency in computer skills to effectively utilise digital imaging systems, mirroring the concerns articulated by participants.⁵² Overcoming resistance to change emerges as another critical hurdle, necessitating the implementation of training programs and effective communication strategies to garner buy-in from radiography professionals, as highlighted by other studies.^{53,54} Furthermore, equipment selection must prioritise factors such as durability, image resolution, and compatibility with existing systems to ensure effective utilisation, as emphasised by our study participants.

The study aligns with existing literature on the importance of correctly setting exposure parameters in medical imaging.^{55,56} It revealed that many hospitals still lag in adopting modern technology, with some radiographers lacking familiarity with these critical settings. This issue impacts radiation safety and is exacerbated by Zambia's lack of diagnostic reference levels (DRLs) for dose management.

The study identified inadequate data management strategies and infrastructure, highlighting privacy and confidentiality concerns associated with sharing radiographic images on platforms like WhatsApp. These concerns include the risk of unauthorised information distribution, security risks with personal devices, and potential image quality loss leading to misdiagnosis. The study stressed the need for robust storage solutions, uniform devices, and secure communication protocols to address these issues. Implementing comprehensive data management strategies, such as PACS and RIS, is essential for mitigating risks, improving efficiency, and safeguarding patient well-being in DR.^{57,58}

The research explores radiographers' experiences within the DTF, focusing on three interconnected stages. In the digitisation phase, transitioning from traditional X-ray films to digital imaging systems presents opportunities and challenges. Radiographers adapt to new technologies, enhancing image quality and reducing radiation exposure while facing a learning curve and concerns about data security. In the digitalisation stage, radiographers leverage PACS and RIS systems to improve collaboration and streamline workflows, enhancing patient care and diagnostic accuracy while necessitating continuous training and adherence to data security protocols.¹⁶ Overall, Zambia's imaging departments are primarily at the intermediate

level of the DTF, indicating progress in integrating digital tools but highlighting the need for further development and support to realise the benefits of digital transformation in radiography.

Limitations of the study

This study used a purposive sample of radiographers working in the Copperbelt province. Therefore, the findings may not be generalisable beyond this study site. Future research should consider using mixed methods design where the qualitative findings could be generalised with quantitative .¹⁵

Conclusion

The study highlighted positive experiences, such as improved departmental workflow. Negative aspects included difficulties with technical adaptation, and challenges like inadequate data management protocols and the sharing of sensitive X-ray images via WhatsApp posed significant issues. Despite these obstacles, the study emphasised the potential for improvement through targeted initiatives and collaboration within the radiography profession and the broader Zambian healthcare sector.

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See the title page

Competing interests

The authors declare no conflict of interest related to this research.

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Declaration of generative AI and AI-assisted technologies in the writing process

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