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Preregistration radiography education in sub-Saharan Africa: Impact assessment on graduate competence and employability

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A B S T R A C T

Introduction: Sub-Saharan Africa (SSA) faces increasing demands for medical imaging; however, radiography education is heterogeneous. This study examines preregistration diagnostic radiography (standalone or combined with radiotherapy) programmes in SSA, assessing how training prepares graduates for clinical practice.
Methods: A quantitative online cross-sectional survey was distributed to SSA radiography educators, recent graduates, and managers to examine preregistration radiography programme structures, workload allocation, and graduate competence.
Results: Analysis of 258 responses from 23 SSA countries showed variation in programme duration and modalities. Curricula emphasised projection radiography and general ultrasound, with limited coverage of Computed Tomography (CT), Magnetic Resonance Imaging (MRI), nuclear medicine (NM), and radiotherapy (RT). Factor analysis revealed that core imaging expertise was the best predictor of graduate competence, with clinical placements being crucial for proficiency in cross-sectional imaging. Competencies in CT and ultrasound demonstrated moderate development at graduation, whereas skills in MRI, NM, and radiotherapy were acquired on the job. Despite comprehensive training in generic skills, both taught and clinical programme characteristics showed significant negative correlation with industry expectations ($r = -0.26$, $p < 0.01$ and $r = -0.27$, $p < 0.01$, respectively).
Conclusion: Radiography education in SSA is varied and demonstrates limited graduate preparedness in cross-sectional imaging, with a misalignment to employer expectations. A single-modality exit curriculum model, embedded within a multi-modality threshold competency framework, could improve graduate work-readiness. Better integration of clinical placements and partnerships between academia and industry are essential.
Implications for practice: Educational institutions and policymakers in SSA must prioritise curriculum reform that aligns with health system needs and training realities. This should involve implementing targeted strategies to build a workforce capable of meeting evolving demands through enhanced collaborative frameworks, industry-aligned modular curricula, and expanded clinical exposure to cross-sectional imaging modalities.

Introduction

Radiography professionals are central to modern healthcare, supporting diagnosis, treatment planning, and patient management.[1–3] Their role is vital as the global disease burden

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rises,[4,5] making healthcare systems increasingly dependent on clinical radiography.[6] In Africa, this trend is particularly evident[7,8] with health systems experiencing rapid growth in the volume and variety of imaging procedures.[9] Although precise, up-to-date healthcare education output and workforce data are limited in many low-middle-income countries, evidence consistently suggests that countries in SSA struggle to maintain an adequately trained and appropriately sized radiography workforce.[7,10–12]

Preregistration education is the bedrock of radiographers' development of clinical competence,[13–15] providing graduates with technical knowledge and professional attributes.[16] In Africa, preregistration radiography programmes must prepare graduates across multiple modalities, often with limited access to cross-sectional imaging modalities and clinical supervision.[17–20] In this study, we use the term competence to mean performing tasks autonomously and responsibly, as defined by the European Qualifications Framework[21] and radiography to refer to both diagnostic and therapeutic aspects of the profession unless categorically stated.

Despite a 70 % increase in healthcare workforce education output across Africa (2018–2022),[22] the continent represents 10 % of the global population, 25 % of the disease burden, and only 4 % of the global healthcare workforce.[23,24] These disparities are evident in radiography: Africa, with a combined population of approximately 1.2 billion people across 47 of its 54 countries,[11] has an estimated 25,804 imaging professionals, compared to 271,200 in the United States (US) (≈population of 347 million),[25] 19,851 in Australia (population ≈ 27 million)[26] and 43,040 in the United Kingdom (UK), (population ≈69 million),[27,28] highlighting significant workforce shortages.

Radiography education in Africa faces ongoing challenges affecting graduate competency levels, skills mix, and workforce availability.[17,18,20,29–32] Limited radiotherapy education[33] and cross-sectional imaging access,[17] plus use of curricula beyond review times,[34] create misalignment with the workplace demands.[14] This disconnect poses a significant barrier to developing work-ready graduates who can confidently meet the clinical, technological, and professional expectations of modern healthcare systems.

While numerous studies have explored radiography education in regions such as Europe, the USA, and Australia, a notable lack of multi-country research exists that addresses the broader African context.[14,35–40] In most international studies, South Africa is the sole African representative from the continent, thereby limiting the generalisability of findings to the wider African region.[35,41,42] National-level evaluations have been conducted in select countries,[39,43,44] providing valuable insights; however, these evaluations remain limited in scope and do not capture the broader continental landscape of training outcomes, educational models, or graduate readiness.

This study, therefore, examines preregistration radiography educational programmes across SSA, addressing a gap in the literature regarding radiography training quality. It analyses programme characteristics and alignment between educational content and graduate competencies. Through an evaluation of graduate outcomes and stakeholder assessments, the study examines competency levels and identifies key factors contributing to imaging modality competence. It assesses graduate preparedness in professional attributes, such as communication, critical thinking, and teamwork. By analysing correlations between educational structures, clinical exposure, industry expectations, and competency levels, this study provides insights for curriculum development, policy formulation, and workforce readiness within SSA and globally.

Methods

Study design

This cross-sectional study was part of a broader mixed-methods project that explored radiography education and its impact on graduate knowledge, competence, and employability across the SSA. Due to the lack of a comprehensive database, convenience sampling was used to distribute the survey to participants via online professional networks and social media platforms.

Study population, inclusion and exclusion criteria

The study focused on educators, recent graduates, and radiology service managers to gather their views on how preregistration education impacts graduates' competence and employability. While participation was open across SSA, the questionnaire was only available in English. However, English speakers from countries where French or Portuguese are prevalent could take part. Although clinical radiography services exist throughout SSA, not all countries offer preregistration radiography education. In some cases (e.g., Botswana), radiographers are usually trained abroad, often in neighbouring countries such as Zambia or Zimbabwe.[45] Educator responses, therefore, reflect only those countries with established radiography training, while recent graduates and managers had a wider representation from all 23 responding countries. Additionally, the study focused on diagnostic radiography programmes, either standalone or combined with radiotherapy, as the unit of analysis. It examined programme characteristics, graduate practice areas, and competency levels in imaging disciplines typically included in such curricula in SSA, such as projection radiography, medical ultrasound, computed tomography, magnetic resonance imaging, nuclear medicine, and radiotherapy. Standalone programmes in these fields were excluded from the factor analysis.

Data collection

The questionnaire adapted a design from previous radiotherapy education research across the European Union.[46] The research team developed programme characteristics and graduate competency statements based on prior literature reviews.[14,34] Four subject experts validated content and context: a medical education and radiography specialist, a statistician, and two radiography education professionals. The experts evaluated each item for relevance and alignment with the study's conceptual framework.[47,48] Using the content validity ratio method,[49] items were classified as "essential," "not essential," or "in need of modification." A pilot study with ten participants from Nigeria, Ghana, Zambia, and Kenya assessed questionnaire clarity.[50] Feedback refined the questionnaire before deployment, enhancing face validity for data capture in low and middle-income countries.

The questionnaire consisted of four sections aligned with the study objectives: participant demographics, educational programme characteristics, graduate competency ratings across imaging practice areas, and perceived effectiveness of licensure examinations. Findings on licensure examinations were reported separately. Fig. 1 provides an overview of the questionnaire constructs presented in Supplementary file 1.

Data analysis

Data analysis was conducted using SPSS version 29.0.1.0 (171) with a two-tailed α level of 0.05 for statistical significance. Data

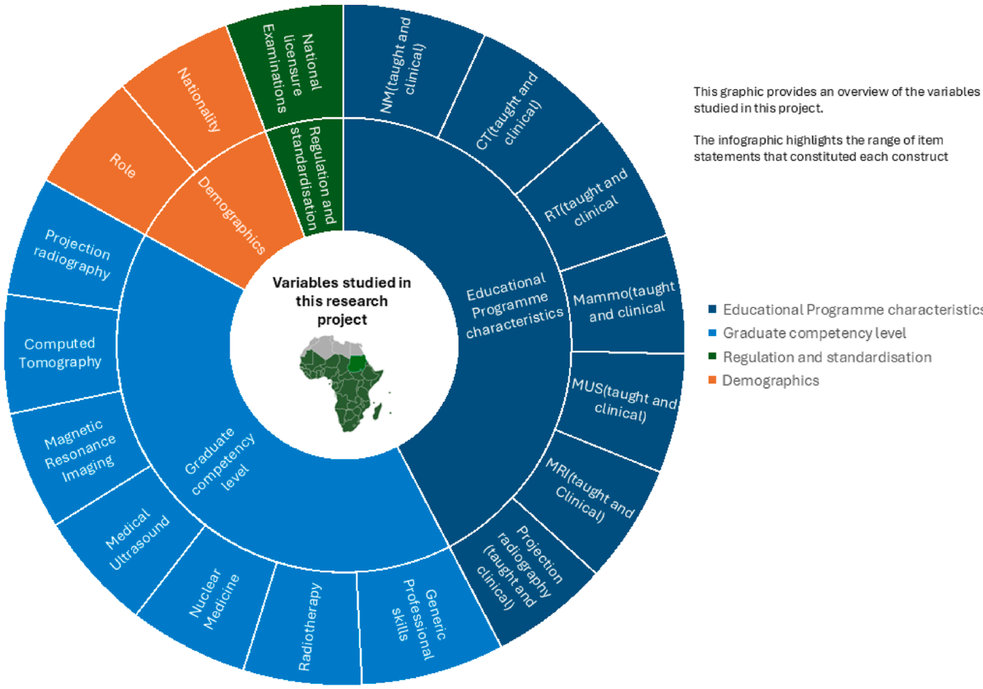


Figure 1. Overview of the variables studied in this research project.

were cleaned and checked for missing values and outliers using frequency distribution tables and box plots. Categorical variables were summarised using means and standard deviations. Internal consistency was assessed via Cronbach's alpha (threshold 0.6), with coefficients ranging from 0.68 to 0.94[51]. Exploratory factor analysis via principal axis factoring identified programme characteristics associated with educational objectives and variables contributing to graduate competency levels in each modality.[52] A fixed factor model retained all variables.[53] Graduate competency factors refer to the core clinical expert attributes in diagnostic imaging and radiotherapy that radiographers must achieve to ensure quality patient outcomes.

Results

Demographics

A total of 258 professionals from 23 sub-Saharan African countries participated (Fig. 2a). Recent radiography graduates ($n = 133$, 52 %), radiology service managers ($n = 80$, 31 %), and only 45 *(17 %) were radiography educators* (Fig. 2b). In this study, radiotherapy, nuclear medicine, and ultrasound are reported as modalities that were taught within diagnostic radiography curricula. We recognise that in some SSA countries, these disciplines are also offered as standalone programmes; however, such independent pathways were excluded from the factor analysis.

Main characteristics of preregistration radiography programmes across sub-saharan Africa

Preregistration radiography educational programmes varied in imaging modalities covered and duration. Most countries offered 4–5-year undergraduate degrees with multi-modality diagnostic radiography pathways, while three-year diploma programmes focused on projection radiography and limited ultrasound practice. Some countries reported single-modality specialisations in medical ultrasound and radiotherapy. Ethiopia and Cameroon offered 5–6-year dual-qualification programmes in diagnostic and radiation therapy (Fig. 2c and d).

Taught and clinical content workload allocation across imaging modalities

The analysis showed projection radiography dominated both taught and clinical components, with less time given to ultrasound, CT, MRI, NM, and RT. The bar chart summarises the responses regarding workload allocation to taught and clinical content in the curriculum (Fig. 3).

The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were conducted on three factor groupings. All KMO values exceeded 0.60, indicating an adequate sample size for factor analysis (Table 1). Bartlett's test produced $p < 0.001$, confirming that the correlation matrices were appropriate for structure detection. These results strongly support proceeding with exploratory factor analysis (EFA) using principal axis factoring (PAF). Normality tests using the Kolmogorov–Smirnov and Shapiro–Wilk methods showed that all variables violated multivariate normality ($p < 0.05$), as indicated in Table 2. Due to these violations, PAF was chosen for EFA, as it is robust to non-normal distributions. Likert-scale items were transformed into continuous variables and analysed using Spearman's rank-order correlation.

This section presents key results from the factor analysis and competency development across imaging modalities in preregistration radiography programmes, covering the taught component, clinical placement, competency factor loadings and graduate competency levels.

Part 1: taught component

Results show projection radiography (0.863) was most strongly represented, with 85 % of respondents rating it high/very high (mean: 4.34). Radiotherapy had 0.808 loading, with 70 % indicating very low/low allocation (mean: 2.08). Nuclear medicine (0.779)

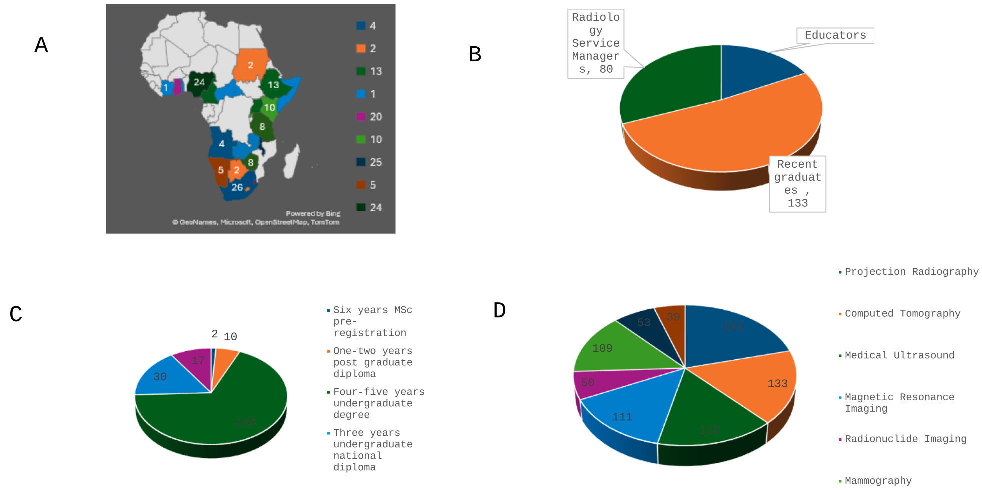


Figure 2. Demographic data. Distribution of participants by A-country, B-role and distribution of programmes by C-duration, D-modality covered. (The numbers in each figure above represent the number of responses.

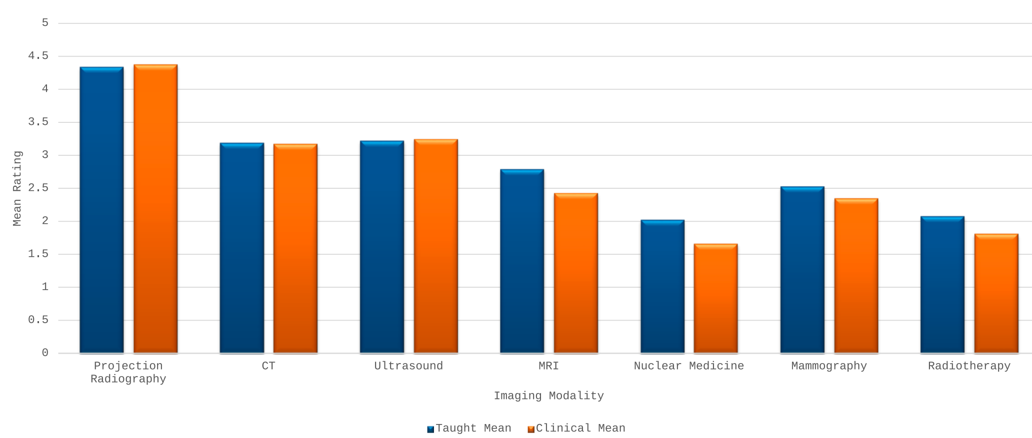


Figure 3. Bar chart comparing mean taught and clinical workload allocation ratings across imaging modalities in preregistration radiography programmes.

showed 70 % very low/low allocation (mean: 2.02). Ultrasound (0.778) had 45 % rating it very high/high. MRI had 0.610 loading, with 22 % rating it high/very high (mean: 2.79). CT showed the lowest loading (0.562), with 37 % rating high/very high (mean: 3.19). Mammography (0.33) was excluded due to loading below 0.50 (Table 3).

Part 2: clinical placement

Clinical placement loadings ranged from 0.517 to 1.00. Ultrasound had 1.00 loading (mean: 3.25), with 50 % indicating moderate/high allocation. Radiotherapy showed 0.85 loading (mean: 4.38), though 76 % indicated minimal programme time. Projection radiography (0.79 loading) had an 83 % high/very high allocation. Nuclear medicine showed 84 % low/very low allocation, while CT had 62 % moderate-high placement despite 0.54 loading. Mammography had the lowest loading (0.51), with 60 % indicating low/very low allocation. MRI (0.22) was excluded due to subthreshold loading. These findings were explored in a follow-up qualitative study (Table 3).

Part 3: graduate competency factor loadings by modality

The analysis demonstrated particularly strong loadings in radiotherapy and nuclear medicine. Across all modalities, standout skills such as "perform RT techniques," "perform NM procedures," "perform contrast and non-contrast CT procedures, "perform MRI," and "perform ultrasound" emerged as central to competency in these areas. While CT and MRI showed moderate loading patterns, the consistently strong results in projection radiography and generic professional skills suggest that these areas benefit from more comprehensive curricular integration (Table 4).

Graduate competency development by practice area

When participants were asked to rate the development of each skill across five stages (not developed, partially developed,

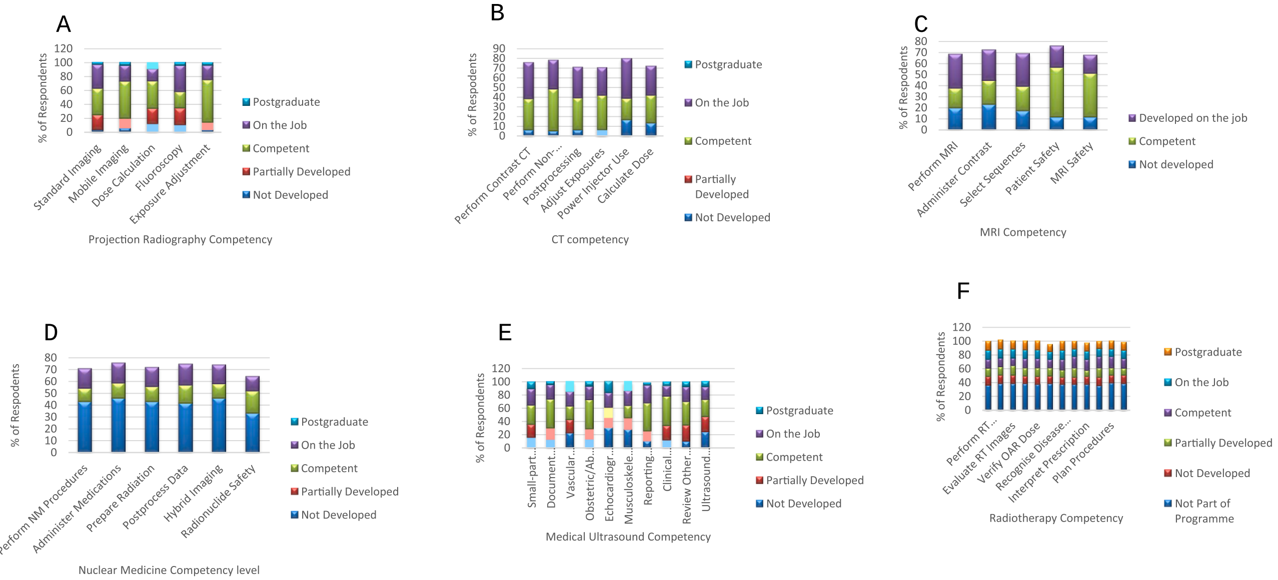


Figure 4. An overview of graduate competency levels by practice area (A-F) representing projection radiography, CT, MRI, nuclear medicine ultrasound, and radiotherapy, respectively.

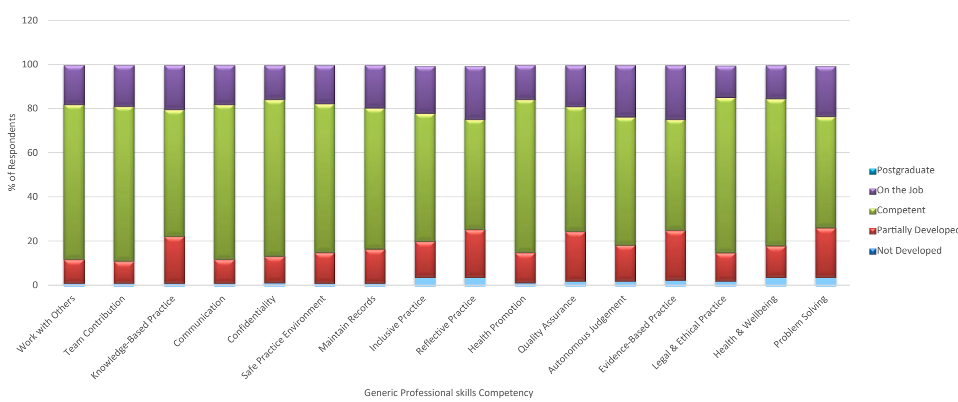


Figure 5. Generic skills, such as communication, confidentiality, and teamwork, are well-developed by graduation, suggesting a strong emphasis on training programmes.

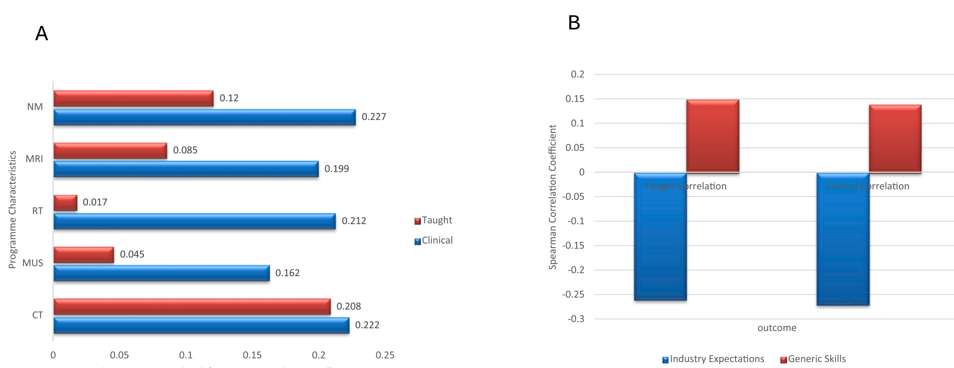


Figure 6. a: Correlation between programme characteristics and graduate competency levels; b: correlation between programme characteristics with industry expectations and non-imaging competencies (generic professional skills).

Table 1
Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity.

Factor Grouping		Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy	Bartlett's test of sphericity.
Part	Factors		
A	Taught and clinical programme characteristics and projection radiography competence	*0.754*	*P = 0.0001*
B	Graduate competence in computed tomography, magnetic resonance imaging and nuclear medicine	*0.934*	*P = 0.0001*
C	Graduate competence in radiotherapy, medical ultrasound, generic skills, and industry expectations	*0.905*	*P = 0.0001*

competent at graduation, developed on the job, or developed at the postgraduate level), the perceived development of each skill among recent graduates before graduation is shown in Fig. 4: A—F and Fig. 5.

Correlation analysis of programme characteristics, radiographic competencies, generic professional skills and industry expectations

The correlation analysis reveals a clear divergence in how programme characteristics influence educational outcomes. While clinical placements show stronger positive correlations with graduate competencies in cross-sectional imaging modalities, particularly computed tomography, nuclear medicine, and radiotherapy, the taught and clinical components exhibit negative correlations with industry expectations. In contrast, they exhibit modest positive correlations with generic professional skills, highlighting a strength in fostering transferable competencies, but also indicating a potential misalignment with current workplace demands (Fig. 6).

Discussion

This study on preregistration radiography education across 23 sub-Saharan African countries examines programme structure, graduate competencies, and industry alignment. It analysed academic and clinical training characteristics, evaluated graduate outcomes with stakeholder assessments across imaging modalities, and assessed their alignment with employer expectations.

The study contributes new evidence indicating that while graduates develop core competencies in projection radiography and ultrasound, preparedness in CT, MRI, nuclear medicine, or radiotherapy is often limited at graduation and is acquired post-registration through on the job training. This raises questions about whether preregistration training in SSA should remain generalist, with specialisation deferred to the postgraduate level,[54] or whether innovative, context-sensitive, new single-modality exit models should be introduced at the undergraduate level, particularly given the limited availability of cross-sectional imaging equipment for training.[55–61] The existence of standalone programmes in ultrasound, nuclear medicine and radiotherapy in some SSA countries points to alternative models that warrant further investigation.

Additionally, clinical expert skills emerged as the strongest predictors of graduate competence across imaging modalities. Factor analysis showed that competencies in optimal equipment use and patient-centred image acquisition were essential in diagnostic radiography, whereas safe treatment delivery was critical in radiotherapy. This analysis was not intended to compare diagnostic and therapeutic radiography as distinct pathways; rather, it examined how individual skills loaded within each practice area, with the highest loading interpreted as contributing most to how competence in that practice area is defined. In this way, factor analysis makes a vital contribution by distilling broader, modality-specific competency profiles[14,34,46,62–70] and streamlining clusters of expert clinical skills into those that most strongly define graduate readiness, often called threshold competencies.[71] Graduate readiness is widely acknowledged as a complex, multidimensional, context-specific construct.[72] The competencies required extend beyond core imaging, which encompasses broader professional capabilities. The findings of our study support Sloane's[73] position and contribute to this discourse by offering a strategic framework for preregistration curriculum reform. Specifically, the results advocate for early consolidation of high-impact multimodality threshold competencies, followed by structured, modality-specific training pathways in the final year. This staged approach ensures that foundational competence meets regulatory requirements while enabling targeted skill development that is aligned with workforce demands.[14,40,74–76]

Sub-Saharan African health and regulatory systems require graduates to be proficient across multiple imaging domains.[12,14,77] However, as this study demonstrates, compressing comprehensive multimodality expectation into traditional, projection radiography-dominant curricula without designing a new model of radiography education risks undermining the depth of training in cross-sectional imaging. Thus, a single-modality exit model with a multimodality core competency framework presents a sustainable approach to radiography education in low-resource settings. Similar concerns have been raised internationally, where rapid curricular expansion has led to graduates lacking confidence and competence in specialised modalities.[40,78]

Notably, this study underscores the crucial role of clinical placement in fostering competency development across various advanced imaging modalities. Significant correlations existed between clinical exposure and graduate proficiency in computed tomography, medical ultrasound, radiotherapy, magnetic resonance imaging (MRI), and nuclear medicine (ranging from $r = 0.16$ to 0.23, $p < 0.05$), reinforcing the overall importance of

Table 2
Normality test for competency areas.

	Kolmogorov–Smirnov[a]			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Projection radiography	0.113	207	0.000	0.987	207	0.050
Computed tomography	0.092	207	0.000	0.979	207	0.003
Medical ultrasound	0.068	207	0.022	0.978	207	0.002
Radiotherapy	0.156	207	0.000	0.878	207	0.000
Magnetic resonance imaging	0.102	207	0.000	0.966	207	0.000
Nuclear medicine	0.188	207	0.000	0.850	207	0.000
Industry expectation	0.120	207	0.000	0.961	207	0.000
Generic skills	0.137	207	0.000	0.951	207	0.000

[a] Lilliefors Significance Correction.

Table 3
Factors and descriptive analysis of educational programme characteristics.

Category	Pattern Matrix			Please rate the distribution of workload within the programme.					Mean	SD
	Survey item statement	Factor Loadings		Very Low N (%)	Low N (%)	Moderate N (%)	High N (%)	Very High N (%)		
		Taught Content Workload Allocation	Clinical Placement Allocation							
Educational Programme characteristics	Please rate how much the course's taught content is dedicated to projection radiography	0.863		2 (1.1)	4 (2.2)	21 (11.8)	55 (30.9)	96 (53.9)	4.34	0.88
	Please rate how much the course's taught content is dedicated to radiation therapy	0.808		79 (44.4)	40 (22.5)	36 (20.2)	11 (6.2)	12 (6.7)	2.08	1.00
	Please rate how much the course's taught content is dedicated to nuclear medicine	0.779		69 (38.8)	56 (31.5)	38 (21.3)	8 (4.5)	6 (3.4)	2.02	1.05
	Please rate how much the course's taught content is dedicated to medical ultrasound	0.778		24 (13.5)	26 (14.6)	48 (27.0)	47 (26.4)	33 (18.5)	3.22	1.29
	Please rate how much the course's taught content is dedicated to magnetic resonance imaging.	0.610		22 (12.4)	43 (24.2)	74 (41.6)	28 (15.7)	11 (6.2)	2.79	1.05
	Please rate how much the course's taught content is dedicated to computed tomography.	0.564		9 (5.1)	31 (17.4)	73 (41.0)	48 (27.0)	17 (9.6)	3.19	1.00
	Please rate how much clinical placement time is dedicated to medical ultrasound.		1.000	28 (15.7)	21 (11.8)	48 (27.0)	38 (21.3)	42 (23.3)	3.25	1.36
	Please rate how much clinical placement time is dedicated to radiation therapy.		0.854	105 (59.0)	31 (17.4)	25 (14.0)	5 (2.8)	12 (6.7)	1.81	1.19
	Please rate how much clinical placement time is dedicated to projection radiography.		0.791	6 (3.4)	4 (2.2)	20 (11.2)	35 (19.7)	113 (63.5)	4.38	1.00
	Please rate how much clinical placement time is dedicated to nuclear medicine.		0.762	108 (60.7)	41 (23.0)	18 (10.1)	3 (1.7)	8 (4.4)	1.66	1.04
	Please rate how much clinical placement time is dedicated to computed tomography.		0.544	14 (7.9)	28 (15.7)	76 (42.7)	34 (19.1)	26 (14.6)	3.17	1.12
	Please rate how much clinical placement time is dedicated to mammography.		0.517	52 (29.2)	54 (30.3)	43 (24.2)	16 (9.0)	13 (7.3)	2.35	1.20

experiential learning in radiography education.[20,79–81] No correlation was found for projection radiography, which appeared to be more influenced by academic instruction.

These patterns suggest that certain competencies depend more on clinical immersion, although the reasons for these variations remain unclear. Access to projection radiography equipment in educational institutions may reduce dependence on clinical placements. Cross-sectional imaging requires hands-on experience, which is often unavailable in academic settings. MRI's exclusion from factor analysis, despite clinical exposure correlation, raises questions about the impact of equipment access and mentorship on training outcomes; however, empirical evidence for this requires future qualitative exploration.

Interestingly, this study found significant heterogeneity in terms of programme structure, duration, and modality coverage. While projection radiography dominates, cross-sectional modalities and radiotherapy receive limited emphasis in the curriculum and clinical training, as previous studies have shown.[40,73,82,83] This imbalance affects graduate readiness, which necessitates consistent regional standards. International professional bodies advocate for harmonising radiography education globally while maintaining contextual flexibility; thus, curriculum developers must balance breadth and depth using modular approaches or structured post-registration training.

Another consistent finding across all imaging modalities is the heavy reliance on employer-led training to develop essential clinical imaging skills, particularly in cross-sectional imaging modalities and radiotherapy. In CT and MRI, more than 30 % of respondents reported that graduates developed core skills through on-the-job training. Nuclear medicine and ultrasound competencies were frequently reported as either “not developed” or “developed on the job,” highlighting gaps in preregistration training. Previous Sudanese[39] and Australian research[84] reports transitioning challenges for new radiographers. These studies identified that graduates often have limited preregistration exposure to cross-sectional imaging, requiring structured on-the-job training.

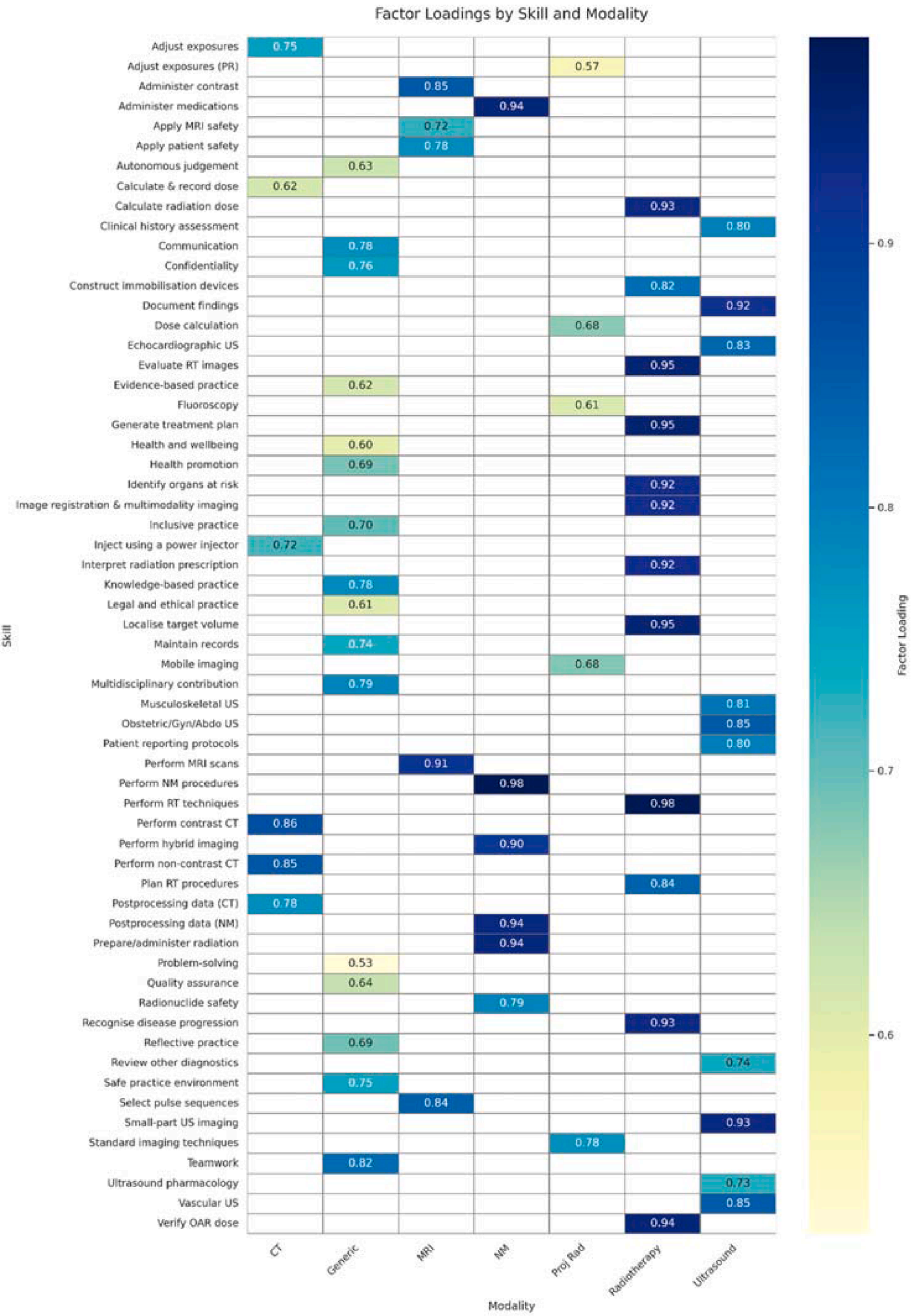
Overreliance on employer-led post-registration training may burden clinical systems, compromise standardisation of training, and delay the development of professional autonomy. The findings of this phase highlight a clear pattern of core skill development being deferred postgraduation. While this study phase reveals an important systemic challenge, it also raises new questions requiring deeper exploration: What are the barriers to more robust clinical exposure? How do stakeholders perceive the current training model? The current phase of this study further revealed a significant mismatch between educational and industry expectations, as discussed below.

A statistically significant negative correlation was found between radiography education components and employer expectations, indicating a misalignment between educational programme characteristics and clinical practice needs. While such gaps exist in high-income countries, particularly in CT and MRI,[40] the misalignment is more evident in low-resource contexts where graduates have limited access to cross-sectional imaging pregraduation.[20,55–61,80,85,86] The causes remain unclear, but may include curricula anchored in traditional paradigms, while industry expectations evolve with technology, and limited academic-clinical collaboration hampers innovative curriculum development. Despite modality-specific gaps, the study demonstrated high competence in professional skills, such as communication and teamwork, which are essential for effective healthcare delivery.

Strengths and limitations

This study's key strengths include wide geographic coverage across 23 sub-Saharan African countries and data triangulation from educators, graduates, and employers. Factor analysis enabled

Table 4
Heatmap visualisation of factor loadings across radiographic skills and imaging modalities, highlighting the strength of the associations between competencies and domains of practice. Darker shades indicate stronger relationships (loadings closer to 1.0), suggesting core skills that should be the focus of the curriculum.



examination of the relationship between the educational components and graduate competence. However, the cross-sectional design and self-reported data limit causal interpretation. A further limitation is the exclusion of standalone programmes in radiotherapy, nuclear medicine or ultrasound. This decision was methodologically necessary to maintain a consistent unit of analysis. Consequently, the study only reflects findings from single diagnostic radiography or those combined with radiotherapy education, as a unit of analysis; as such, they may not capture the full scope of training in countries where these disciplines exist as independent educational pathways.

Conclusion

The study reveals critical insights into radiography education across sub-Saharan Africa, identifying clinical expertise as the primary determinant of graduate competence. Clinical placements are essential for developing proficiency in cross-sectional imaging and radiotherapy. The misalignment between education and industry expectations highlights the need for curriculum reform and enhanced academia-clinical collaboration. While generic professional skills are well integrated, disparities exist in modality-specific training.

Implications for practice and future research

Educational institutions must prioritise threshold competencies and guarantee access to clinical training. Regulators should support post-registration training to address gaps in advanced modalities. The planned qualitative phase will gather stakeholder perspectives on clinical placements and gaps between academia and industry. Longitudinal studies could monitor graduate preparedness and identify models for curriculum reform.

Ethics approval and consent to participate

Ethical approval for this study was obtained from Bournemouth University Ethics Committee (APPROVAL NUMBER/ID 52773).

Written informed consent was obtained for anonymised participant information to be published in this article.

Availability of data

Data required for this study may be made available by the author(s) upon reasonable request.

Author contributions

ES: Conceptualisation, Methodology, Formal Analysis, Data curation, Writing- Original Draft preparation, Visualisation, Investigation, Writing- Reviewing and Editing, funding acquisition, project administration.

JT: Conceptualisation, Validation, Supervision, Writing-Reviewing and Editing.

TNA: Conceptualisation, Validation, Supervision, Writing-Reviewing and Editing, and funding acquisition.

Generative AI use

Not applicable.

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Conflict of interest statement

None. TNA is a current Associate Editor at *Radiography*; however, as an author of this submission, he had no role in or visibility of the handling of the manuscript through the editorial or peer review process.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2025.103221.

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