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Challenges and strategies for retaining Africa's radiography workforce in the continent amidst a competitive global market: Insights from 17 countries

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ABSTRACT

Introduction: African countries face a critical challenge as radiography professionals and other healthcare workers migrate to high-income countries with better-resourced health systems. This study sought to identify the factors influencing the migration of qualified radiography professionals and evaluate the challenges and strategies for retaining the radiography workforce across the continent.
Methods: This quantitative cross-sectional study was conducted using an online questionnaire. The link to the questionnaire was widely advertised through professional body platforms, as well as the professional and social media pages of radiography professionals across Africa. Descriptive, inferential statistics and exploratory factor analysis using principal component analysis were used to examine the data.
Results: A total of 755 radiography professionals from 17 African countries participated. Poor salary was the most commonly cited push factor for migration, reported by 80.00 % of participants. In the exploratory factor analysis, five factors were identified, explaining 55.57 % of the variation in the data on push factors for migration among radiography professionals. These factors include the health system, economic concerns, professional challenges, political issues, and social conditions. Better salaries (86.49 %) and improved living conditions (86.35 %) were the most common pull factors. Additionally, 92.00 % of participants identified improving radiography professionals' salaries as the most effective strategy for reducing migration.
Conclusion: Low salaries, inadequate working conditions, and the pursuit of better opportunities abroad are key contributors to the migration of radiography professionals from Africa. To address this issue, African healthcare systems must prioritise improving remuneration, enhancing working conditions, investing in health infrastructure, and implementing targeted policies focused on professional development and career growth.

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Implication for practice: Retaining radiography professionals in Africa requires a multifaceted approach to strengthen the workforce and improve healthcare systems.

Introduction

The global shortage of healthcare professionals is a critical concern, intensified by the increasing demand for medical services in the post-COVID-19 era. Despite efforts to expand the healthcare workforce, the gap between demand and supply remains substantial,[1] necessitating urgent attention. Countries around the world are striving to retain their healthcare workers while competing globally to attract foreign talent by offering better working conditions, competitive remuneration, and other incentives.

Africa, along with other low-income countries faces a significant challenge in retaining their skilled healthcare professionals amidst this global competition. A key issue facing Africa's healthcare sector is the emigration of highly skilled healthcare professionals including radiography professionals to high-income countries.[2] The impact of this migration on Africa's healthcare systems is profound.[3] Méango[4] notes that high-skilled workers in Sub-Saharan Africa are significantly more likely to migrate than their low-skilled counterparts. This exodus deepens the already critical shortages of healthcare workers, undermining healthcare delivery and contributing to negative health outcomes.[5,6]

Radiography professionals, also referred to in this study as radiographers, radiologic technologists, medical imaging technologists, or medical radiation practitioners, among other titles, are essential healthcare professionals facing workforce shortages, particularly in Africa.[7] A report on the radiography workforce in 47 out of the 54 countries in Africa estimates the number of radiography professionals at 25,804,[7] which is lower than the national workforce strength of the United Kingdom, which has about 43,550 such professionals.[8] These low radiography workforce numbers suggest that a lack of retention and insufficient training of new radiography professionals on the continent could impact medical imaging and radiotherapy services, which are vital for accurate diagnoses and effective treatment of critical health conditions. This migration trend has intensified in recent years, driven by a range of factors broadly categorised into push and pull factors.[9]

Push factors are conditions within the home country of the professional that compel them to leave, while pull factors are those in destination countries that attract migrants.[10] Push factors typically associated with countries of origin include poverty, limited social mobility, violence, political instability, and insufficient opportunities for career advancement.[11,12] In the case of radiography, specific push factors include unfavourable government policies, limited access to postgraduate training, lack of advanced technology for research and practice, low wages, and poor working conditions.[2,13] Conversely, pull factors associated with destination countries include improved living conditions, better health infrastructure, better professional growth opportunities, supportive work environments, higher wages, improved safety, and superior working conditions.[2,14]

The Special Working Group on the World Health Organization (WHO) Constitution highlighted the issue of brain drain in Africa and recommended that the WHO ask member states to assess the factors related to the migration of health professionals.[15] Despite the importance of this issue, there is a notable lack of research on the specific push and pull factors influencing the migration of radiography professionals from Africa to high-income countries. While general studies on health worker migration exist, they often overlook or do not adequately focus on the unique experiences and motivations of radiography professionals. This research gap limits the development of strategies aimed at retaining radiography professionals and ensuring the continent maintains a sufficient workforce to deliver safe and high-quality healthcare.

This study, therefore, sought to fill this gap by investigating the complex interplay of push and pull factors that influence the migration of qualified radiography professionals from Africa. It aims to provide targeted policy recommendations, and to explore strategies to improve the retention of radiography professionals and subsequently retain adequate numbers of these professionals within the continent for effective healthcare delivery, thereby strengthening healthcare services across the continent.

Methods

Study design

After obtaining ethical approval (see the Ethics and Declaration section) in accordance with research ethics principles,[16] a cross-sectional study design was used to distribute the survey questionnaire (see supplementary file 1) to radiography professionals across Africa. The link to the questionnaire was widely advertised through the radiography professional bodies' platforms, and social media pages across Africa. This approach was selected to facilitate the collection of data from a large number of radiography professionals across the continent. The design was selected because it facilitated and allowed for efficient and cost-effective data collection across the continent, enabling appropriate conclusions about the variables of interest.[17,18]

Study population

The exact size of the radiography workforce in Africa is not well-documented. However, at the time of this study, an estimate from a recent study[7] suggested that there were approximately 25,804 radiography professionals (also referred to, per the article,[7] as technicians in medical imaging and equipment operations) across 47 of the 54 countries. The current study was open to all practising radiography professionals in Africa and the required minimum sample size was calculated using the calculator.net mathematical software tool.[19] Based on the determined population estimate, a minimum sample size of 700 radiography professionals was determined to be sufficient for generating meaningful statistical inferences.

Data collection

The questionnaire was developed by adapting questions from a previous study by Ohene-Botwe et al.[2] which originally focused on a national context. A pilot study was conducted among radiography professionals in Ghana to assess the validity and clarity of the questionnaire, leading to necessary revisions before deployment in the main study. The questionnaire was designed to align with the study's aims and objectives and consisted of mainly close-ended questions, with one item asking participants to write down their age. This was necessary to generate descriptive statistics, such as the median and interquartile range, to provide a concise summary of the age distribution among participants. The five-sectioned questionnaire consisted of demographic information such as country of practice, age, gender, educational level, and specialty (Section A), information on radiography professionals' intentions to migrate, modes of migration, and whether they planned to return to their home countries after seeking better opportunities abroad (Section B), examination of the push and pull factors influencing radiography professionals' migration decisions using a 5-point Likert scale. In particular, this section included 22 push factors categorised into economic (4 items), health system (5 items), professional (5 items), social (4 items), and political (4 items) factors. For pull factors, 28 items were included under similar themes: economic (5 items), health system (5 items), professional (7 items), social (7 items), and political (4 items). Section D of the questionnaire investigated the implications of the migration on their practice in their respective countries, while Section sought participants' opinions on immediate implementable measures that could encourage radiography professionals to remain in their home countries.

Due to resource constraints, the questionnaire was not translated into other languages. Participation was therefore limited to radiography professionals in English-speaking countries, and acknowledged as a limitation of the study. The questionnaire was hosted on Google Forms and distributed through professional radiography networks and radiography-specific social media groups (e.g., WhatsApp, Twitter, Facebook, and LinkedIn) to maximise participation. A combination of convenience and snowball sampling methods was employed to recruit participants.

Data analysis

Both descriptive and inferential statistics were generated using Stata 13.1 and the statistical significance of the inferential statistics was set at a 95 % ($p = 0.05$) level. The first step on the data involved cleaning and scanning the data for out-of-range values using frequency distribution tables, box and whisker plots as well as histograms. Continuous variables were checked for normality, and normally distributed variables were summarised using mean and standard deviation, while those deviating from normality were reported using median and interquartile ranges. Categorical variables were summarised using frequencies (counts) and percentages. The questions on the 5-point Likert scale were scored 1–5 where; 1 = strongly disagree to 5 = strongly agree. The Cronbach's alpha of the push and pull factors combined was 0.95.

Exploratory factor analysis (EFA) using principal component analysis (PCA) was conducted on the data to examine the push and pull factors of migration. In particular, the PCA groups these factors into distinct components, allowing for better understanding of which factors most significantly influence migration.[20] Data was divided into push factors (22 items) and pull factors (28 items), and then checked suitability for factor reduction. The first assumption to be checked was a correlation, with the resultant correlation matrix for both push and pull factors showing several coefficients with $r \geq 0.3$, thus, indicating a high correlation among factors for factor analysis.[20] The Bartlett test of sphericity showed a p-value of <0.001 for both push and pull factor items, which confirmed a strong correlation for the application of dimensionality reduction.[20] The Kaiser-Meyer-Olkin measures of sampling adequacy were 0.90 for push factors and 0.94 for pull factors, and also confirmed the adequacy of the sample for factor analysis.[21]

Factor extraction was conducted using PCA, retaining factors with eigenvalues >1, in accordance with Kaiser's criterion.[22] Scree plots were used to visualise the factors and determine the number of factors to retain. Varimax rotation was used for factor rotation, and items with factor loadings of at least 0.4 were considered to contribute to the factor.[21,23] Internal consistency was assessed using Cronbach's alpha with a threshold of 0.7.[24] The overall Cronbach's alpha for the 22 push factors and pull factors were 0.88 and 0.94, respectively.

Results

Demographics

A total of 755 radiography professionals from 17 African countries (as detailed in Fig. 1) participated in this study. This was higher than the estimated sample size of 700, suggesting that the increased sample size strongly impacted the statistical outcomes, providing a more reliable and robust dataset for analysis. The median (interquartile range) age was 30 (26; 37) years and most respondents were males (72.05 %), which reflects the common trends of demographics of African radiographers. Slightly more than half of the radiography professionals (52.05 %) had a first degree as their highest level of education. More than a quarter of the radiography professionals (26.23 %) were practising in Nigeria (Fig. 1). Further details on the country distribution of radiography professionals are presented in Appendix 1. Table 1 shows the demographic findings in detail.

X-ray machines were by far the most common type of equipment used by radiography professionals in their day-to-day execution of duties. Ultrasound machines and CT scanners were second and third, respectively, while MRI scanners were a distant fourth. Only 54 radiography professionals identified LINAC machines to be their most used equipment. These findings are shown in Fig. 2. Additionally, 663 participants (83.84 %) indicated that they have the intention to practice in another country if the opportunity arises, while only 122 participants (16.16 %) stated that they have no such intention. When asked about their most preferred country to work in, 636 participants mentioned 52 countries in total, while the rest of the respondents did not respond. The top 4 preferred countries of work were United Kingdom ($n = 193$; 30.35 %), Canada ($n = 110$; 17.30 %), Australia ($n = 75$; 11.79 %) and United States ($n = 66$; 10.38 %) and preferred by 444(69.81 %) of the respondents. Further details on the distribution of the preferred destination country for radiography professionals are presented in Appendix 2.

Push factors of migration among radiography professionals

Poor salaries were the most common push factors for migration amongst radiography professionals as confirmed by 80 % of respondents (Agree – 24.5 %; Strongly agree – 55.5 %). Other push factors of note were the desire to fulfil self-aspirations (76.82 % [Strongly agree – 45.56 %; Agree – 31.26 %]), devaluation of the country's currency (71.79 % [Strongly agree – 46.09 %; Agree – 25.7 %]), and poor economic policies (71.52 % [Strongly agree – 44.24 %; Agree – 27.28 %]). These findings are presented in detail in Fig. 3.

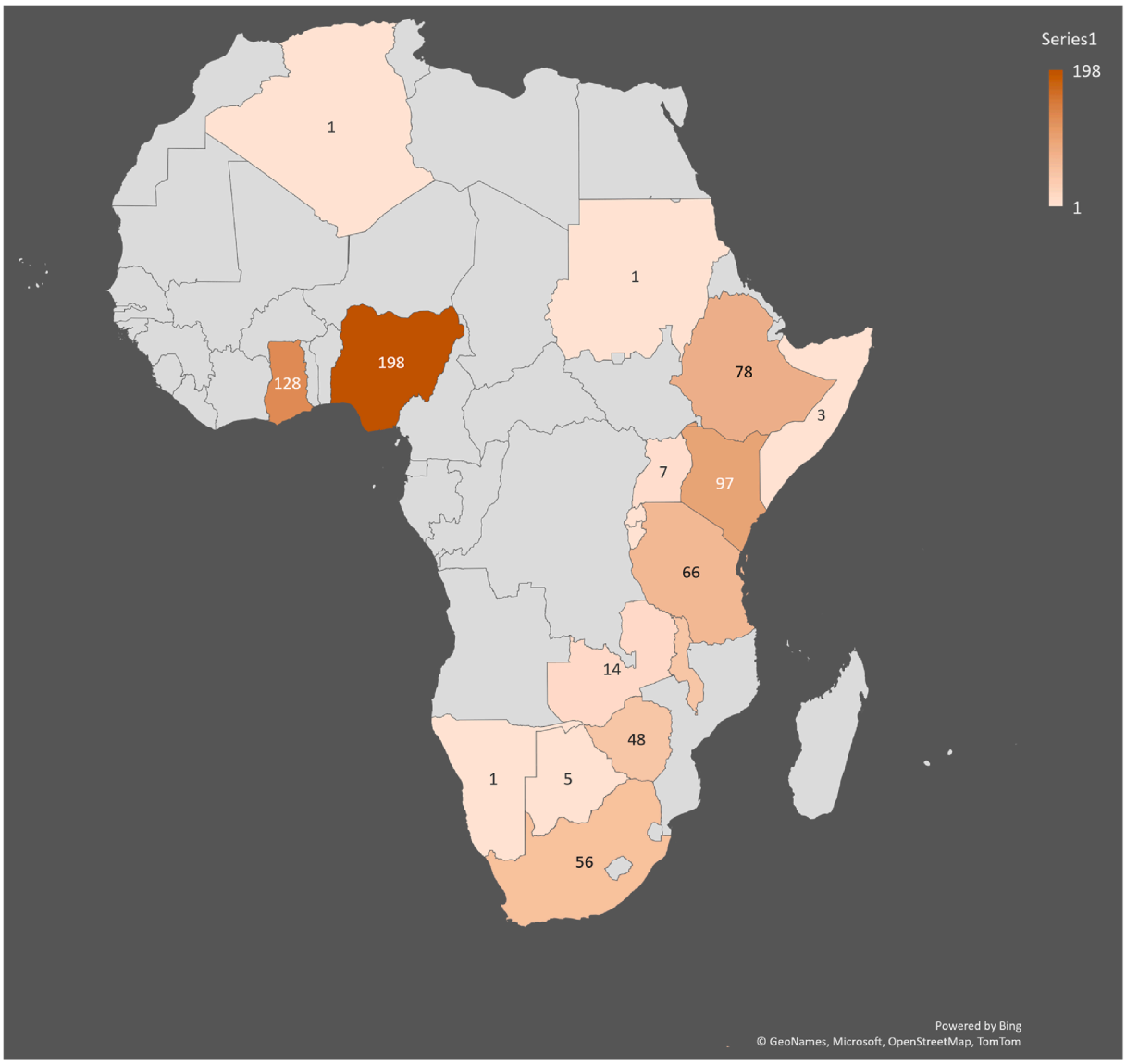

Figure 1. Country distribution of respondents.

In the exploratory factor analysis, five factors named Health system, Economic, Professional, Political, and Social were identified which explained 55.57 % of the variation in the data on push factors of migration amongst radiography professionals. Health system factors had the highest eigenvalue of 6.39 accounting for 29.03 % of the variation in the data, of which poor health infrastructure had the highest factor loading of 0.75. Economic factors had the second highest eigenvalue of 1.75, accounting for 7.97 % of the variation in the data. Under economic factors, poor living conditions and devaluation of the country's currency had the highest factor loading of 0.73 each. Social factors showed the lowest eigenvalue of 1.17 in this five-factor model, explaining 5.34 % of the variation in the data. The desire to fulfil self-aspirations had the highest factor loading (0.83) compared to other social factors. These findings are presented in Tables 2 and 3.

Pull factors of migration among radiography professionals

Better salaries and better living conditions were the top common pull factors among radiography professionals, with 86.49 % and 86.35 % of radiography professionals strongly agreeing/agreeing to these statements respectively. Other notable pull factors worth mentioning include better health infrastructure (83.84 % [strongly agree – 56.42 %, agree – 27.42 %]), opportunities to gain better clinical experience (83.31 % [strongly agree – 55.76 %, agree – 27.55 %]) and several career advancement and training opportunities (82.39 % [strongly agree – 52.32 %, agree – 30.07 %]). These findings are presented in Fig. 4.

Exploratory factor analysis of the data on pull factors of migration produced a six-factor model explaining 64.76 % of the variation in data. Factor 1, with an eigenvalue of 10.44 and explaining 37.29 % of the variation in the dataset had professional

Table 1
Demographics of the study participants.

Variable	Categories	Frequency, *n*(%)
Gender	Male	544 (72.05)
	Female	209 (27.68)
	Prefer not to say	2 (0.26)
Education	Diploma	148 (19.60)
	First degree	391 (52.05)
	Postgraduate certificate/Diploma	99 (13.11)
	MSc/MPhil	94 (12.45)
	MBA	1 (0.13)
	Ph.D. or equivalent	20 (2.65)
Marital status	Single	387 (51.26)
	Married	365 (48.34)
	Divorced	3 (0.40)
Years of experience (years)	5 and below	365 (48.34)
	6–10	185 (24.50)
	11–15	115 (15.23)
	16–20	41 (5.43)
	21–25	17 (2.25)
	26 or more	32 (4.24)
Area of specialty	Diagnostic radiography	619 (81.99)
	Therapy radiography	30 (3.97)
	Both diagnostic & therapy radiography	96 (12.72)
	Clinical applications trainer	1 (0.13)
	Interventional radiography	1 (0.13)
	Diagnostic radiography & nuclear medicine imaging	1 (0.13)
	Nuclear medicine imaging	1 (0.13)
	Sonography	2 (0.26)
	Therapy radiography & sonography	1 (0.13)
	Lectureship	2 (0.26)
	Ultrasonography & radionuclide imaging	1 (0.13)
Current role title	Clinical radiographer	556 (73.64)
	Clinical academic radiographer	76 (10.07)
	Academic radiographer	15 (1.99)
	Academic radiographer/Radiologic technologist	21 (2.78)
	Fresh graduate/Intern radiographer	39 (5.16)
	Interventional radiographer	1 (0.13)
	Quality assurance officer	1 (0.13)
	Therapy radiographer- clinical	2 (0.26)
	Radiology manager	30 (3.97)
	Research radiographer	7 (0.93)
	Research radiographer/Radiologic technologist	2 (0.26)
	Retired radiographer	5 (0.66)
Structure of facility	Government facility	483 (63.97)
	Military facility	14 (1.85)
	Mission facility	1 (0.13)
	Non-governmental organization	5 (0.66)
	Not yet hired	1 (0.13)
	Private public partnership	1 (0.13)
	Partly government & partly private	1 (0.13)
	Private facility	216 (28.61)
	Quasi-government facility	33 (4.37)

Note: Radiographers, also referred to in this study as radiography professionals, radiologic technologists, medical imaging technologists, or medical radiation practitioners, among other titles.

factors loading heavily on it. Opportunity for professional networking had the highest factor loading of 0.74, while opportunity for research had the second highest factor loading of 0.73 on factor 1. Factor 2, with an eigenvalue of 2.35, and explaining 8.38 % of the variation in data, had health system factors loading on it. Adequate equipment and supplies had the highest factor loading on this factor (0.82) followed by better health infrastructure (0.80). The other factors in this six-factor model were economic, political, social acceptance and social adventure with eigenvalues of 1.77; 1.44; 1.13 and 1.00, respectively. These findings are presented in Tables 4 and 5.

Effects of migration

Shortage of academic and clinical personnel to train radiography professionals was identified by 640 participants (85 %) as the most common effect of radiography professionals' migration from their home countries. Other identified effects of migration include increased workload on the remaining radiography professionals, decreased quality of healthcare delivery, and patient dissatisfaction among others as shown in Fig. 5.

Measures to curb migration

Radiography professionals identified several measures to curb migration. Improving salaries was the most common measure as identified by 695 (92.00 %) radiography professionals. Other measures include availing career advancement opportunities to radiography professionals, provision of better conditions of service within hospitals, and provision of comprehensive free health insurance for them and their immediate family. These findings are presented in Fig. 6.

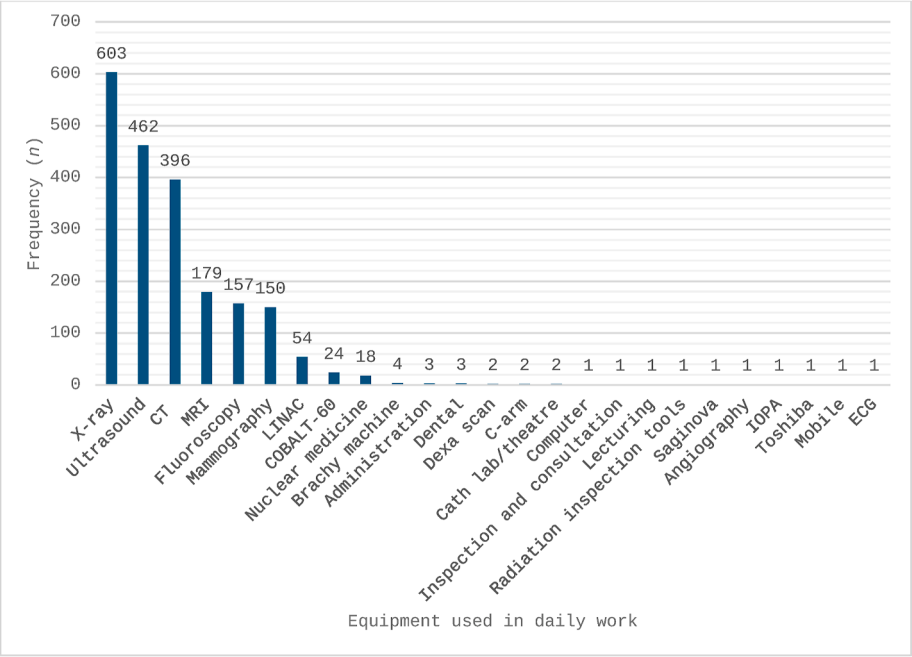

Figure 2. Type of equipment used for daily work.

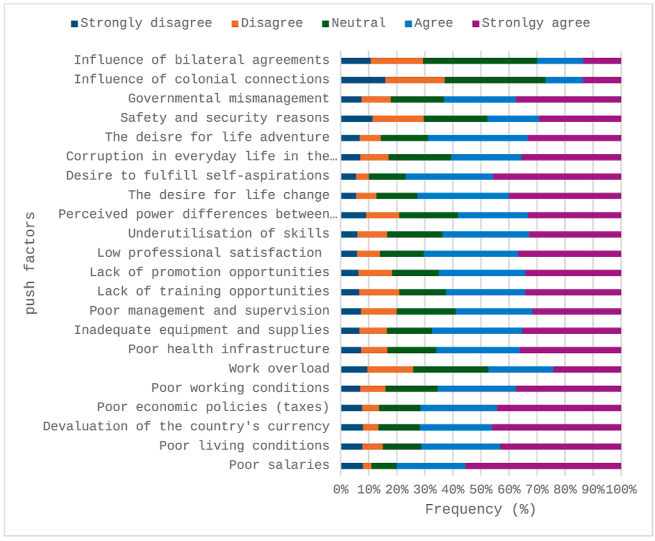

Figure 3. Push factors of migration among radiography professionals.

Discussion

Radiography professionals are integral to both the diagnostic and therapeutic components of healthcare and play pivotal roles in achieving good health and well-being as outlined in the Sustainable Development Goal (SDG) 3 agenda.[25] However, there is a growing global concern about the shortage of radiography professionals, particularly in rural and remote areas, in both developed and developing nations. According to Ahmat et al.,[7] this concern is more pronounced in developing nations. In African countries, challenges in retaining these professionals are exacerbated by migration trends reflecting broader patterns of global health worker mobility.[26] These dynamics place additional strain on healthcare systems already grappling with resource constraints and inequitable workforce distribution.[2]

This study delves into the complex interplay of push and pull factors influencing the migration of qualified radiography professionals from Africa. It reveals that 83.84 % of respondents indicated an intention to practice in another country if the opportunity arises. Among the 636 participants who provided preferences, 52 countries were identified as potential destinations. The United Kingdom emerged as the most preferred country ($n = 193$; 30.35 %), followed by Canada ($n = 110$; 17.30 %), Australia ($n = 75$; 11.79 %), and the United States ($n = 66$; 10.38 %). These four nations accounted for 69.81 % of the preferred destinations of these skilled professional.

The concentration of preferences toward high-income countries highlights the strong pull factors driving migration, which, according to Capuano & Marfouk,[5] include better remuneration, advanced career development opportunities, and improved working conditions.[6] These findings align with a previous study, such as those by Ohene-Botwe et al.,[2] which documented similar trends among Ghanaian radiographers migrating to high-income nations.

Table 2
Description of push factors and their variance analysis.

Factor	Description	Eigen value	Proportion of variance[a]	Cumulative variance[a]
1	Health system	6.34	29.03	29.03
2	Economic	1.75	7.97	37.01
3	Professional	1.57	7.12	44.13
4	Political	1.34	6.10	50.23
5	Social	1.17	5.34	55.57

[a] Unrotated.

Table 3
Factor loadings of push factors of migration.

Statement	Factor loading				
	Factor 1 ($\alpha = 0.80$)	Factor 2 ($\alpha = 0.78$)	Factor 3 ($\alpha = 0.75$)	Factor 4 ($\alpha = 0.72$)	Factor 5 ($\alpha = 0.71$)
Poor health infrastructure	**0.75**	0.22	0.06	0.10	0.11
Inadequate equipment and supplies	**0.74**	0.12	0.18	0.14	0.15
Poor management and supervision	**0.69**	0.20	0.14	0.07	0.08
Poor working conditions	**0.67**	0.17	0.24	0.02	0.09
Work overload	**0.60**	0.12	0.15	0.20	0.01
Poor living conditions	0.17	**0.73**	0.16	0.04	0.11
Devaluation of country's currency	0.13	**0.73**	0.11	0.18	0.12
Poor salaries	0.17	**0.72**	0.13	−0.02	0.13
Poor economic policies (taxes)	0.25	**0.70**	0.07	0.08	0.18
Lack of training opportunities	0.16	0.08	**0.69**	0.15	0.03
Lack of promotion opportunities	0.09	0.21	**0.67**	0.16	0.12
Underutilisation of skills	0.18	0.14	**0.65**	0.16	0.15
Low professional satisfaction	0.30	0.07	**0.64**	0.08	0.18
Perceived power differences	0.14	0.17	**0.58**	0.06	0.20
Influence of colonial connections	0.10	0.04	0.07	**0.79**	0.15
Influence of bilateral agreements	0.10	−0.01	0.14	**0.71**	0.11
Safety and security reasons	0.09	0.12	0.12	**0.69**	0.02
Governmental mismanagement	0.17	0.24	0.17	**0.60**	0.05
Desire to fulfil self-aspirations	0.10	0.10	0.07	0.08	**0.83**
Desire for life change	0.08	0.16	0.13	0.03	**0.81**
Desire for life adventure	0.14	0.14	0.17	0.26	**0.63**
Corruption in everyday life	0.05	0.26	0.20	0.26	**0.40**

Bold values indicate the highest factor loading for each item, suggesting the factor to which the item is most strongly related.

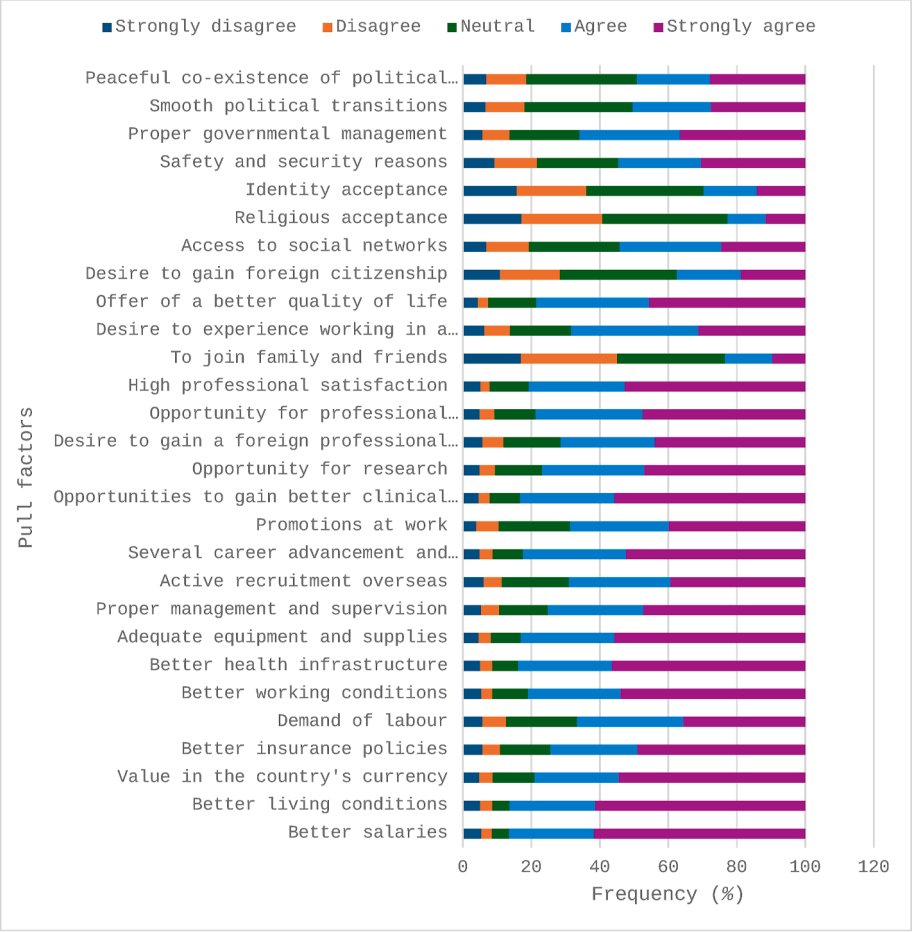

Figure 4. Pull factors of migration among radiography professionals.

The implications of these trends are far-reaching. The potential loss of such a high proportion of clinical radiography professionals poses a severe threat to healthcare delivery in Africa, particularly in diagnostic imaging and radiotherapy services that are critical for disease detection and treatment planning and therapeutic interventions. Without an adequate workforce, healthcare systems

Table 4
Description of pull factors and their variance analysis.

Factor	Description	Eigenvalue	Proportion of variance[a]	Cumulative variance[a]
1	Professional	10.44	37.29	37.29
2	Health system	2.35	8.38	45.67
3	Economic	1.77	6.33	52.00
4	Political	1.44	5.15	57.15
5	Social acceptance	1.13	4.04	61.19
6	Social adventure	1.00	3.58	64.76

[a] Unrotated.

Table 5
Factor loadings of pull factors of migration.

Statement	Factor loading					
	Factor 1 ($\alpha = 0.89$)	Factor 2 ($\alpha = 0.88$)	Factor 3 ($\alpha = 0.85$)	Factor 4 ($\alpha = 0.85$)	Factor 5 ($\alpha = 0.73$)	Factor 6 ($\alpha = 0.72$)
Opportunities for professional networking	**0.74**	0.21	0.08	0.19	0.02	0.24
Opportunities for research	**0.73**	0.20	0.20	0.15	0.07	0.06
Opportunities to gain better clinical experience	**0.72**	0.25	0.27	0.11	0.09	−0.02
High professional satisfaction	**0.71**	0.23	0.13	0.14	0.07	0.19
Desire for foreign professional qualification	**0.70**	0.16	0.16	0.15	0.03	0.23
Several career advancement and training opportunities	**0.66**	0.30	0.18	0.12	0.14	0.01
Promotions at work	**0.66**	0.19	0.16	0.14	0.14	0.07
Adequate equipment and supplies	0.24	**0.82**	0.23	0.13	0.08	0.05
Better health infrastructure	0.22	**0.80**	0.25	0.15	0.10	0.07
Better working conditions	0.21	**0.75**	0.28	0.16	0.09	0.04
Proper management and supervision	0.23	**0.74**	0.20	0.09	0.06	0.17
Active overseas recruitment	0.28	**0.52**	0.19	0.14	0.03	0.38
Better living conditions	0.24	0.24	**0.80**	0.10	0.12	0.02
Better salaries	0.22	0.25	**0.76**	0.13	0.08	−0.03
Value of country's currency	0.13	0.30	**0.74**	0.11	0.08	0.20
Better insurance policies	0.15	0.26	**0.69**	0.13	0.08	0.26
Demand for labor	0.22	0.22	**0.40**	0.24	0.11	0.28
Smooth political transitions	0.13	0.14	0.11	**0.82**	0.15	0.11
Peaceful coexistence of political parties	0.16	0.08	0.11	**0.80**	0.12	0.12
Proper governmental management	0.19	0.23	0.13	**0.75**	0.07	0.16
Safety and security reasons	0.16	0.11	0.11	**0.72**	0.14	0.07
Religious acceptance	0.08	0.10	0.13	0.19	**0.81**	0.03
Identity acceptance	0.12	0.07	0.10	0.15	**0.79**	0.14
To join family and friends	0.04	0.13	0.09	0.05	**0.62**	0.19
Desire for foreign citizenship	0.10	0.10	0.06	0.18	**0.47**	0.45
Desire to experience working in a different environment	0.25	0.14	0.14	0.18	0.14	**0.68**
Access to social networks	0.14	0.09	0.09	0.27	0.31	**0.62**
Offer of a better quality of life	0.27	0.19	0.27	0.23	0.09	**0.58**

Bold values indicate the highest factor loading for each item, suggesting the factor to which the item is most strongly related.

risk becoming overburdened, and the capacity to meet patient needs and progress toward achieving SDG 3 are diminished and severely hindered.

Push factors of migration among radiography professionals

In this study, 80 % of the respondents attributed low salaries as the main driving reason to leave their positions. Other studies on the African continent have reported similar findings. Consistent with this, a study by Ohene-Botwe et al.,[2] ranked poor salaries as the first push factor driving the migration of Ghanaian radiography professionals to high-income countries, while a South African study found that working conditions and poor remuneration play a significant role in job satisfaction amongst radiography professionals employed by public tertiary hospitals in the Gauteng province.[27] Similarly, a systematic review of 107 studies that synthesised the factors influencing healthcare workers' intentions to migrate from low- and middle-income countries, identified poor remuneration as the primary driver of migration.[28] Poor salaries are a significant finding that reflects the broader economic struggles faced by healthcare professionals in Africa. However, while poor salary is the most cited reason for leaving, this study also observed other related push factors, such as the desire to fulfil personal aspirations. This suggests that the migration crisis is multifaceted and driven by both financial and personal motivations.

The exploratory factor analysis emphasises this complexity by identifying five main contributors—health system, economic, professional, political, and social factors—explaining why radiography professionals seek opportunities abroad. Notably, the emphasis on health system factors—inferior infrastructure—highlights pressing systemic healthcare issues that must be addressed to enhance retention.

Pull factors of migration among radiography professionals

The analysis of pull factors, on the other hand, reveal that better salaries and living conditions are the foremost attractions for radiography professionals considering migration, with overwhelming agreement from respondents in the current study. These findings are consistent with existing literature from across the African continent.[2,29,30] The opportunity for improved health infrastructure and clinical experience further adds to the allure of relocating. The exploratory factor analysis of these pull factors

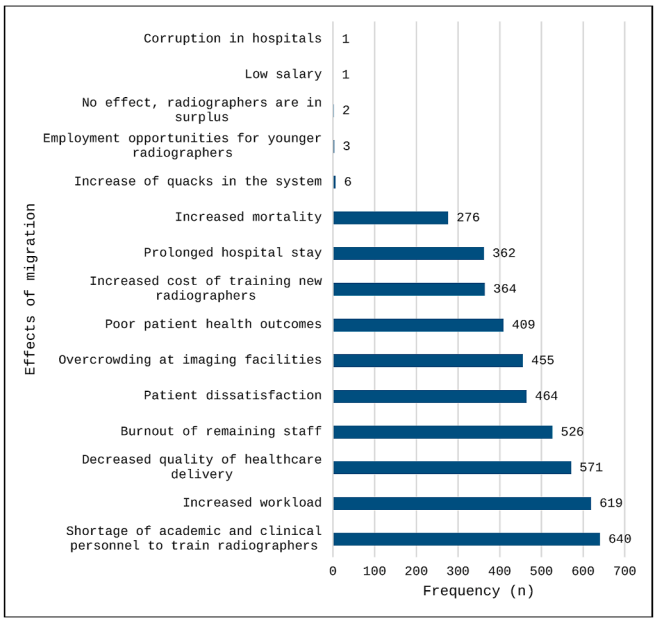

Figure 5. Effects of radiography professionals' migration on radiography practice and healthcare.

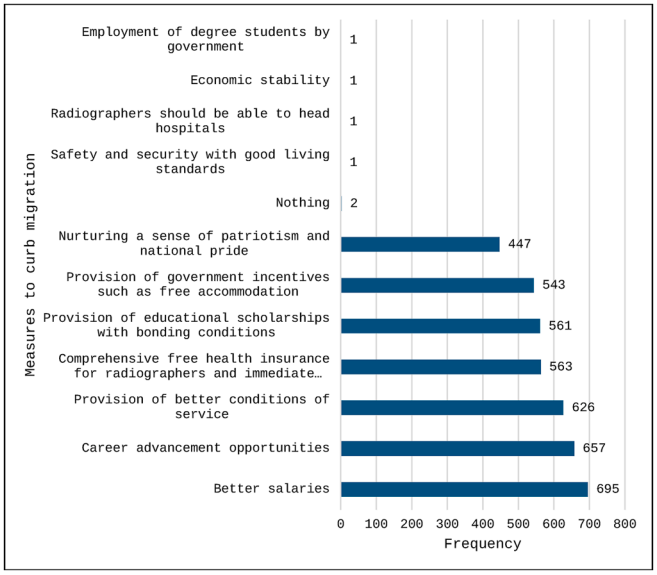

Figure 6. Measures to curb migration.

delineates a six-factor model, with professional factors being the most influential. This further highlights the importance of professional growth and networking opportunities in retaining talent within the field of radiography. The findings encourage healthcare systems to explore ways to enhance working conditions and professional opportunities to mitigate the brain drain effect.[26]

The interplay of push and pull factors identified in the current study is consistent with Lee's Push-Pull Theory of Migration.[31] Lee categorises the factors influencing the decision to migrate and the migration process into four distinct groups: (i) factors related to the area of origin, (ii) factors associated with the area of destination, (iii) intervening obstacles, and (iv) personal factors. This perspective is further supported by Mejia, Pizurki, and Royston,[32] who assert that migration is influenced by a complex array of forces operating at both the origin and destination. These forces encompass political, social, economic, legal, historical, cultural, and educational dimensions, which together shape migration patterns. By recognising the political, social, economic, legal, historical, cultural, and educational dimensions that influence migration patterns, healthcare systems can develop comprehensive strategies to retain an adequate number of these professionals within the continent for effective healthcare delivery.

Effects of migration

The significant shortage of academic and clinical radiography professionals due to migration, as acknowledged by 85 % of participants, highlights a serious consequence of the current migration trend. This shortage increases the workload and stress for the remaining staff and also undermines the quality of healthcare delivery, leading to patient dissatisfaction.[30]

The cyclical nature of this issue implies that inadequate staffing can create conditions that drive even more migration, making it essential to urgently address this problem. The migration of radiography professionals from African countries results in the loss of valuable and costly training investments.[33] Additionally, many African countries are experiencing significant increases in the incidence and prevalence of infectious diseases, such as COVID-19, AIDS, malaria, and tuberculosis. This places even greater demands on already overburdened healthcare systems.[34]

Specific strategies

To effectively address the shortage of radiography professionals and strengthen the workforce across the continent, several targeted strategies must be implemented. These include offering competitive salaries, creating clear pathways for career advancement, improving working conditions within healthcare facilities, and providing comprehensive health insurance for radiography professionals and their families. These recommendations closely align with those of previous studies.[2,27,29] Additionally, training more radiography professionals through a scholarship scheme that requires graduates to work within the sector for a specified period would be a viable solution. This strategy was successfully employed in Ghana's nursing sector until workforce levels were sufficient to discontinue the practice.[35] Furthermore, Ohene-Botwe et al.[2] have emphasised the importance of expanding radiography training programmes both to meet local demand and to address unemployment issues through the potential export of skilled professionals. In cases where the number of local teaching staff is inadequate, supplementing the workforce with foreign lecturers can be a viable solution. These lecturers may be engaged on a full time or part time basis, and where appropriate, can also contribute remotely. This flexible approach helps to address critical teaching gaps while enhancing the overall capacity of the education system. Additionally, universities should be provided with adequate support to expand their training capacities to, enable more students to pursue radiography—particularly considering the high number of qualified applicants turned away due to limited admission slots. Finally, providing additional incentives, such as housing for radiography workers could further help attract and retain talent, particularly in underserved, remote and rural areas.

Strengths & limitations

This study is limited by its self-reported data, which may be subject to bias and subjectivity. However, self-reported data, despite its limitations, can provide valuable quantitative insights into the motivations, intentions, and trends among radiography

professionals regarding migration. The cross-sectional design of the study limits the ability to infer causality between identified factors and migration intentions. The lack of qualitative data may hinder a deeper understanding of the personal narratives and experiences of radiography professionals who migrate. The study's temporal context may impact the relevance of findings due to the rapidly evolving socio-economic and political landscape in Africa. Due to resource constraints, the questionnaire was not translated into other languages, limiting participation to radiography professionals in English-speaking countries. As a result, the study's findings cannot be generalised to non-English-speaking countries or those with lower participation from the professional radiography workforce. Also, the study does not evaluate existing policies or their effectiveness in addressing retention challenges among radiography professionals. Additionally, it does not account for global trends in labour mobility that may influence migration patterns. These limitations suggest the need for further research with a broader range of healthcare professionals and diverse methodologies. To the best of our knowledge, this is the first exploration into the push and pull factors driving migration trends among the radiography workforce in Africa. The study has achieved an optimal response which is deemed statistically appropriate for the generalisability of the findings and thus, inferences from these findings need to be interpreted against this background.

Conclusions

The migration of radiography professionals from African countries presents a significant challenge to achieving good health and well-being, as outlined in SDG Goal 3. Contributing factors such as low salaries, poor working conditions, and the pursuit of better opportunities abroad exacerbate this migration crisis. To address this issue, African healthcare services or systems must implement targeted policies to enhance working conditions, improve remuneration, and invest in health infrastructure. Additionally, fostering professional development and career growth opportunities can encourage radiography professionals to remain and thrive in their roles within their home countries.

As a strategic action plan, key policy interventions should focus on:

- Raising salaries and improving financial incentives to enhance job competitiveness.
- Enhancing workplace conditions by providing better equipment, support, and resources.
- Establishing mentorship and professional development programmes to promote career growth.
- Strengthening healthcare infrastructure to equip professionals with the necessary tools for effective service delivery.

To achieve this, healthcare policymakers, institutional leaders, and educational bodies must collaborate on these strategies, ensuring that Africa's radiography workforce is not only retained but also empowered to meet the growing healthcare needs of the continent. In addition to these efforts, future research should explore the personal narratives of migrating radiography professionals through qualitative methodologies, providing deeper insights into the motivations and challenges driving this trend. Longitudinal studies will also be essential to evaluate the long-term impact of retention strategies and ensure their effectiveness over time.

Ethics approval and consent to participate

This study is part of a larger research project (RADIOGRAPHY-Workforce-AFRICA), which received ethical approval from the Ethics and Protocol Review Committee of the University of Ghana School of Biomedical & Allied Health Sciences (SBAHS/AA/RAD/21847/2022–2023).

Availability of data

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

Author contributions

B. O–B., W. K. A., C. A., T. N. A., L-S. M., B. C., S. N. A: Conceptualisation, Methodology, B. O.-B., W. K. A., C. A., T. N. A., L.-S. M., B. C., S. N. A. Q., M. Y. D., S. S. M., C. B., M. J. K., J. S., R. S., S. M., J. Z. D.: Visualisation, Investigation, B. O.-B., W. K. A., C. A., T. N. A, D., C. M., R. A: Supervision; Validation, B. O–B., W. K. A., C. A., T. N. A., L.-S. M., B. C., S. N. A. Q., M. Y. D., S. S. M., C. B., M. J. K., J. S., B. O–B., L.-S. M: Software, B. O–B., L.-S. M: Formal Analysis, Resources, B. O–B., W. K. A., C. A., T. N. A., L.-S. M., B. C., S. N. A: Data curation, Writing- Original Draft preparation, B. O–B., W. K. A., C. A., T. N. A., L.-S. M., B. C., S. N. A. Q., M. Y. D., S. S. M., C. B., M. J. K., J. S., R. S., S. M., J. Z. D., C. M., R. A: Writing- Reviewing and Editing.

Generative AI use

Not applicable.

Conflict of interest statement

None.

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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.2025.103001.

Appendix 1. Further details on the distribution of radiography professionals by country

Country	Frequency (*n*)	Percentage (%)
Algeria	1	0.13
Botswana	5	0.66
Burundi	1	0.13
Ethiopia	78	10.33
Ghana	128	16.95
Kenya	97	12.85
Malawi	47	6.23
Namibia	1	0.13
Nigeria	198	26.23
Rwanda	4	0.53
Somalia	3	0.4
South Africa	56	7.42
Sudan	1	0.13
Tanzania	66	8.74
Uganda	7	0.93
Zambia	14	1.85
Zimbabwe	48	6.36

Appendix 2. Further details on the distribution of preferred destination country for radiography professionals

Country	Frequency (*n*)	Percentage (%)
United Kingdom	193	30.35
Canada	110	17.30
Australia	75	11.79
United States	66	10.38
Ireland	28	4.40
Botswana	24	3.77
New Zealand	16	2.52
Germany	14	2.20
Saudi Arabia	12	1.89
South Africa	10	1.57
Qatar	9	1.42
Austria	6	0.94
Namibia	6	0.94
United Arab Emirates	6	0.94
Norway	5	0.79
Kenya	4	0.63
India	3	0.47
Switzerland	3	0.47
Denmark	3	0.47
Kuwait	2	0.31
Bahrain	2	0.31
Iceland	2	0.31
Netherlands	2	0.31
Tanzania	2	0.31
Finland	2	0.31
Malaysia	2	0.31
Ethiopia	2	0.31
Spain	2	0.31
Japan	2	0.31
China	1	0.16
Belgium	1	0.16
Afghanistan	1	0.16
Luxembourg	1	0.16
Rwanda	1	0.16
Malawi	1	0.16
Sweden	1	0.16
Egypt	1	0.16
Korea, North	1	0.16
Mauritius	1	0.16
Ghana	1	0.16
Morocco	1	0.16
Central African Republic	1	0.16
Armenia	1	0.16
Congo, Democratic Republic of the	1	0.16
Cameroon	1	0.16
Israel	1	0.16
France	1	0.16
Czech Republic	1	0.16
Nigeria	1	0.16
Korea, South	1	0.16
Argentina	1	0.16
Oman	1	0.16

(*continued on next page*)

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References

1. Liu JX, Goryakin Y, Maeda A, Bruckner T, Scheffler R. Global health workforce labor market projections for 2030. *Hum Resour Health* 2017;**15**:1–12.
2. Ohene-Botwe B, Anim-Sampong S, Adjeley Quaye SN, Akudjedu TN, Antwi WK. The drivers of migration of Ghanaian radiographers to high-income countries. *Heliyon* 2024;**10**(15):e34778.
3. Kweitsu R. Brain drain: a bane to Africa's potential |Mo Ibrahim Foundation [cited 2024 Aug 21]. Available from: https://mo.ibrahim.foundation/news/2018/brain-drain-bane-africas-potential.
4. Meango R. What makes brain drain more likely? Evidence from Sub-Saharan Africa? (December 1, 2016). CESifo Working Paper Series No. 6209, Available at: SSRN: https://ssrn.com/abstract=2897461 or https://doi.org/10.2139/ssrn.2897461. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2897461.
5. Capuano S, Marfouk A. African brain drain and its impact on source countries: what do we know and what do we need to know? *J Comp Policy Anal Res Pract* 2013;**15**(4):297–314. https://doi.org/10.1080/13876988.2013.813122 [cited 2024 Aug 21], http://www.tandfonline.com/action/journalInformation?journalCode=fcpa20.
6. Mlambo VH, Adetiba TC. Effects of brain drain on the South African health sector; analysis of the dynamics of its push factors. *J Econ Behav Stud* 2017;**9**(4):62–72 [cited 2024 Aug 21], https://ojs.amhinternational.com/index.php/jebs/article/view/1822.
7. Ahmat A, Okoroafor SC, Kazanga I, Asamani JA, Millogo JJS, Illou MMA, et al. The health workforce status in the WHO African Region: findings of a cross-sectional study. *BMJ Glob Heal* 2022;**7**(Suppl 1):e008317 [cited 2024 Aug 21], https://gh.bmj.com/content/7/Suppl_1/e008317.
8. HCPC. *Diversity data: radiographers - March 2023*. https://www.hcpc-uk.org/resources/data/2023/diversity-data-radiographers-2023/, 2023. [Accessed 29 August 2024].
9. Ulupinar S, Şen Y, Eycan Ö. Original Research: nurses' attitudes toward brain drain and the associated factors. *Am J Nurs* 2024;**124**(3):22–32 [cited 2024 Aug 21], https://pubmed.ncbi.nlm.nih.gov/38386830/.
10. Almansour H, Aldossary A, Holmes S, Alderaan T. Migration of nurses and doctors: pull factors to work in Saudi Arabia. *Hum Resour Health* 2023;**21**(1):1–8. https://doi.org/10.1186/s12960-023-00809-5.
11. Dodani S, LaPorte RE. Brain drain from developing countries: how can brain drain be converted into wisdom gain? *J R Soc Med* 2005;**98**(11):487–91. https://doi.org/10.1177/014107680509801107.
12. Urbański M. Comparing push and pull factors affecting migration. *Economies (Basel)* 2022;**10**(1):21. https://doi.org/10.3390/economies10010021.
13. Akafa TA, Okeke A, Oreh A. Push and pull factors of emigration among physicians in Nigeria. *Int J Emerg Multidiscip Biomed Clin Res.* 2023;**1**(2).
14. PAHO/WHO. Health workers perception and migration in the Caribbean region - PAHO/WHO | Pan American Health Organization [cited 2024 Aug 21]. Available from: https://www.paho.org/en/documents/health-workers-perception-and-migration-caribbean-region.
15. African Union A. Migration policy framework for Africa and plan of action (2018 - 2030). Executive Summary. [cited 2024 Aug 21]; Available from: https://au.int/sa.
16. Mondragón Barrios L, Martínez Levy GA, Díaz-Anzaldúa A, Estrada Camarena E. Rethinking benefits in health research, reflections of an ethics Committee. *Yale J Biol Med* 2022;**95**(3):389–98.
17. Sedgwick P. Cross sectional studies: advantages and disadvantages. *BMJ* 2014;**348** [cited 2024 Aug 21], https://www.bmj.com/content/348/bmj.g2276.
18. Setia MS. Methodology series module 3: cross-sectional studies. *Indian J Dermatol* 2016;**61**(3):261–4 [cited 2024 Aug 21], https://pubmed.ncbi.nlm.nih.gov/27293245/.
19. *Sample size calculator* [cited 2024 Aug 21], https://www.calculator.net/sample-size-calculator.html.
20. Tabachnik B, Fidell L. *Using multivariate statistics*. 6th ed. Pearson. Boston: Pearson; 2013.
21. Pituch KA, Stevens JP. *Applied multivariate statistics for the social Sciences: analyses with SAS and IBM's SPSS*. 6th ed. Appl Multivar Stat Soc Sci Anal with SAS IBM's SPSS; 2015 [cited 2024 Aug 21]; 1–793 https://asu.elsevierpure.com/en/publications/applied-multivariate-statistics-for-the-social-sciences-analyses.

22. Braeken J, Van Assen MALM. An empirical Kaiser criterion. *Psychol Methods* 2017;**22**(3):450–66.
23. Guadagnoli E, Velicer WF. Relation of sample size to the stability of component patterns. *Psychol Bull* 1988;**103**(2):265–75.
24. Taber KS. The use of Cronbach's alpha when developing and reporting research instruments in science education. *Res Sci Educ* 2018;**48**(6):1273–96 [cited 2024 Jan 9], https://link.springer.com/article/10.1007/s11165-016-9602-2.
25. United Nations. *The sustainable development goals report 2019*, vol. 10. United Nations Publ issued by Dep Econ Soc Aff; 2019. p. 1–64.
26. Awases M, Gbary A, Nyon J, Chatora R. Migration of health professionals in six countries. *World Heal Organ* 2004;**1–66**. https://www.afro.who.int/sites/default/files/2017-06/hrh.migration_en.pdf.
27. Sibiya MN, Khoza TE, Nkosi BP. Factors motivating intent to leave amongst radiographers employed by public tertiary hospitals in the Gauteng Province, South Africa. *Afr Health Sci* 2022;**22**(3):674–80.
28. Thomas T-. *Drivers of health workers' migration, intention to migrate and non-migration from low/middle-income countries*. 1970. 2022: a systematic review | Enhanced Reader.
29. Khoza TE, Sibiya MN, Nkosi BP. Radiography A model to enhance job satisfaction for radiographers in the public healthcare system in Gauteng province, South Africa. *Radiography* 2021;**27**(1):120–6. https://doi.org/10.1016/j.radi.2020.07.005.
30. Chinene B, Bwanga O. Exploring the perceptions of radiographers pertaining to the provision of quality radiological services in Zimbabwe. *J Med Imag Radiat Sci* 2023;**54**(3):634–43. https://doi.org/10.1016/j.jmir.2023.07.013.
31. Lee ES. A theory of migration: demography 1966;**3**(1):47–57.
32. Mej'ia A, Pizurki H, Royston E. *Physician and nurse migration : analysis and policy implications , report on a WHO study*. WHO; 1979 [cited 2024 Aug 21], https://iris.who.int/handle/10665/37260.
33. Buchan J. Nurse migration and international recruitment. *Nurs Inq* 2001;**8**(4):203–4 [cited 2024 Aug 21], https://onlinelibrary.wiley.com/doi/full/10.1046/j.1440-1800.2001.00112.x.
34. Kline DS. Push and pull factors in international nurse migration. *Journal of nursing scholarship : an official publication of Sigma Theta Tau. Int Honor Soc Nurs* 2003;**35**(2):107–11. https://doi.org/10.1111/j.1547-5069.2003.00107.x.
35. BBC. How Ghana has reversed exodus of nurses.https://www.bbc.co.uk/news/world-africa-31637774#:~:text=It/began/a/scheme/funding,to/keep/them/under/bond. Accessed on: 16/August/2024.