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Radiation protection knowledge, attitudes, and practices among radiology managers in Kampala Central Division: A cross-sectional study.

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ABSTRACT

Background:

Medical applications account for nearly all human-made sources of ionizing radiation exposure, making radiation protection (RP) essential for safeguarding patients and healthcare workers (HCWs). Radiology managers are central to ensuring compliance with safety standards, promoting a positive safety culture, and overseeing RP resources. However, their knowledge, attitudes, and practices (KAP) regarding radiation safety are insufficiently documented in Uganda.

Objective:

To assess the RP KAP of radiology managers in medical facilities within Kampala Central Division and generate evidence to strengthen radiation safety systems.

Methods:

A cross-sectional quantitative study was conducted among radiology managers from all 19 Atomic Energy Council licensed facilities in Kampala Central Division. Data were collected using a structured, self-administered questionnaire adapted from validated tools. Descriptive statistics summarized demographic characteristics and KAP levels. Knowledge was categorized using Bloom's cut-off points, and attitudes were assessed using a 5-point Likert scale. Associations between demographic characteristics and knowledge levels were examined using the Chi-square test.

Results:

Nineteen managers participated (73.68% male; mean age 26 years). Knowledge levels were mostly low (47.37%) or moderate (47.37%), with only one participant achieving a high score. Level of education ($p = 0.038$) and hospital type ($p = 0.002$) were significantly associated with knowledge. Attitudes toward RP were highly positive, with mean scores above 4.8 on key items. RP practices were generally adequate, including universal availability of AEC regulations and high encouragement of PPE use, although gaps such as inconsistent dosimeter monitoring were noted.

Conclusion:

Although radiology managers expressed strong attitudes toward RP, their knowledge levels were suboptimal. Strengthening training, promoting continuous professional development, and reinforcing institutional RP systems are essential to improving radiation safety for HCWs and patients.

Recommendation:

Facilities should implement targeted and continuous training programs, especially through CMEs, for radiology managers to strengthen their knowledge of radiation safety principles.

Keywords: *Radiation Protection, Radiation Safety, Radiology Managers, Ionizing Radiation, Knowledge Assessment, Occupational Safety*
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INTRODUCTION

Of all human-made sources of ionizing radiation, medical applications for diagnostic and therapeutic purposes account for approximately 98% of the total population dose. (WHO, 2023). While the use of ionizing radiation in medicine has revolutionized healthcare by enhancing

diagnostic accuracy and improving treatment outcomes, it also presents potential health risks when exposure is not properly managed. Patients exposed to high doses may experience short-term effects such as skin erythema and radiation-induced dermatitis, which are often reversible. However, the more concerning long-term consequences include damage to the lens of the eye, immune system impairment, cytogenetic alterations, and genetic mutations that increase the risk of malignancies. (Liu et al., 2024). Both experimental and epidemiological studies have established associations between low-dose ionizing radiation exposure and the development of solid cancers and leukemia. (Tong & Hei, 2020). Importantly, children and adolescents are at a significantly higher risk compared to adults due to their greater radiosensitivity and longer post-exposure lifespan during which radiation-induced effects can manifest (WHO, 2023). These findings underscore the critical importance of radiation protection (RP) awareness and strict adherence to safety protocols in medical practice to minimize unnecessary exposure and safeguard both patients and healthcare workers (HCWs).

Radiology managers play a vital role in promoting radiation safety by fostering a positive safety culture, ensuring regulatory compliance, and managing essential resources such as equipment and staff. However, limited literature has explored the relationship between radiology managers and their radiation safety responsibilities. (Orders & Wright, 2003). In Uganda, most studies on radiology knowledge, attitudes, and practices (KAP) have focused on radiology staff and medical imaging students. (Baluku, 2023), with little attention to managers. Narendran et al. (2025) Similarly, significant gaps in radiation safety KAP among cardiac catheterization lab professionals highlight occupational health risks linked to poor radiation monitoring.

This study, therefore, assessed the KAP levels of radiology managers in medical facilities within Kampala Central Division to inform strategies for strengthening radiation protection and enhancing the safety of both HWCs and patients.

METHODS

Study Design

A cross-sectional quantitative study was conducted

Study site:

The study took place in Kampala Central Division, one of the five administrative divisions of Uganda's capital city. The division hosts over 50 medical facilities, 19 of which are registered and licensed by the Atomic Energy Council. (Council, 2025c) to operate ionizing radiation-emitting equipment.

Out of the 19 AEC-registered facilities, 17 are private-for-profit, and 2 are public. Of the total, 7 were specialized clinics (3 dental clinics, 3 diagnostic imaging centers, and 1 orthopedic clinic). Additionally, there were 12 general medical facilities (6 hospitals, 2 Health Centre IVs, and 4 Health Centre IIIs). Equipment across these facilities comprised intraoral and panoramic dental X-rays, fixed and mobile X-ray machines, CT scanners, fluoroscopy units, and a cardiac catheterization laboratory. Radiology departments were managed by radiographers, imaging technologists, radiologists, and dentists (dental clinics). Data was collected from August to October 2024

Study population

The study population included radiology managers responsible for supervising and administering medical imaging departments, ensuring safe, efficient, and compliant operations within Kampala Central Division.

Sampling and Sample Size:

All managers from the 19 registered facilities participated in the study. A strict eligibility criterion and sampling frame were used to mitigate selection bias.

Inclusion and Exclusion Criteria:

All radiology managers available during data collection were included, while those engaged in emergency duties were excluded

Data collection:

Data were obtained through a self-administered structured questionnaire adapted from (Maharjan et al., 2020) with modifications. The tool contained three sections assessing knowledge, attitudes, and practices related to radiation protection. After obtaining informed consent, participants completed the questionnaire in the presence of the researcher, who immediately reviewed submissions for accuracy and completeness.

Data Management and Analysis:

Data were entered into a password-protected Epidata version 3.01 database and securely backed up on Google Drive. Analysis was performed using STATA statistical software. Descriptive statistics, including frequencies and percentages, summarized demographic data and radiation protection practices. Knowledge levels were categorized using Bloom's cut-off points (<60% = low, 60–79% = moderate, >80% = high). In addition, individual item-level knowledge was analyzed to identify specific areas of strength and gaps in understanding among the participants. A chi-square was used to determine a statistically significant relationship between knowledge levels, practices, and attitudes. A $p < 0.05$ was considered statistically significant. Attitudes toward radiation protection were assessed using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), as outlined in Table 1

Journal of Imaging Science for Diagnosis
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Table 1. Grading of managers' attitudes towards radiation protection on a 5-point Likert Scale Measurements.

Likert-scale descriptions	Likert-scale	Likert-scale interval
Strongly disagree	1	1.00-1.80
Disagree	2	1.81-2.60
Neutral	3	2.61-3.40
Agree	4	3.41-4.20
Strongly agree	5	4.21-5.00

Ethical Consideration

The study was ethically approved by Mengo Hospital Research Ethics Committee (MH/REC/58/04-2024) on the 26th Aug, 2024

RESULTS

Social demographic characteristics.

A total of 19 radiology managers were recruited into the study, with the majority of them, 73.68% (14), being male. The mean age of the participants was 26 years; only 3 of them had a master's, and 84.21% (16) worked in private health facilities. Many of the participants were found to have attended RP training, as illustrated in Table 2.

Table 2. Social demographic characteristics of the radiology managers.

Gender	**Frequency**	**Percentage**		
Female	5	26.32		
Male	14	73.68		
Age				
25-29	5	26.32	Mean	26.78
30-34	3	15.79	SD	10.41
35-39	5	26.32	Min	25
Above 39	6	31.58	Max	67
Zone of work				
Radiology	18	94.74		
Radiology and Radiotherapy	1	5.26		
Level of education				
Degree	14	73.68		
Diploma	2	10.53		
Masters	3	15.79		
Level of experience				
2-5 years	8	42.11		
<2 years	1	5.26		
>5 years	10	52.63		
Hospital Type				
Private	16	84.21		
Public	3	15.78		
RP training attended				
Professional program				
No	8	42.11		
Yes	11	57.89		
AEC				
No	6	31.58		
Yes	13	68.42		

Self-Learning				
No	10	52.63		
Yes	9	47.37		
Workshops				
No	7	36.84		
Yes	12	63.16		

Overall, Knowledge Levels of RP among Participants.

Out of the 19 participants, only 1 was found to have a high level of knowledge in RP. The rest of them had either moderate (9) or low (9) levels of knowledge, as in Table 3.

Table 3. Knowledge levels of RP among participants.

Knowledge level	Frequency	Percentage
Low level (60%)	9	47.37
Moderate level (60-79%)	9	47.37
High Level (>80%)	1	5.26

Participants' Knowledge Per Questionnaire Item

The majority of the participants (18, 94.7%) and (17, 89.5%) selected conventional radiography and computed tomography, respectively, as imaging modalities that utilize ionizing radiation. Most of the participants selected 1-year-old females (11, 57.9%) and 1-year-old males (11, 57.9%) as the age and sex of patients that are the most sensitive to ionizing radiation. The majority (17, 89.5%) of participants selected gonads and thyroids as the tissues that are more susceptible to ionizing radiation-related damage. Leukemia (14,73.7%) was the most selected disease that may be a result of long-term effects of radiation damage. All participants reported that dose reports should be in the radiation safety file. The RSO (17, 89.5%) was most reported to be responsible for the radiation safety of others, as shown in Table 4

Table 4: Participants' knowledge per question.

a)

Question	n (%)
Imaging modalities that use ionizing radiation	
Computed tomography	17(89.5)
Fluoroscopic Studies	15(78.9)
Magnetic Resonance Imaging	1(5.3)
Radionuclide Imaging	12(63.2)
Ultrasound	1(1.19)
Conventional Radiology	18(94.7)
Which of the following patients are most sensitive to ionizing radiation?	
I year old female	11(57.9)
20-year-old female	3(15.8)
1-year-old male	11(57.9)
Not related to age and sex	6 (31.6)
Not sure	1(1.19)
Which of the following tissues is more susceptible to ionizing radiation-related damage	
Bone marrow	8 (42.1)
Breast	5 (26.3)
Gonads	17 (89.5)
Liver	1(1.19)
Lungs	1(1.19)
Muscle	4(21.1)
Skin	4(21.1)
Thyroid	17(89.5)
Kidney	3(15.8)

Choose documents that are supposed to be in the radiation safety file.	
Copies of the license	18 (94.7)
Dose reports	19(100.0)
Machine assessment reports	17(89.5)
Receipts	4(21.1)
Service reports	18 (94.7)
Worker's training certificates	17(89.5)
RSO appointment	16 (84.2)
Which of the following diseases may be a result of long-term effects of radiation damage?	
Alopecia	4(21.1)
Cataract	8 (42.1)
Leukemia	14 (73.7)
Dermatitis	2 (10.5)
All answers are correct	3(15.8)

b)

A government body responsible for radiation protection, safety, and licensing of Imaging facility equipment in Uganda.	
Atomic Energy Council	18 (94.7)
Ministry of Energy and Mineral Development	3(15.8)
Who among your workers is responsible for the radiation safety of others?	
Nurse	2 (10.5)
RSO	17(89.5)
Radiographer	6 (31.6)
Radiologist	4(21.1)
What is the annual limitation dose for medical radiation practitioners?	
10 mSv	5 (26.3)
20 mSv	12 (63.2)
Not sure	2 (10.5)
To monitor radiology staff and others, which dosimeter is applied routinely?	
Thermo-luminescent dosimeter (TLD)	18 (94.7)
Don't know	1(1.19)
Do personal dosimeters offer protection to your workers from radiation exposure?	
No	18 (94.7)
Yes	1(1.19)
How far should your workers or the operator be positioned from the X-ray tube?	
2 m	9 (48.4)
3 m	10 (52.6)

Factors Associated with Knowledge Levels of RP and Hazards among Participants

Level of education and hospital type were found to be statistically associated with participants' knowledge of radiation protection. Among participants with a Master's degree, 2 (66.7%) had a moderate level of RP knowledge. Most of the degree holders (8, 57.1%) had a low level of RP knowledge. Most of the participants in public hospitals had a moderate level of RP knowledge (2, 66.7%) (*Table 5*).

Journal of Imaging Science for Diagnosis
Vol. 3 No. 3 (2026): March 2026 issue
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Original Article

Table 5: Factors associated with knowledge levels of RP and hazards among participants

Variable	Low level	Moderate level	High level	X^2 values
Gender				0.129
Female	1 (20.0%)	3 (60.00%)	1 (20.0%)	
Male	8 (57.1%)	6 (42.86%)	0 (0.00%)	
Age				0.387
25-30	1 (20.0%)	4 (80.0%)	0 (0.00%)	
30-34	1 (33.3%)	2 (66.7%)	0 (0.00%)	
35-39	3 (60.0%)	2 (40.0%)	0 (0.00%)	
Above 35 years	4 (66.6%)	1 (16.7%)	1 (16.7%)	
Zone of work				0.556
Radiology	9 (50.0%)	8 (44.4%)	1 (5.6%)	
Radiotherapy	0 (0.00%)	1 (100.0%)	0 (0.00%)	
Level of education				0.038
Masters	1 (33.3%)	2 (66.7%)	0 (0.00%)	
Degree	8 (57.1%)	6 (42.8%)	0 (0.00%)	
Diploma	0 (0.00%)	1 (50.0%)	1 (50.0%)	
Level of experience				0.48
<2 years	0 (0.00%)	1 (100.0%)	0 (0.00%)	
2-5 years	3 (37.5%)	5 (62.5%)	0 (0.00%)	
>5 years	6 (60.0%)	3 (30.0%)	1 (10.0%)	
Hospital type				0.002
Private	9 (56.3%)	7 (43.8%)	0 (0.00%)	
Public	0 (0.00%)	2 (66.7%)	1 (33.3%)	

Attitude of participants regarding RP.

All the participants 100% (19) strongly agreed that health workers should stand behind a lead barrier during exposure, scoring the highest mean of 5. With a mean score of 1.263, participants strongly disagreed that radiographers should be asked to hold patients during exposure (Table 6).

Journal of Imaging Science for Diagnosis
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Original Article

Table 6: Attitude of radiology managers regarding RP

Attitude	1	2	3	4	5	Mean	Decision
Radiation protection for workers and patients is important.	0(0.00)	0(0.00)	0(0.00)	1(5.26)	18(94.74)	4.947	Strongly agree
It is important to have protective (lead) equipment in the facility.	0(0.00)	0(0.00)	0(0.00)	1(5.26)	18(94.74)	4.947	Strongly agree
Health workers should stand behind a lead barrier during exposure.	0(0.00)	0(0.00)	0(0.00)	0(0.00)	19(100)	5.000	Strongly agree
It is important to build X-ray rooms following AEC standards and guidelines.	0(0.00)	0(0.00)	0(0.00)	1(5.26)	18(94.74)	4.947	Strongly agree
Radiographers should be asked to hold patients during exposure.	15(78.95)	3(15.79)	1(5.26)	0(0.00)	0(0.00)	1.263	Strongly disagree
Health workers are okay to stand directly in the path of the primary radiation	17(89.47)	0(0.00)	0(0.00)	0(0.00)	2(10.53)	1.421	Strongly disagree
It is necessary to display caution or a warning sign while taking an exposure.	0(0.00)	1(5.26)	0(0.00)	1(5.26)	17(89.47)	4.789	Strongly agree
If within the same area, should health workers stand 6feet away from the patient	3 (15.79)	0(0.00)	0(0.00)	7(36.84)	9(47.37)	4.000	Agree
It is important to document and file all aspects of radiation safety.	0(0.00)	0(0.00)	1(5.26)	0(0.00)	18(94.74)	4.894	Strongly agree
It is okay to allow people to come inside the room during exposure to x-rays	17(89.47)	1(5.26)	1(5.26)	0(0.00)	0(0.00)	1.158	Strongly disagree

Participants RP Practices

All 19 (100%) of the facilities had the Atomic Energy Council Act of 2008, and 2012 regulations, and the radiology managers all 19 (100%) encouraged their workers to protect themselves with available PPE, as shown in Table 7

Journal of Imaging Science for Diagnosis
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Original Article

Table 7: Participants' RP Practices.

Practices	Frequency	Percentage
Do you have the Atomic Energy Council Act of 2008 and 2012 regulations?		
Yes	19	100
How often are workers monitored with a monitoring device/dosimeter in a year?		
Annually	3	15.79
Quarterly	12	63.16
Monthly	2	10.53
Other	2	10.53
How often do you get radiation protection reports from your workers?		
Quarterly	13	68.42
Monthly	1	5.26
Other	5	26.32
Do you encourage your workers to protect themselves with available PPE?		
Yes	19	100
In your department, is there a safety warning sign?		
No	1	5.26
Yes	18	94.74
In your department, is there a lining of walls and doors?		
No	2	11.11
Yes	16	88.89
Would you use a lead apron and thyroid shield for patient protection?		
Yes (always)	11	57.89
Yes (Occasionally)	8	42.11
How often do you invite an expert, like a medical physicist, to do a quality check?		
Annually	6	31.58
Quarterly	10	52.63
Other	3	15.79

DISCUSSION

Radiology managers play a crucial role in implementing policies for patient and public protection. Their responsibility includes promoting radiation safety awareness among staff, patients, and the public. Despite Uganda having legislation on radiation safety, there is a lack of documentation regarding knowledge, attitudes, and practices among radiology managers and administrators. This cross-sectional study aimed to assess the RP KAP of radiology managers and administrators in Kampala- Central to address gaps and provide baseline data for establishing RP culture and policy implementation in Uganda. To the best of our knowledge, this is the first study to be done among radiology administrators and managers in Uganda, and there is scant information about the same study worldwide.

The study found that the mean age of participants was 26 years, implying the inclusiveness of young people at decision-making levels. 84% of participants worked in private facilities, as these were easy to access because of the minimal steps required in getting administrative clearance. Most (57.89 %) were found to have attended RP training in their professional programs.

Participants' Knowledge Levels on RP

Overall, the participants in this study exhibited predominantly moderate (47.37%) to low (47.37%) levels of RP knowledge. This limited knowledge base is likely attributable to the absence of dedicated RP training programs, as well as the minimal RP content integrated into their respective professional training curricula. Our finding is similar to (Behzadmehr et al., 2021) A systematic review study done on related published articles extracted from three international databases (Web of Science, PubMed, and Scopus) reported that more than half of HCWs exhibited only average knowledge of RP.

Level of education was found to be statistically significant (p = 0,038) with participants' knowledge of RP after finding that participants with a Master's degree (66.7%) had a moderate level of RP knowledge, whereas degree holders (57.1%) had a low level. This is similar to Maharjan et al. (2020). A study found that diploma-level radiology professionals and students possessed inadequate knowledge (55.42%), which was notably lower than that of participants with higher academic qualifications. However, Keshtkar and Masoumi (2021) observed in an Iranian study that educational level did not necessarily influence RP knowledge, as some respondents, particularly operating room staff, had not received formal RP training during their academic programs. The hospital type was also statistically significant (p = 0.002) with participants' knowledge. Those who worked in private, 56.3% have low knowledge levels, and 66.7% of those in public have moderate levels. This may be attributed to the fact that public facilities benefit so much from the Continuous Medical Education activities provided by government bodies like health ministries. These CMEs may contain some content on RP.

Goula et al. (2021) Recommended enhancing participants' knowledge through continuous staff training, with particular emphasis on strategies to minimize radiation exposure. They further highlighted the need to strengthen healthcare professionals' trust and sense of security by improving their working environments and ensuring the provision of adequate resources to support safe radiological practices.

Notably, more than half of the managers (52.63%) in this study reported not engaging in self-directed learning to enhance their KAP related to RP. Most participants had only experienced passive learning approaches, such as formal instruction during university or tertiary training (57.89%), Atomic Energy Council (AEC) workshops (68.42%), or other professional seminars (63.16%). The observed low-to-moderate knowledge levels suggest that such conventional training alone may be insufficient for sustained knowledge retention and meaningful behavioral change. (Utunen et al., 2024). To achieve lasting improvements in RP competence, future interventions should integrate active learning strategies that promote continuous, self-motivated engagement and practical application beyond formal training sessions. (Utunen et al., 2024).

Most participants identified conventional radiology (94.7%) and CT (89.5%) as some of the imaging modalities that utilize ionizing radiation. A small proportion still choose MRI and Ultrasound as ionizing radiation generation equipment. This is attributed to the fact that MRI and Ultrasound are categorized as radiology imaging modalities in Uganda.

Most of the participants selected 1-year-old females (57.9%)and 1-year-old males (57.9%) as the age and sex of patients that are the most sensitive to ionizing radiation. This is similar to a study done on radiation awareness in PHCC, Qatar, in 2024, which revealed that most participants realized that children are the most sensitive to ionizing radiation exposures. (Ali et al., 2024). However, the 1-year-old female is more sensitive to radiation than the 1-year-old male because young females have a higher concentration of sensitive stem cells, the presence of breasts, and the influence of sex hormones.

The majority (89.5%) of participants selected gonads and thyroids as the tissues that are more susceptible to ionizing radiation-related damage. This is also similar to Ali's study on PHCC in Qatar. (Ali et al., 2024). However, very few could identify the breast, which ICRP put as one of the most radiosensitive organs, especially in young females, with a tissue weighting factor of 0.12 (Protection, 2007). This points to a direction of more sensitization on the effects of radiation on the human body.

Leukemia (73.7%) was the most selected disease, which may be a result of long-term effects of radiation damage. This implies that participants were well aware of the stochastic effects of radiation. This is similar to a study done on dental students assessing their KAP towards RP, which found that students were highly aware of the effects ($P<0.001$) (Srivastava et al., 2017).

All participants reported that dose reports should be included in the radiation safety file. Other essential documents identified were copies of the license (94.7%), service reports (94.7%), machine assessment reports (89.5%), and workers' training certificates (89.5%). This is likely because these documents are required by the AEC for authorization, compelling managers to ensure that they are properly maintained in the safety file. These findings align with the requirements set by the AEC for documents to be available in the radiation safety file during routine inspections. (Council, 2025b). Similarly, the Radiation Safety – Record Keeping guidelines developed by the South Eastern Sydney Local Health District in 2023 specify the need to maintain equipment assessment records and dose reports on file. (District, 2023). This indicates that the managers were well versed with the documentation requirements necessary for authorization by the council. Additionally, the AEC was the most (94.7%) frequently identified government body

responsible for RP, safety, and the licensing of imaging facility equipment in Uganda. This high level of recognition suggests that facility managers clearly understand and acknowledge the central regulatory role of the AEC in overseeing the safe and peaceful use of ionizing radiation in the country.

The Radiation Safety Officer was identified by most participants (89.5%) as the primary individual responsible for ensuring radiation safety within their facilities. This indicates that managers are aware of the AEC's requirement to appoint an RSO to oversee RP for both patients and staff. The legal basis for this requirement is outlined in Section 36 of the Atomic Energy Act, Cap. 154, particularly Section 36(4), and further elaborated in the Atomic Energy Regulations of 2008 (Council, 2009).

A majority of managers (63.2%) correctly identified the annual occupational dose limit as 20 mSv, demonstrating a reasonable level of awareness of international and national RP guidelines. Their understanding of this limit is expected, as it is crucial for ensuring their own safety in the workplace. This is consistent with the dose limits recommended by the International Commission on Radiological Protection (ICRP) (Protection, 2007), which form the basis for national regulatory frameworks, including those enforced by the AEC. Such awareness is essential, as knowledge of dose limits directly influences compliance, implementation of protective measures, and overall safety culture within imaging facilities.

Furthermore, nearly all respondents (94.7%) reported that thermo-luminescent dosimeters (TLDs) are the primary devices used to monitor radiation exposure among radiology staff. This may be because TLDs are the officially approved devices for monitoring occupational radiation doses, and they are readily available at AEC. This aligns with widely accepted practice in many resource-limited settings, where TLDs remain the standard due to their reliability, sensitivity, and suitability for cumulative dose measurement. The widespread use of TLDs among the surveyed facilities suggests an encouraging level of adherence to personal monitoring requirements, which are central to effective RP programs. Additionally, an equally high proportion of participants (94.7%) correctly acknowledged that personal dosimeters, including TLDs, do not protect workers from radiation exposure but only serve to measure it. This distinction is crucial for ensuring that staff do not develop a false sense of security or misunderstand the purpose of monitoring devices. These findings indicate that facility managers possess a strong foundational understanding of dose limits, monitoring devices, and their limitations. This awareness is vital for promoting compliance with regulatory standards and for fostering an environment where staff remain vigilant about the application of practical RP principles.

In light of the preceding findings, not all responses were 100 showing that there exist knowledge gaps that require attention. This gap underscores the need for enhanced awareness and more targeted training initiatives for facility leaders, particularly on nuanced aspects of RP and regulatory compliance. By strengthening their understanding of these key areas, managers will be better positioned to uphold safety standards, support RSOs, and foster a robust radiation safety culture.

Participants' Attitudes towards RP

The overall mean attitude score of participants toward key radiation safety practices was high, indicating strong agreement with the importance of these practices. Similarly, (Batista et al., 2019) A study done on health professionals in different sectors of a teaching hospital reported that 92.86% of radiographers demonstrated a positive attitude toward radiation safety standards.

A vast majority (94.74%) of the participants agreed that radiation protection for workers is essential, and none expressed any disagreement. The overall mean attitude score of 4.947 reflects a strong positive attitude toward radiation safety. These findings align with those of Kyei et al. (2025) In a study among HCWs in a resource-limited setting in Ghana, where all participants regarded radiation safety as highly important, and 55% reported being extremely confident in their ability to implement radiation safety practices.

Most participants (94.74%) recognized the importance of having lead aprons in the facility, with a mean score of 4.947. This reflects a strong awareness of personal protection measures.

The attitude mean score was low for all the poor radiation safety practices, indicating that participants generally and strongly disagreed with engaging in such unsafe behaviors. This pattern is expected and reflects a positive safety culture, where workers are aware of the risks associated with improper radiation practices and consciously reject actions that compromise protection standards. Low mean scores for unsafe behaviors further suggest that, despite gaps in knowledge, participants possess a strong ethical orientation toward maintaining safety, consistent with findings in similar studies where health professionals expressed strong disapproval of hazardous practices. (Tagle & Bogale, 2021). Our findings are also similar to (Ravikiran Bolpat, 2023) study on the level of attitudes being adequate.

Participants' Practices of RP

A substantial proportion of managers (63.16%) correctly indicated that their staff was monitored using personal dosimeters on a quarterly basis, aligning with the monitoring frequency recommended by the AEC. (Council, 2025a). This pattern is consistent with findings from other studies, such as Sethole et al.'s (2019) study, which reported quarterly monitoring as the most common practice among radiographers in provincial hospitals in the Tshwane District, andobserved similar trends in radiodiagnostic centres in South Eastern Nigeria. However, contrasting evidence from Makumbi et al.'s (2022)The study highlights that continuous dose assessment using appropriate monitoring devices at

monthly intervals is advised under ICRP recommendations. Notably, a small proportion of participants (10.53%) reported that they had never monitored their workers using dosimeters or any form of personal monitoring device, highlighting a significant area of concern. Although these respondents attributed the lack of monitoring to the unavailability of TLDs and other appropriate devices, this justification appears insufficient given that the AEC freely issues TLDs to licensed facilities upon application and provides dose-reading services at an affordable fee. This discrepancy suggests possible gaps in managerial awareness, compliance, or administrative follow-through, underscoring the need for targeted sensitization and strengthened enforcement to ensure universal adherence to personnel monitoring requirements. This finding is consistent with Abdulkadir et al. (2021), who reported that although radiodiagnostic staff demonstrated strong theoretical understanding of personnel radiation monitoring, this knowledge was not translated into routine practice. Their study attributed the gap between knowledge and practice to several factors, including inadequate provision of monitoring devices by facility management, limited appreciation among radiographers of the critical importance of these systems during clinical procedures, and, in some cases, simple staff negligence. Such observations further underscore the multifaceted challenges spanning administrative support, training, and professional accountability that influence effective radiation safety compliance.

Most of the managers (68.42%) reported that their workers submitted to them RP reports quarterly. This suggests that, in many facilities, mechanisms for routine monitoring and documentation of occupational exposure are in place. Regular submission of these reports is essential for tracking dose trends, identifying potential safety concerns, and ensuring compliance with regulatory requirements. However, the fact that not all managers receive reports this frequently may indicate inconsistencies in monitoring practices across facilities, highlighting the need for standardized reporting protocols to strengthen radiation safety oversight. All the participants (100%) reported that they encouraged workers to protect themselves with available PPE, and all of them had the Atomic Energy Act of 2008 and 2012 regulations, which are in line with the AEC regulatory and operational guidelines. (Council, 2009).

The majority (94.74%) of the participants reported the presence of safety warning signs, which play a critical role in restricting access to X-ray and CT rooms and alerting workers, patients, and the public to radiation hazards. However, the 5.26% who reported an absence of such signage highlight an important safety concern, as missing warning signs can increase the risk of accidental exposure. These findings align with those of Ahmed's study about RP practices of diagnostic imaging facilities using ionizing radiation in Somalia, who similarly observed deficiencies in safety signage, with 5.4% of rooms lacking warning signs and 20% displaying only a red light without written warnings. Lack of signage may also be attributed to some laxity in the enforcement of some details by AEC in these facilities.

An average proportion of participants (52.63%) reported inviting a medical physicist quarterly to conduct quality checks on imaging machines, indicating that many facilities recognize the importance of routine quality assurance. This is in line with IAEA Human Health Series publication 47, which outlines the quality control tests necessary and the timelines in which they should be done. (Agency, 2023).

Overall, the findings show that many essential RP practices, such as quarterly dose monitoring, submission of safety reports, use of PPE, presence of warning signs, and periodic quality checks, are largely implemented across facilities. However, notable gaps still exist, including inconsistent monitoring, absence of safety signage in some centers, and irregular quality assurance practices. These shortcomings point to weaknesses in managerial awareness, compliance, and standardization. Strengthening training, enforcement, and routine oversight is therefore essential to ensure consistent adherence to national regulations and alignment with international radiation safety standards.

CONCLUSION

This study revealed that radiology managers in Kampala-Central generally exhibit moderate to low knowledge of RP, despite demonstrating positive attitudes and largely implementing key safety practices such as the use of PPE, display of warning signs, and routine monitoring of staff with dosimeters. Knowledge levels were influenced by education and hospital type, with managers in public facilities and those with higher academic qualifications showing relatively better understanding. While most facilities conducted quarterly monitoring, maintained radiation safety documentation, and engaged medical physicists for quality checks, gaps remain in consistent monitoring, signage, and standardized quality assurance practices. These findings highlight the need for targeted training, enhanced managerial awareness, and strengthened regulatory oversight to foster a robust radiation safety culture and ensure full compliance with national and international standards.

LIMITATIONS

This is a cross-sectional study design; the associations that may have been described are not causal. Much as these findings are desirable, the Likert scale, which was used to assess the level of attitudes of the participants, provides subjective data; therefore, individual interpretations varied.

GENERALIZABILITY

The facilities included in the study only represented a single division in Kampala District. Therefore, the results may not be generalized to the rest of the country.

RECOMMENDATIONS

Facilities should implement targeted and continuous training programs, especially through CMEs, for radiology managers to strengthen their knowledge of radiation safety principles, regulatory requirements, and best practices on the job. Additionally, the facilities should establish uniform protocols for staff dose monitoring, safety report submission, and routine equipment quality checks to ensure consistency. Furthermore, facilities should adhere to AEC regulations through regular audits, enforcement of safety documentation, and provision of resources such as TLDs and warning signage to address existing gaps in radiation protection practices.

LIST OF ABBREVIATIONS

AEC – Atomic Energy Council
CT – Computed Tomography
CME – Continuous Medical Education
HCWs – Healthcare Workers
ICRP – International Commission on Radiation Protection
IAEA – International Atomic Energy Agency
KAP – Knowledge, Attitude, and Practices
MRI – Magnetic Resonance Imaging
RP – Radiation Protection
RSO – Radiation Safety Officer

DECLARATIONS

Consent for Publication

Not Applicable

Availability of Data and Material

The data supporting this study are available upon request from the Co-Responding Author.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Author's contributions

LAN conceptualized the study, coordinated the research activities, and contributed to writing and reviewing the manuscript. RM and VN contributed to analysis, writing, and reviewing the manuscript. AM provided overall mentorship, supervised, and provided overall guidance, resources, and ideas for the research.

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