

Radiation safety knowledge and attitudes among female medical students at college of health sciences, Makerere University: A cross-sectional study.

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ABSTRACT

Background:

Ionizing radiation is essential in modern medical practice but carries risks such as cancer and other stochastic effects when used inappropriately. Although international bodies like the ICRP emphasize structured radiation protection (RP) training, several studies report persistent knowledge gaps among healthcare workers (HCWs) and students. Limited research has explored RP knowledge among female medical trainees, despite their heightened biological susceptibility to radiation.

Objective:

This study assessed RP knowledge and attitudes among undergraduate female medical students at the College of Health Sciences, Makerere University.

Methods:

A quantitative cross-sectional study was conducted among 208 female undergraduate students. Data were collected using a structured, self-administered electronic questionnaire distributed via KoboToolbox. The tool assessed demographic characteristics, RP knowledge, and attitudes. Knowledge scores were categorized based on Bloom's cut-off points, while attitudes were rated on a five-point Likert scale. Descriptive statistics were performed using STATA version 16.

Results:

Most participants (89.9%) were aged 19–24 years, with a mean age of 22.4 years. Overall, 50% demonstrated moderate RP knowledge, 44.23% had low knowledge, and only 5.77% scored within the high-knowledge range. Significant gaps were noted in understanding age- and sex-related radiosensitivity, key RP principles, and the identification of professionals most likely to be exposed. Despite these gaps, attitudes toward radiation safety were positive, with an overall mean score of 4.25. Most participants acknowledged the importance of RP protocols and expressed willingness to engage in radiation safety programs.

Conclusion:

Although female medical students showed strong positive attitudes toward radiation protection, substantial knowledge deficits persist. Strengthening RP training through integrated curricula, practical demonstrations, and continuous educational programs is essential to enhance preparedness for safe clinical practice and minimize unnecessary radiation exposure.

Recommendation:

RP training should be integrated across all relevant undergraduate programs and strengthened with practical hands-on demonstrations.

Keywords: Radiation Protection, Radiation Safety, Female Medical Students, Ionizing Radiation, Knowledge Assessment, Makerere University, Occupational Exposure

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INTRODUCTION.

Ionizing radiation, a fundamental component of modern diagnostic imaging and therapeutic procedures, accounts for the majority of human-made radiation exposure. (Alkhayal et al., 2023). Despite its invaluable role in medicine, inappropriate or excessive use of ionizing radiation increases the risk of stochastic effects such as cancer and other radiation-related health consequences, with even low doses carrying measurable risks.

The International Commission on Radiological Protection (ICRP) emphasizes the importance of radiation protection (RP) knowledge through accredited education and training programs that include measurable assessments. These should be integrated into professional curricula and continuously reinforced through Continuing Medical Education (CME) activities and workshops to ensure safe and effective clinical practice. (Clement et al., 2021).

However, several studies have demonstrated significant knowledge gaps in RP among healthcare workers (HCWs). For instance, a global survey of 708 interventional physicians reported that although 93% were concerned about radiation-related health effects, only 63% had received formal radiation safety training, and none of the survey questions achieved $\geq 80\%$ correct responses. (Provenzano et al., 2021). Similarly, O'Sullivan et al. (2010) identified major deficiencies in medical students' understanding of RP, while Shafiq and Mehmood (2024) concluded that the overall knowledge of medical students regarding radiation hazards remains poor

According to the National Academy of Sciences' BEIR VII report, women may have a significantly higher risk of radiation-induced cancer than men at equivalent exposure levels. (Narendran et al., 2019). Despite this, limited research has explored gender-specific outcomes or knowledge levels in RP, particularly within Sub-Saharan Africa.

Therefore, this study aimed to assess the knowledge and attitudes of female medical students toward RP at the College of Health Sciences, Makerere University. By focusing on female students across various health-related programs, the study seeks to identify existing knowledge gaps and contribute to evidence-based strategies for improving RP education and awareness among future healthcare professionals.

METHODS

Study design

A quantitative, cross-sectional study was done among undergraduate female medical students.

Study site

The study was conducted at the Makerere University College of Health Sciences (MakCHS), located at Mulago

National Referral Hospital, which is the teaching hospital for the university. During their 3rd and 4th years, students undertake clinical rotations in the radiology department of this hospital, where they may be exposed to ionizing radiation.

As of 2022, MakCHS had an estimated total student population of 3,300, comprising 2,185 undergraduates and 1,115 postgraduate students. Most undergraduates are enrolled in the Bachelor of Medicine and Bachelor of Surgery (MBCbB) program. The college consists of five schools: The School of Biomedical Sciences, the School of Dentistry, the School of Public Health, the School of Health Sciences, and the School of Medicine. The study was conducted over a three-week period from 26th May to 16th June 2024

Study population

The target population comprised undergraduate female medical students enrolled at MakCHS.

Inclusion criteria

All undergraduate female medical students at MakCHS were considered.

Exclusion criteria

Students who were attending to emergencies.

Sample size determination

A sample size of 230 participants was determined using Cochran's formula for descriptive cross-sectional studies. A non-response rate of 10% was considered, making the sample size 253. A convenience sampling approach was employed to recruit participants who met the inclusion criteria and were accessible during the study period. A strict eligibility criterion and sampling frame were used to mitigate selection bias.

Data collection tool and procedure

Data were collected using a self-administered structured questionnaire developed on the KoboToolbox platform and distributed electronically via WhatsApp. The questionnaire included an informed consent section followed by three main sections: demographic information, knowledge of radiation safety, and attitudes toward radiation safety. Several items in the questionnaire were adapted from previously validated tools used in similar studies.

Data analysis

Data were analyzed using STATA version 16. Descriptive statistics (frequencies and percentages) were used to summarize demographic characteristics.

Knowledge scores were computed and categorized

according to Bloom's cut-off points (Low: <60%, Moderate: 60–70%, High: >71%), adapted from (Wally et al., 2024). In addition, individual item-level knowledge was analyzed to identify specific areas of strength and gaps in understanding among the participants.

Attitudinal data were analyzed using descriptive statistics (means and percentages) and interpreted based on the qualitative framework of the 5-point Likert scale as described by (Nyutu et al., 2021)

Ethics Approval

Ethical approval for this study was obtained from the Research and Ethics Committee of the Department of

Radiology, School of Medicine, Makerere University on the 19th August, 2024. Participation was voluntary, and informed consent was obtained from all respondents prior to data collection.

RESULTS.

Social demographic characteristics:

Out of 253, 45(17%) did not respond because the data collection process was affected by examinations period. Out of 208 responses, the majority, 187(89.9%) of the participants were aged 19-24 years, and the mean age was 22 years, as shown in **Table 1**.

Table 1: Social demographic characteristics of the participants.

Variable	n=208(%)
Age	
19-24	187(89.90)
25-30	12(5.77)
31-36	9(4.33)
Mean(SD)	22.4(2.87)
Name of school	
School of Biomedical Sciences	8(3.85)
School of Dentistry	24(11.54)
School of Health Sciences	38(18.27)
School of Medicine	132(63.46)
School of Public Health	6(2.88)
Courses	
BDS	22(10.58)
BDT	2(0.96)
BEHS	3(1.44)
BMAM	102(49.04)
BNUR	11(5.29)
BOPT	7(3.37)
BPHA	22(10.58)
BSB	7(3.37)
BSLT	6(2.88)
BSMR	25(12.02)
BCYT	1(0.48)
Year of study	
1 st year	46(22.12)
2 nd year	44(21.15)
3 rd year	24(11.54)
4 th year	71(34.13)
5 th year	23(11.06)

BDS – Bachelor of Dental Surgery, BPHA – Bachelor of Pharmacy, BMAM – Bachelor of Medicine and Bachelor of Surgery, BNUR – Bachelor of Science in Nursing, BSMR – Bachelor of Science in Medical Radiography, BEHS – Bachelor of Environmental Health Science, BSLT – Bachelor of Science in Speech and Language Therapy, BSB – Bachelor of Science in Biomedical Sciences, BDT –

Bachelor of Science in Dental Laboratory Technology, BCYT – Bachelor of Cytotechnology, BOPT – Bachelor of Optometry

Overall, Knowledge Levels of RP among Participants

The distribution of knowledge levels indicates that the majority of students (104, 50%) demonstrated a moderate level (60–79%) of understanding, as shown in Table 2.

Table 2: Distribution of knowledge levels among respondents based on blooms cut-off points

Knowledge level (Cut-off Points)	Frequency	Percentage
Low-level (<60%)	92	44.23
Moderate Level (60-79%)	104	50.00
High Level (>80%)	12	5.77

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Participants' Knowledge Per Questionnaire Item

From this study, the most important knowledge questions under RP principles, like age, sex, and RP practices, were considered. Our results indicated that 62.5% of the

participants failed the question regarding which age and sex is most sensitive to ionizing radiation. A small proportion (1.92%) of the participants failed the question on the purpose of wearing lead aprons in radiology, as shown in Table 3

Table 3: Participants' knowledge per question

Question	Passed (%)	Failed (%)
Knowledge about ionizing radiation-related risks	40.87	59.13
Age and sex most sensitive to ionizing radiation	37.50	62.50
The most common source of ionizing radiation	81.25	18.75
Purpose of wearing lead aprons in radiology	98.08	1.92
Radiation safety measures that reduce exposure time	46.63	53.37
Responsible for ensuring radiation safety in a medical facility	37.98	62.02
Action to be taken with radioactive waste	70.19	29.81
Importance of monitoring radiation exposure	74.04	25.96
Advise an X-ray for a pregnant woman	85.10	14.90
Tissues that are more susceptible	52.40	47.60
Radiation protection principle	56.73	43.27
Professionals most likely to be exposed to radiation	11.06	88.94
The best way to reduce radiation exposure	83.65	16.35

Attitudes towards RP among Participants

The overall mean score was 4.25, indicating a positive attitude toward radiation safety as shown in Table 4.

Table 4: Attitude of undergraduate female students towards radiation safety

Item	Response Options					Mean
	1	2	3	4	5	
I believe that proper radiation safety protocols are important for the well-being of both patients and healthcare providers.	1(0%)	1(0%)	2(1%)	34(16%)	171(82%)	4.78
I feel confident in my ability to implement radiation safety measures in clinical practice	12(6%)	15(7%)	57(27%)	64(31%)	61(29%)	3.70
To advance my knowledge and abilities, I am prepared to actively participate in the radiation safety program	1(0%)	4(2%)	25(12%)	89(43%)	90(43%)	4.26
Overall Mean						4.25

DISCUSSION

This study was done among undergraduate female students at MakCHS. Women have higher radio-sensitivity in several tissues, like the breast and reproductive organs, so that even low-dose scatter radiation during clinical rotations increases cumulative lifetime exposure, and as such, understanding RP reduces these avoidable exposures. To the best of our knowledge, this is the first study to be done among female undergraduate students at MakCHS.

From this study, we found that the majority of participants were aged between 19 and 24 years, with a mean age of 22 years, reflecting the fact that the majority of the Ugandan population is young. (Statistics, 2024).

This age range correlates with other studies done on undergraduate students in other countries. (Alamoudi et al., 2025; Yürük, 2024). Approximately 63% of the respondents were enrolled in the School of Medicine, while only 2% were from the School of Public Health. Of the 208 participants, 71 were fourth-year students, primarily because they were more accessible during the study period and generally more accustomed to participating in research activities, demonstrating a higher willingness to contribute.

Participants' Knowledge Levels on RP

This study showed that 50% of the participants had a moderate level of knowledge, and 44% had low knowledge. The finding that 44% of participants had low knowledge about RP underscores a significant educational gap. This is in line with a study done at Atatürk Faculty of Health Sciences and Atatürk Health Services Vocational School of Dicle University in Turkey, which showed 39% of students had poor knowledge in RP. (Yürük, 2024). This finding can be attributed to the absence or inadequacy of courses on the use of medical radiation and RP in the curriculum. This denies the students the opportunity to learn about radiation protection. It is very important to raise awareness and inform students who will be exposed to radiation, especially in work environments such as radiography, oral and dental health, anesthesia, and nursing.

More still, we found that 37.5% of the participants suggested that ionizing radiation sensitivity is not age dependent, revealing a gap in understanding since younger individuals are more biologically vulnerable. Brenner (2001) estimated that a single abdominal CT scan in a 1-year-old carries approximately 0.18% lifetime cancer mortality risk and 0.07% for a head scan, risks roughly ten times higher than those for adults. (Brenner et al., 2001). This finding is similar to a study done at the University Hospital of Pisa in Italy, which found that medical students often fared poorly on questions about patient and tissue susceptibility to radiation damage. (Faggioni et al., 2017).

In this study, the majority of the respondents also recognized X-rays as the most common source of ionizing radiation,

indicating a reasonable baseline awareness. This resonates with the study done at the University of Gondar in Ethiopia, which found that 77% of 473 medical students correctly identified X-rays as a source of ionizing radiation in a survey to assess their knowledge regarding radiation exposure from diagnostic imaging procedures. (Amare & Dagne, 2020). This finding can be explained by the fact that X-rays are the most commonly used ionizing radiation in diagnostic radiology.

In this study, 83.65% had knowledge of the best way to reduce radiation exposure. This is in line with Faggioni et al. (2017) A study done on medical students, radiography students, and radiology residents at an academic hospital in Italy showed that many participants selected reducing exposure time and using shielding, confirming better knowledge in practices that reduce radiation dose exposures. In this study, 95.7 % of the participants indicated that pregnant women could not have an x-ray which is similar to Alabdulwahid (2021) A study that showed 65.4% of participants responded the same. This is also in line with Ali et al. (2025) A study that reported 69.7%. This suggests that the majority of the participants were aware of the possible effects of exposure to pregnant women. Numerous biological effects, including intrauterine mortality, developmental abnormalities, and mutagenic carcinogenic effects, are caused by radiation exposure to pregnant women. In exceptional cases, a radiological examination should be performed in the second and third trimesters while wearing protective gear such as a thyroid collar and lead apron. (Alabdulwahid, 2021).

Most of the participants suggested that radioactive waste should be stored in a designated area, which showed a good understanding of radiation waste disposal, which aligns with international standards. The International Atomic Energy Agency (IAEA) guidelines state that radioactive waste should be stored in specially designed waste storage rooms or buildings that accommodate the specific needs of radioactive waste generated in research and educational facilities. These storage areas should be equipped with appropriate safety measures, including ventilation and shielding, to minimize exposure risks. (Agency, 2006).

Participants' Attitudes towards RP

In this study, the majority of the respondents, 64 (31%) and 61 (29%, strongly agreed that they are confident in the ability to implement radiation safety measures in clinical practice. The moderate level of confidence in putting these measures into practice, however, raises the possibility of a disconnect between theoretical knowledge and practical implementation. This aligns with Goula et al. (2021) who reported that lack of knowledge can lead to misconceptions and behaviors that may affect the health services provided.

This is also mentioned in another study done by Simmi Sharma (2025)

A combined 86% of respondents agreed or strongly agreed to the fact that they were prepared to actively participate in the radiation safety program, reflecting a high level of readiness to participate in radiation safety programs. This is in line with a study done on medical and dental students at McGill University in Montreal, Canada, which revealed that the majority of students 77.1% were willing to learn more about radiation safety through the various programs. (Mengenjo et al., 2019). Additionally, Mengenjo et al. (2019) The study revealed that a greater percentage of students expressed a desire to acquire knowledge through workshops, seminar and online modules, which also corresponds to the findings in this study, where the majority of the students were willing to participate in the same.

Overall, most of the students showed a positive attitude towards radiation safety, as shown by the overall mean score of 4.25. This finding agrees with a study done on undergraduate medical students at Shalamar Institute of Health Sciences (SIHS) in Lahore, Pakistan, which showed that females had higher attitudes (40.44%) (Ali et al., 2025). This may be explained by the fact that these students recognize RP's direct relevance to their safety, their future clinical practice, and patient care. Additionally, they understand that the knowledge they gain can prevent long term health risks, reduce unnecessary exposure, and improve clinical decision-making.

CONCLUSION

This study assessed the knowledge and attitudes toward radiation protection among undergraduate female medical students at the College of Health Sciences, Makerere University. Despite their upcoming roles in clinical practice and the increased radiosensitivity associated with female biological tissues, a substantial proportion of respondents demonstrated inadequate knowledge of essential radiation safety principles. Nearly half of the participants scored below the recommended threshold for satisfactory knowledge, and key misconceptions were identified—particularly regarding age-related radiosensitivity, RP principles, and radiation-related risks. These gaps highlight critical deficiencies in the current training and suggest that existing curricular exposure to radiation safety is insufficient to prepare students for safe clinical environments.

Nonetheless, the students exhibited overwhelmingly positive attitudes toward radiation protection. The high attitudinal scores, including willingness to participate in RP programs and recognition of the importance of radiation safety protocols, indicate a strong foundation upon which improved educational strategies can be built. This positive disposition represents an opportunity for the integration of

structured, competency-based RP education within the undergraduate curriculum.

Overall, the findings emphasize the urgent need for strengthened and standardized radiation protection training at MakCHS. Incorporating mandatory RP modules, practical demonstrations, and continuous professional development opportunities aligned with ICRP recommendations will help equip future healthcare professionals with the knowledge and skills required to minimize unnecessary radiation exposure for themselves and their patients. Further research should explore broader gender-based comparisons and evaluate the effectiveness of enhanced RP educational interventions within the Ugandan context.

LIMITATIONS

The study was limited to a single study site, which limits generalizability to other sites.

GENERALIZABILITY

The results were obtained from a single training institution, and so the results may not represent other institutions in the country. However, Makerere University is Uganda's oldest and most prestigious institution of higher learning and one of the leading Universities in Africa; therefore, the results from this university give a reflection of what is happening in other institutions.

RECOMMENDATIONS

RP training should be integrated across all relevant undergraduate programs, strengthened with practical hands-on demonstrations during clinical rotations, and supported through regular CME sessions and workshops to ensure continual reinforcement of radiation safety principles.

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
MakCHS – Makerere College of Health Sciences
MRI – Magnetic Resonance Imaging
RP – Radiation Protection

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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This research had no funding.

Author's contributions

PN 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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