Assessment of Radiation Safety Awareness Among Medical Professionals and Students: A Medical College-Based Study

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ABSTRACT

Background

Ionizing radiation is an essential component of modern medical diagnosis and treatment. However, unnecessary or un optimized exposure may result in adverse biological effects. Adequate knowledge of radiation hazards and radiation-protection principles among healthcare professionals and students is therefore essential for maintaining occupational and patient safety.

Aim

To assess the knowledge and awareness of radiation safety principles among medical professionals, paramedical staff, and medical students in a medical college and to identify factors associated with better radiation-safety awareness.

Materials and Methods

A cross-sectional, questionnaire-based study was conducted among 210 participants from different professional groups and clinical departments of a medical college. A structured questionnaire containing 13 multiple-choice questions was used. Questions 1–7 assessed knowledge of radiation and its biological effects, while Questions 8–13 assessed awareness of radiation-protection principles and protective measures. Each correct response was awarded one point, giving a maximum score of 13. Data were analyzed using descriptive and appropriate inferential statistical methods. A p-value <0.05 was considered statistically significant.

Results

Among the 210 participants, 78 (37.1%) demonstrated inadequate radiation-safety knowledge, 102 (48.6%) demonstrated adequate knowledge, and 30 (14.3%) demonstrated excellent knowledge. Medical physicists had the highest mean total score (11.9 ± 0.8), followed by radiological technologists (11.1 ± 1.0) and consultants/faculty doctors (10.7 ± 1.2). B.Sc. medical students had the lowest mean total score (7.0 ± 1.9). Participants who had received prior radiation-safety training had a significantly higher mean total score than those without prior training (11.0 ± 1.1 vs. 8.2 ± 1.6; $p<0.01$). Personal dosimeter use was also significantly associated with radiation-safety knowledge ($p<0.05$).

Conclusion

Radiation-safety awareness among the study participants was moderate but not optimal. Participants with formal radiation-safety training and those using personal dosimeters demonstrated better awareness. Regular institutional training, appropriate occupational monitoring, and incorporation of radiation-protection education into undergraduate curricula are recommended to improve radiation safety among healthcare personnel and students.

Keywords: Radiation safety; radiation protection; medical professionals; medical students; occupational exposure; dosimeter; ALARA; medical imaging.

1. INTRODUCTION

The discovery of X-rays by Wilhelm Conrad Röntgen on 8 November 1895 revolutionized medicine and subsequently led to numerous applications in science, industry, and other fields. The rapid development of diagnostic and therapeutic applications of ionizing radiation has made radiation-based procedures an integral part of modern healthcare.

The early pioneers of radiology were exposed to high levels of ionizing radiation and subsequently experienced radiation-related health effects, including skin injuries, hematological abnormalities, cataracts, and malignancies. These historical observations established the importance of radiation protection for individuals working with ionizing radiation.

Although ionizing radiation has transformed medical diagnosis and treatment, it remains a potential health hazard when used without appropriate justification and optimization. Exposure to ionizing radiation has been associated with biological effects, and the carcinogenic potential of radiation exposure remains an important consideration in medical imaging.

Radiation protection in medical practice is based on the principles of justification, optimization, and dose limitation for occupational and public exposure. The principle of **ALARA (As Low As Reasonably Achievable)** emphasizes minimizing radiation exposure while maintaining the required diagnostic or therapeutic objective.

Optimization of radiation use in medical imaging requires the collective efforts of referring physicians, radiologists, orthopedic surgeons, dentists, anesthesiologists, medical physicists, radiological technologists, nurses, other healthcare professionals, and patients. Awareness of radiation hazards and appropriate protective measures is therefore essential for all personnel who may be occupationally or indirectly exposed to ionizing radiation.

Radiation-safety education among healthcare workers and students can contribute to the rational use of ionizing radiation, improve adherence to protective practices, and reduce unnecessary occupational and patient exposure. Therefore, the present study was undertaken to assess radiation-safety knowledge and awareness among medical professionals, paramedical staff, and medical students in a medical college.

2. AIM AND OBJECTIVES

Aim

To assess the level of knowledge, awareness, and understanding of radiation-safety principles among medical professionals, paramedical staff, and medical students in a medical college.

Primary Objectives

1. To assess the understanding of radiation and radiation safety among medical and paramedical personnel.
2. To provide basic radiation-science information relevant to healthcare professionals.

Secondary Objectives

1. To evaluate knowledge of radiation hazards and their potential health effects.
2. To assess awareness of radiation-protection principles, including ALARA (As Low As Reasonably Achievable).
3. To determine awareness and use of radiation-protective measures and devices.
4. To compare radiation-safety awareness among different professional groups and between healthcare professionals and medical students.
5. To identify sources of radiation-safety education and training among participants.
6. To identify gaps in knowledge and areas requiring improvement in radiation-safety practices.

3. MATERIALS AND METHODS

3.1 Study Design

This was a cross-sectional, questionnaire-based study conducted to assess knowledge and awareness of radiation safety and radiation-protection principles among medical professionals, paramedical staff, postgraduate residents, and undergraduate students.

3.2 Study Setting

The study was conducted at **Alluri Sitarama Raju Academy of Medical Sciences Hospital, Eluru, Andhra Pradesh, India**.

Participants were recruited from the following departments:

- Department of Radio-Diagnosis and Medical Imaging
- Department of Orthopedics
- Department of Anesthesiology
- Department of Dentistry
- Other relevant clinical areas

These departments were selected to include participants with varying degrees of occupational or indirect exposure to diagnostic and interventional radiological procedures.

3.3 Study Population

A total of **210 participants** were included in the study. The study population represented different categories of medical professionals, paramedical personnel, and students.

The participants included:

- Consultants/faculty doctors
- Postgraduate residents
- Medical physicists
- Radiological technologists
- Operation theatre technologists
- Staff nurses
- B.Sc. medical students

3.4 Inclusion Criteria

Participants meeting the following criteria were eligible for inclusion:

- Medical professionals, including consultants/faculty doctors and postgraduate residents.
- Medical physicists and radiological technologists.
- Operation theatre technologists and staff nurses.
- Eligible undergraduate/B.Sc. medical students working or studying in the selected departments.

3.5 Exclusion Criteria

There were no specific exclusion criteria among participants who met the inclusion criteria.

3.6 Study Instrument

Data were collected using a structured, self-administered questionnaire designed to assess knowledge and awareness of radiation safety.

The questionnaire collected baseline information regarding:

- Professional category/designation
- Department
- Years of professional experience
- Use of personal radiation-monitoring devices/personnel dosimeters
- Previous formal radiation-safety training

The questionnaire consisted of **13 multiple-choice questions (MCQs)**. Questions 1–7

assessed knowledge regarding:

- Sources of radiation
- Radiation hazards
- Biological effects
- Radiosensitive organs
- Occupational exposure
- Radiation dose and related units Questions

8–13 assessed awareness regarding:

- Radiation-protection principles
- ALARA
- Protective devices
- Radiation-safety guidelines
- Safe working practices

- Radiation-safety training

Each correct response was awarded **one point**, while an incorrect or unanswered response received **zero points**. No negative marking was applied. The maximum possible score was **13**.

The questionnaire was pretested for clarity and content validity by experts in radiology and medical education.

3.7 Study Variables

Independent Variables

The independent variables included:

- Professional category/designation
- Department
- Years of professional experience
- Personal dosimeter use
- Prior formal radiation-safety training

Dependent Variables

The dependent variables were:

- Knowledge score: 0–7
- Radiation-protection awareness score: 0–6
- Overall radiation-safety score: 0–13

3.8 Data Collection

Eligible staff and students from the selected departments were invited to participate. Hard-copy questionnaires were distributed by the principal investigator and completed in the investigator's presence to facilitate completeness and clarification of questions.

Each correct response was assigned one point, and each incorrect response was assigned zero points.

Study period: six to nine months

Important: The original draft states both a six-month and a seven-month study duration. The final manuscript should contain the actual study period consistently throughout.

3.9 Statistical Analysis

Data were entered and analyzed using computer-based statistical software.

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize participant characteristics and questionnaire scores.

Appropriate inferential statistical tests were used to assess differences and associations between variables. A **p-value <0.05** was considered statistically significant.

Based on the total percentage score, participants were categorized as follows:

- **Inadequate:** <60%
- **Adequate:** 60–80%

- **Excellent:** 80–100%

The exact boundary at 80% should be defined consistently in the final statistical analysis.

4. RESULTS

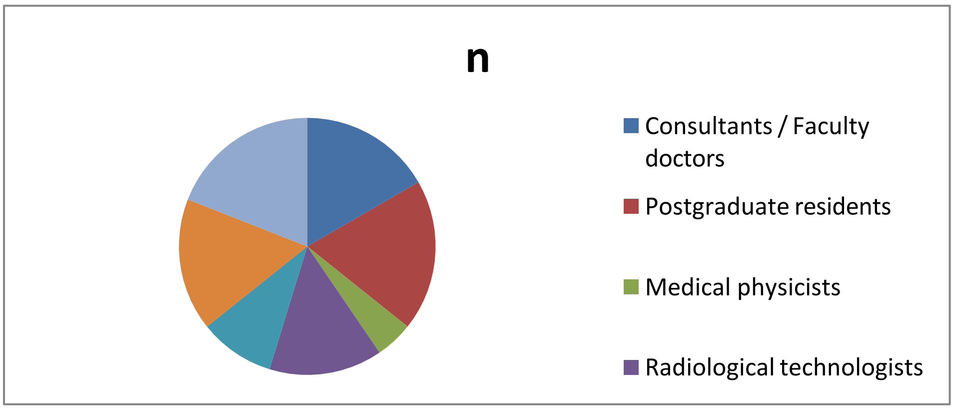
A total of **210 participants** were included in the study.

Table 1. Distribution of Participants by Professional Category (N = 210)

Professional Category	n	%
Consultants / Faculty doctors	35	16.7
Postgraduate residents	40	19.0
Medical physicists	10	4.8
Radiological technologists	30	14.3
OT technologists	20	9.5
Staff nurses	35	16.7
B.Sc. medical students	40	19.0
Total	**210**	**100.0**

The largest groups were postgraduate residents and B.Sc. medical students, each comprising 19.0% of the study population.

Figure 1. 1Distribution of Participants by Professional Category (N = 210)



Graph 1.2 Distribution of Participants by Professional Category (N = 210)

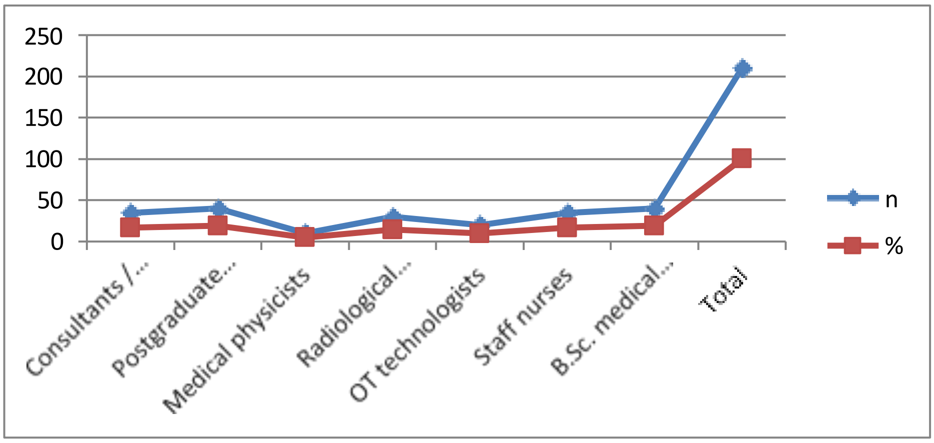


Table 2. Distribution of Participants by Department (N = 210)

Department	n	%
Radiodiagnosis & Medical Imaging	55	26.2
Orthopedics	45	21.4
Anesthesiology	50	23.8
Dentistry	40	19.0
Others	20	9.6
Total	**210**	**100.0**

Participants were distributed across several clinical departments, with the largest proportion from Radiodiagnosis and Medical Imaging (26.2%).

Figure 2.1 Distribution of Participants by Department (N = 210)

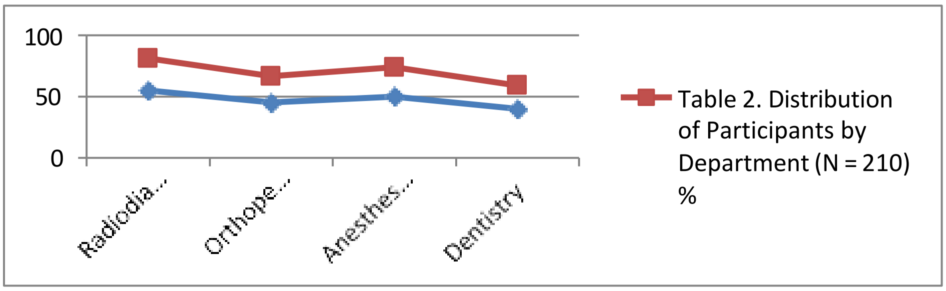


Figure 2.1 Distribution of Participants by Department (N = 210)

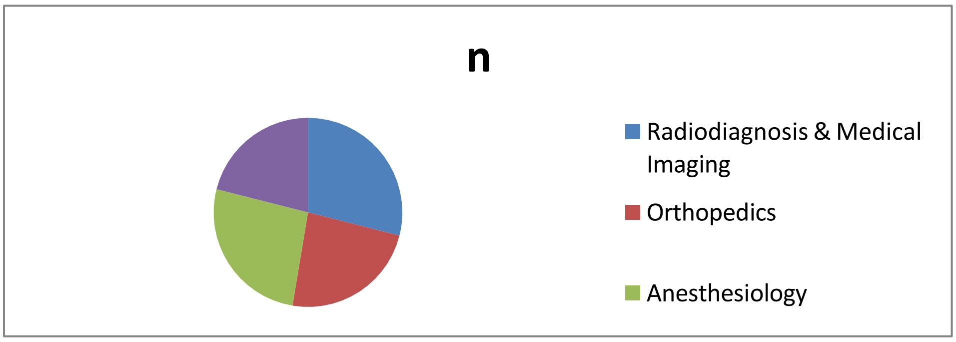


Table 3. Years of Professional Experience Among Participants (N = 210)

Years of Experience	n	%
<1 year	35	16.7
1–5 years	80	38.1
6–10 years	55	26.2
>10 years	40	19.0
Total	**210**	**100.0**

The largest proportion of participants (38.1%) had 1–5 years of professional experience.

Table 3. 1Years of Professional Experience Among Participants (N = 210)

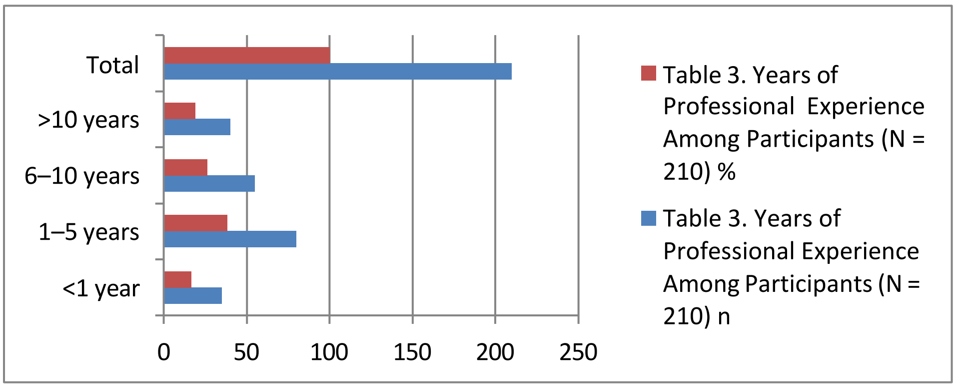
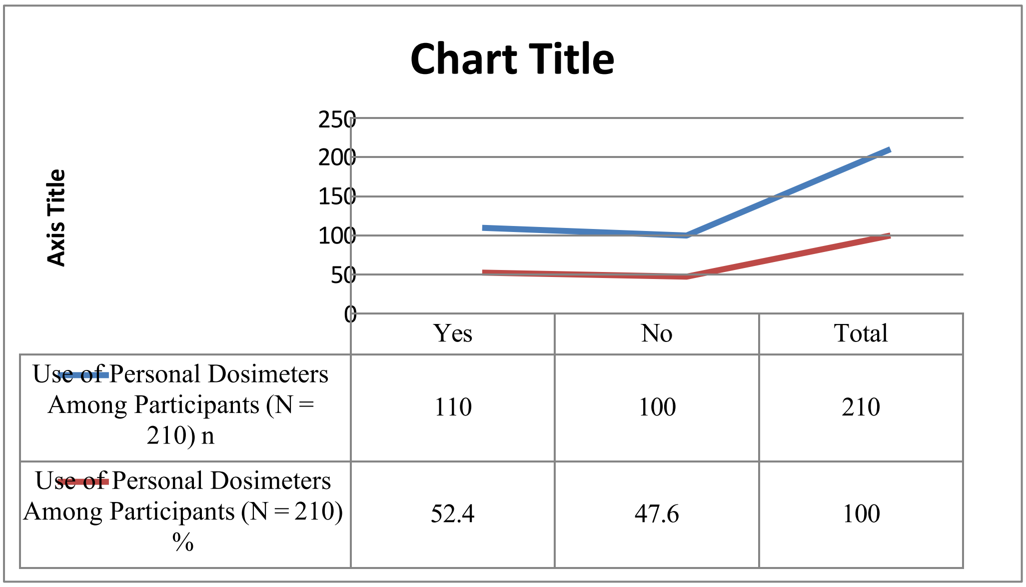


Table 4. Use of Personal Dosimeters Among Participants (N = 210)

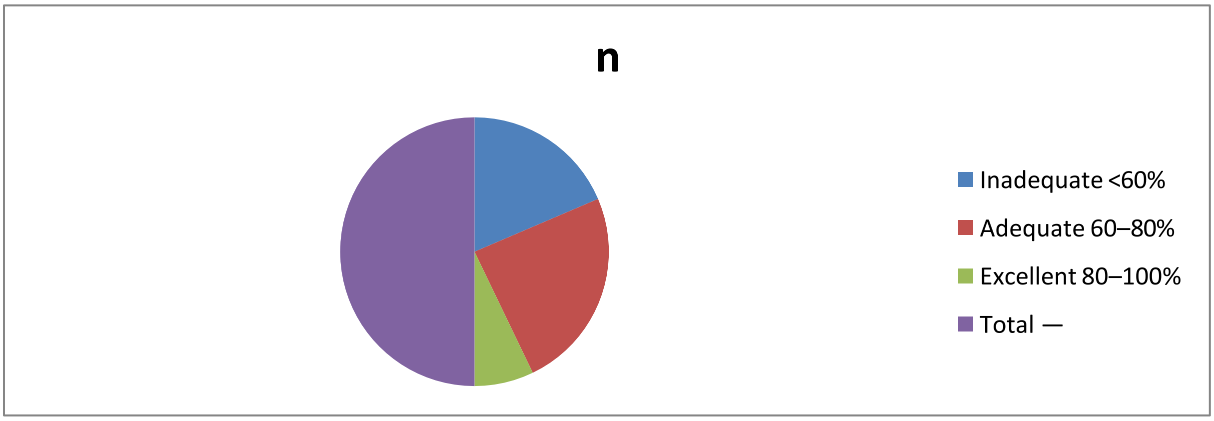


Personal dosimeters were used by 110 participants (52.4%), while 100 participants (47.6%) reported that they did not use personal dosimeters.

Table 5. Overall Radiation-Safety Knowledge Level Among Participants (N = 210)

Knowledge Category	Score Range	n	%
Inadequate	<60%	78	37.1
Adequate	60–80%	102	48.6
Excellent	80–100%	30	14.3
Total	—	**210**	**100.0**

Figure 5. Overall Radiation-Safety Knowledge Level Among Participants (N = 210)



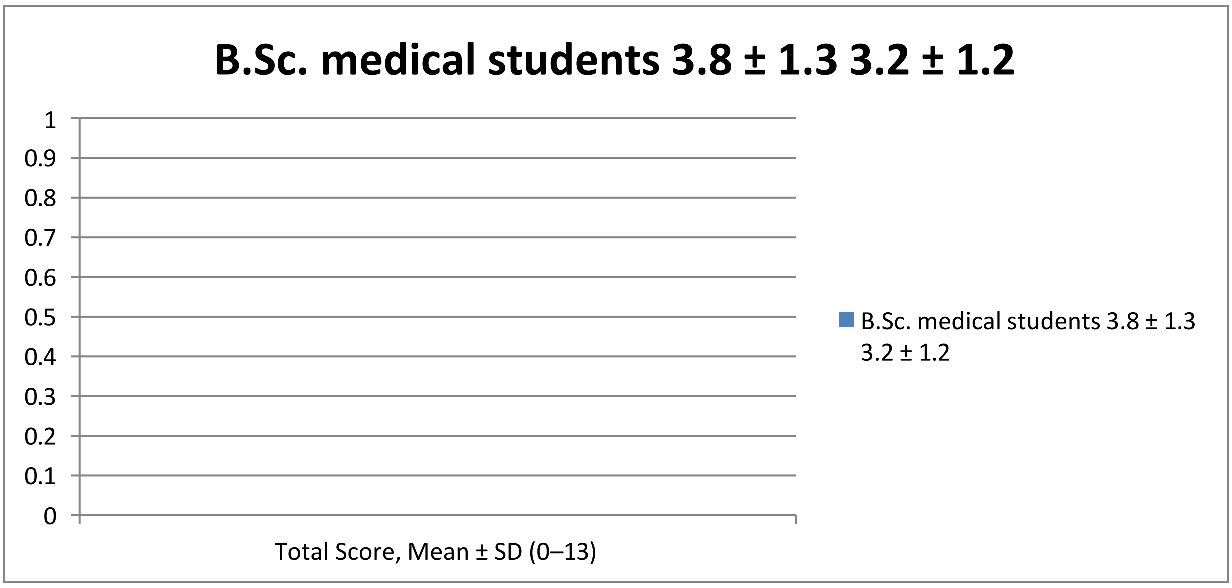
Nearly half of the participants (48.6%) demonstrated adequate radiation-safety knowledge. However, 37.1% demonstrated inadequate knowledge, while only 14.3% demonstrated excellent knowledge.

Note: The boundary between the adequate and excellent categories at exactly 80% should be defined consistently before submission.

Table 6. Mean Knowledge, Awareness, and Total Scores by Professional Group

Professional Group	Knowledge Score, Mean ± SD (0–7)	Awareness Score, Mean ± SD (0–6)	Total Score, Mean ± SD (0–13)
Consultants / Faculty doctors	5.8 ± 0.9	4.9 ± 0.8	10.7 ± 1.2
PG residents	5.2 ± 1.0	4.4 ± 0.9	9.6 ± 1.4
Medical physicists	6.4 ± 0.6	5.5 ± 0.5	11.9 ± 0.8
Radiological technologists	6.0 ± 0.8	5.1 ± 0.7	11.1 ± 1.0
OT technologists	4.6 ± 1.1	3.8 ± 1.0	8.4 ± 1.6
Staff nurses	4.2 ± 1.2	3.6 ± 1.1	7.8 ± 1.7
B.Sc. medical students	3.8 ± 1.3	3.2 ± 1.2	7.0 ± 1.9

Table 6.1 Mean Knowledge, Awareness, and Total Scores by Professional Group



Values are expressed as mean ± standard deviation (SD).

Medical physicists had the highest mean total score (11.9 ± 0.8), followed by radiological technologists (11.1 ± 1.0). B.Sc. medical students had the lowest mean total score (7.0 ± 1.9).

Table 7. Comparison of Radiation-Safety Awareness According to Prior Training

Radiation-Safety Training	n	Mean Total Score ± SD (0–13)	p-value
Received prior training	70	11.0 ± 1.1	<0.01
No prior training	140	8.2 ± 1.6	—

Statistical test: Student's t-test.

Participants who had received prior radiation-safety training had a significantly higher mean total score than those who had not received training.

Table 8. Association Between Personal Dosimeter Use and Radiation-Safety Knowledge Level

Personal Dosimeter Use	n	Inadequate, n (%)	Adequate, n (%)	Excellent, n (%)	p-value
Yes	110	23 (20.9)	62 (56.4)	25 (22.7)	<0.05
No	100	54 (54.0)	40 (40.0)	6 (6.0)	—

Statistical test: Chi-square test. Percentages are row percentages.

Participants who used personal dosimeters had a greater proportion of adequate and excellent knowledge than those who did not use personal dosimeters.

IMPORTANT DATA CHECK BEFORE SUBMISSION: The counts implied by Table 8 total 77 participants with inadequate knowledge and 31 with excellent knowledge, whereas Table 5 reports 78 and 30, respectively. The original participant-level dataset should therefore be checked and Table 5 or Table 8 corrected accordingly.

5. DISCUSSION

The present study assessed radiation-safety knowledge and awareness among medical professionals, paramedical staff, and medical students in a medical college setting. The findings indicate that although a considerable proportion of participants demonstrated adequate knowledge, radiation-safety awareness was not optimal across all professional groups.

In the present study, 48.6% of participants demonstrated adequate radiation-safety knowledge, while 37.1% demonstrated inadequate knowledge. Only 14.3% achieved an excellent score. These findings suggest that a substantial proportion of healthcare personnel and students may have gaps in their understanding of radiation hazards and radiation-protection principles.

Medical physicists and radiological technologists demonstrated the highest mean total scores. Their relatively higher scores may be related to their professional education and routine involvement in radiation-based procedures. Consultants and postgraduate residents also demonstrated comparatively higher scores. In contrast, OT technologists, staff nurses, and B.Sc. medical students demonstrated lower mean scores.

These findings emphasize the importance of professional exposure and formal education in determining radiation-safety awareness. Personnel who work more closely with radiation-producing equipment are generally expected to have greater familiarity with radiation hazards, dose concepts, protective equipment, and occupational monitoring.

An important finding of this study was the significant association between prior radiation-safety training and knowledge scores. Participants who had received formal radiation-safety training had a substantially higher mean total score than those without prior training (11.0 ± 1.1 versus 8.2 ± 1.6; $p<0.01$). This finding supports the implementation of structured and periodic radiation-safety training programs within healthcare institutions.

Radiation-safety training should include basic radiation science, biological effects, occupational exposure, dose limits, ALARA principles, appropriate use of shielding, distance and time optimization, personal dosimetry, and safe working practices. Periodic refresher training may be particularly useful for professionals who are routinely exposed to ionizing radiation.

The study also demonstrated a significant association between personal dosimeter use and radiation-safety knowledge. Participants who used personal dosimeters had higher proportions of adequate and excellent knowledge compared with those who did not use dosimeters. Although the association does not establish causation, routine occupational monitoring may be an indicator of greater institutional radiation-safety awareness and compliance.

The relatively lower scores among undergraduate students indicate a need for greater emphasis on radiation protection during undergraduate medical and allied-health education. Basic radiation-safety principles should be introduced before students begin clinical rotations involving radiological procedures.

The findings also have implications for non-radiology clinical departments. Physicians and other healthcare workers may request or assist with radiological procedures without being directly employed in radiology departments. Therefore, radiation-safety education should not be restricted to radiology personnel. Departments such as orthopedics, anesthesiology, dentistry, and operating theatres may also require targeted radiation-protection training because of their involvement in procedures using ionizing radiation.

The present findings are broadly consistent with previous reports indicating that radiation-safety knowledge varies among healthcare professionals and that formal education and occupational exposure are important determinants of awareness.

Overall, the findings support the development of institutional radiation-safety programs involving medical physicists, radiation-safety officers, radiologists, and hospital administration. Such programs should include regular educational sessions, monitoring of occupational exposure, appropriate use of protective equipment, and reinforcement of ALARA principles.

6. LIMITATIONS

The present study has several limitations.

First, it was conducted at a single medical institution, which may limit the generalizability of the findings to other hospitals or medical colleges.

Second, the study used a questionnaire-based assessment, and responses may not necessarily reflect actual radiation-safety practices in clinical settings.

Third, the questionnaire assessed knowledge and awareness rather than directly observing participants' compliance with radiation-protection practices.

Fourth, the sample sizes differed between professional groups, which may affect comparisons between groups.

Finally, the study did not evaluate changes in knowledge following a structured radiation-safety educational intervention.

Future multicenter studies with larger samples and intervention-based designs could provide further evidence regarding the effectiveness of radiation-safety education.

7. CONCLUSION

Radiation-safety awareness among medical professionals, paramedical staff, and medical students in the present study was **moderate but not optimal**.

Medical physicists and radiological technologists demonstrated the highest levels of knowledge and awareness, whereas B.Sc. medical students and some non-radiology healthcare personnel demonstrated comparatively lower scores.

Formal radiation-safety training was significantly associated with higher radiation-safety scores. Personal dosimeter use was also significantly associated with a more favorable radiation-safety knowledge profile.

These findings highlight the need for regular institutional radiation-safety training, appropriate occupational monitoring, consistent use of radiation-protective measures, and integration of radiation-protection education into undergraduate medical and allied-health curricula.

Strengthening radiation-safety awareness among all healthcare professionals can contribute to the reduction of unnecessary occupational and patient exposure and promote a stronger culture of radiation protection within healthcare institutions.

8. REFERENCES

Note: The references supplied in the original manuscript are incomplete. Full bibliographic details should be verified from the original publications before submission. The following format is therefore provided as a corrected template rather than inventing missing publication information.

1. Szarmach A, Piskunowicz M, Swieton D, Muc A, Mockatto G, Dzierzanowski J, Szurowska E. Radiation safety awareness among medical staff. **[Insert journal name, year, volume, issue, page numbers, and DOI if available].**
2. Le Heron J, Padovani R, Smith I, Czarwinski R. Radiation protection of medical staff. **[Insert journal name, year, volume, issue, page numbers, and DOI if available].**
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