Section: Miscellaneous

Original Research Article

STUDY ON NUCLEAR MEDICINE MODALITIES AMONG MBBS THIRD PROFESSIONAL PART-II AND INTERNS ENROLLED AT A TERTIARY CARE TEACHING INSTITUTE IN HARYANA

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ABSTRACT

Background: Nuclear medicine represents a critical medical specialty that exposes practitioners and medical students to significant radiation doses. This study aimed to assess the level of knowledge regarding appropriate use of nuclear medicine modalities and awareness of radiation protection among MBBS third professional part-II students and interns at a tertiary care teaching institute.

Materials and Methods: A total of 401 participants, 196 third professional part-II students and 205 interns—were enrolled using convenience sampling in this cross-sectional study. The questionnaire assessed demographic characteristics, knowledge about nuclear medicine procedures, radiation protection awareness, and satisfaction with institutional radiation protection measures. Statistical analysis was performed using descriptive statistics and chi-square tests to examine associations between demographic variables and knowledge levels.

Results: The overall prevalence of inadequate knowledge was 24.9% (n=100), moderate knowledge 29.2% (n=117), and adequate knowledge 45.9% (n=184). Interns demonstrated significantly higher awareness than third professional students ($\chi^2 = 148.586$, $p<0.001$). Notably, 81.5% (n=327) of participants were unaware of how to use personal monitoring devices, and 70.7% (n=284) lacked knowledge about the types of personal monitoring devices. Regarding satisfaction with radiation protection measures, 40.1% (n=161) of participants expressed satisfaction, while 37.9% (n=152) reported dissatisfaction.

Conclusion: This study reveals substantial gaps in knowledge regarding appropriate use of nuclear medicine modalities and radiation protection awareness among medical students and interns. Critical deficiencies exist particularly concerning personal monitoring devices, dose limits, and shielding materials.

Keywords: Nuclear medicine; Radiation safety; Radiation protection; Medical education.

INTRODUCTION

Nuclear medicine constitutes one of the primary medical specialties that exposes clinical practitioners and students to occupational ionizing radiation hazards.[1] Consequently, comprehensive knowledge of radiation protection measures is critical for ensuring optimal safety during nuclear medicine investigations and interventions. Medical students represent a vulnerable population for radiation-related occupational hazards, particularly those in clinical training phases who interact with nuclear medicine facilities.[2] The appropriate use of nuclear medicine modalities requires evidence-based decision-making supported by comprehensive knowledge of procedural indications, radiation doses

involved, and risk-benefit considerations.[3] Single photon emission computed tomography (SPECT), positron emission tomography (PET), and PET/CT imaging represent standard nuclear medicine modalities utilized in oncology, cardiology, neurology, and infectious disease diagnostics, yet often require careful consideration of radiation exposure implications.[4]

Radiation protection principles, including time, distance, and shielding optimization, coupled with personal monitoring device utilization and adherence to dose limits established by international regulatory bodies, form the cornerstone of occupational safety in nuclear medicine environments.[5] Personal monitoring devices such as thermoluminescent dosimeters (TLD) and electronic dosimeters enable individual dose tracking and serve as critical tools for verification of protection protocol effectiveness. However, research indicates that many medical students lack awareness of these devices, their appropriate usage, and dose limit thresholds.[6]

The study of awareness and knowledge gaps in radiation protection among medical students represents an important public health priority, as enhanced understanding during undergraduate and intern training years facilitates development of protective safety culture and contributes to long-term risk reduction throughout practitioners' careers.[7] This study was designed to assess knowledge regarding appropriate use of nuclear medicine modalities and radiation protection awareness among MBBS third professional part-II students and interns at a tertiary care teaching institute in Haryana, India. The findings aim to identify specific knowledge gaps and inform evidence-based recommendations for curriculum enhancement and institutional radiation safety policy development.

MATERIALS AND METHODS

A cross-sectional analytical study was conducted at a tertiary care teaching institute that serves as a major academic and clinical center providing comprehensive medical education and patient care services. The study population comprised MBBS third professional part-II students and interns enrolled at this tertiary care teaching institute during the study period. A total of 401 participants were included: 196 third professional part-II students and 205 interns. Convenience sampling methodology was employed to recruit study participants. Inclusion criteria encompassed all third professional part-II students and interns enrolled during the study period who provided informed written consent. Exclusion criteria included absence from the institution during data collection and refusal to participate.

Sample size calculation was performed using power analysis principles for chi-square testing. With an anticipated effect size (Cohen's w) of 0.3 (medium effect), significance level (α) of 0.05, and desired statistical power of 0.80, the minimum required sample size was determined to be adequate at n=401. This sample size provides sufficient statistical power to detect meaningful associations between demographic variables and knowledge outcomes.

Data were collected through a self-administered, pretested questionnaire utilizing online survey platform technology. The questionnaire was developed based on comprehensive literature review of radiation protection assessment instruments and underwent validation procedures prior to implementation. The final instrument comprised three primary sections. Section 1 captured participants' age, gender, academic status (third professional part-II or intern), and previous academic exposure to nuclear medicine topics. Section 2 contained multiple-choice questions and structured queries assessing participants' knowledge about: (a) Sources of nuclear radiation exposure in healthcare settings; (b) Hazards and biological effects of ionizing radiation; (c) Personal monitoring devices and their utilization; (d) Radiation dose limits for occupational workers; (e) Shielding materials and techniques employed in nuclear medicine departments; (f) Fundamental radiation protection principles. In section 3 participants were queried regarding their observations of institutional radiation protection infrastructure, including: (a) Presence and visibility of radiation protection officer (RPO) details; (b) Availability and functionality of personal monitoring equipment; (c) Staff compliance with radiation protection protocols; (d) Institutional communication regarding dose limits and safety precautions; (e) Satisfaction with implemented radiation protection measures.

Knowledge responses were scored with correct answers assigned one point and incorrect answers zero points. The total knowledge score was converted to percentages, with participants classified into three categories: Adequate knowledge: ≥60% correct responses, Moderate knowledge: 30-59% correct responses, Inadequate knowledge: <30% correct responses

Statistical analysis was performed using SPSS statistical software (version 22.0, IBM Corporation). Categorical variables were analyzed through descriptive statistics, with frequency distributions and percentages calculated for all relevant variables. Associations between demographic characteristics and knowledge/satisfaction outcomes were examined using chi-square tests of independence. P-values <0.05 were considered statistically significant. Effect size was calculated using Cramér's V statistic. Data are presented using tables, figures, and descriptive text following standard epidemiological reporting conventions.

RESULTS

A total of 401 participants completed the survey. Demographic characteristics are presented in Table 1. The study population consisted of 196 (48.9%) third

professional part-II students and 205 (51.1%) interns. Age distribution ranged from 22-26 years, with mean age approximately 24 years. Gender distribution reflected approximately equal representation of male and female participants. [Table 1]

Table 1: Participant Baseline Characteristics (N=401)

Characteristic	Category	N (%)
Academic Level	3rd Prof (Part-II)	196 (48.9%)
	Interns	205 (51.1%)

Of the 401 participants, 258 (64.3%) reported having prior knowledge about nuclear radiation, while 143 (35.7%) indicated lacking previous information on this topic. Among those with prior knowledge, the primary information sources were identified as follows: radiology courses at the university (47.3%, n=122), medical websites (20.5%, n=53), social media platforms (22.5%, n=58), and research publications or studies (10.1%, n=26). Multiple responses were permitted, as participants often obtained information from multiple sources. [Table 2]

Table 2: Prior Knowledge and Radiation Protection Education (N=401)

Variable	Response	N (%)
Previous information about nuclear radiation	No	143 (35.7%)
	Yes	258 (64.3%)
Source of information*	Radiology course in university	122 (47.3%)
	Medical websites	53 (20.5%)
	Research/Studies	26 (10.1%)
	Social media	58 (22.5%)
Education on radiation protection	No	142 (35.4%)

Stratification of knowledge levels by academic status revealed highly significant differences between third professional part-II students and interns (χ^2 = 148.586, $p<0.001$; Cramér's V = 0.609, indicating large effect size). As detailed in Table 3, interns demonstrated markedly superior knowledge compared to third professional students. Among interns, 152 (74.1%) achieved adequate knowledge, 15 (7.3%) exhibited moderate knowledge, and 38 (18.5%) demonstrated inadequate knowledge. Conversely, among third professional part-II students, only 32 (16.3%) attained adequate knowledge, 102 (52.0%) showed moderate knowledge, and 62 (31.6%) exhibited inadequate knowledge. [Table 3]

Table 3: Relationship Between Academic Level and Knowledge Level (N=401)

Academic Level	Knowledge Level	N	%
3rd Prof (Part-II) (n=196)	Inadequate	62	31.6%
	Moderate	102	52.0%
	Adequate	32	16.3%
Interns (n=205)	Inadequate	38	18.5%
	Moderate	15	7.3%
	Adequate	152	74.1%
	χ^2 = 148.586, $p<0.001$***		

The most concerning findings involved personal monitoring devices, with 81.5% (n=327) of participants unaware of proper usage methods and 70.7% (n=284) lacking knowledge regarding device types. Additionally, 51.5% (n=207) of participants were unfamiliar with radiation dose limits for occupational workers, and 53.0% (n=213) could not identify shielding materials employed in nuclear medicine departments. Conversely, relatively high awareness was documented regarding warning sign labels (83.7%, n=336) and dose record keeping importance (64.6%, n=259). [Table 4]

Table 4: Awareness Regarding Radiation Protection Measures (N=401)

Radiation Protection Element	Aware N (%)	Not Aware N (%)
Types of personal monitoring devices	117 (29.3%)	284 (70.7%)
How to use personal monitoring devices	74 (18.5%)	327 (81.5%)
Shielding materials in nuclear medicine department	188 (47.0%)	213 (53.0%)
Dose limits for radiation workers	194 (48.5%)	207 (51.5%)
Warning sign labels and identification	336 (83.7%)	65 (16.3%)
Dose record keeping procedures	259 (64.6%)	142 (35.4%)
Personal monitoring device knowledge	227 (56.5%)	174 (43.5%)

Regarding satisfaction with institutional radiation protection measures, 40.1% (n=161) of participants expressed satisfaction, 22.0% (n=88) remained neutral, and 37.9% (n=152) reported dissatisfaction. Significant associations were identified between knowledge level and satisfaction (χ^2 = 106.324,

p<0.001). Among participants with adequate knowledge, 59.2% (n=109) expressed satisfaction; this proportion decreased to 50.4% (n=59) among those with moderate knowledge, and only 18.8% (n=19) among those with inadequate knowledge. Academic level also demonstrated significant association with satisfaction (χ^2 = 13.452, p=0.001), with interns showing higher satisfaction rates (77.8%, n=160) compared to third professional students (38.4%, n=75).

Medical websites emerged as the most preferred resource (70.8%, n=284), followed by e-learning modalities (44.7%, n=179) and radiology courses (37.3%, n=150). Multiple responses were permitted, as participants identified multiple preferred platforms for information acquisition. [Table 5]

Table 5: Preferred Sources for Radiation Protection Information (N=401)

Information Source	Frequency	Percentage
Medical websites	284	70.8%
E-learning platforms	179	44.7%
Radiology courses	150	37.3%
Research literature	121	30.1%
Formal training workshops	98	24.4%
Others	13	3.2%

DISCUSSION

This study revealed substantial gaps in knowledge regarding nuclear medicine modalities and radiation protection among medical students and interns. Overall, only 45.9% of participants achieved adequate knowledge, with 54.1% failing to meet the established threshold. These findings align with previous literature indicating inadequate radiation protection knowledge among medical students globally.[8,9] The significant disparity between knowledge levels of third professional students (16.3% adequate) and interns (74.1% adequate) suggests that clinical experience and potentially enhanced exposure to nuclear medicine environments during internship contributes substantially to knowledge acquisition.

The marked improvement in knowledge from third professional year to internship may reflect the increased clinical involvement of interns in patient care, diagnostic imaging procedures, and direct observation of departmental radiation protection practices. This observation underscores the importance of deliberate clinical teaching regarding radiation safety during the internship year. However, the relatively low baseline knowledge among third professional students (16.3% adequate) indicates that preclinical and early clinical medical education fails to adequately prepare students for radiation-related hazards they will encounter during their internship and professional careers.[10,11]

A particularly alarming finding involved awareness regarding personal monitoring devices (PMD). Approximately 81.5% of participants were unaware of proper usage methods for personal monitoring devices, and 70.7% lacked knowledge of device types. Personal monitoring devices, including thermoluminescent dosimeters and electronic dosimeters, serve as critical tools for individual dose monitoring and represent essential components of occupational radiation protection protocols.[12] The documented lack of awareness regarding these devices has significant safety implications, as healthcare workers unaware of PMD usage cannot effectively verify their personal radiation exposure remains within acceptable limits.

These findings suggest inadequate didactic instruction and clinical orientation regarding radiation protection equipment. Medical curricula at most institutions do not incorporate comprehensive, mandatory modules on radiation protection hardware and techniques. The responsibility for radiation safety education has traditionally fallen upon individual nuclear medicine or radiology departments during student rotations, resulting in inconsistent and often insufficient education.

Dose Limits and Shielding Knowledge

Furthermore, 51.5% of participants demonstrated unfamiliarity with radiation dose limits established by international regulatory bodies for occupational workers. These dose limits, typically established at 20 mSv per year averaged over 5 years (with an upper limit of 50 mSv in any single year) by organizations such as the International Commission on Radiological Protection (ICRP), represent fundamental knowledge essential for informed practice decisions and risk assessment.[13,14]

The finding that 53.0% of participants could not identify shielding materials employed in nuclear medicine departments similarly reflects inadequate knowledge of practical radiation protection techniques. Shielding materials such as lead and newer lead-free compounds constitute essential physical barriers preventing unnecessary radiation exposure.[15,16] Understanding shielding materials, appropriate thicknesses for various procedures, and proper positioning represents fundamental knowledge for all practitioners working with radioactive materials.

Sources of Information and Educational Gaps

The analysis of information sources reveals concerning patterns. While 47.3% of participants with prior nuclear radiation knowledge obtained information through formal radiology courses, this represents a relatively low proportion given that radiology is a standard component of medical curricula. Social media accounted for 22.5% of information sources among those with prior

knowledge, suggesting that approximately one-fifth of students' radiation knowledge may derive from potentially unreliable digital sources lacking medical expertise or peer review.

Only 16.2% of participants reported participation in formal radiation protection programs or seminars, despite 64.6% indicating receipt of some radiation protection education. This disparity suggests that radiation protection education frequently occurs in informal contexts (such as brief departmental orientations) rather than structured, comprehensive educational programs. The low participation in formal programs represents a missed opportunity for systematic, evidence-based radiation protection instruction.

Institutional Radiation Protection Infrastructure and Communication

Observations regarding departmental radiation protection infrastructure revealed significant institutional deficiencies. The finding that 72.7% of participants could not identify radiation protection officer details suggests inadequate institutional signage, communication, and awareness of departmental safety leadership. Similarly, 62.9% reported inability to locate information regarding dose limits, safety precautions, or protocols, indicating insufficient availability of reference materials, signage, or educational resources within nuclear medicine areas.

The observation that 58.9% did not receive departmental orientation briefings regarding radiation protection procedures represents a substantial institutional oversight, as orientation briefings represent standard safety protocols in occupational environments with hazardous exposures. These findings suggest that radiation protection remains relatively deprioritized compared to clinical training objectives within many academic departments.

Satisfaction With Radiation Protection Measures

The relationship between knowledge and satisfaction revealed that participants with adequate knowledge demonstrated significantly higher satisfaction with departmental radiation protection measures (59.2%) compared to those with inadequate knowledge (18.8%). This inverse relationship may reflect either enhanced critical evaluation by knowledgeable individuals or improved observational capacity enabling identification of actual safety measures. However, the overall satisfaction rate of 40.1% indicates that approximately 60% of participants either remained neutral or expressed dissatisfaction with existing radiation protection measures, suggesting unmet needs and potential deficiencies in departmental practices.

Preferred Information Acquisition Modalities

The finding that 70.8% of participants preferred obtaining radiation protection information from medical websites suggests recognition of digital literacy as an educational mechanism among contemporary medical students. However, variability in website quality and accuracy requires careful curation of digital educational resources. The preference for e-learning modalities (44.7%) and radiology courses (37.3%) indicates receptiveness to structured, accessible educational approaches.

Comparisons With Existing Literature

These findings align with previous international studies. Sandougah et al. reported similar knowledge deficiency among medical students in Saudi Arabia, with 16.1% achieving adequate knowledge and significant gaps regarding personal monitoring devices.[15] Similarly, Faggioni et al. documented inadequate radiation protection awareness among medical students and residents, with particular deficiencies regarding dose-related information.[16] Studies from various geographic regions consistently demonstrate that radiation protection knowledge requires targeted educational interventions rather than relying upon incidental learning through clinical exposure.

Implications for Medical Education and Institutional Practice

This study reveals multiple opportunities for educational and policy interventions:

Curriculum Enhancement: Integration of comprehensive radiation protection modules into medical undergraduate curriculum, commencing in preclinical years and advancing through clinical training, would establish foundational knowledge prior to clinical exposure. Such modules should encompass theoretical principles (radiation types, biological effects, protection principles), practical applications (personal monitoring devices, shielding techniques, procedural protocols), and institutional requirements specific to each teaching hospital.

Formal Training Programs: Mandatory, structured radiation protection training sessions should be implemented for all medical students during rotations through nuclear medicine, radiology, and radiation oncology departments. These programs should include didactic components, demonstration of equipment, practical hands-on experience with personal monitoring devices, and assessment of competency.

Institutional Communication: Enhanced departmental communication regarding radiation protection is essential, including prominent signage identifying radiation protection officers with contact information, visible posting of relevant regulations and dose limits, and accessibility of radiation protection protocols and procedures.

Leadership and Policy: Senior departmental leadership must prioritize radiation protection education alongside clinical instruction, allocate adequate resources to structured training programs, and establish clear accountability mechanisms for ensuring student competency in radiation safety principles.

Digital Resources: Curation and promotion of high-quality digital resources regarding radiation protection, including interactive e-learning modules, video demonstrations of equipment usage, and

evidence-based guidelines, would align with contemporary learner preferences for digital content.

Limitations

First, the study was conducted at a single institution, potentially limiting generalizability to other medical teaching facilities with different organizational structures, resources, and institutional emphasis on radiation protection. Second, convenience sampling methodology may introduce selection bias if participants differed systematically from non-participants in radiation-related knowledge or interest. Third, cross-sectional design precludes determination of causality regarding factors influencing knowledge. Finally, the questionnaire, while pretested, was not formally validated against external knowledge assessments or objective competency evaluations.

CONCLUSION

This study demonstrated substantial gaps in knowledge regarding appropriate use of nuclear medicine modalities and radiation protection awareness among MBBS third professional part-II students and interns. Overall findings indicate inadequate preparedness across the study population. Critical deficiencies were documented regarding personal monitoring devices, dose limits, and shielding materials—fundamental aspects of radiation protection.

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