Section: Miscellaneous

Original Research Article

STUDY ON UNDERSTANDING OF UTILITY AND CLINICAL IMPLICATIONS OF NUCLEAR MEDICINE AS A MEDICAL SPECIALITY AMONG MEDICAL STUDENTS IN A TERTIARY CARE TEACHING HOSPITAL FROM HARYANA

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ABSTRACT

Background: Despite significant advances in nuclear medicine, awareness and understanding of this specialty among Indian medical students and young clinicians remain suboptimal. This study aimed to evaluate the understanding of utility and clinical implications of nuclear medicine as a medical speciality and subject among undergraduate medical students at a tertiary care teaching institution in Haryana state. **Materials and Methods:** The study cohort comprised 772 medical students: 210 from 1st Professional, 194 from 2nd Professional, 196 from 3rd Professional (Part-I), and 172 from 3rd Professional (Part-II). Participants completed a structured questionnaire. Scoring utilized fractional responses for multi-correct items. Statistical analysis employed one-way ANOVA and Tukey's HSD post-hoc testing. **Result:** Of 772 students approached, 772 completed the survey (100% response rate). Percent score ranges for awareness were 14–46% (1st Prof), 35–68% (2nd Prof), 61–84% (3rd Prof Part-I), and 58–89% (3rd Prof Part-II). Approximately 89% reported no formal nuclear medicine education during their training, yet 91% expressed strong interest in dedicated nuclear medicine curriculum components. **Conclusion:** Undergraduate medical students demonstrate inadequate awareness and knowledge of nuclear medicine modalities. Curriculum reform incorporating nuclear medicine postings, and interactive case-based learning sessions, is essential to enhance competency and promote appropriate utilization of these modalities in patient management.

INTRODUCTION

Nuclear medicine represents a distinctive medical specialty that employs trace quantities of radioactive material (radionuclides or radiotracers) administered via intravenous injection, oral ingestion, or inhalation for the diagnosis and therapeutic management of numerous benign and malignant medical conditions.[1,2] Modern nuclear medicine has evolved substantially with the integration of hybrid imaging technology, combining functional nuclear medicine imaging with anatomical cross-sectional modalities.3
The fundamental principle underlying nuclear medicine imaging is its ability to detect functional and metabolic changes within tissues, often preceding the structural and morphological alterations that become evident on anatomical imaging modalities.[4]

Despite substantial technological advances and demonstrated clinical utility, numerous international studies have documented inadequate teaching and suboptimal awareness of nuclear medicine principles and appropriate clinical applications among medical students, junior doctors, and practicing clinicians.[5,6] These knowledge deficits translate into underutilization of nuclear medicine modalities, delayed diagnoses, and compromised patient outcomes.[7]
Despite significant advances in nuclear medicine, awareness and understanding of this specialty among Indian medical students and young clinicians remain suboptimal. This study aimed to evaluate the understanding of utility and clinical implications of nuclear medicine as a medical speciality and subject among undergraduate medical students at a tertiary care teaching institution in Haryana state.

MATERIALS AND METHODS

This was a descriptive cross-sectional study conducted at a tertiary care teaching hospital and medical college in Haryana, North India. The institution serves as a major referral center for the region and recently established a functional nuclear medicine department. The study received institutional ethics committee approval prior to commencement.

The study cohort comprised 772 medical students: 210 from 1st Professional, 194 from 2nd Professional, 196 from 3rd Professional (Part-I), and 172 from 3rd Professional (Part-II). Inclusion Criteria were undergraduate medical students from all four professional years (1st 2nd, 3rd Part-I, and 3rd Part-II), students willing to provide informed consent and students available during the study period. Students who declined participation and students unable to complete the questionnaire within the allocated timeframe were excluded from this study. All students were approached for participation; no sampling was employed.

The questionnaire was developed by nuclear medicine specialists and reviewed for content validity by senior radiologists and medical educators. The instrument comprised 26 items organized into three sections: Section A: General Awareness (6 questions); Section B: Knowledge and Appropriate Use (14 questions); Section C: Educational Exposure and Attitudes (6 non-scoring questions).

Participants were invited to complete the questionnaire during dedicated time slots arranged with individual professional classes. Each participant received written information explaining the study's objectives, emphasizing data anonymity, and assuring voluntary participation. Informed consent was obtained from all participants.

The questionnaire was administered through Google Forms with an automated 25-minute timer to minimize external consultation and ensure response validity. The timer was integrated using Quilgo.com add-on services. Once the timer expired, responses were automatically submitted without possibility of modification. Each participant could access the form only once, precluding duplicate entries or response alterations.

Scoring System

Awareness Score: Calculated from Section A responses, with a maximum of 12 points and conversion to percentage score (0–100%).

Knowledge Score: Calculated from Section B responses, with a maximum of 28 points and conversion to percentage score (0–100%).

Overall Performance Categories were Poor: <50%, Moderate: 50–75%, Good: >75%

Data were entered into SPSS Version 25.0 (IBM Corporation, Armonk, NY, USA) for analysis. Categorical variables were expressed as frequencies and percentages. Continuous variables were expressed as mean ± standard deviation (SD). Statistical significance was defined as $p < 0.05$. All tests were two-tailed. Proportional adjustments in reporting were made to account for differential sample sizes across groups, ensuring representative comparison.

RESULTS

Of 772 students approached, 772 completed the survey, yielding a 100% response rate. The study population represented all four professional years with the following distribution: 1st Professional (1st Year): 210 students (27.2%); 2nd Professional (2nd Year): 194 students (25.1%); 3rd Professional Part-I (3rd Year): 196 students (25.4%); 3rd Professional Part-II (3rd Year): 172 students (22.3%). All participants had completed their medical education requirements for their respective professional years and were engaged in clinical training at the time of study.

Mean awareness scores demonstrated a progressive and statistically significant increase from 1st Professional (0.52 ± 0.14) through 3rd Professional Part-II (1.61 ± 0.23). Approximately 68% of 1st Professional students could correctly identify nuclear medicine as a distinct medical specialty, compared to 82% of 3rd Professional Part-II students. [Table 1]

Table 1: Mean Scores for General Awareness of Nuclear Medicine Modalities by Professional Year

Study Group	Mean Score (Awareness)	SD	95% CI
1st Prof (n=210)	0.52	0.14	(0.48-0.56)
2nd Prof (n=194)	1.19	0.18	(1.14-1.24)
3rd Prof Part-I (n=196)	1.50	0.21	(1.44-1.56)
3rd Prof Part-II (n=172)	1.61	0.23	(1.55-1.67)

Mean knowledge scores for appropriate clinical utilization of nuclear medicine modalities demonstrated substantial differences across professional years, with 1st year students obtaining 0.22 ± 0.07 compared to 3rd year students achieving 1.03 ± 0.19. [Table 2]

Table 2: Mean Scores for Knowledge and Appropriate Use of Nuclear Medicine Modalities by Professional Year

Study Group	Mean Score (Knowledge)	SD	95% CI
1st Prof (n=210)	0.22	0.07	(0.19-0.25)
2nd Prof (n=194)	0.39	0.09	(0.35-0.43)
3rd Prof Part-I (n=196)	0.91	0.17	(0.87-0.95)
3rd Prof Part-II (n=172)	1.03	0.19	(0.98-1.08)

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Cardiology represented an area of relatively better knowledge, with 72% of 3rd year students correctly identifying myocardial perfusion imaging as the optimal non-invasive modality for risk stratification in acute coronary syndrome, compared to 22% of 1st year students. [Table 3]

Table 3: Correct Response Distribution for Awareness Questions by Professional Year

Question	1st Prof (%)	2nd Prof (%)	3rd Prof I (%)	3rd Prof II (%)
Q1: NM as specialty	68	75	79	82
Q2: Career options	42	56	68	71
Q3: Training institutes	35	48	61	66
Q4: NM modalities	44	61	72	74
Q5: NM scope	38	52	68	71
Q6: Oncology/non-oncology	41	58	69	73

Oncological applications showed modest performance overall. Only 33% of 1st year students and 83% of 3rd year students correctly identified 18F-FDG PET/CT for cancer staging and detection of metastatic disease. Knowledge regarding 68Ga-PSMA and other novel tracers was substantially limited, with fewer than 20% of participants demonstrating familiarity. [Table 4]

Table 4: Correct Response Distribution for Knowledge and Appropriate Use Questions

Clinical Application	1st Prof (%)	2nd Prof (%)	3rd Prof I (%)	3rd Prof II (%)
Q1: Radiation exposure	28	44	67	71
Q2: Early detection capability	31	47	72	76
Q3: Pediatric applications	19	38	61	65
Q4: ECDTPA kidney function	33	52	71	77
Q5: FDG-PET/CT fever unknown	26	43	68	74
Q6: Thyroid therapy	35	61	79	84
Q7: Bone scan metastasis	28	51	73	78
Q8: Cardiac MPI in ACS	22	41	65	72
Q9: Radioiodine indications	42	68	87	91
Q10: FDG-PET/CT cancer staging	33	56	76	83
Q11: TB/vasculitis imaging	24	39	64	71
Q12: PET/CT radiation dose	27	45	66	73
Q13: Pregnancy precautions	31	52	74	79
Q14: Pregnancy contraindication	21	37	61	68

Post-hoc analysis revealed that the greatest awareness differences existed between 1st Professional students and 3rd Professional Part-II students (p<0.001). Comparisons between consecutive years also demonstrated significant differences, except between 3rd Professional Part-I and 3rd Professional Part-II for awareness (p=0.324), suggesting stabilization of awareness in final year. [Table 5]

Table 5: Tukey's HSD Post-Hoc Pairwise Comparisons

Comparison	Mean Difference	95% CI	p-value
1st vs 2nd Prof (Awareness)	-0.67	(-0.88 to -0.46)	<0.001
1st vs 3rd Prof Part-I	-0.98	(-1.19 to -0.77)	<0.001
1st vs 3rd Prof Part-II	-1.09	(-1.31 to -0.87)	<0.001
2nd vs 3rd Prof Part-I	-0.31	(-0.52 to -0.10)	0.004
2nd vs 3rd Prof Part-II	-0.42	(-0.64 to -0.20)	<0.001
3rd Prof Part-I vs Part-II	-0.11	(-0.33 to 0.11)	0.324
1st vs 2nd Prof (Knowledge)	-0.17	(-0.22 to -0.12)	<0.001
1st vs 3rd Prof Part-I	-0.69	(-0.74 to -0.64)	<0.001
1st vs 3rd Prof Part-II	-0.81	(-0.86 to -0.76)	<0.001
2nd vs 3rd Prof Part-I	-0.52	(-0.57 to -0.47)	<0.001
2nd vs 3rd Prof Part-II	-0.64	(-0.69 to -0.59)	<0.001
3rd Prof Part-I vs Part-II	-0.12	(-0.17 to -0.07)	<0.001

Overall, 54% of all students scored in the poor category (<50%), 38% in the moderate category (50–75%), and only 8% achieved good performance (>75%). However, marked disparities existed across professional years: 89% of 1st year students fell into the poor category compared to 16% of 3rd year Part-II students. Conversely, only 1% of 1st year students achieved good performance versus 19% of 3rd year Part-II students. [Table 6]

Table 6: Distribution of Overall Performance Categories

Performance Category	1st Prof	2nd Prof	3rd Prof I	3rd Prof II	Overall
Poor (<50%)	187 (89%)	156 (80%)	45 (23%)	28 (16%)	416 (54%)
Moderate (50-75%)	21 (10%)	35 (18%)	128 (65%)	112 (65%)	296 (38%)
Good (>75%)	2 (1%)	3 (2%)	23 (12%)	32 (19%)	60 (8%)

DISCUSSION

This comprehensive cross-sectional study of 772 medical students reveals substantially deficient awareness and knowledge regarding nuclear medicine among undergraduate medical trainees. The findings demonstrate a progressive and statistically significant increase in awareness and knowledge scores across professional years, yet even final-year students demonstrate only moderate competency. Overall, 54% of students achieved poor performance scores, 38% moderate, and merely 8% demonstrated good knowledge levels. These results underscore urgent need for curriculum reform and structured nuclear medicine education at the undergraduate level.

Our findings align substantially with previous international studies. Zakavi et al. reported inadequate knowledge among Iranian general practitioners regarding nuclear medicine applications.[8] Dasgupta and Ryan documented a significantly low level of awareness among junior doctors in a United Kingdom district general hospital.[9]

In contrast to these earlier studies that reported somewhat higher awareness in some populations, our Indian cohort demonstrated markedly lower baseline knowledge. This discrepancy likely reflects the absence of nuclear medicine departments in many Indian medical colleges and limited exposure opportunities for undergraduate students.

Adambounou et al. study,[10] in sub-Saharan Africa examined radiologists' nuclear medicine knowledge and identified similar patterns of knowledge deficiency attributed to limited departmental accessibility and inadequate training infrastructure. While their study population (radiologists) possessed more medical knowledge than our undergraduate cohort, both studies identified insufficient undergraduate exposure as a critical limiting factor. Remarkably, our data suggests that even among radiologists-in-training, without structured nuclear medicine exposure, knowledge remains substantially inadequate.

An encouraging finding was relatively superior performance regarding cardiac and endocrinological applications. With 72% of 3rd year students correctly identifying myocardial perfusion imaging's role in acute coronary syndrome and 91% knowing radioiodine therapy indications, these domains demonstrated more robust knowledge. This likely reflects greater emphasis on these topics in cardiology and endocrinology rotations. Similar patterns were documented in European universities, who noted variable coverage of nuclear medicine topics across curricula.[11,12]

Progressive improvement across professional years strongly suggests that clinical exposure and cumulative medical knowledge substantially contribute to nuclear medicine literacy. The statistically significant differences between consecutive years ($p<0.001$ for most comparisons) indicate that informal exposure through clinical practice, journal reading, and incidental learning substantially benefits knowledge acquisition.

However, the absence of formal, structured nuclear medicine education throughout all four years represents a missed opportunity.[13,14] The observation that 91% of students expressed interest in formal nuclear medicine training suggests that targeted educational interventions would be enthusiastically received and potentially highly effective.

Knowledge regarding 18F-FDG PET/CT's utility in evaluating infections and inflammatory conditions was suboptimal, with only 24% of 1st year and 71% of 3rd year students providing correct responses. This represents a critical gap given the growing recognition of nuclear medicine's role in tuberculosis diagnosis and monitoring, vasculitis assessment, and fever investigation.[15]

The striking finding that 89% of students reported zero formal nuclear medicine education during their undergraduate training represents a critical deficiency. This contrasts sharply with other specialties where students receive mandatory rotations.[16] The absence of structured exposure directly correlates with poor knowledge and limited willingness to utilize these modalities in clinical practice.

The observation that only 54% of students expressed willingness to recommend nuclear medicine modalities in clinical practice is concerning. This substantially impairs healthcare delivery quality, as inappropriate or delayed utilization of nuclear medicine results in diagnostic delays, inadequate staging, and compromised patient outcomes. Notably, among students achieving good knowledge scores (>75%), 96.7% expressed willingness to utilize nuclear medicine, compared to 28.4% among poor performers. This demonstrates that knowledge directly influences clinical practice patterns.

Limitations of the Study

Findings from one study centre may not generalize to all Indian medical colleges, particularly those in different geographic regions or with different nuclear medicine infrastructure Cross-sectional design captured knowledge at single time point; longitudinal tracking would identify retention and progression. Single-point assessment does not capture knowledge acquisition trajectory or retention over time. Longitudinal studies would provide more comprehensive understanding of learning patterns.

CONCLUSION

This comprehensive assessment of nuclear medicine awareness and knowledge among 772 medical students at this study site reveals critically deficient understanding across all professional years, with only 8% of students achieving good knowledge levels and 54% performing poorly. Undergraduate medical students demonstrate inadequate awareness and knowledge of nuclear medicine modalities. Curriculum reform incorporating nuclear medicine postings, and interactive case-based learning sessions, is essential to enhance competency and promote appropriate utilization of these modalities in patient management.

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