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Research Article

Knowledge and Awareness Regarding Nuclear Medicine Among Non-Radiological Physicians: A Cross-Sectional Study in Two Centers in Türkiye

Radyoloji Dışı Hekimler Arasında Nükleer Tıp Hakkındaki Bilgi ve Farkındalık: Türkiye'deki İki Merkezde Gerçekleştirilen Kesitsel Bir Çalışma

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Abstract

Aim: Nuclear medicine has an expanding role in diagnosis and therapy, yet physicians working outside the departments of Nuclear Medicine and Radiology may have limited knowledge of its indications, radiation doses, and clinical applications. This study aimed to assess the knowledge and awareness of physicians working outside these two specialties regarding diagnostic and therapeutic methods in nuclear medicine.

Material and Methods: This cross-sectional study was conducted in April–May 2025 at two teaching hospitals in Diyarbakır, Türkiye. A structured questionnaire was administered to 285 physicians working outside the departments of Nuclear Medicine and Radiology. The survey assessed demographic characteristics, knowledge of radiation measurement and nuclear medicine practices, and attitudes toward radiation-related risks. A knowledge score ranging from 0 to 11 was calculated from the knowledge items.

Results: The mean knowledge score was 6.41 ± 2.23, indicating a moderate level of knowledge. While 65.3% correctly identified the sievert as the unit of radiation dose, knowledge of annual natural background radiation (46.0%) and the approximate dose of a posteroanterior chest radiograph (46.3%) was limited. Awareness of therapeutic roles was higher for hyperthyroidism (71.9%) and thyroid cancer (77.9%) than for prostate cancer (54.4%) and neuroendocrine tumours (57.2%). Misconceptions were common: 62.1% believed Nuclear Medicine imaging is highly likely to cause cancer, and 43.2% believed it may cause infertility. More than half considered their undergraduate Nuclear Medicine education inadequate (57.2%). Knowledge scores were significantly associated with age, professional experience, gender, professional title, and clinical use of Nuclear Medicine methods.

Conclusions: Physicians demonstrated moderate knowledge, with notable gaps in radiation dose knowledge, therapeutic applications, and risk perception. These findings suggest a need for stronger educational support in Nuclear Medicine.

Keywords: Nuclear medicine; Radiation awareness; Medical education; Physicians; Theranostics; Knowledge; Risk perception; Continuing medical education

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Öz

Amaç: Nükleer tıp, tanı ve tedavide giderek artan bir role sahip olmakla birlikte, Nükleer Tıp ve Radyoloji bölümlerinin dışında çalışan hekimlerin, nükleer tıbbın endikasyonları, radyasyon dozları ve klinik uygulamaları hakkındaki bilgileri sınırlı olabilir. Bu çalışma, bu iki uzmanlık alanının dışında çalışan hekimlerin nükleer tıpta tanı ve tedavi yöntemleri hakkındaki bilgi ve farkındalıklarını değerlendirmeyi amaçlamıştır.

Gereç ve Yöntemler: Bu kesitsel çalışma, Nisan-Mayıs 2025 tarihlerinde Diyarbakır'daki iki eğitim hastanesinde gerçekleştirilmiştir. Nükleer Tıp ve Radyoloji bölümleri dışında çalışan 285 hekime yapılandırılmış bir anket uygulanmıştır. Anket, demografik özellikleri, radyasyon ölçümü ve nükleer tıp uygulamaları hakkındaki bilgileri ve radyasyonla ilgili risklere yönelik tutumları değerlendirmiştir. Bilgi maddelerinden 0 ile 11 arasında değişen bir bilgi puanı hesaplanmıştır.

Bulgular: Ortalama bilgi puanı 6,41 ± 2,23 olup, orta düzeyde bir bilgi düzeyini göstermektedir. Katılımcıların %65,3'ü sievert'i radyasyon dozunun birimi olarak doğru bir şekilde tanımlarken, yıllık doğal arka plan radyasyonu (%46,0) ve posteroanterior göğüs röntgeninin yaklaşık dozu (%46,3) hakkındaki bilgi sınırlıydı. Hipertiroidizm (%71,9) ve tiroid kanseri (%77,9) için tedavi edici roller hakkındaki farkındalık, prostat kanseri (%54,4) ve nöroendokrin tümörlerden (%57,2) daha yüksekti. Yanlış anlamalar yaygındı: %62,1'i Nükleer Tıp görüntülemesinin kansere neden olma olasılığının yüksek olduğuna, %43,2'si ise kısırlığa neden olabileceğine inanıyordu. Yarısından fazlası (%57,2) lisans düzeyindeki Nükleer Tıp eğitimini yetersiz buldu. Bilgi puanları yaş, mesleki deneyim, cinsiyet, meslek unvanı ve Nükleer Tıp yöntemlerinin klinik kullanımı ile anlamlı şekilde ilişkiliydi.

Sonuç: Hekimlerin bilgi düzeyinin orta düzeyde olduğu, ancak radyasyon dozu bilgisi, tedavi uygulamaları ve risk algısı konularında belirgin eksiklikler gösterdiği tespit edilmiştir. Bu bulgular, Nükleer Tıp alanında daha güçlü eğitim desteğine ihtiyaç duyulduğunu göstermektedir.

Anahtar kelimeler: Nükleer tıp; Radyasyon farkındalığı; Tıp eğitimi; Hekimler; Teranostik; Bilgi; Risk algısı; Sürekli tıp eğitimi

Introduction

Nuclear medicine has evolved well beyond a purely diagnostic discipline and now plays a central role in precision medicine through molecular imaging and targeted radionuclide therapy, particularly in oncology [1]. Nuclear theranostics has further strengthened this role by linking lesion-specific imaging with individualized treatment selection and response assessment within the same biologic pathway [2]. In parallel, rapid advances in radiopharmaceutical therapy, hybrid imaging, and disease-oriented workflows have made nuclear medicine increasingly relevant to physicians involved in referral, staging, treatment planning, and follow-up across multiple specialties [3].

Because many imaging and treatment decisions originate outside nuclear medicine units, the knowledge and awareness of physicians working in other specialties have become increasingly important for appropriate utilization and patient safety [4]. Recent studies continue to show that healthcare professionals often have incomplete knowledge of ionizing radiation, examination doses, and radiation protection principles, despite frequent involvement in imaging-based decision-making in daily practice [5, 6]. This problem is not limited to general radiologic awareness; a 2025 survey reported that non-radiologist medical staff had poor knowledge of PET/CT despite generally positive attitudes toward the modality [7], highlighting a persistent educational gap in clinically relevant nuclear medicine applications.

Although the literature supports ongoing deficiencies in radiation literacy and imaging awareness, studies specifically evaluating physicians' knowledge of both diagnostic and therapeutic nuclear medicine remain limited, and data from middle-income healthcare settings are particularly scarce [5, 8]. In addition, much of the available evidence combines heterogeneous healthcare staff groups or focuses mainly on radiation safety rather than broader awareness of indications, clinical utility, and therapeutic options in nuclear medicine [9, 10]. To our knowledge, contemporary multicenter data from Türkiye focusing on physicians working outside the departments of Nuclear Medicine and Radiology remain limited.

We hypothesized that, despite the expanding clinical importance of nuclear medicine, physicians working outside the departments of Nuclear Medicine and Radiology would have important gaps in knowledge and awareness, particularly regarding clinical indications, radiation exposure, and therapeutic applications. Therefore, this study aimed to assess the knowledge and awareness of physicians working outside these two specialties regarding diagnostic and therapeutic methods in nuclear medicine.

Material And Methods

This cross-sectional study was conducted between April 15 and May 15, 2025. The study was carried out at two hospitals in Diyarbakır that house nuclear medicine diagnosis and treatment centers. The population consisted of physicians (research assistants, specialists, faculty members) working at Dicle University and Gazi Yaşargil Training and Research Hospital. An a priori power analysis was performed to estimate the minimum sample size required for the primary continuous outcome, namely the knowledge score. Using a two-tailed one-sample t-test framework, a small effect size (Cohen's d = 0.22), $\alpha = 0.05$, and power $(1-\beta) = 0.95$ were assumed, yielding a required sample size of 271 participants. Physicians were invited to participate in the study via convenience sampling, and 285 physicians meeting the inclusion criteria were enrolled.

Eligibility Criteria

The inclusion criteria were as follows: (1) actively working as a physician at one of the study institutions, (2) providing written informed consent, and (3) working outside the departments of Nuclear Medicine and Radiology. Physicians from the departments of Nuclear Medicine and Radiology were excluded. Participants who did not complete the questionnaire or had missing data in key variables were also excluded.

Data Collection and Questionnaire Content

Data were collected both online and face-to-face in clinical and academic units of the participating institutions using a structured questionnaire. The questionnaire was developed following a review of the relevant literature and in consultation with medical specialists. In addition to factual knowledge, it was designed to assess physicians' self-perceived preparedness and educational needs related to nuclear medicine.

The questionnaire consisted of three sections. The first section included demographic variables such as age, sex, institution, marital status, monthly income level, academic/professional title, duration of professional experience, and specialty area. The second section assessed knowledge related to radiation measurement, radiation exposure, and nuclear medicine practices, including the unit of radiation dose, natural background radiation, approximate dose of a posteroanterior chest radiograph, pregnancy and lactation considerations, risk-benefit perceptions of imaging and treatment methods, and the diagnostic and therapeutic roles of nuclear medicine. The third section focused on awareness and attitudes, including self-efficacy, use of nuclear medicine methods in clinical practice, participation in multidisciplinary meetings, awareness of specific procedures such as PET/CT, scintigraphy, and transarterial radioembolization (TARE), and concerns related to radiation exposure.

Knowledge Score

A knowledge score was calculated based on the items in the second section of the questionnaire. Each item was answered as "true," "false," or "unsure." Correct responses were scored as 1 point, whereas incorrect and "unsure" responses were scored as 0. The total knowledge score ranged from 0 to 11, with higher scores indicating greater knowledge of radiation and nuclear medicine.

Statistical Analysis

Analyses were performed using SPSS (IBM SPSS Statistics for Windows, Version 25.0; IBM Corp., Armonk, NY). The normality of continuous variables was assessed with the Shapiro-Wilk test. Normally distributed variables are presented as mean ± standard deviation, non-normally distributed variables as median (minimum–maximum); categorical variables are presented as number and percentage (n, %). For comparisons between two independent groups where normality was not met, the Mann-Whitney U test was used; for comparisons among more than two groups, the Kruskal-Wallis test was used. Post-hoc pairwise comparisons following overall significance were performed using the Dunn-Bonferroni correction. Relationships between continuous/ordinal variables were evaluated using the Spearman's correlation coefficient (rs). A two-tailed $p < 0.05$ was considered statistically significant.

Ethical Principles

The study was conducted after obtaining approval from the Non-Interventional Clinical Research Ethics Committee of the Health Sciences University Gazi Yaşargil Training and Research Hospital (date and decision/number: 17/01/2025, No: 313). Written institutional permission obtained from the Chief Medical Officer of Dicle University. Written informed consent was obtained from all participants. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

Demographic Characteristics

A total of 285 physicians were included in the study. The

mean age was 34.6 ± 8.4 years, and 64.6% (n = 184) were male. Most participants worked at Dicle University (69.5%, n = 198), and 67.4% (n = 192) were residents/research assistants. Regarding specialty, 61.4% (n = 175) were from internal medical sciences and 33.3% (n = 95) from surgical sciences. The mean professional experience was 8.15 ± 7.9 years. In addition, 79.6% (n = 227) reported that an active Nuclear Medicine clinic was available at the university from which they graduated, whereas 16.5% (n = 47) reported a personal history of Nuclear Medicine imaging (Table 1).

Knowledge Levels on Radiation and Nuclear Medicine

Physicians demonstrated a moderate level of knowledge regarding radiation measurement and nuclear medicine practices. While 65.3% (n = 186) correctly identified the sievert as the unit of radiation dose, knowledge of the average annual natural background radiation dose and the approximate dose of a posteroanterior chest radiograph was limited, with correct response rates of 46.0% (n = 131) and 46.3% (n = 132), respectively. Awareness of the therapeutic role of nuclear medicine was higher for hyperthyroidism (71.9%, n = 205) and thyroid cancer (77.9%, n = 222) than for prostate cancer (54.4%, n = 155) and neuroendocrine tumours (57.2%, n = 163). In addition, 68.8% (n = 196) correctly recognized that nuclear medicine imaging provides better physiological data than radiological imaging, whereas 50.9% (n = 145) indicated that it provides better anatomical detail (Table 2).

Risk Perception and Attitudes

Participants showed considerable concern and uncertainty regarding radiation-related risks and the use of nuclear medicine imaging. Half of the respondents (50.5%) reported that they might prefer alternative imaging methods because of concerns about radiation exposure. Only 45.3% considered nuclear medicine diagnostic procedures applicable in breastfeeding women, whereas 26.3% were unsure. Misconceptions regarding risk were common: 43.2% believed that nuclear medicine imaging can cause infertility, and 62.1% believed that it is highly likely to cause cancer. In addition, 81.1% considered nuclear medicine methods to be high-cost (Table 3).

Self-perceived Knowledge, Educational Adequacy, and Clinical Engagement

Participants reported limited self-perceived knowledge and educational preparedness regarding Nuclear Medicine. More than half considered their knowledge about the short- and long-term effects of radiation inadequate (51.9%, n = 148), whereas only 29.5% (n = 84) considered it adequate. Similarly, only 17.2% (n = 49) considered their knowledge of radiation doses from radiological imaging sufficient, while 65.3% (n = 186) reported that it was insufficient. Regarding undergraduate education, 57.2% (n = 163) regarded the Nuclear Medicine education they received during medical school as inadequate, whereas 25.3% (n = 72) considered it adequate. Only 22.5% (n = 64) reported sufficient knowledge about procedures performed in Nuclear Medicine clinics, while 61.8% (n = 176) felt inadequately informed. Perceived knowledge of radiation doses was also low for scintigraphic tests (15.8%, n = 45), PET/CT examinations (21.8%, n = 62), and Nuclear Medicine treatments (21.8%, n = 62); in each of these areas, more than half of respondents reported insufficient knowledge. Although 60.7% (n = 173) reported using Nuclear Medicine methods in clinical practice, only 36.1% (n = 103) participated in multidisciplinary discussions involving the Nuclear Medicine clinic. In addition, 38.6% (n = 110) reported knowledge of the TARE procedure, whereas 47.7% (n = 136) reported no knowledge of it (Table 4).

Factors Associated with Knowledge Scores

A substantial proportion of participants (60.7%, n = 173) self-reported that completing the questionnaire prompted them to reconsider their views regarding Nuclear Medicine, and 63.5% (n = 181) reported concern regarding radiation doses associated with Nuclear Medicine imaging or treatment. The median knowledge score was 6 (range, 0–11), corresponding to a mean of 6.41 ± 2.23. Knowledge score showed weak but statistically significant positive correlations with age (r_s = 0.160, p = 0.007) and professional experience (r_s = 0.130, p = 0.029). Male physicians had significantly higher knowledge scores than female physicians (median 7 vs. 6, $p < 0.001$). A significant association was also observed for professional title (p = 0.001), with the highest scores among faculty members. In addition, physicians who reported using Nuclear Medicine methods in clinical practice had significantly higher knowledge scores than those who did not ($p < 0.001$). No significant associations were found for institution, marital status, monthly income level, specialty, availability of an active Nuclear Medicine clinic at the university of graduation, or personal history of Nuclear Medicine imaging (Table 5).

Table 1. General characteristics of the participating physicians.	
Variables	**All participants n = 285**
Age, years	34.6 ± 8.4
Gender, n (%)	
Female	101 (35.4)
Male	184 (64.6)
Institution, n (%)	
Dicle University	198 (69.5)
Gazi Yasargil Training and Research Hospital	87 (30.5)
Marital status, n (%)	
Single	106 (37.2)
Married	171 (60.0)
Divorced	8 (2.8)
Monthly income level, n (%)	
Income below expenses	50 (17.5)
Income equal to expenses	101 (35.5)
Income above expenses	134 (47.0)
Professional title, n (%)	
Resident / Research assistant	192 (67.4)
Specialist	55 (19.3)
Faculty member	38 (13.3)
Professional experience, years	4 (1-35)
Specialty, n (%)	
Surgical sciences	95 (33.3)
Internal medical sciences	175 (61.4)
Basic medical sciences	15 (5.3)
Availability of an active Nuclear Medicine clinic at the university of graduation, n (%)	
Yes	227 (79.6)
No	36 (12.6)
Unsure	22 (7.8)
Personal history of Nuclear Medicine imaging, n (%)	
Yes	47 (16.5)
No	219 (76.8)
Unsure	19 (6.7)
Data are expressed as mean ± standard deviation, median (minimum: maximum) or n (%).	

Table 2. Physicians' knowledge regarding radiation measurement, radiation exposure, and nuclear medicine practices.

	Yes	No	Unsure
The unit of radiation dose is the sievert.	186 (65.3)	13 (4.6)	86 (30.2)
The average annual natural background radiation dose is 2.4 mSv.a	131 (46)	24 (8.4)	130 (45.6)
The approximate radiation dose of a PA chest X-ray is 0.02 mSv.	132 (46.3)	23 (8.1)	130 (45.6)
Pregnancy must be ruled out in female patients prior to nuclear medicine procedures.	248 (87)	13 (4.6)	24 (8.4)
Side effects of nuclear medicine treatments are greater than those of other treatments.	97 (34)	108 (37.9)	80 (28.1)
Nuclear medicine has a therapeutic role in hyperthyroidism.	205 (71.9)	27 (9.5)	53 (18.6)
Nuclear medicine has a therapeutic role in thyroid cancer.	222 (77.9)	23 (8.1)	40 (14)
Nuclear medicine has a therapeutic role in prostate cancer.	155 (54.4)	39 (13.7)	91 (31.9)
Nuclear medicine has a therapeutic role in neuroendocrine tumors.	163 (57.2)	27 (9.5)	95 (33.3)
Nuclear medicine imaging provides better anatomical detail than radiological imaging.	145 (50.9)	82 (28.8)	58 (20.4)
Nuclear medicine imaging provides better physiological data than radiological imaging.	196 (68.8)	36 (12.6)	53 (18.6)

Data are expressed as n (%). a Background radiation is ionizing radiation naturally present in our environment to which we are constantly exposed. mSv, millisievert.

Table 3. Participants' attitudesand risk perceptions regarding nuclear medicine imaging.

	Yes	No	Unsure
I would prefer alternative imaging methods over nuclear medicine because of concerns about radiation exposure.	144 (50.5)	95 (33.3)	46 (16.1)
Nuclear medicine diagnostic procedures can be performed in breastfeeding women.	129 (45.3)	81 (28.4)	75 (26.3)
Nuclear medicine imaging can cause infertility.	123 (43.2)	105 (36.8)	57 (20.0)
Nuclear medicine imaging is highly likely to cause cancer.	177 (62.1)	57 (20.0)	51 (17.9)
Nuclear medicine methods are high-cost.	231 (81.1)	22 (7.7)	32 (11.2)

Data are expressed as n (%).

Table 4. Physicians' self-perceived knowledge, educational adequacy, and clinical engagement regarding Nuclear Medicine.

Variables	Yes	No	Unsure
I consider my knowledge about the short- and long-term effects of radiation to be adequate.	84 (29.5)	148 (51.9)	53 (18.6)
I consider my knowledge about radiation doses from radiological imaging to be sufficient.	49 (17.2)	186 (65.3)	50 (17.5)
I consider the Nuclear Medicine education I received during medical school to be adequate.	72 (25.3)	163 (57.2)	50 (17.5)
I feel sufficiently informed about the procedures performed in Nuclear Medicine clinics.	64 (22.5)	176 (61.8)	45 (15.8)
I use Nuclear Medicine methods for my patients in clinical practice.	173 (60.7)	95 (33.3)	17 (6.0)
I consider my knowledge about radiation doses from scintigraphic tests to be sufficient.	45 (15.8)	182 (63.9)	58 (20.4)
I consider my knowledge about radiation doses from PET/CT examinations to be sufficient.	62 (21.8)	159 (55.8)	64 (22.5)
I consider my knowledge about radiation doses from Nuclear Medicine treatments to be sufficient.	62 (21.8)	162 (56.8)	61 (21.4)
I have knowledge about the TARE procedure.	110 (38.6)	136 (47.7)	39 (13.7)
I participate in multidisciplinary patient discussions involving the Nuclear Medicine clinic.	103 (36.1)	150 (52.6)	32 (11.2)
Nuclear medicine imaging provides better physiological data than radiological imaging.	196 (68.8)	36 (12.6)	53 (18.6)

Data are expressed as n (%).CT, computed tomography; PET, positron emission tomography; TARE , transarterial radioembolization.

Discussion

In this two-center cross-sectional study, physicians working outside the departments of Nuclear Medicine and Radiology demonstrated a moderate overall level of knowledge, with particularly visible gaps in radiation dose awareness, therapeutic applications, and risk perception. These findings are important because Nuclear Medicine is expanding rapidly from conventional diagnostic imaging toward molecular imaging and theranostic practice, increasing the need for referring physicians to understand its indications, benefits, and limitations [3, 11]. Our results also suggest that familiarity with Nuclear Medicine is uneven: participants appeared more comfortable with long-established thyroid-related applications than with newer oncologic theranostic uses, while self-perceived preparedness remained low in several clinically relevant domains.

A central finding of this study was the gap between basic conceptual awareness and practical dose-related knowledge. Although a majority of participants correctly identified the sievert as the unit of radiation dose, fewer than half knew the approximate annual natural background radiation dose or the dose of a posteroanterior chest radiograph. This pattern is broadly consistent with previous studies showing that physicians often recognize that radiation matters but have limited knowledge of actual dose levels and dose comparisons relevant to referral and counselling [12-15]. This suggests that dose literacy remains a weak point even when general awareness is present, which may affect confidence in discussing imaging-related risks with patients [16-19].

Another notable result was the uneven awareness of therapeutic Nuclear Medicine indications. Awareness was higher for hyperthyroidism and thyroid cancer, whereas knowledge was lower for prostate cancer, neuroendocrine tumors, and TARE. This difference is clinically plausible because radioactive iodine has long been embedded in routine medical teaching and practice, whereas modern theranostic applications in prostate cancer and neuroendocrine neoplasms have expanded more recently and require more updated, disease-specific knowledge [20-22]. Contemporary guidance also emphasizes that theranostics now requires broader interdisciplinary familiarity, not just specialist expertise within Nuclear Medicine [11, 23].

Our data also showed a marked mismatch between perceived and likely actual radiation-related risks. A substantial proportion of participants believed that Nuclear Medicine imaging is highly likely to cause cancer or may cause infertility, and half stated that they might prefer alternative imaging methods because of radiation concerns. Similar overestimation of radiation risk has been described in earlier work on physician and healthcare-worker awareness, suggesting that uncertainty about dose often coexists with heightened anxiety about harm [5, 24]. Uncertainty regarding breastfeeding-related imaging decisions in our cohort is also in line with recent evidence showing that healthcare professionals continue to have important knowledge gaps in this area [25, 26]. Taken together, these findings suggest that the problem is not only insufficient factual knowledge, but also difficulty translating radiation information into balanced clinical risk communication.

Several mechanisms may help explain these findings. First, the field of Nuclear Medicine is changing rapidly, and educational content may not be keeping pace with developments in radiopharmaceutical therapy, PSMA-based imaging and treatment, peptide receptor radionuclide therapy, and broader theranostic models [3, 11, 21]. Second, physicians who use Nuclear Medicine more often in practice may gain cumulative exposure to its indications and workflows, which is compatible with our finding that knowledge scores were higher among those reporting clinical use of Nuclear Medicine methods. These findings also echo the results of previous studies among medical students, residents and practising physicians, which have consistently reported inadequate training in radiation protection and nuclear medicine [27-30]. Third, low participation in multidisciplinary discussions involving Nuclear Medicine may reduce opportunities for case-based learning and direct interaction with specialists, which may further limit practical familiarity. The broader theranostics literature increasingly frames multidisciplinary collaboration as a core requirement for safe and effective practice [31, 32].

These findings have several clinical and educational implications. Because many imaging and treatment decisions originate outside Nuclear Medicine departments, improving physicians' knowledge may support more appropriate referrals, more accurate counselling, and better alignment between clinical need and imaging or therapeutic choice. Evidence-based imaging referral frameworks have also been associated with improved care quality and reduced unnecessary use, underscoring the value of better-informed referral behavior [4]. In our cohort, more than half of participants considered their undergraduate Nuclear Medicine education inadequate, and only a minority felt sufficiently informed about procedures,

PET/CT, scintigraphic doses, or Nuclear Medicine treatments. These patterns support the need for stronger undergraduate reinforcement, continuing medical education, and workplace-based learning opportunities that include theranostics, radiation safety, and patient communication [11, 33]. When compared with similar studies in national and international literature, our results therefore do not only confirm a universal need to enhance nuclear medicine awareness, but also highlight specific educational targets for curriculum development and continuing professional development (CPD) programmes [34-36].

This study has several limitations that should be considered. Its cross-sectional design does not allow causal inference, and the data were obtained from two centers in a single city, which may limit generalizability to other physician groups and healthcare settings in Türkiye. The questionnaire-based design may also have introduced response-related bias, and the survey was developed for this study rather than as a formal scale-development project. Despite these limitations, the study provides contemporary multicenter data on physicians working outside Nuclear Medicine and Radiology in Türkiye and identifies specific domains in which educational support appears necessary. Overall, our findings indicate that physicians had moderate knowledge but substantial gaps in radiation dose awareness, therapeutic Nuclear Medicine applications, and risk perception, supporting the need for more structured and up-to-date educational support rather than suggesting any deficiency in clinical commitment [3, 11].

Conclusions

Physicians working outside the departments of Nuclear Medicine and Radiology demonstrated a moderate level of knowledge regarding diagnostic and therapeutic methods in Nuclear Medicine. However, important gaps were identified in radiation dose awareness, therapeutic applications, and risk perception, particularly in relation to newer theranostic approaches and special clinical situations. These findings suggest that current undergraduate and postgraduate training may not provide sufficient preparation for the evidence-based use of Nuclear Medicine in daily practice. Strengthening Nuclear Medicine education, multidisciplinary interaction, and continuing medical education may help improve physicians' knowledge, confidence, and clinical decision-making.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Health Sciences University Gazi Yaşargil Training and Research Hospital (protocol code 313 and date of approval 17/01/2025).

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions.

Author Contributions

Conceptualization, ZK, YG, HK, HO and HK2; methodology, ZK, YG, HK, HO and HK2; software, ZK, HK and HK2; validation, ZK, YG, HK, HO and HK2; formal analysis, ZK, HO and HK; investigation, ZK, HK and HK2; resources, ZK and YG; data curation, ZK and HK2; writing—original draft preparation, ZK; writing—review and editing, ZK, YG, HK, HO and HK2; visualization, ZK and HK2; supervision, ZK and YG.All authors have read and agreed to the published version of the manuscript.

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