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Evaluating Medical Doctors' Knowledge of Basic Nuclear Medicine Applications in Limpopo Province, South Africa

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Abstract

Introduction: Nuclear medicine is increasingly becoming common in South Africa, and there is an increase in referral to the unit, the exposure of medical doctor to basic knowledge of nuclear medicine varies, and therefore it is important to assess the knowledge of the referring doctors about the basic application of nuclear medicine. The study aimed to assess the knowledge of Medical Doctors in Limpopo about the basic application of Nuclear Medicine. **Methods**: A cross-sectional study design was used to collect information from medical doctors at the Pietersburg/Mankweng hospital complex in Limpopo about their exposure to nuclear medicine training and knowledge about the basic application of nuclear medicine. The 23-itemised questionnaire consisted of basic clinical application of nuclear medicine. The knowledge score was categorised into pass (<50%) and fail (≥50%). **Results**: A total of 103 medical doctors with an average of 6(3-12) years of experience participated in the study, 93.1% of the participants have referred patients to nuclear medicine. The median knowledge score among the doctors surveyed was 31.82(22.72-40.91) %, and only 12% scored ≥ 50%. The survey revealed that a significant proportion of medical doctors in Limpopo possess limited knowledge about the basic applications of nuclear medicine. Conclusion: The study findings highlight that there is a pressing need for targeted educational initiatives to enhance the knowledge of nuclear medicine among medical doctors in Limpopo. By improving awareness and understanding of nuclear medicine applications, patient care can be significantly improved through better diagnostic accuracy and treatment planning. Future efforts should focus on integrating nuclear medicine education into both undergraduate medical curricula and continuous professional development programs.

Keywords: *Nuclear Medicine; Medical Knowledge; Diagnostic Imaging; Medical Education; Medical Doctors; South Africa*

Introduction

In nuclear medicine (NM), the body is imaged "from the inside out." Radiotracers, often in the form of complex radiopharmaceuticals, are administered internally. The diagnostic inference is gained by recording the distribution of the radioactive material in both time and space. Tracer pharmacokinetics and selective tissue uptake form the basis of diagnostic utility. To understand nuclear imaging procedures, it is necessary to understand a sequence of concepts, beginning with the physics of radioactivity, continuing through the process of detecting radiation and selecting appropriate radiopharmaceuticals, and ending with the uptake and distribution of those pharmaceuticals in health and disease. Molecular imaging is used to determine the extent and severity of a disease, identity the most effective therapy and assess the effectiveness of a treatment regimen putting into consideration the properties of the tumour and the patients biologic characteristics [1]. Early use of nuclear medicine was limited to scanning of the thyroid, however, with advancement in science and technology, there is an increase in the clinical application of nuclear medicine in patient diagnosis and management [2].

With the increasing cost of healthcare, clinicians are responsible for choosing the most appropriate and cost-effective method to achieve the desired goal in patient management. At the same time, clinicians also need to be aware that many of the diagnostic imaging investigations increase the risk of patient exposure to radiation and these risks should be considered before investigations are made [3]. The challenge for medical professionals who have specialised in imaging as well as medical educators is to adequately prepare and educate future clinicians regarding the cost-effective application of new diagnostic procedures. The importance of limiting the radiation burden to the patient must also be stressed [3].

In the nuclear medicine department at Pietersburg/Mankweng Hospital, South Africa, it has been our experience that any Doctor can refer (both senior and junior). Request forms are often inadequately completed (a perennial problem) but also the investigations that are requested are sometimes inappropriate or even unnecessary [4]. A large study conducted by [5] to assess "the degree of formal teaching at the undergraduate level for the medical specialties of radiology and nuclear medicine" and 70 universities resident in 20 different countries participated in the study. An audit of the University of Pretoria in South Africa showed that medical students are exposed to a total of 22 sessions of nuclear medicine lectures during their medical training [5]. Another study to evaluate the nuclear medicine curriculum in 71 countries in Europe showed that the teaching of nuclear medicine showed various time allocations, content and structure [6]. Time allocations varied from 1-2 to 40 hours, the teaching is often integrated with radiology and sometimes taught [6]. According to [5] reiterated the need for education on nuclear medicine at undergraduate level focussed on the uses, values, limitations, hazards and financial implications.

[2] Assessed the knowledge of general practitioners in Iran about the clinical applications of nuclear medicine using a multiple-choice question self-administered questionnaire. The knowledge questionnaire was categorised into two groups focussed on general information in nuclear medicine and common clinical applications of nuclear medicine [2]. The study reported that 62% of the medical doctors had poor knowledge of nuclear medicine; this is not surprising as 69% of the medical doctors had no nuclear medicine training in undergraduate medical school and the 31% that reported exposure to nuclear medicine only have 3-15 hours of teaching during their training [2]. Several studies have been conducted to assess the level of knowledge of undergraduates and qualified medical doctors regarding patient's radiation exposure to ionising radiation in practice and the knowledge is generally poor regardless of geography [7-12]. Therefore, it is imperative that non-nuclear medicine clinicians be educated on basic nuclear medicine given their legal responsibility under the ionising radiation regulations. Clinicians play a vital role in explaining these procedures to patients and in giving the correct information to patients undergoing these scans or therapies [8]. In South Africa, [13] assessed the teaching of nuclear medicine

among medical students and an average of 20 minutes of teaching was allocated to teach students during their 5th year of study. Recently, an e-learning framework was implemented at the University of Bergen in Norway to teach medical students nuclear medicine and radiology and the e-learning framework was effective in teaching the students basic nuclear medicine competencies with 87% passing the PET/CT station of their OSCE [14]. To adopt nuclear medicine training approaches for medical doctors, due to the variations in education and exposure, it is necessary to understand their current knowledge and exposure to nuclear medicine teaching, these will be used to develop a basic introductory curriculum that could be implemented at various academic hospitals in South Africa. The aim of this study was to assess the knowledge of medical doctors in South Africa on the basic principles and clinical applications of nuclear medicine.

Research Methodology and Design

Research Design and Setting

This cross-sectional descriptive study was conducted at the Pietersburg/Mankweng hospital complex, located in the Capricorn district of Limpopo province, South Africa. This hospital complex provides tertiary-level healthcare services to the entire population of Limpopo province, which has approximately 5.9 million residents. The Pietersburg/Mankweng hospital is the sole public facility offering these services within the province.

Study Population

The study targeted medical doctors employed at the Pietersburg/Mankweng hospital complex. At the time of the study, there were 430 medical doctors registered with the Health Professional Council of South Africa (HPCSA) and actively employed at either Pietersburg /Mankweng hospital.

Inclusion and Exclusion Criteria

Inclusion Criteria: Medical doctors currently registered with the HPCSA and engaged in clinical practice at either Pietersburg/Mankweng hospital.

Exclusion Criteria: Medical doctors who are not involved in clinical practice, such as those in administrative roles or on extended leave, were excluded from the study.

Knowledge Questionnaire

The 23 itemised knowledge questionnaire was adapted from [2], a similar questionnaire was used by [13] in South Africa to assess the knowledge of interns and registrars about basic application of nuclear medicine. The internal reliability of the questionnaire is 0.64 which implies moderate reliability.

Sampling and Sample Size

All the medical doctors currently employed by the Pietersburg/Mankweng hospital complex were consecutively recruited to participate in the study. The Openepi sample size calculator (http://www.openepi.com/SampleSize/SSPropor.htm) using proportions was used to determine the sample size using the following parameters – population of 430, anticipated frequency of 20% and 80% confidence level and random effect of 1. A minimum sample size of 85 participants will be sufficient to determine the knowledge of doctors about the application of nuclear medicine in this study.

Data Collection

Data were collected using a structured questionnaire designed in consultation with nuclear medicine specialists. The questionnaire aimed to assess the doctors' knowledge of nuclear medicine applications, their primary sources of information, and their attitudes towards further education in this field. The questionnaire comprised multiple-choice questions to capture a broad spectrum of insights.

Procedure

Recruitment: Participants were recruited through direct communication and departmental meetings. Information about the study's purpose and significance was provided to encourage participation.

Survey Administration: The questionnaire was distributed to the participants in both electronic and paper formats, depending on their preference. Participants were given two weeks to complete and return the questionnaire.

Data Handling: Completed questionnaires were collected and anonymized to ensure confidentiality. Data were then entered into a secure database for analysis.

Data analysis

Descriptive statistics of median and interquartile range was used to summarise the data. Non parametric statistics of Mann Whitney U and Kruskal Wallis test to determine the significant difference in the knowledge score between the groups. The knowledge score was categorised into pass (<50%) and fail (≥50%). The internal reliability of the knowledge questionnaire was determined by using the Cronbach Alpha. Level of significance was set at $p<0.05$.

Results

Table 1 reveals that 103 medical doctors participated in this study, with an average experience of 6 years (range: 3-12 years). The bulk of these doctors received their training in South Africa. Their most common department is paediatrics. Almost all participants have referred patients to nuclear medicine, and more than half claim job experience as their major exposure to nuclear medicine. While exposure to nuclear medicine instruction was more widespread during postgraduate study, a significant proportion did not acquire it throughout their undergraduate studies [14]. All participants had a median knowledge score of 31.82 (interquartile range 27.27-40.91). However, only 11.7% of participants achieved 50% or better on the nuclear medicine knowledge assessment. Furthermore, the majority of the doctors (49.51%) stated that they learned about nuclear medicine mostly from job experience. The findings were provided in **Table 1** demonstrates that the median knowledge score among medical doctors polled was poor, with just a tiny percentage scoring 50% or higher. Exposure to nuclear medicine during postgraduate training [36.36(29.55-45.46)] appears to improve knowledge ratings, highlighting the value of continuing education in this subject. There were no significant variations in knowledge ratings based on other variables, demonstrating that postgraduate training is an important component in increasing nuclear medicine expertise among practitioners. Additionally, **Table 1** shows the distribution of knowledge scores among polled doctors, with 12% scoring ≥ 50% and 88% scoring <50%.

Table 1: Sociodemographic characteristics of the participants

Variable	
Experience in months, Median (IQR)	6(3-12)
Country of study	
South Africa	86(83.5)
Foreign	8(7.77)
Not specified	9(8.74)
Level of experience	
Consultant	17(16.5)
Intern	20(19.42)
Medical officer	32(31.07)
Registrar	31(30.1)
Other	1(0.97)
Not specified	2(1.94)
Department	
General surgery	19(18.45)
Internal medicine	18(17.48)
Pediatrics	34(33.01)
Radiology diagnostics	8(7.77)
Urology	6(5.83)
Orthopedics	8(7.77)
Not specified	2(1.94)
Plastic and reconstruction surgery	1(0.97)
Oncology	7(6.80)
Not specified	6(5.83)
Have you ever referred a patient or patients to Nuclear Medicine?	
Yes	94(93.1)
No	7(6.9)
Which one would you say is the best place where you exposed to Nuclear Medicine?	
Undergraduate	20(20.6)
Postgraduate	26(26.8)
Work experience	51(52.6)
Did you have exposure to Nuclear Medicine Education in your undergraduate training?	
Yes	33.7(34)
No	67(66.3)
Did you have exposure to Nuclear Medicine Education in your postgraduate training?	
Yes	65(66.3)
No	33(33.7)

The pie chart illustrates the percentage distribution of medical doctors' knowledge scores regarding specific questions about Nuclear Medicine. The chart is divided into two segments: the majority of doctors, 88%, scored below 50%, indicating a lower level of knowledge in the subject. In contrast, a smaller portion, 12%, achieved a knowledge score of 50% or higher, suggesting a better understanding of Nuclear Medicine concepts. This distribution highlights a significant knowledge gap among medical professionals in this area, with most scoring less than half of the total possible score, indicating a need for enhanced education and training in Nuclear Medicine.

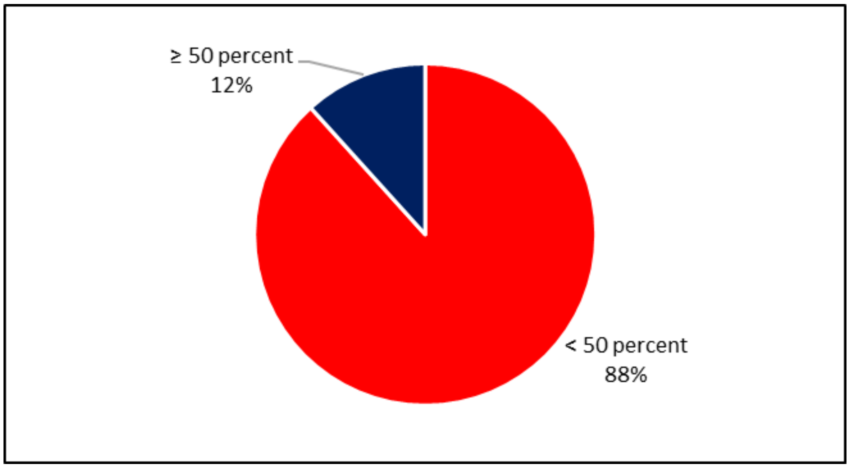

Figure 1:Percentage knowledge score of the medical doctors

Nuclear Medicine Knowledge Among Respondents

The results in **Table 2** shows respondents have various levels of knowledge about Nuclear Medicine among respondents. Certain areas, such as the sensitivity of organs to radiation (89.3%) and the necessity of keeping radiation exposure as low as reasonably achievable (76.7%), showed high awareness. However, there are significant knowledge gaps in other areas, such as the understanding of specific non-ventilation radiopharmaceuticals (1.9%) and the misconception about the potential explosiveness of nuclear materials used in medicine (3.9%). Additionally, no respondents correctly identified that IV contrast material increases radiation dose during an F18 FDG PET-CT scan. Overall, these results can guide educational initiatives to improve knowledge in weaker areas. Table 2 also presents responses to a set of specific knowledge questions related to Nuclear Medicine. The table indicates the number of respondents and their percentage who selected each answer for various questions. For instance, 35 respondents (34%) identified the best use of Nuclear Medicine, while 27 respondents (28.4%) were familiar with Myocardial Perfusion Imaging in Nuclear Medicine. Additionally, 18 respondents (17.5%) selected the indication of Myocardial Perfusion Imaging that they believed did not belong in a given grouping.

Questions related to knowledge of specific conditions and procedures in Nuclear Medicine, such as 99Tcm-dimercaptosuccinic acid (DMSA) and 99mTc diethylenetriaminepentaacetic acid (DTPA) scans for evaluating certain diseases, were answered correctly by 34 respondents (33%). When asked about the sensitivity of detection methods for bone metastasis in prostate cancer, 55 respondents (53.4%) identified the most sensitive option. Questions regarding safety concerns, such as the safety of nuclear material (4 respondents, 3.9%), the need for pregnancy testing before nuclear medicine scintigraphy (72 respondents, 69.9%), and dose thresholds for safe exposure (23 respondents, 22.3%), showed varying levels of awareness among respondents.

The awareness of the ALARA principle, which stands for keeping radiation exposure "As Low As Reasonably Achievable," was relatively high, with 79 respondents (76.7%) acknowledging its importance. However, only a small percentage (12.6%) correctly understood the comparative radiation doses between MRI scans and F18 FDG PET scans, and none (0%) recognized that intravenous contrast material in F18 FDG PET-CT scans increases radiation exposure. The perception of Nuclear Medicine as a safe and effective diagnostic tool was shared by a significant proportion of respondents, with 34 respondents (33%) acknowledging its utility in various medical specialties, and 34 respondents (33%) recognizing its role in providing quick, safe, and accurate diagnoses.

Table 2: Specific knowledge questions

Questions	Knowledge	n (%)
1	Which of the following would you say is the best use of Nuclear Medicine?	35(34)
2	Are you familiar with Myocardial Perfusion Imaging in Nuclear Medicine?	27(28.4)
3	Which of the following: Indications of Myocardial Perfusion Imaging do you think doesn't belong in this grouping?	18(17.5)
4	Which of the following indications for VQ do you think doesn't belong in this grouping?	21(20.4)
5	Which of the following do you think is not a Ventilation radiopharmaceutical?	2(1.9)
6	Do you think Myocardial Perfusion Imaging (MPI) is the most performed procedure in Nuclear Medicine?	1(1)
7	Do you think Nuclear Material used in Nuclear medicine is potentially explosive?	4(3.9)
8	99Tcm-dimercaptosuccinic acid (DMSA) and 99mTc diethylenetriaminepentaacetic acid (DTPA) scans are diagnostic modalities for evaluation of ………diseases.	34(33)
9	In a case of prostate cancer which of the following options has more sensitivity for the detection of bone metastasis?	55(53.4)
10	Which of the following pathologies is not an indication for the Nuclear Medicines thyroid scan?	42(40.8)
11	Is Nuclear Medicine forbidden in cases of gestational age<3months?	42(40.8)
12	Should every woman of childbearing age be submitted to a pregnancy test before being submitted to Nuclear Medicine scintigraphy?	72(69.9)
13	Is there a dose threshold below which exposure is safe?	23(22.3)
14	The time interval during which the total amount of radiation was received does not influence the risk of cancer development. Is this right or wrong?	28(27.7)
15	Are there organs or tissues more sensitive to radiation than others?	92(89.3)
16	Should any activity involving radiation be justified in relation to available alternatives?	73(70.9)
17	Should all exposures to radiation be maintained as low as reasonably achievable (ALARA)?	79(76.7)
18	The radiation dose to the patient is higher with an MRI scan than with an F18 FDG PET (without the CT component) Scan	13(12.6)
19	IV contrast material injected during an F18 FDG PET-CT Scan increases the radiation dose to the patient?	0(0)
20	Nuclear Medicine procedures are among the best and most effective life-saving tools available	17(16.5)
21	Nuclear Medicine is safe and painless and does not require anesthesia	16(15.5)
22	Nuclear Medicine procedures are helpful to a broad span of medical specialties, from pediatrics to cardiology to psychiatry.	34(33)
23	Nuclear Medicine allows for quick, safe, early, and more accurate medical diagnoses.	34(33)

Discussion

In this study, the average knowledge score was 31.82%, which implies that the knowledge score was averagely poor. With the knowledge score classified into good (≥ 50%), and poor (< 50%), only 12% had good knowledge of nuclear medicine. The poor knowledge score is not surprising as only 34% of the medical doctor's surveyed reported exposure to nuclear medicine during their undergraduate training and 49.5% reported exposure to nuclear medicine as a result of work experience. This is a concern as 94% of these study participants are currently referring to nuclear medicine. Despite the poor knowledge scores, medical doctors with postgraduate training, although scored poorly had a significant higher scores than participants without postgraduate training. Comparing our results to an earlier study conducted by [2], where 62% of the medical doctors had poor knowledge of nuclear medicine with 69% of the participants had no exposure to nuclear medicine training, those that had had exposure of between 3-15 hours during their undergraduate training. The outcomes of the study by [2] in Iran comparable to our study as the content and the time allocation for nuclear medicine has high variability and therefore the basic knowledge is not standardised. A similar study conducted in South Africa by [13] to assess the knowledge of interns and registrars at two academic hospitals in Gauteng about basic and clinical applications of nuclear medicine, the results showed that 31% of the medical doctors had poor knowledge while 44% had a medium knowledge and only 25% had good knowledge.

Apart from the average knowledge scores, specific questions were further assessed and we observed that on questions 9, 12, 15, 16, and 17 the more than 50% of the medical doctors correctly got the right answer. Questions 5, 6, 7, and 19 were particularly problematic for respondents. The questions were focussed on ventilation radiopharmaceuticals, myocardial perfusion imaging, and nuclear material and IV contrast material. Only 1 % of respondents are familiar with myocardial perfusion imaging (MPI) and only 1% knew that MPI is the most commonly performed procedure. Myocardial perfusion imaging represents more than 50% of the nuclear medicine procedures done, in the United States, 1,000 or more nuclear cardiology procedures are performed per 100,000 people [15]. None of the medical doctors knew that IV contrast material injected during an F18 FDG PET-CT Scan does not increase the radiation dose to the patient. This is probably due to the non-availability of PET/CT in the province and since nuclear medicine training exposure was from work experience, this is not surprising, however, with basic nuclear medicine education, medical doctors should know about basic PET/CT procedures.

The factors responsible for the gross poor knowledge about nuclear medicine among non-nuclear medicine experts should be explored and possible intervention measures should be considered. Possibly, basic nuclear medicine applications should be taught at individual academic hospitals within each department to improve the knowledge of medical doctors about nuclear medicine. These trainings can be conducted by regular workshops, continuous medical education and seminars. The e-learning module as used by the University of Bergen in Norway could be adopted for both undergraduate medical students and medical doctors to further improve on the access to standardised nuclear medicine materials.

Conclusion

The study assessed the knowledge of medical doctors in Limpopo regarding the basic applications of nuclear medicine, revealing significant gaps in understanding and awareness. The findings indicate that many doctors lack adequate knowledge about key aspects of nuclear medicine, including the principles of nuclear imaging techniques (such as PET and SPECT), the indications for various nuclear medicine procedures, and the safety protocols associated with the use of radioactive materials. These inadequacies underscore the crucial need for tailored educational interventions. To address these knowledge gaps, enhanced training programmes at the undergraduate level as well as continual professional development are required. By strengthening medical practitioners' understanding and application of nuclear medicine, healthcare delivery can be significantly enhanced, resulting in better diagnostic accuracy and more successful treatment regimens for patients.

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Authors' contributions

NM conceptualised the study design and wrote the manuscript.

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Availability of Data and Materials

Data will be made available upon reasonable request to the corresponding author.

Ethics Approval and Consent to Participate

The study was conducted according to the guidelines of the National Health Research Ethics Council (NHREC), and approved by the Turfloop Research Ethics Committee (TREC) (TREC/102/2023)

Consent for Publication.

Not applicable

Competing Interest

The author declares no competing interest.

Conflict of Interest

The author declares no conflict of interest.

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