RESEARCH COMMUNICATION

Planning of Nuclear Medicine in Turkey: Current Status and Future Perspectives

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Abstract

Background and Purpose: An analysis of the current nuclear medicine (NM) status and future demand in Turkey in line with the international benchmarks was conducted to establish a comprehensive baseline reference. Methods: Data from all NM centers on major equipment and manpower in Turkey were collected through a survey and cross-checked with the primary research and governmental data. Data regarding manpower currently working were obtained from the relevant academic centers and occupational societies. Results: The current numbers of NM laboratories, NM specialists, gamma cameras, PET/CT scanners, radioiodine treatment units for thyroid cancer are 217, 474, 287, 75 and 39, respectively. There was personnel and equipment need underestimated in the field compared to developed countries. Equipment insufficiency was more significant in the Ministry of Health (MoH) hospitals. These gaps should be eliminated with strategic planning of equipment and NM laboratories. Currently, the number of the PET/CT devices is at the level of the developed countries. The number of specialists in the field should reach the expected goal in 2023. By 2023, Turkey will need around 820 NM specialists, 498 gamma cameras and 99 PET/CT devices. In addition, further studies should be made regarding other related staff, particularly for health physicians, radiopharmacists and NM technicians. Conclusion: There is an insufficiency of personnel and equipment in Turkey's NM field. Comprehensive strategic planning is required to allocate limited resources and the purchase of the equipment and employment policies should be structured as part of "National Special Feature Requiring Health Service Plan".

Keywords: Nuclear medicine - equipment - staff - future policy decisions - Turkey

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Introduction

Nuclear Medicine (NM) is a discipline which uses radioactivity in diagnosis and treatment of disease. The field is mainly used in Oncology, Cardiology, Endocrinology, Nephro-Urology and also connected with some other clinical divisions.

Cancer remains as a major health problem in the 21st century. According to the World Health Organization, the burden of cancer has doubled in the past 30 years. In addition, during 2020-2030 it is estimated to at least double the current figures. NM procedures are indisputable in diagnosis and treatment of cancer, and its importance is increasing. These applications contribute in diagnosis of diseases, staging, and monitoring response to therapy and also to the re-staging procedures if needed. NM procedures, with the use of hybrid systems in this field in recent years have gained a different dimension. In addition to PET/CT systems currently used in routine, SPECT-CT systems have started to spread in the field of oncology (WHO, 2003; World Cancer Report, 2008; Alberini et al., 2011). Coronary Artery Disease (CAD) is a very important encountered sickness in Cardiology. The incidence of death due to CAD in women is still rising in Turkey (Arch Turk Soc Cardiol, 2010). Myocardial Perfusion Scintigraphy provides additional contributions to the diagnosis of suspected CAD, the detection of the prevalence of the disease after revascularization and the study of re-stenosis. Additionally, non-invasive coronary angiography is another commonly used indication (Mowatt et al., 2004; Underwood et al., 2004). NM is used extensively in the diagnosis of endocrine diseases which are highly seen in Turkey. "I-131 Ablation Treatment of Well-differentiated thyroid cancer" and "Treatment of Hyperthyroidism" are major application areas for NM (Cetin et al., 2010). Thyroid cancers have shown a dramatic increase in recent years and have become the third most frequently encountered cancer in female population in Turkey (Kanser.gov, 2004-2006; Tuncer et al., 2010). I-131 ablation therapy is used in the field of NM, which can treat about 90% of such cancers (Konrády et al., 2011). In addition, some specific and sophisticated

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treatments are applied in the field of NM such as pain palliation, radiosynovectomy, hepatic radioembolisation and intracavitary treatments and others (Malygina et al., 1978; Murthy et al., 2006; Janen et al., 2010; Liepe et al., 2011).

In this context, it should be emphasized that, NM as a very special branch of science, which can be utilized in both diagnostic and therapeutic procedures. Turkey has an important potential for the applications in NM not only because of the frequency of the above-mentioned diseases; but also due to the potentially high young patient population (Karakaya, 2009). However, there is no any previously published report for the baseline situation in Turkey.

This article summarizes the current level of NM facilities and manpower in Turkey and is unique since it is the first needs assessment and comprehensive data set analysis for Turkey in this field. This article is also the first analysis of Turkey that aims to align closer with international benchmarks. The authors hereby aim to provide an example for NM planning for other developing countries where limited resources demands careful planning.

Materials and Methods

Baseline status survey

A survey prepared by the Ministry of Health (MoH) was sent to all NM Centres in Turkey through each city's medical authority. The survey included questions regarding the type and model of imaging devices in addition to the name of the NM centre, the type of the centre (Ministerial/ University/ Private) as well as the related information on working staff. In order to evaluate the manpower status, all centres were asked to report the number of NM physicians, medical physicists and NM technicians. Information on undergraduate personnel currently on training and institutions providing such education was supplied by the Turkish Council of Higher Education. The survey data was then compared with the information provided by the companies that supply the devices.

Survey was sent in October 2010 and collected from all centres by December 2011. A response rate of 100% was achieved. The survey results were cross-checked and complemented by the data from Turkish Atomic Agency and MoH Curative Services Department, to which all centres are required to apply for licensing and updating every 1-2 years. In addition to such verification, data was confirmed through authors' primary research. Full data set was consolidated by the MoH.

MoH within the scope of this study has classified the NM centers into three levels. Level 1 defined as Comprehensive NM Centers with minimum 1 PET/CT, 1 SPECT/CT, 2 Dual Head Gamma Camera, 1 Radioiodine Uptake device, 1 USG device (for neck/thyroid examination) and 8 bedrooms for Radioiodine Therapy. And also there must be 4 NM Physicians, 2 Medical Physicist, 2 Technicians per scanner, 3 Hot Laboratory staff, 2 Secretary specialized in the field of NM and 3 nurses specialised in field also. Level 2 defined as NM Diagnosis and Treatment Centers with minimum 2 Dual Head Gamma Camera, 1 Raidoiodine Uptake device, 1 USG device (for neck/thyroid examination) and 2 bedroom for Radioiodine Therapy, 2 NM Physicians, 2 Medical Physicists, 2 Technicians per scanner, 2 Hot Laboratory staff, 2 Secretary and 2 Nurse specialised in the field. Level 3 defined as NM Service Units. If this is a Private Center there shall be all kinds of NM device according to the needs of the region, such as PET/CT or SPECT/CT. If this center is a Thyroide Disease Diagnosis and Treatment Center there must be 1 Single Head Gamma Camera, 1 Radioiodine Uptake device, 1 USG device (for neck/thyroid examination) and 1 Thyroid Gamma Camera (according to needs), 1 NM Physicians, 1 Medical Physicist, 2 Technicians per scanner, 2 Hot Laboratory staff, 1 Secretary and 1 Nurse specialised in the field.

Demand Analysis & Ministerial Plans

Main considerations in determining the number of personnel and equipment is the number of newly diagnosed and follow up patients who are usually oncological, endocrinological, cardiologic, and nephrourologic diseases. In recent years, the number of oncologic and cardiologic patients in Turkey and all around the world has increased (Kanser.gov, 2004-2006; Mowatt et al., 2004; Tuncer et al., 2010; Göksel et al., 2011). The average number of patients scanned with a dual head gamma camera is around 15 to 20 per day; thus the number of scanners can be calculated according to the number of patients per day.

During planning, given different socioeconomic factors, population size, and travel related behaviour of patients, the country was divided into 29 medical regions by the MoH - as shown in Figure 1. With this allocation, approximately 4-5 cities were linked to each oncology center. Essential manpower and equipment planning was done in accordance to these population segments.

There is no a universally accepted guideline or country specific thresholds for gamma camera counts or NM expert numbers. There are 19 units of gamma camera per a million populations in Canada. According to a study in India in 2002, the average of gamma cameras is reported as a ratio 72/one million people for developed countries. In the comprehensive study carried out by MoH "National Special Feature Requiring Health Service Plan", the number of gamma camera recommended for major cities (as Ankara, Istanbul and Izmir) is 1 gamma camera per maximum of 100.000 population. The number of gamma cameras recommended for major health provinces is one

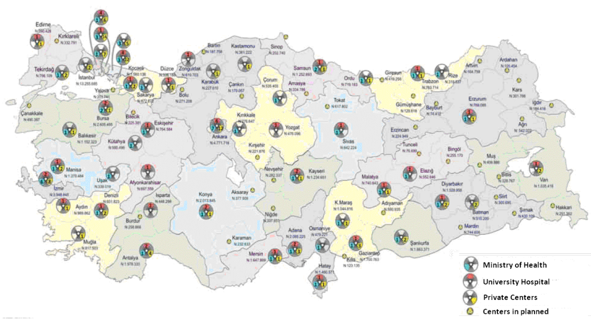

Figure 1. Regions of Health and NM Laboratories

device per maximal of 150.000 populations and for minor health provinces is one device per maximal of 150.000 populations (Göksel et al., 2011).

There is no worldwide standard set for planning the number of PET/CT Scanner. Suggested numbers are variable but on average one PET/CT scanner is recommended per 500.000 to 1.500.000 population. According to some others, 10 patients per day should be planned for each PET/CT scan and with these figures; larger numbers can be expected for planning. If examined number of patients is 10-15 per scanner, this will result in 2.500-3.000 annual examinations and the number of scanner can be determined according to the annual incidence of patients (Michael et al., 2004; Mudur, 2008). Furthermore, number of radiation oncology experts and necessary equipments should also be considered during planning of PET/CT devices. Since PET/CT is also commonly used for planning of the radiotherapy treatments, PET/CT country specific planning is usually done in accordance with the number of oncology patients both in the other countries and in Turkey as described in this manuscript (Blodgett, 2010; Purandare et al., 2010).

On the other hand PET/CT reporting process is extremely time-consuming. Furthermore, NM Specialist spends time for patient preparation, imaging planning, interim assessment, other scintigraphic examination, chancellery etc. All these interim jobs and necessary staff should be taken into consideration while the planning the number of NM specialists.

Turkish Statistical Institute data was used in this research for current population statistics (TUIK, 2011). With the increase in population to 82.293.000 till 2023 and increased incidence of cancer at 3-3, 2 per 1.000 predominantly due to aging population, the newly diagnosed patients per year is expected to be around 245.000-265.000 (Karakaya, 2009; TURKSTAT, 2011). Finally, the ideal supply for future was then calculated based on some international benchmarks and the planning principles presented above.

Results

Facilities

NM facilities currently available in Turkey are summarized in Table 1; while the distribution of the NM Laboratories, PET/CT Hybrid Scanners, Gamma Camera Scanners, SPECT/CT Hybrid Scanners and I-131 Treatment Services are shown in Figure 1. There are currently 217 NM centres in 42 cities of Turkey. This indicates one centre per 334.000 populations.

Nearly 8,7% of centers are level 1, 15.6% are level 2 and 76% are level 3. Fifty-two percent of all centers are private hospital or centres, whereas 24% is publicly owned and 24% are university hospitals. Private centers are distributed between level 2 and 3 centers. By year 2023, 14 level 1 centers and 34 level 2 centers owned by Ministry, and 18 level 1 and 27 level 2 centers owned by university hospitals are planned to fill the gap defined above.

It is also observed that western, southern and middle regions of Turkey have less than 770.000 populations per center whereas this number is close to 1 million in the north and 1.5 million in the southern eastern regions of Turkey. Allocations of new centers are planned in accordance to this population dynamics.

Equipment

Currently, there are 287 gamma cameras in Turkey. Thirty-nine percent of these devices are located in private centers, 37% in University Hospitals and remaining 24% are located in the ministerial hospitals. The number of scanners varies one to six according to the size of the centers. There are ten hybrid Gamma Camera scanners (SPECT/CT) in Turkey. Four located at the ministerial hospitals, 5 at university hospitals and the last one located at a private center. There are ten dedicated cardiac gamma camera systems. Nine located at the universities and the other at a private center. There is no dedicated cardiac gamma camera system in Ministerial hospitals.

There are 75 PET/CT centers across the country and the distribution of the PET/CT centres is shown in Figure 1. This indicates one center per 1 million populations.

There are 38 "Radioiodine Treatment Unit for Thyroid Cancer" centers in Turkey. Bed capacity of these centers varies from 1-10. 10% of these centers are private, 54% and 36% belong to the universities and Ministry; respectively.

Given international benchmarks and Turkey's current strategic plan, the aim is to have 99 PET/CT scanners and 379 gamma camera scanner by 2023. An interesting finding of currently available equipments was wide regional gaps. Almost 51% of all PET/CT scanners and 44% of all gamma cameras were installed in Istanbul and Ankara.

Personnel status

NM Specialist: The number of NM Specialists has risen from 231 in 2003 to 446 by 2010 and to 474 in 2011. Currently out of 474 NM Specialists, 229 work for public hospitals, 155 work for university hospitals and around 90 work for private institutions.

The Figure for developed countries is 1 NM specialist per 100.000 people. According to 2011 conscious data of Canada, there is only 1 NM specialist available for 150.000 people. Given 446 NM specialists existing in Turkey, there is only 1 NM specialist for 170.000 people according to 2010 conscious data. Statistics project that the growing population in Turkey will reach nearly 82.2 million in year 2023. Therefore, it is expected to have at

Table 1. Current NM Facilities

	Ministry of Health	University Hospital	Private Hospital or Imaging Centre	Total
Specialist	229	155	90	474
NM Laboratories	53 (29 city)	53	111	217 (42 city)
Gamma Camera	70	105	112	287
PET / PET-CT	19	26	30	75 (20 city)
SPECT/CT	4	5	1	10
I-131 Treatment Services	14	21	4	39

Table 2. NM Equipments and Advised Hospitals

Device	Hospital
SPECT (One Headed Gamma Camera)	General Hospital, Oncology Diagnosis and Treatment Center
SPECT (Dual Headed Gamma Camera)	General Hospital, Oncology Diagnosis and Treatment Center
SPECT-BT***	Comprehensive Oncology Center, Oncology Diagnosis and Treatment Center
PET-BT	Comprehensive Oncology Center, Oncology Diagnosis and Treatment Center
PET-MR	The Campus Hospitals (In each province up to one)
Dedicated Cardiac Gamma Camera	Planning Cardiovascular Surgery Center (KVC) A1, A2
Solid State Cardiac Gamma Camera*	Planning KVC center A1, A2
Iyot Uptake	All of them
Thyroid Gamma Camera**	All of them
Gama Probe	General Hospital, Comprehensive Oncology Center, Oncology Diagnosis and Treatment Center
Ventilation Devices for V/Q Scan	General Hospital,
İnrtaoperatif Imaging****	Comprehensive Oncology Center,
Hot Laboratory Equipment	All of them
C-14 Breath Test Device	All of them
I-131 Treatment Service	General Hospital, Comprehensive Oncology Center, Oncology Diagnosis and Treatment Center
Treadmill Device	General Hospital A1, A2

*There are two versions. The first is the system that can shoot sitting, is about the same price with the conventional cardiac gamma cameras, can make attenuation correction with X-ray if necessary. İmaging time is half-time or less. The other is a special developed system that shortens the imaging time to 3 minutes. However its price is about 2-2,5 times of dual dedector gamma camera. These systems can be recommended for a hospital especially that has cardiology and cardovascular surgery clinics; **Only one firm producing. It is a system which doesn't cover much area and easy to installation. It is recommended for Nuclear Medicine Clinics; *** It has three different types. The aim of the first produced series is improving image quality by meking attenuation crrection. With nondiagnostic, low dose CT component limited contributes to find anatomic localization. This model replaced by multislice SPECTCT systems. With these systems nuclear medicine prosedures as well as every CT examinations except coronary angiography can be done and provides by all of the Nuclear Medcine device manufactures. This system which produce by single manufacturer has a limited field of view an it stands out especially in the fieled of orthopedics. SPECT/CT systems costs around 2-2,5 times of a dual detector gamma camera; ****İt is a new developed system

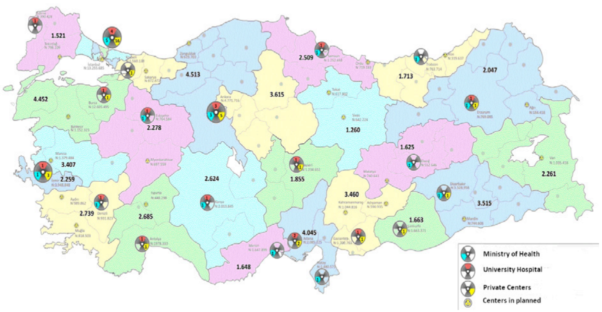

Figure 2. Regions of Health and PET/CT Devices

least 820 NM specialists by this year so that there will be 10 NM specialists available per 1 million people. In year 2005 there were 298 NM specialists and 247 related treatment equipments, which equal 1 unit equipment per 1.21 specialists. In 2011, there were 474 NM specialists and 372 units (equipments) in operation, which means, 1 unit for 1,217 specialists. But in Canada the ratio is 3 to 1, meaning 3 units per 1 specialist (Gonzales, 1996; Durak, 2005; Karakaya, 2009; Göksel et al., 2011).

Medical physicists: There is an overt gap for the number of medical physicists. Since this is a long history of gap, Ministry of Health has started an in depth analysis for the reasons and possible solutions which is not presented in this article.

Discussion

NM has come a long way in Turkey but still there is more room for advancement and modification. In general, there are 2 types of imaging techniques in Nuclear Medicine, SPECT (gamma camera) and Molecular

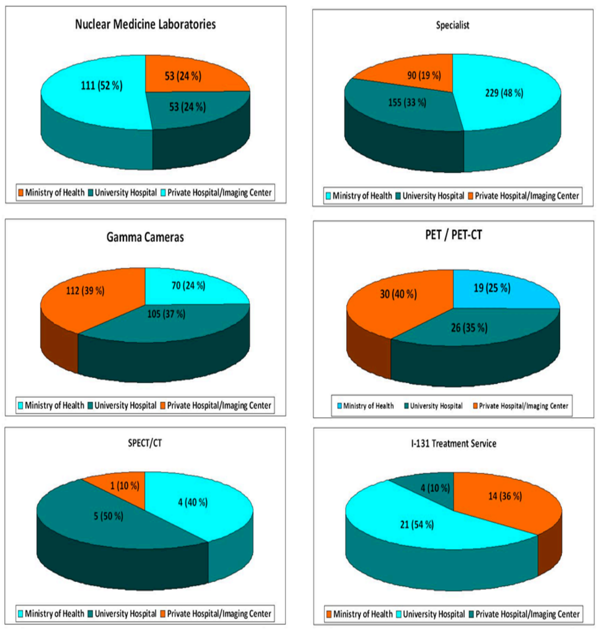

Figure 3. Current NM Equipments and Personnel Status

imaging (PET). After 2002, PET scanners are integrated to CT (computed tomography) and became a hybrid PET/CT scanner. In recent years by adding MRI to the PET scanner, hybrid PET/MRI imaging is also available. The similar technology applied to SPECT Gamma Cameras and integrated to CT scanner to become hybrid SPECT/CT scanner. In the recent years, SPECT/MRI device had also been built. With such hybrid methods, anatomic and functional images especially for oncologic patients have been vastly used and this seems to be used even more within coming years (28-32). In recent years, SPECT gamma cameras are being built using solid state detector, which are specifically being used in cardiology. The latest and the most recent NM equipment currently existing in Turkish market today is shown in the Figure 2. Developing countries should consider the dynamic aspect and variability of the NM apparatus and make future purchase plans.

In such a planning, factors such as demographic data, the difference in cancer and other disease burdens can be used to determine the amount of requirement. For instance, the number of patients who had gone through the imaging device annually would be very useful key parameter in determining the required number of personnel and the quantity of related devices.

In Canada, 1 specialist can attend 100.000 people and 1 scanner is accessible for 3 specialists. Based on a research in India in 2002, there are 72 gamma camera devices for addressing 1 million people. In 42 cities in Turkey there are currently 217 medical laboratories facilitated with 287 gamma camera scanner; which equals to 1 laboratory for 332.000 people and approximately 4 cameras for 1 million people.

In Germany there are 83 PET devices, 1 device per a million populations. Currently there are 75 centers in 20 cities in Turkey. Our country is above the world average in terms of PET/CT and has achieved the level of developed countries. However there are regional deficiencies. PET/CT investments should be structured in a way that for Ankara, Izmir and Istanbul 1 device for maximum 700.000 people, for health region center city 1 device for 700.000 to 1.000.000 people and for other cities 1 device should serve for 1.000.000 people. On the other hand, PET/CT devices should also be planned in accordance with radiotherapy device planning.

Between April 2006 and April 2011, 161 NM specialists were appointed under public service obligation. This means every year, 30 NM trainees will graduate as specialist. If there is 1 specialist per 100.000 people, currently there must be 720 specialists in Turkey. Considering that it takes 4 years to become a NM specialist, one forth of the current students enrolled in the NM training become specialist every year, each year 30 specialist will graduate. Assuming the Turkish population to reach to 82,2 million by 2023, having 1 specialist for 100000 person will take approximately 11 years (Göksel et al., 2011; TURKSTAT, 2011).

In the field of NM, Medical Radiation physician (Health Physician) has a great importance. Health Physician is a person who graduates physics engineering, nuclear energy engineering education and one of the fields of radiation therapy physics, diagnostic radiology physics or NM physics; and has a clinical experience in the field of NM. Modern medical advances have made it necessary to work together for diagnosis and treatment of diseases by education of specialists in different fields. This issue is important for especially NM that one of the branches of using extremely complex devices which produce radiation or contain radioactive sources. According the directives of EURATOM 97/43 responsibilities such as protection of radiation that error-free working of this devices, providing the best diagnosis and treatment of patients, the dosimeter of the patient for the least amount of radiation exposure to the doctor and another personal, development and use of complex methods and tools, including quality control, quality assurance and irradiation has been given to Medical Physic Specialist (Medical Radiation Physics) (EURATOM 97/43). There are obvious deficits in this area in the NM clinics, especially private centers and ministerial hospitals in Turkey. It is necessary to do advanced studies in order to eliminate this deficit.

A very beneficial course was organized by ministry of health for the reduction of problems in this area in 2011. However, this pioneering study should be continued. Certified staff in the field of radiopharmacy must be kept during licensing Departments of Nuclear Medicine once the sufficient situation reached.

In conclusion, developing countries like Turkey need a comprehensive analysis and proper planning as outlined in this article before such expensive investments. This article compares the current supply with the international benchmarks and projects the demand for the year 2023.

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