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Editorial, PET/CT.

Nuclear Medicine Status in Egypt: Our Beginnings and Where We Are Now.

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Nuclear medicine began to take shape in the early 20th century with the discovery of radioactivity and has since grown into a crucial important medical specialty that uses radioisotopes for imaging, diagnosis, and treatment in health care [1]. The first radiopharmaceutical, sodium iodide-I-131, was developed in the 1930s for thyroid treatment [2]. The 1940s and 1950s saw significant growth in nuclear medicine, with the development of imaging techniques such as the gamma camera and the introduction of new radiopharmaceuticals [3]. In the mid-20th century, nuclear medicine began to establish itself as a distinct medical specialty. Professional societies and organizations dedicated to nuclear medicine were founded to promote research, education, and clinical practice [4]. Advances in imaging technology, such as Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET), further expanded the diagnostic capabilities of nuclear medicine [5]. Today, nuclear medicine continues to evolve with ongoing research and development of new radiopharmaceuticals, imaging modalities, and therapeutic applications. It plays a vital role in personalized medicine and the diagnosis and treatment of various diseases [6]. Nuclear medicine emerged in Egypt in the early1970s, and since then it has shown gradual improvement, but it has also faced many challenges that cannot be separated from the political and economic changes that Egypt has gone through.

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Infrastructure and Facilities:

In 1970, The first Rectilinear scanner installed was Picker Scanner followed (1979) by a dual head Siemens "Sentiamat 2" scanner at Kasr Al-Ainy, Cairo University followed by a two Plane gamma machine from CGR France in 1981. This was followed by the installation of a series of gamma cameras in other different hospitals, where the Siemens "Ohio nuclear" model was installed in 1980 at the Arab Contractors Medical Center and Al Salam Hospital, Cairo and in 1982, the "Sigma 400 Camera" was installed in Maadi hospitals. Al-Azhar University owned the first GE SPECT gamma camera in 1985. National cancer institute (NCI), Cairo university also owned the first Trionix gamma camera in 1993. Egypt is divided into 27 governorates. Currently, there are several well-established nuclear medicine centers located primarily in Cairo and Giza governorates. These centers are equipped with modern diagnostic equipment. The number of gamma cameras with and without SPECT/ CT has reached 80 cameras distributed over 18 governorates in Egypt from Siemens, General Electric and Philips companies. **Figure 1** In 1997 the first Siemens PET machine was installed at the International Medical Center (IMC) in Cairo with a cyclotron (CTI model RDS 111). In 2007, two integrated PET/CT scanners were installed at Children's Cancer Hospital, Egypt (CCHE)-57357 which was a subsidiary of Siemens and at IMC which was a subsidiary of Philips Gemini. A GE cyclotron was also installed at CCHE in 2010. The number of current PET/CT machines in Egypt is about and may exceed 77 scanners distributed in 15 governorates from Siemens, GE, Philips and Neusoft. There is only one PET/MRI scanner at the Misr Radiology Center. **Figure 2 and 3.**

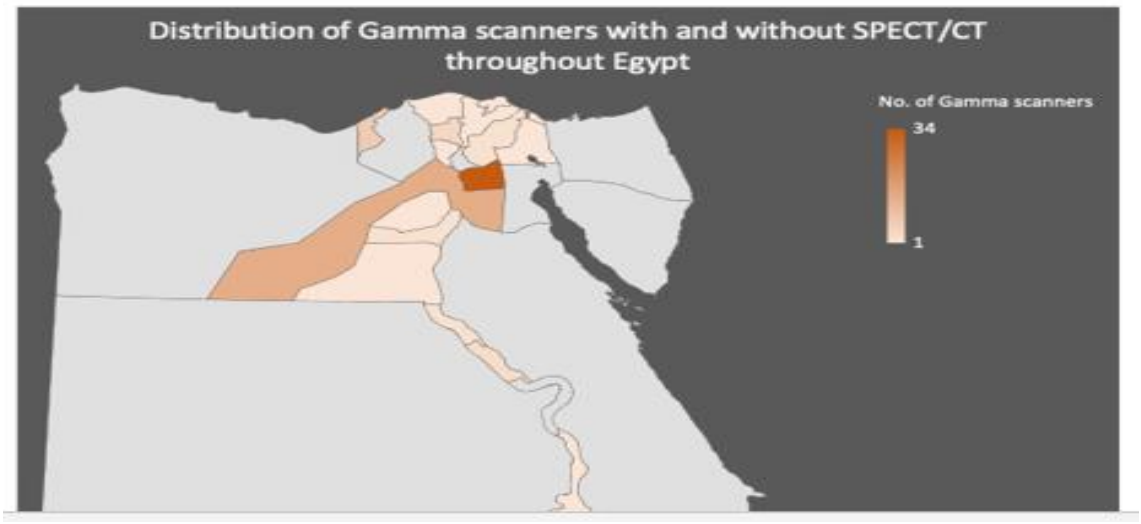


Figure (1): A map shows distribution of Gamma scanners with and without SPECT/CT devices throughout different Egyptian governorates.

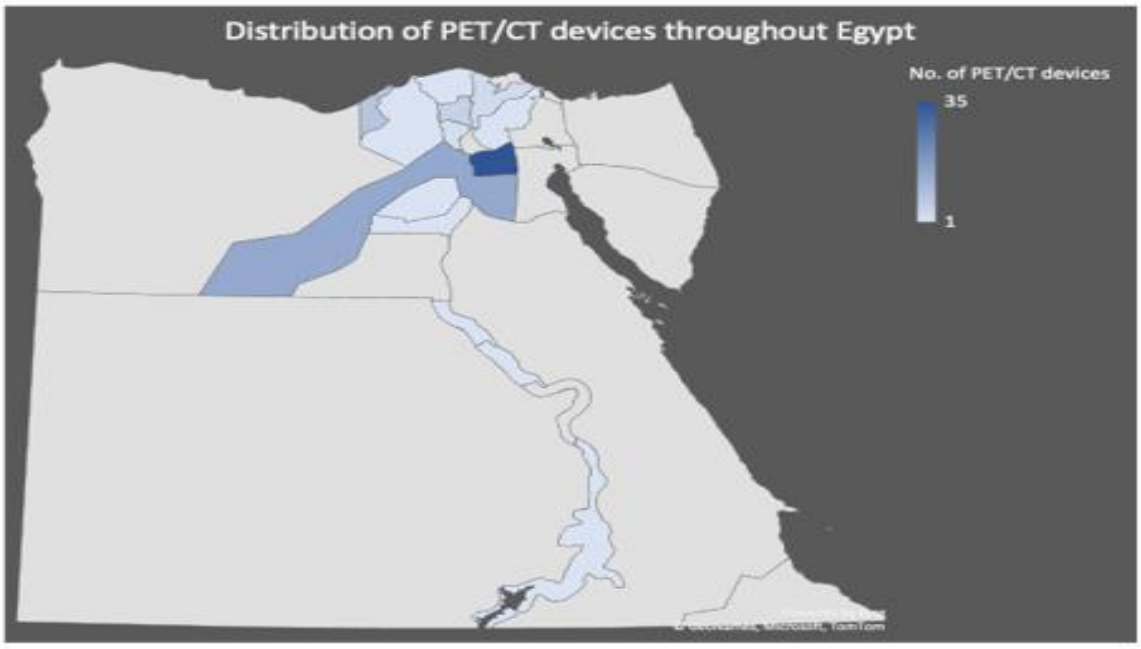
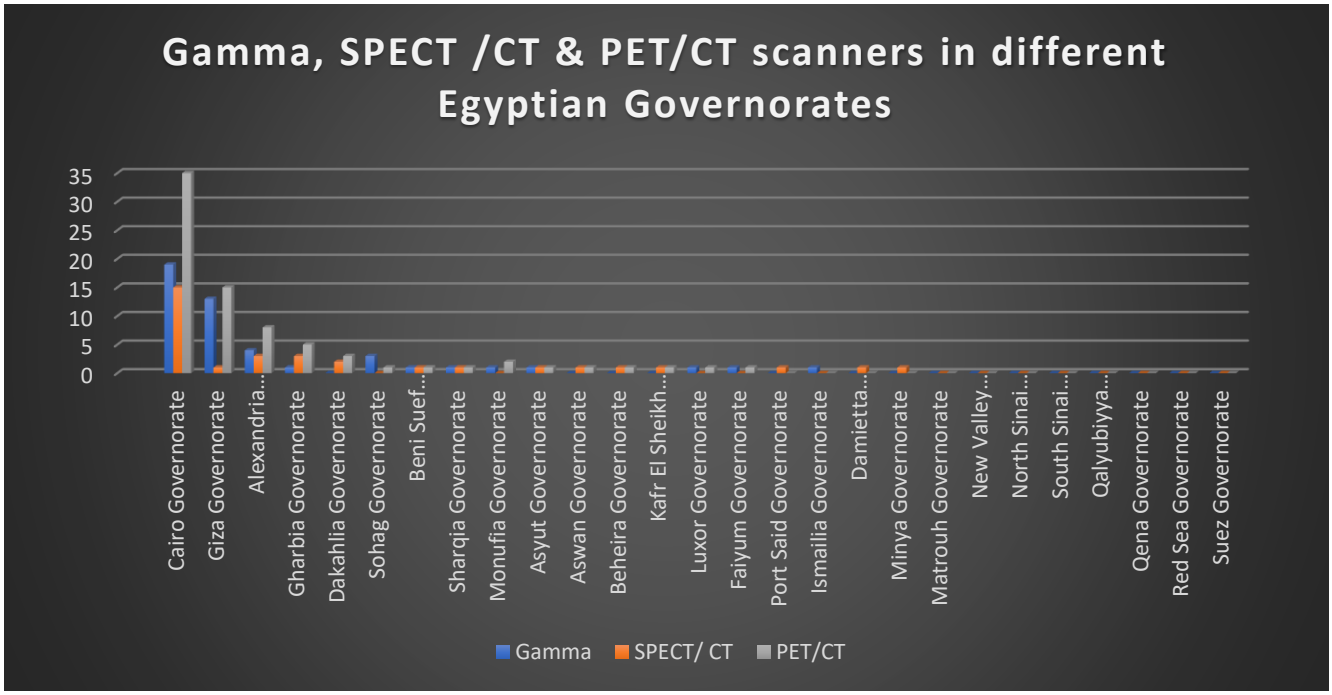


Figure (2): A map shows distribution of PET/CT devices throughout different Egyptian governorates.



Figure(3): A graph represents number of Gamma, SPECT/CT and PET/CT scanners in different Egyptian governorates.

[18F]FDG is the most widely used PET tracer, however other PET tracers have found their way into the Egyptian market such as 18F/68Ga-PSMA, 68Ga-DOTATE, [18F]FET, [18F]Na F and even 68Ga-FAPI. The availability of these tracers depends on the capabilities and resources of individual PET centers, which vary across different regions of the country. Initially, Different scans were interpreted by oncologists until 1990 when nuclear medicine was declared a stand-alone specialty at Cairo University, with separate training programs including diagnostic and therapeutic applications of nuclear medicine. Clinics for nuclear medicine therapy were also established at Units of Nuclear medicine affiliated to Cairo university which are at Kasr Al-Ainy and National cancer institute. Radioactive iodine 131 (RAI-131) for management of malignant and benign thyroid diseases was the first and stayed the main therapy provided by University clinics. During last two decades different Radionuclide therapies were applied in Egypt beside RAI-131 including Lutetium-177 Therapy, Yttrium-90 hepatic radioembolization and Iodine-131 metaiodobenzylguanidine (I-131 mIBG). Other radionuclide therapies previously available but not currently in common use include: strontium-89 [Sr-89] and samarium-153 [Sm-153] for bone metastases, radioactive synovectomy and phosphorus-32 in the treatment of polycythemia vera.

The Egyptian Society of Nuclear Medicine Specialists (ESNMS):

Increasing nuclear medicine applications and increasing staff led to the establishment of the Egyptian Society of Nuclear Medicine Specialists (ESNMS) in 1997. The first president of the society was Prof. **Dr. Mohamed Abd El Razzak** and the current president of the society is **Prof**. **Dr. Hosna Moustafa**. It is a society affiliated with the European association of Nuclear Medicine. ESNMS focuses on advancing the professional development of nuclear medicine specialists in Egypt. This includes providing continuing medical education opportunities, organizing annual conferences, workshops, and seminars to update members on the latest developments in the field. ESNMS promotes collaboration and communication between nuclear medicine specialists within Egypt and potentially with their international counterparts. This cooperation helps in exchanging knowledge, exchanging best practices, and enhancing comprehensive expertise in this field. It plays a role in establishing and promoting standards of practice and guidelines for nuclear medicine procedures and patient care in Egypt. Membership in ESNMS is open to nuclear medicine doctors, Physicists, radiopharmacists, technologists, and researchers involved in or interested in this field. Members benefit from access to professional resources, educational opportunities, and networking events. The Society also publishes semi-annual issues of the Egyptian Journal of Nuclear Medicine (EJNM) to disseminate research results and clinical guidelines. The first issue of EJNM was published in 2009. The first editor-in-chief was **Professor Dr. Mohamed Abd El Razzak** and the current one is **Professor Dr. Hosna Moustafa**. The goal of the EJNM is to provide a forum for the exchange of clinical and scientific information for the nuclear medicine community and related professions at both national and international levels. ESNMS is also active in organizing the annual Nuclear Medicine Conference. The First Nuclear Medicine Conference was held from February 25 to 27, 2000 in Hurghada, headed by **Prof**. **Dr. Mohamed Abd El Razzak**.

Personnel, Training and Education:

According to ESNMS registration data, the number of nuclear medicine doctors (specialists and consultants) is 160, the number of medical physicists is 42, the number of technicians is 115, and the number of radiopharmacists is 7. The heavy flow of patients on a daily basis, especially in large central hospitals, has helped a lot in building the expertise of nuclear medicine doctors in Egypt along with the training programs offered by many universities in Egypt. The discipline is recognized as an important field within medical education, and efforts are made to train professionals to meet the country's healthcare needs.

There are several faculties of medicine in different universities in Egypt (about 11) that provide master and doctorate certified training programs and degrees in nuclear medicine, some of them provide degree in both diagnostic and therapeutic nuclear medicine as separate specialty/training program as in "Kasr El-Aini Center for Radiation Oncology and Nuclear Medicine (NEMROCK)", Cairo university and others provide the therapeutic nuclear medicine with clinical oncology program and the diagnostic nuclear medicine with radiodiagnosis program as faculty of medicine, Ain shams University. Nuclear medicine specialty in Universities can be classified as two groups: group "A" where Nuclear medicine is a separate specialty (includes both diagnostic and therapeutic NM) and group "B" where nuclear medicine combined with clinical oncology (or) the therapeutic aspect with oncology and the diagnostic part with radiodiagnosis: Group "A" includes Cairo university "Kasr El-Aini Center for Radiation Oncology and Nuclear Medicine (NEMROCK)", Sohag university, Assiut university, Mansoura university and the armed forces college of medicine (AFCM). Group "B" includes Ain shams University, Al-Azhar University, Alexandria University, Menoufia University, Tanta University and Suez Canal University. The duration of master's degree training program is three years and the duration of doctorate degree is two to four years after obtaining the master degree. For universities that provide programs include both diagnostic and therapeutic nuclear medicine; training for the master's and Residency program includes the first part of basic science courses, followed by examinations, then the thesis followed by specialized courses and examinations related to the second part. This includes written and oral examinations, clinical cases, technical and imaging reporting. The doctoral degree includes advanced training and scientific activities, a thesis followed by examinations.

Radiopharmaceuticals production and supply:

Radiopharmaceuticals are produced in Egypt primarily through nuclear reactors and particle accelerators. The Egyptian Atomic Energy Authority (EAEA) operates facilities such as the Inshas Nuclear Research Center, which houses the ETRR-2 research reactor used for isotope production [7]. The Inshas Nuclear Research Center in Egypt began its operations in the 1960s [8]. It was established as part of Egypt's efforts to develop nuclear science and technology for peaceful purposes, including research, medical applications, and industrial uses. The center houses various facilities, including research reactors and laboratories, to support nuclear research, training, and the production of isotopes for medical and other scientific applications [7]. Its history reflects Egypt's ongoing commitment to advancing nuclear capabilities while adhering to international safety and regulatory standards. Egypt also has about three centrally located cyclotron facilities that play a role in the production of radiopharmaceuticals for medical and research purposes. The Egyptian Atomic Energy Authority (EAEA) regulates nuclear activities, including nuclear medicine, to ensure safety and compliance with international standards [9]. This regulatory framework helps maintain quality and safety in the practice of nuclear medicine.

Collaboration and International Relations:

Egypt collaborates with international organizations and countries to enhance its nuclear medicine capabilities. This includes training programs, joint research projects, and exchanges of expertise. The International Atomic Energy Agency (IAEA) also plays a significant role in supporting nuclear medicine activities in Egypt through various programs and collaborations. the IAEA's involvement in nuclear medicine in Egypt helps enhance the country's capacity to provide advanced diagnostic and therapeutic services, ensures the safe and effective use of nuclear technology in healthcare, and contributes to improving public health outcomes through better access to nuclear medicine technologies and treatments. Egypt participates in the IAEA's Technical Cooperation (TC) Program, which includes projects aimed at strengthening nuclear medicine capabilities [10]. This involves training healthcare professionals and supporting the establishment and operation

of nuclear medicine facilities. The IAEA organizes training courses and workshops in Egypt and other African countries in which Egyptian health care professionals working in the field of nuclear medicine participate. These programs cover various aspects such as radiation safety, quality control, clinical applications of radiopharmaceuticals, and advanced imaging techniques (e.g., PET/CT) [11]. The IAEA assists Egypt in developing and implementing quality assurance programs for nuclear medicine practices. This includes guidelines on the production, distribution, and use of radiopharmaceuticals, as well as ensuring compliance with international standards for patient safety and diagnostic accuracy [12,13]. The IAEA assists Egypt in strengthening radiation protection measures in nuclear medicine facilities. This involves training on radiation safety practices, monitoring radiation exposure levels, and ensuring compliance with international safety standards. Egypt participates in regional and international networks facilitated by the IAEA, which promote knowledge sharing, collaboration on research initiatives, and harmonization of practices in nuclear medicine across borders.

Challenges and prospects:

Egypt faces several challenges in the field of nuclear medicine, despite its significant capabilities and infrastructure. While Egypt has many nuclear medicine centers, there is an uneven distribution across the country due to them being more centralized and available within large cities, the relatively low numbers of cyclotrons, and the long distance of transporting PET tracers to remote areas presents a difficult situation. It leads to disparities in access to advanced diagnostic and therapeutic services, especially in rural areas. Regarding skilled Personnel, as reported by **Juweid** et al [14], the ratio of nuclear medicine physicians in Egypt per 10,000 cancer patients based on the 2019 WHO Cancer Profiles was 8.1, and thus there is still a need for more trained nuclear medicine physicians, as well as technologists. and radio pharmacists to meet the growing demand, ensure quality of care, and make nuclear medicine services available to all segments of the population.

There are still misconceptions or lack of awareness among the public regarding the safety and benefits of nuclear medicine, which can affect patient acceptance and utilization of these services. Thus, effective communication strategies are needed to educate the public, healthcare professionals, and policymakers about the role and benefits of nuclear medicine in

diagnosing and treating diseases. Finally, financial sustainability is needed to acquire and maintain nuclear medicine equipment and facilities which can be expensive. Addressing these challenges requires coordinated efforts that include government support, private sector engagement, international cooperation (such as with the International Atomic Energy Agency), and continued innovation in technology and health care delivery models. By overcoming these challenges, Egypt can enhance its capacity in the field of nuclear medicine, improve patient outcomes, and contribute to the development of healthcare in the region.

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