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ARASIA

Nuclear Medicine Capacities and Regional Resource Centres

CO-OPERATIVE AGREEMENT FOR ARAB STATES IN ASIA FOR RESEARCH, DEVELOPMENT AND TRAINING RELATED TO NUCLEAR SCIENCE AND TECHNOLOGY

2024

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Introduction

ARASIA State Parties are advancing to the forefront of cancer management, combining expertise, innovation, and collaboration to improve patient outcomes. With IAEA support, and concerted efforts in research, technology integration, and medical training, ARASIA countries are making significant strides in the fight against cancer. ARASIA focuses on enhancing the early detection, advanced treatment modalities, and comprehensive patient care, to ensure that every individual receives the best possible treatment. Together, we are building a healthier future for our communities."

Dr. Bilal Nsouli, ARASIA Chairman

The Cooperative Agreement for Arab States in Asia for Research, Development, and Training Related to Nuclear Science and Technology (ARASIA) aims to promote the peaceful use of atomic energy and technology in Arab states within Asia, in various fields including human health.

The ARASIA Cooperative Agreement entered into force on 29 July 2002, and includes ten state parties; the Republic of Iraq, the Hashemite Kingdom of Jordan, the State of Kuwait, the Republic of Lebanon, the Sultanate of Oman, the State of Qatar, the Kingdom of Saudi Arabia, the Syrian Arab Republic, the United Arab Emirates, the Republic of Yemen.

The technical cooperation programme of the International Atomic Energy Agency (IAEA), is the primary mechanism for transferring nuclear technology to its Member States, helping them to address key development priorities in areas such as health and nutrition, food and agriculture, water and the environment, industrial applications, and nuclear knowledge development and management.

ARASIA, in cooperation with the IAEA, promotes and coordinates activities for training, research, development and applications of nuclear science and technology. Collaborating with the IAEA and other organizations, ARASIA has made significant strides in nuclear medicine, agriculture, water resource management, emergency response, and radiation monitoring systems. It plays a vital role in advancing technical capabilities and contributing to socio-economic development in the Arab region.

This ARASIA booklet provides information and insights into the status of nuclear medicine in ARASIA state parties. It serves as a valuable resource for individuals, organizations, and countries interested in understanding various aspects of nuclear medicine within these states. The booklet shares success stories that showcase the collaboration between Regional Resource Centres (RRCs), Collaborating Centres in ARASIA state parties, and the IAEA. It offers an overview of the nuclear medicine landscape regarding facilities, equipment, and human resources. It also emphasizes the significance of capacity building and knowledge sharing within the region, promoting collaboration in application, research, and technology transfer through the RRCs and Collaborating Centres.

Nuclear Medicine in ARASIA State Parties

Nuclear medicine has been steadily growing and gaining prominence in recent years within ARASIA state parties. Many countries in the region have established nuclear medicine departments in hospitals and healthcare institutions, utilizing these techniques for diagnosis, treatment, and research purposes. However, the levels of nuclear medicine services vary across the region. Some countries possess cutting-edge nuclear medicine services, while others lag due to national circumstances. Countries that have invested in advanced nuclear medicine facilities and technologies, and established collaborations with leading international organizations for knowledge transfer, research, and training, have made notable progress.

Major hospitals in the region have well-developed nuclear medicine departments equipped with advanced PET/CT and SPECT/CT scanners, facilitating significant research endeavors. As a result, numerous important publications, particularly in nuclear oncology, have emerged from the region. Prominent centers such as the King Hussein Cancer Center (KHCC) in Jordan, the Kuwait Cancer Control Centre (KCCC) in Kuwait, and the American University of Beirut Medical Center (AUBMC) in Lebanon have been designated as IAEA Collaborating Centers in the field of nuclear medicine to enhance training and research. Centers in Kuwait and Lebanon have signed agreements to be appointed as Regional Resource Centres for ARASIA.

These IAEA Collaborating Centres, through regional and international collaborations, promote the peaceful applications of nuclear sciences by providing advanced clinical services, training, and research opportunities. They utilize state-of-the-art nuclear medicine imaging equipment and theranostics facilities, and host specialized conferences, workshops, and regional training courses for ARASIA. Countries such as the UAE, Saudi Arabia, Qatar, and Oman, with advanced nuclear medicine departments, have hosted regional and international nuclear medicine conferences, attracting experts and researchers globally. Dubai, in particular, has significantly contributed to hosting ARASIA activities related to non-communicable diseases in nuclear medicine.

Syria, through the Syrian Atomic Energy Commission's high-energy cyclotron, contributed significantly to the production and supply of radiopharmaceuticals in the region over the past decade. However, local constraints in the last ten years have halted these contributions, impacting ongoing nuclear medicine services. Iraq, affected by strict international constraints over the past two decades, has seen recent stabilization, promoting the establishment of many new and advanced nuclear medicine centers. In Yemen, nuclear medicine services have been entirely stopped due to several limitations and restrictions. However, ARASIA and the IAEA are working together to reverse this situation and resume nuclear medicine services by supporting the installation of new equipment, capacity building, and strengthening regulatory and safety infrastructures.

In summary, while nuclear medicine in ARASIA state parties has seen significant advancements, with several countries establishing state-of-the-art facilities and promoting research, other countries are striving to re-establish their services and follow the field's progress. Political and social dynamics in the region may also impact the development and utilization of nuclear medicine in certain areas.

Map of ARASIA State Parties

Radiopharmaceuticals in ARASIA State Parties

Radiopharmaceuticals are radioactive materials that are used in nuclear medicine for both diagnostic and therapeutic purposes. They are commonly used in the treatment of various conditions and cancers, such as thyroid cancer, bone metastases, prostate cancer and neuroendocrine tumors. The production, availability, and accessibility of radiopharmaceuticals for therapy is influenced by several factors including regulatory frameworks, infrastructure, and resources.

Certain ARASIA States parties may face limitations in the production and availability of radiopharmaceuticals for diagnosis and therapy, which may necessitate importing these materials from other countries. These countries might encounter difficulties due to inadequate infrastructure for radiopharmaceutical production or regulatory requirements that impact the accessibility and availability of these materials.

In contrast, some other ARASIA State Parties have made significant investments in establishing radiopharmaceutical production facilities and developing capabilities for producing and ensuring the availability of radiopharmaceuticals for diagnosis and therapy. These countries have established regulatory frameworks, infrastructure, and expertise in place to support the production and use of radiopharmaceuticals for therapy.

It is worth noting that the regulatory frameworks for therapeutic radiopharmaceuticals can vary across countries in the ARASIA States parties and may be subject to local laws, regulations, and guidelines. These regulations are in place to ensure the safe production, handling, transportation, and administration of radiopharmaceuticals, and to protect the patients, healthcare professionals, and the public from potential radiation risks.

In summary, the availability of radiopharmaceuticals for therapy in ARASIA State Parties can vary across countries and regions, depending on factors such as production capabilities, regulatory frameworks, infrastructure, and resources. Some countries have established capabilities for radiopharmaceutical production and availability, while others still face limitations or challenges in this regard. Further development, investment, and regulatory harmonization are needed to ensure adequate access to radiopharmaceuticals for diagnosis and therapy in the region.

Theranostics in ARASIA States Parties

Theranostics, combining therapeutic and diagnostic agents in nuclear medicine, is an emerging field gaining significant attention worldwide, including in ARASIA state parties. Theranostics involves using radiopharmaceuticals for both diagnosis and therapy of various diseases, such as cancer, neuroendocrine tumors, and certain types of metastatic cancers.

Several countries in the ARASIA state parties have shown growing interest in theranostics, developing capabilities in this field. Some have established theranostic centers, specialized facilities, or collaborations with international institutions to provide these services. These centers typically possess state-of-the-art imaging equipment, such as PET and SPECT scanners, for diagnostic imaging, and have the capability to produce or import radiopharmaceuticals for both diagnostic and therapeutic purposes.

Theranostics in ARASIA state parties primarily focuses on treating cancer, particularly neuroendocrine tumors and prostate cancer. Radiopharmaceuticals such as lutetium-177 (Lu-177) and iodine-131 (I-131) are commonly used for targeted radionuclide therapy (TRT) of cancer. These radiopharmaceuticals are administered to patients with tumors expressing specific receptors, with radioactive emissions selectively targeting and destroying tumor cells while sparing healthy tissues.

Regulatory frameworks for theranostics in ARASIA state parties are governed by national health authorities or regulatory bodies, following international standards and guidelines for radiation safety, patient protection, and quality assurance. These frameworks ensure that theranostic procedures are performed safely and effectively, and that radiopharmaceuticals used in theranostics are produced, handled, and administered according to established regulations.

Theranostics is still an evolving field, and the availability and accessibility of services may vary across ARASIA state parties. Factors such as infrastructure, expertise, and funding impact the establishment and growth of theranostics capabilities. However, theranostics is gaining momentum as a promising approach for personalized and targeted cancer treatment, with efforts underway to further develop and expand capabilities in the region.

ARASIA Regional Resources Centers and Collaborating Centers with IAEA

The Kuwait Cancer Control Center, Kuwait

Introduction

The Kuwait Cancer Control Center (KCCC) is a comprehensive facility dedicated to providing cancer care across the State of Kuwait. Established in 1968, KCCC is a governmental center affiliated with Kuwait's Ministry of Health (MOH). The center is housed in a 200-bed hospital complex and employs over 600 highly qualified medical oncology staff. It consists of several specialized buildings: the Hussain Makki Juma Building for Specialized Surgery, the Shikha Badriya Al Sabah Medical Oncology Building, the Yacob Behbehani Center for Bone Marrow Transplant and Specialized Laboratories, and the Faisal Sultan Ibn Issa Diagnostic Imaging Building.

Nuclear medicine is well established in Kuwait, featuring advanced medical imaging systems and procedures for the administration of radiopharmaceuticals. The KCCC is a notable example of an institution equipped with extensive oncology facilities for treating malignant tumors. It offers services including surgery, chemotherapy, radiotherapy, pediatric oncology, and palliative care. Efforts have been made to establish capacity for short-lived radionuclide production. The establishment of a facility with a cyclotron for radiopharmaceutical production necessitates trained personnel for its operation and utilization.

A significant development is the ongoing construction of a new tower for KCCC, expected to open in 2024. This state-of-the-art facility will include 600 beds and will be one of the largest cancer centers in the region. The new 12-story building will house all nuclear medicine departments and serve as the main Cancer Center.

KCCC Collaboration Agreements

- On November 30, 2018, an official ceremony designated the Kuwait Cancer Control Center (KCCC) as an ARASIA Regional Resource Centre (RRC) in Nuclear Medicine.
- A Memorandum of Understanding was signed in February 2022 between the ARASIA Chairman and the Kuwait Cancer Control Center (KCCC). This agreement focuses on cooperation to support ARASIA technical cooperation activities for human resource development in nuclear medicine.

Memorandum of Understanding

between

The Board of Representatives of the "Co-operative Agreement for Arab States in Asia for Research, Development and Training Related to Nuclear Science and Technology" (ARASIA)

and

The Kuwait Cancer Control Center - KCCC
Kuwait

on

Cooperation in Supporting ARASIA Technical Cooperation Programmes for

Human Resource Development in Nuclear Medicine

Nuclear Medicine Department

KCCC's Nuclear Medicine Department, established in 1968, is the first of its kind in Kuwait. It is a well-established department with competent professionals and technical staff specializing in advanced medical imaging systems and procedures. The department adopts an integrated approach to cancer control with four dedicated units: general nuclear medicine, positron emission tomography-computed tomography (PET/CT), medical physics, and a central radiopharmacy unit. It is equipped with two PET/CT cameras, three SPECT/CT cameras, a Breast-Specific Gamma Camera (BSGC), a Positron Emission Mammography (PEM), and an 11 MeV Cyclotron that produces primarily F-18 FDG, F-18 NaF, and F-18 FES. The department offers both diagnostic and therapeutic services, with a total of 6523 cases reported in the 2023 annual statistics.

Diagnostic Procedures and Radionuclide Theranostics

Radionuclide theranostics is an evolving and expanding field within the KCCC Nuclear Medicine Department. Several clinical challenges exist, including proper patient selection, planning, treatment scheduling and administration, monitoring, and treatment assessment. Multidisciplinary discussion is essential to achieving optimal outcomes. The current theranostics services at KCCC include I-131 for benign cases, Lu-177 DOTATATE for neuroendocrine tumors, Lu-177 PSMA for prostate cancer, and Y-90 radioembolization.

The diagnostic and therapeutic services include the following:

Diagnostic Procedures:

PET/CT:

- 18F-FDG PET/CT: This is a positron emission tomography (PET) combined with computed tomography (CT) that uses fluorodeoxyglucose (FDG) as a tracer to visualize metabolic activity in the body, it is primarily used for oncology indications and helps in the detection and staging of various cancers.
- 18F- Na-F PET/CT: Sodium fluoride (Na-F) PET/CT a highly sensitive bone-seeking PET tracer used for detection of skeletal abnormalities including evaluation of bone metabolism and detection of bone metastases.
- 68Ga-DOTATATE PET/C: A PET/CT scan that uses a gallium-labeled tracer used specifically for neuroendocrine tumors, it allows for accurate imaging and assessment of these tumor
- 68Ga-PSMA PET/CT: Prostate-specific membrane antigen (PSMA) imaging using a gallium-labeled tracer for the detection and staging of prostate cancer, it helps in the diagnosis, staging, and evaluation of treatment response.
- 18F-FES PET/CT: Used for the detection of estrogen receptor (ER)-positive lesions as an adjunct to biopsy in patients with recurrent or metastatic breast cancer (MBC).

PEM:

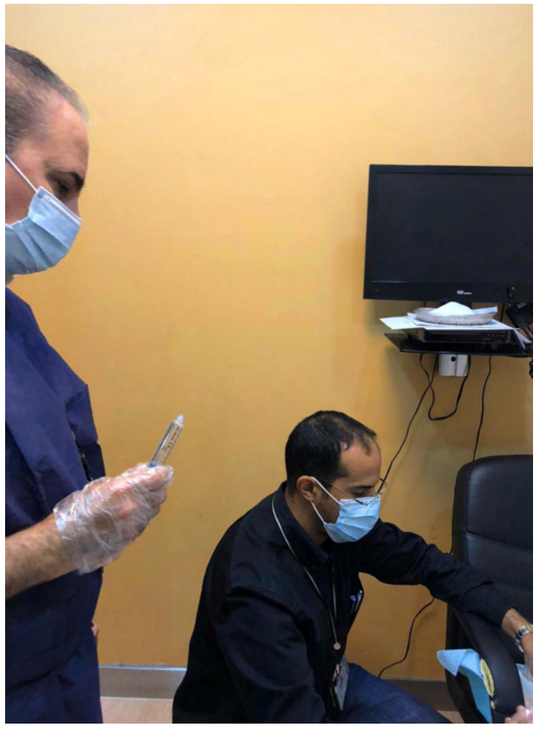
- Positron Emission Mammography using 18F-FDG that has higher resolution and more localized field of view than that of PET/CT in breast cancer cases.

Gamma camera SPECT/CT:

- SPECT/CT hybrid imaging: A gamma camera equipped with single-photon emission computed tomography (SPECT) technology in combination with CT for various imaging purposes. This advanced technology combines functional and anatomical imaging, providing detailed image information and precise tumor localization, also used for diagnosis of many different procedures to examine most organs in the body, enabling the visualization of specific physiological processes and the assessment of organ function, allowing for a comprehensive diagnostic evaluations.

Theranostics & Radionuclide therapy:

- Radioactive iodine therapy: Used for treating benign thyroid tumors.
- 177Lu-DOTATAE peptide receptor radionuclide therapy (PRRT): Specifically used for neuroendocrine tumors.
- PSMA-targeted Radioligand Therapy (PRLT): Employed for advanced prostate cancer treatment by Lu-177 & Tb-161.
- Therasphere (Yttrium-90): A targeted radiotherapy treatment using radioactive microspheres for the treatment of liver cancer.



KCCC Technical Cooperation with the IAEA & support to capacity building

The Government of Kuwait is committed to achieving and maintaining high-quality standards in nuclear medicine practice and seeks to enhance services with support from the IAEA. The IAEA has supported Kuwait's national efforts to improve the quality and expand the capacity of nuclear medicine for diagnosing non-communicable diseases, particularly cancer, through various technical cooperation projects, both at the national and regional levels, including:

- Upgrading the Secondary Standards Dosimetry Laboratory (SSDL) and Patient-Specific Internal Dosimetry for Nuclear Medicine (KUW6007).
- Enhancing Safety and Effectiveness in Diagnostic Radiology through Training of Medical Imaging Professionals in Quality Practices (RAS6081).
- Strengthening Technical Capabilities in Asia and the Pacific Region for Medical Radiation Protection in Compliance with the Requirements of the New International Basic Safety Standards (RAS9079).
- Performing a QUANUM Mission (TCR-11640) for KCCC's Nuclear Medicine Department, in March, 2017.
- Minimizing the Risk of Radiation Cataractogenesis Among Medical Workers in Kuwait (KUW9009).
- Improving the Medical Radioactive Waste Management Infrastructure in Kuwait (KUW9010). Strengthening Capabilities in Nuclear Medicine, Radiation Oncology, and Radiopharmaceutical Production for Diagnostics and Treatment of Cancer and Non-Communicable Diseases (RAS6102 – ARASIA), including the purchase of five personal dosimeters for medical applications in November 2022.
- Manufacturing of cGMP-Compliant F-18 Radiopharmaceuticals at KCCC, as part of TC project on "Producing Current Good Manufacturing Practices Compliant Fluorine-18 Radiopharmaceuticals in the Cancer Control Centre" (KUW6009).

KCCC support to Human Resource Development with IAEA

Kuwait hosted in recent years a number of joint capacity building activities with IAEA support including:

- The conference on radiation protection in nuclear medicine, in November 2014.
- A comprehensive Regional Training Course for Health Professionals in Radiation Protection in Medicine, including patient dose reduction and optimization of clinical protocols (under project RAS9079), in April 2016.
- A training supporting the application of emerging targeted therapeutic radiopharmaceuticals for radionuclide therapy (under project RAS6082), in December 2017.
- A fellowship on radiopharmaceutical preparation and dose preparation for patients at KCCC, in March 2021.
- Three training courses/fellowship in September, October and November 2023 under the ARASIA regional flagship on “Strengthening Capabilities in Nuclear Medicine, Radiation Oncology, and Radiopharmaceutical Production for Diagnostics and Treatment of Cancer and Non-Communicable Diseases (RAS6102)”:
  1. Regional Training Course on The Current and Future Trends of Theranostics of Prostate Cancer and Neuroendocrine Tumors.
  2. Regional Training Course on Production and Quality Control of F-18 FDG.
  3. Group Fellowship for Technologists & Physicists on QC/QA for Enhanced Capabilities in Hybrid Imaging (SPECT/CT) for NCD management.

The American University of Beirut, Lebanon

Introduction

The American University of Beirut Medical Center (AUBMC) has been providing high-quality care to patients across Lebanon and the region since 1902. Initially a 200-bed hospital, it has grown into a medical center with over 350 beds, accommodating approximately 425,000 outpatient visits annually.

AUBMC is the only medical institution in the Middle East with five international accreditations: Joint Commission International (JCI), Magnet, College of American Pathologists (CAP), Accreditation Council for Graduate Medical Education – International (ACGME-I), and JACIE. These accreditations reflect its commitment to excellence in patient care, nursing, pathology/laboratory services, and graduate medical education.

The Faculty of Medicine at AUB has graduated over 4,000 medical students and physicians, producing highly skilled and compassionate healthcare professionals. The Rafic Hariri School of Nursing at AUB also ensures excellent education for nursing staff, promoting high-quality patient care.

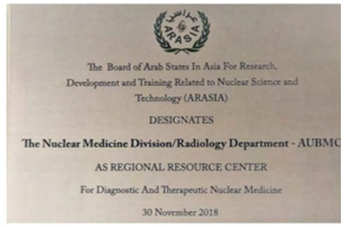
AUBMC effectively meets the healthcare needs of over 400,000 patient visits annually, offering a wide range of specialized medical services and employing state-of-the-art technology to improve community health and well-being.

AUBMC Collaboration Agreements

ARASIA Regional Resource Centre in Nuclear Medicine

AUBMC was designated as one of the ARASIA Regional Resource Centres in nuclear medicine, announced at an official ceremony at the IAEA headquarters on November 30, 2018.

By designating AUB as a Regional Resource Centre, this agreement recognized the university's expertise and capabilities in the field of nuclear science and technology.



The Certification and Designation of the Nuclear Medicine Division at AUBMC as a Regional Resource Centre.

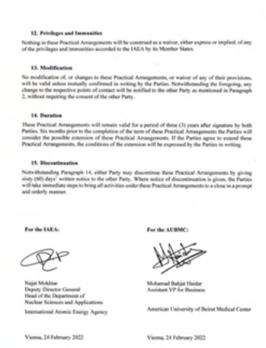
Practical Arrangements with the IAEA (2018)

On November 30, 2018, AUBMC and the IAEA signed a three-year Practical Arrangement Agreement to foster collaboration and enhance clinical nuclear medicine in Lebanon and the Middle East. This collaboration aimed to promote knowledge exchange, share best practices, and advance nuclear medicine in the region.

The signing of the Practical Arrangement - IAEA Deputy Director General, Aldo Malavasi, Imad Sadek, AUBMC and Mohamad B. Haidar, AUBMC. (Photo: O. Morozova/IAEA).

Extension of Practical Arrangements with the IAEA (2022)

On February 24, 2022, the original agreement was extended, strengthening the collaboration between AUBMC and the IAEA. The extended agreement aims to advance nuclear medicine and diagnostic imaging globally, fostering innovation, research, and improved patient care.



Signing of the Extension of the Cooperation Agreement between the IAEA and AUBMC.

Formalization of the designation as ARASIA Regional Resource Centre (2022)

Designation as ARASIA Regional Resource Centre (2022)

On February 25, 2022, AUBMC signed a Memorandum of Understanding with the IAEA in Vienna. This solidified AUB's commitment to fostering cooperation, sharing knowledge, and promoting nuclear science and technology in the region.

Over the past two decades, ARASIA has played a crucial role in facilitating the development of technical and human resource capacities in the region through more than 55 IAEA technical cooperation projects.

AUB's involvement in ARASIA further solidified its commitment to fostering cooperation, sharing knowledge, and promoting the advancement of nuclear science and technology in the region. Through collaboration with ARASIA and its member countries, AUB contributes to the growth and development of nuclear capabilities, ultimately benefiting the healthcare sector, research institutions, and society as a whole in the participating countries.

On 25 February, Memoranda of Understanding were concurrently signed with the aim of enhancing cooperation and knowledge transfer among ARASIA States Parties. (Photo: O. Yusuf/IAEA).

Nuclear Medicine Division and Department of Diagnostic Radiology

The Nuclear Medicine Division within the Department of Diagnostic Radiology is widely recognized as a regional and national leader in providing advanced diagnostic and therapeutic nuclear medicine services. The division offers a diverse range of diagnostic procedures and therapeutic options and houses state-of-the-art cyclotron units. These cutting-edge facilities enable the production of radionuclides and the labeling of radiopharmaceuticals specifically tailored for oncological, neurological, and cardiological procedures. Committed to technological excellence, the Division of Nuclear Medicine strives to deliver the highest standard of care in nuclear medicine, particularly in the era of personalized medicine. The following are some of the diagnostic procedures and therapies provided.

Diagnostic Procedures and therapy

The availability of diagnostic procedures and therapeutic options at the Nuclear Medicine Division allows for comprehensive patient care and personalized treatment approaches in the field of nuclear medicine.

Diagnostic Procedures:

1. FDG PET/CT: This is a positron emission tomography (PET) combined with computed tomography (CT) that uses fluorodeoxyglucose (FDG) as a tracer to visualize metabolic activity in the body.

2. Ga-FAPI PET/CT: Gastrin-releasing peptide receptor (GRPR) imaging using a gallium-labeled fibroblast activation protein inhibitor (FAPI) tracer.

3. Pentixafor: This is a PET/CT scan using a CXCR4 receptor-targeted tracer for imaging certain types of cancers.

4. Ga-PSMA PET/CT: Prostate-specific membrane antigen (PSMA) imaging using a gallium-labeled tracer for the detection and staging of prostate cancer.

5. Ga-Dotatate: A PET/CT scan that uses a gallium-labeled tracer for imaging neuroendocrine tumors.

6. FLT: Fluorothymidine (FLT) PET imaging for assessing cell proliferation in tumors.

7. F-choline: PET/CT scan using a fluorine-labeled choline tracer for imaging prostate cancer.

8. Ammonia: Myocardial perfusion imaging using ammonia as a tracer to evaluate blood flow to the heart.

9. C-11 methionine: A PET scan using a carbon-11-labeled methionine tracer for imaging brain tumors.

10. F-DOPA: Fluorodihydroxyphenylalanine (F-DOPA) PET scan for imaging neuroendocrine tumors and certain brain conditions such as Parkinson disease and brain tumors.

11. Ga-JR-11: Gastrin-releasing peptide receptor (GRPR) imaging using a gallium-labeled JR-11 tracer for neuroendocrine tumors.

12. Na-F: Sodium fluoride (Na-F) PET/CT scan for evaluating bone metabolism and detecting bone metastases.

13. Florbetaben (will be available soon): A PET scan using a florbetaben tracer for imaging beta-amyloid plaques in the brain, which is helpful in the diagnosis of Alzheimer's disease.

PET/CT with automated injector

Gamma Camera SPECT/CT: In addition to PET/CT imaging, the Nuclear Medicine Division also utilizes a gamma camera equipped with single-photon emission computed tomography (SPECT) technology in combination with CT for various imaging purposes. This enables the visualization of specific physiological processes and the assessment of organ function.

Therapy:

1. Therasphere (Yttrium-90): A targeted radiotherapy treatment using radioactive microspheres for the treatment of liver cancer/metastases.
2. Lu-PSMA: Lutetium-177-labeled PSMA therapy for advanced prostate cancer.
3. Ac-PSMA: Actinium-225-labeled prostate-specific membrane antigen (PSMA) therapy for advanced prostate cancer.
4. Lu-Dotatate: Lutetium-177-labeled somatostatin analog therapy for neuroendocrine tumors.
5. 131I-MIBG: Iodine-131-metaiodobenzylguanidine (MIBG) therapy for certain types of neuroendocrine tumors, such as neuroblastoma and pheochromocytoma.
6. 131I: Radioiodine therapy for thyroid disorders, including thyroid cancer and hyperthyroidism.
7. Samarium/Strontium: A therapy by samarium-153 or strontium-89 for palliative treatment of bone metastases.

AUBMC Technical Cooperation with the IAEA & support to capacity building

The Nuclear Medicine Division at AUBMC actively participates in capacity building activities with the IAEA through technical cooperation regional training courses (RTCs), workshops, and conferences to promote education and training in nuclear medicine. Some notable activities so far include:

- An IAEA mission under the technical cooperation project on “Strengthening Nuclear Medicine Applications through Education and Training to Help Fighting Non-Communicable Diseases” (ARASIA) RAS6078 - November 2017 supported with enhanced nuclear medicine applications through education and training.
- Hosting IAEA scientific visits for trainees from Syria and Yemen, facilitated knowledge exchange in the field RAS6078-August-October 2017.
- Hosting IAEA technical cooperation workshops and training courses on various topics, including theranostics, advanced nuclear medicine techniques in neurological diseases, and cardiac multimodality imaging RAS6089- October-November 2018 and September 2019.

ARASIA Regional Training Courses on Cardiac Multimodality Imaging in Clinical Based Setting with Focus on PET/CT and Advanced Nuclear Medicine Techniques in Neurological Diseases: Emphasis on Dementia and Seizure Imaging.

- Under IAEA technical cooperation project RAS6102-November 2022 on “Strengthening Capabilities in Nuclear Medicine, Radiation Oncology, and Radiopharmaceutical Production for Diagnostics and Treatment of Cancer and Non-Communicable Diseases (ARASIA)”, in November 2022 AUBMC hosted two regional training courses that focused on building capacity in hybrid imaging techniques and the production and quality control of radiopharmaceuticals in the Arab countries.

AUB MC hosts IAEA Simultaneous Regional Training Courses to Enhance Cancer Care in ARASIA.

- Received IAEA Quality Management Audits in Nuclear Medicine Practices (QUANUM) for AUBMC Nuclear Medicine Division in Radiology Department in April 2017 under RAS6078.

IAEA

International Atomic Energy Agency

Department of Technical Cooperation, Department of Nuclear Sciences and Applications

Certificate

The American University of Beirut Medical Center/ Nuclear Medicine Division

Successfully Completed The QUANUM Audit

RAS6078 “Strengthening Nuclear Medicine Applications through Education and Training to Help Fighting Non-Communicable Diseases (ARASIA)”

Date: 03-07 April 2017

S. SOMANESAN

ESTRADA LOBATO, Enrique

Conferences

AUBMC has also hosted several significant conferences including:

1. The First Theranostic Conference in Lebanon, in November 2017: the two-day conference was co-organized by the IAEA RAS6078 - November 2017, and featured visiting speakers from the Society of Nuclear Medicine and Molecular Imaging (SNMMI).
2. The Second Theranostic Conference in Lebanon, in September 2019: this conference gathered international speakers to discuss the latest advancements in theranostics and was co-organized by the IAEA RAS6089-September 2019.
3. The Arab Society of Nuclear Medicine’s 2nd Conference (ARSNM), in November 2022: this conference attracted more than 665 attendees and hosted over 30 international speakers. It provided a platform for professionals in the field to exchange knowledge and expertise, RAS6102-November 2022.

These conferences underscore AUBMC’s commitment to organizing impactful events that bring together renowned experts and practitioners in nuclear medicine to foster collaboration, share research findings, and advance the field. AUBMC experts have actively participated in IAEA projects aimed at enhancing disease management through capacity building under the IAEA ‘Training Curriculum for Nuclear Medicine Physicians’, offering regional workshops, training events, and courses. Since 2018, AUBMC’s Practical Arrangements with the IAEA has fostered closer collaborations in nuclear medicine, establishing it as one of the prominent centers worldwide for implementing the IAEA ‘Training Curriculum for Nuclear Medicine Physicians’, notably in the ARASIA State Parties.

Experts from AUBMC have participated as international specialists in several regional and inter-regional training and scientific activities, including QUANUM and imPACT Review missions.

Research and Publications

There have been several research publications and ongoing research projects conducted in collaboration with the IAEA in the field of nuclear medicine. Some of these publications and research activities include:

Haidar M, Abi-Ghanem AS, Moukaddam H, Jebai ME, Al Zakleet S, Al Rayess S, Akkawi AR, Kassas M, Tamim H, Hajj AE, Estrada-Lobato E, Osman MM, Shamseddine A. "68Ga-PSMA PET/CT in early relapsed prostate cancer patients after radical therapy." This research publication in Scientific Reports (2022) focused on the use of 68Ga-PSMA PET/CT imaging in prostate cancer patients experiencing early relapse after radical therapy.

Nassar L, Kassas M, Abi-Ghanem AS, El-Jebai M, Al-Zakleet S, Baassiri AS, Naccoul RA, Barakat A, Tfayli A, Assi H, Berjawi G, Estrada-Lobato E, Giammarile F, Vinjamuri S, Haidar M. "Prone versus Supine FDG PET/CT in the Staging of Breast Cancer." Published in Diagnostics (2023), this study compared the effectiveness of prone and supine FDG PET/CT imaging in the staging of breast cancer.

Cerci JJ, Fanti S, Lobato EE, Al-Ibraheem A, Hourani M, Paez D, and others. "Diagnostic Performance and Clinical Impact of 68Ga-PSMA-11 PET/CT Imaging in Early Relapsed Prostate Cancer After Radical Therapy: A Prospective Multicenter Study (IAEA-PSMA Study)." This publication in the Journal of Nuclear Medicine (2022) reported the findings of a multicenter study evaluating the diagnostic performance and clinical impact of 68Ga-PSMA-11 PET/CT imaging in early relapsed prostate cancer.

Jean-Luc Urbain, Andrew M. Scott, Sze Ting Lee, John Buscombe, Charlotte Weston, Jun Hatazawa, Seigo Kinuya, Baljinder Singh, Mohamad Haidar, Andrew Ross, Francois Lamoureux, Jolanta Kunikowska, Wolfgang Wadsak, Rudi Dierckx, Diana Paez, Francesco Giammarile, Kyung-Han Lee, Joo Hyun O, Modiselle Moshe, Lizette Louw, Stuart More, Helen Nadel, Daniel Lee and Richard Wahl. Theranostic Radiopharmaceuticals: A Universal Challenging Educational Paradigm in Nuclear Medicine. This review has outlined the world's currently available offerings in education and accreditation for theranostics.

In addition to these publications, ongoing research includes the "PROCA Study," a prospective, international multicenter study assessing the value of 68Ga-PSMA-11 PET/CT in staging intermediate and high-risk prostate cancer.

IAEA and ARASIA Support in Coordinated Research

AUB has received support from the IAEA and ARASIA for various Coordinated Research Projects (CRPs) in nuclear medicine. Some of these projects include:

- CRP 103389: "Use of PET-CT with Gallium-68 Labelled Prostate Specific Membrane Antigen in the Diagnosis and Follow-Up of Patients with Prostate Cancer." This project aims to investigate the use of Gallium-68 labeled prostate-specific membrane antigen (PSMA) PET-CT in the diagnosis and follow-up of patients with prostate cancer.
- CRP 103546: "Locally Advanced Breast Cancer Neo-adjuvant Chemotherapy Assessment: A Prospective Comparative Effectiveness Study of MRI Versus Whole Body PET-CT Versus Dedicated Breast PET (PEM)." The objective of this project is to compare the effectiveness of MRI, whole-body PET-CT, and dedicated breast PET (PEM) in assessing the response to neo-adjuvant chemotherapy in patients with locally advanced breast cancer.
- CRP 104250: "Value of [68Ga] Ga-PSMA-11 PET/CT in intermediate and high-risk prostate cancer staging: prospective, international multicenter study (the PROCA Study)." This ongoing international multicenter study aims to evaluate the value of [68Ga]Ga-PSMA-11 PET/CT imaging in the staging of intermediate and high-risk prostate cancer.

AUB has received valuable support from the IAEA (through ARASIA and national TC projects) to enhance various aspects of its nuclear medicine practice. The IAEA has played a crucial role in supporting radioprotection measures for the staff, ensuring quality control and assurance for PET/CT and SPECT/CT, and promoting high-end diagnostic accuracy.

- To strengthen radioprotection, the IAEA provided AUB with personal dosimeters for radiation safety and survey meters for detecting radiation types. These instruments enable the monitoring and measurement of radiation exposure, ensuring the safety of healthcare professionals working in the nuclear medicine department.
- For quality control and assurance of imaging equipment, the IAEA donated phantom sets for the calibration of PET/CT and for the quality control of the gamma camera. These phantoms serve as standardized tools for testing and maintaining the accuracy and performance of imaging systems, ensuring reliable and high-quality diagnostic results.
- In response to the high national demand for Gallium-68 (Ga-68), the IAEA has supported AUB in upgrading its cyclotron to produce Ga-68 as a liquid source instead of relying on a generator. This upgrade allows AUB to meet the increasing demand for Ga-68 radiopharmaceuticals, which are crucial for various diagnostic procedures.

Furthermore, the IAEA have supported AUB/AUBMC to acquire an activimeter for the hot lab. An activimeter is an essential tool for accurately measuring the radioactivity of radioactive materials, ensuring precise and safe handling within the laboratory.

The King Hussein Cancer Center, Jordan

Introduction

The King Hussein Cancer Center (KHCC) is one of the leading comprehensive cancer centers in the Middle East, offering advanced care to both adult and pediatric cancer patients. Named after the late King Hussein, who battled cancer with faith, courage, and dignity, KHCC is dedicated to treating approximately 7,000 new cancer patients from Jordan and the surrounding region each year. The center boasts thirteen operating rooms and 352 beds, including 36 intensive care units, six of which are pediatric.

Over 200 oncologists and consultants, along with 1,164 oncology-trained nurses, work tirelessly to ensure that patients receive the most advanced cancer care available. KHCC performs approximately 300 bone marrow transplants (BMT) annually. The center is a hub for cutting-edge medical technology and holds numerous international accreditations. These include the Joint Commission International Accreditation (JCIA), which KHCC was the first institution in Jordan to receive in 2006; the Joint Commission International Clinical Care Program (CCPC) Accreditation, making KHCC the first center outside the United States to earn this distinction; EARL accreditation from the European Association of Nuclear Medicine (EANM); and the Certificate of Excellence (MAGNET) from the American Nurses Credentialing Center. These accreditations attest to KHCC's dedication to upholding the highest quality standards in providing comprehensive services to cancer patients.

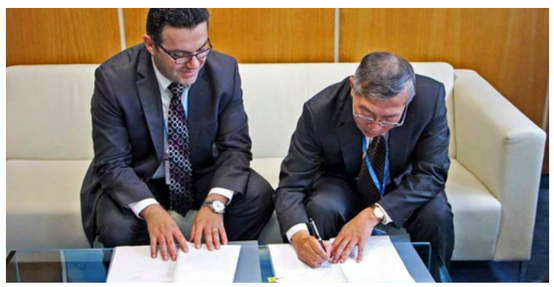
HRH Princess Ghida Talal, chairperson of KHCF and KHCC, welcomes the late IAEA DG H.E. Mr. Yukiya Amano during the inaugural phase of the new KHCC towers in May 2017, presenting him with a token of appreciation to honor the IAEA's invaluable collaboration and support in advancing KHCC's mission.

KHCC Collaboration Agreements

Practical Arrangements with IAEA (2015)

Implementing the International Atomic Energy Agency (IAEA) 'Training Curriculum for Nuclear Medicine Physicians' at the King Hussein Cancer Center (KHCC) was a significant step towards advancing nuclear medicine in the Asia and the Pacific region. The collaboration between the IAEA and KHCC brings numerous benefits to the field of nuclear medicine. The direct training of nuclear medicine professionals is a crucial aspect of the curriculum's implementation. By organizing meetings and workshops on clinical practices, KHCC provides a platform for professionals to enhance their skills and knowledge. This will not only benefit the nuclear medicine professionals at KHCC but also contribute to the overall advancement of nuclear medicine in the region.

KHCC experts have been participating in IAEA projects on enhancing the management of diseases through capacity building under the IAEA 'Training Curriculum for Nuclear Medicine Physicians', offering regional workshops, training events, and courses. Since 2015, the KHCC has Practical Arrangements with the IAEA that have fostered closer collaborations in nuclear medicine as one of seven prominent centers around the world to implement the IAEA curriculum. Experts from KHCC have participated as international experts in several regional and inter-regional training and scientific activities, QUANUM and imPACT review missions.

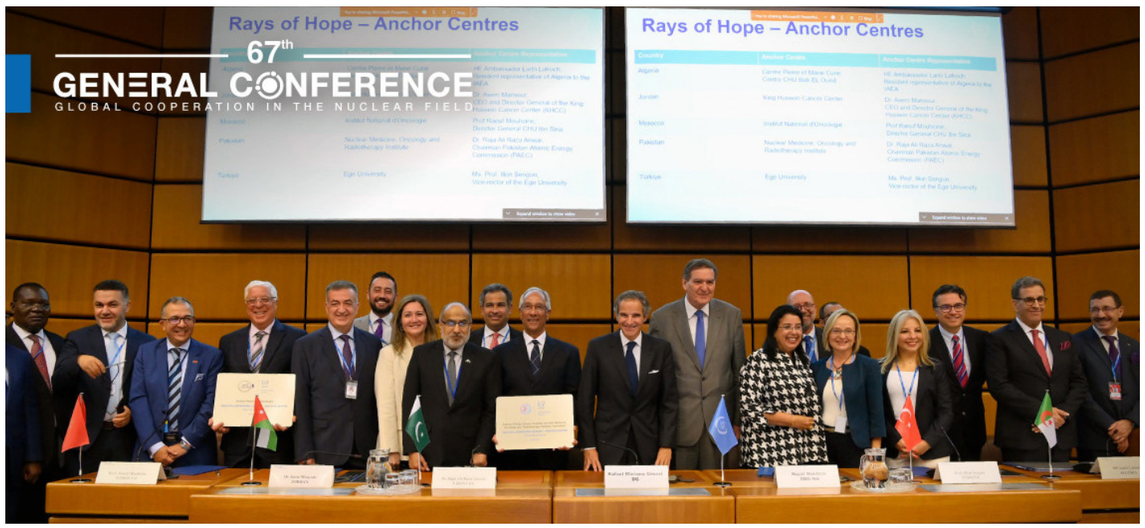


Mr. Dazhu Yang, IAEA Deputy Director General and Head of the Department of Technical Cooperation, and Dr. Akram Al-Ibraheem, representative of the KHCC, signed the Practical Arrangements Vienna, 11 November 2015.

Designation as IAEA Collaborating and Anchor Center

In July 2022, following a long-standing cooperation, the IAEA designated the KHCC as an IAEA Collaborating Centre for radiation oncology, medical physics, nuclear medicine, radiology and nutrition. In September 2023, the King Hussein Cancer Centre (KHCC) signed a cooperation agreement with the International Atomic Energy Agency (IAEA), recognising KHCC as an Anchor Centre in the region for cancer control and treatment, training, and research as part of the Rays of Hope initiative.

The Collaborating Centre agreement signing ceremony took place at the IAEA headquarters in Vienna, on 22 July 2022; King Hussein Cancer Center was represented by Dr. Asem Mansour (DG & CEO), Dr. Akram Al-Ibraheem (Chairman of Nuclear Medicine), and Dr. Jamal Khadr (Radiation Oncologist). IAEA was represented by Dr. Najat Mohktar (Deputy Director General and Head of the Department of Nuclear Sciences and Applications), Dr. May Abdel-Wahab (Director of Human Health Division), Dr. Diana Paez (Head of Nuclear Medicine and Diagnostic Imaging), and Dr. Kamal Akbarov (Radiation Oncologist). The ceremony was attended by the Ambassador of the Hashemite Kingdom of Jordan to Austria, H.E. Mrs. Leena Al-Hadid. (Photo: IAEA/V.Davidovic)



KHCC was among the five inaugural Anchor Centres that were formally established at a side event on the IAEA's Rays of Hope initiative, during the IAEA's 67th General Conference. (Photo: D. Calma/IAEA)

Nuclear Medicine and PET/CT Department

The Department of Nuclear Medicine at King Hussein Cancer Center is recognized as a regional pioneer in offering cutting-edge diagnostic and therapeutic nuclear medicine services for cancer patients. By utilizing nuclear, molecular, and biological technologies, the department plays a crucial role in the comprehensive care and management of cancer patients. The department is equipped with state-of-the-art nuclear medicine technologies, such as Digital PET/CT and SPECT/CT scanners, along with an Automated Radiosynthesis unit. These advanced tools empower the department to offer exceptional quality in both Diagnostic and Theranostics services to cancer patients. The diagnostic and therapeutic services are described in the following paragraph.

Diagnostic Procedures and Therapy

Digital PET/CT at KHCC - Diagnostic procedures: PET/CT

- ^{18}F-FDG PET/CT & ^{68}Ga-FAPI PET/CT: Primarily used for oncology indications, this scan helps in the detection and staging of various cancers.
- ^{68}Ga-DOTATOC PET/CT & ^{68}Ga-JR-11 PET/CT: Specifically used for neuroendocrine tumors, it allows for accurate imaging and assessment of these tumors.
- ^{68}Ga-PSMA PET/CT: Used for prostate cancer, it helps in the diagnosis, staging, and evaluation of treatment response.

The KHCC's Digital PET/CT was one of the first in the region. In the right top corner is the KHCC-IAEA Collaborating Center- Anchor Center Rays of Hope plaque.

Gamma camera SPECT/CT:

- SPECT/CT hybrid imaging: This advanced technology combines functional and anatomical imaging, providing detailed image information and precise tumor localization.
- Gamma camera/nuclear imaging: Over 60 different procedures are available to examine most organs in the body, allowing for comprehensive diagnostic evaluations.
- SPECT (Single-Photon Emission Computed Tomography) using a gamma camera: This imaging technique is employed to visualize the functional aspects of organs and detect abnormalities.

Theranostics & Radionuclide therapy:

- Radioactive iodine therapy: Used for treating both benign and malignant thyroid tumors.
- Radionuclide therapy for bone metastasis: Employed as a palliative treatment to alleviate bone pain caused by metastatic cancer.
- ^{131}I-MIBG radioactive treatment: Utilized for neuroblastoma and suprarenal mass treatment.
- ^{177}Lu-DOTATAE peptide receptor radionuclide therapy (PRRT): Specifically used for neuroendocrine tumors.
- PSMA-targeted Radioligand Therapy (PRLT): Employed for advanced prostate cancer treatment by Lu-177 & Tb-161.
- Alpha Emitter Actinium-225 (^{225}Ac)-PSMA: Used to treat metastatic prostate cancer.

Collaboration with the Jordan Research and Training Reactor (JRTR)

JRTR has begun supplying KHCC with Radioactive Iodine for both diagnosis and treatment. In addition, Terbium, which is considered a novel radiotracer for theranostics, has been irradiated in the JRTR and ultimately utilized at KHCC for the treatment of resistant prostate cancer patients, giving the nuclear medicine team at KHCC the precedence to publish on the potential of this novel radioisotopes as a global leader in the field.

The JRTR facility has advanced design and capabilities in the region.

KHCCC Technical Cooperation with the IAEA & support to capacity building

RTCs & Workshops & Fellowship Training Programs hosted by the Department of Nuclear Medicine Services at KHCC

Project ID/Type	IAEA-KHCC Joint Activities	Venue	Date
SV-RAS6091-1900078	Nuclear Medicine Diagnostic Imaging	KHCC, Amman, JO	September, 2019
(RAS6091-RAS6089) EVT 1801375	Regional Workshop on Clinical Applications on Targeted Imaging and Therapy in Nuclear Medicine (Theranostics)	KHCC, Amman, JO	August, 2018
RAS6081-EVT1701412	Regional Workshop on Occupational Radiation Protection	KHCC, Amman, JO	October, 2017
Workshop (RAS/6/081)	Enhancing safety and effectiveness in Diagnostic Radiology through Training or Medical Imaging professionals in quality practices	KHCC, Amman, JO	October, 2017
Scientific Visit	Establishing Positron Emission Tomography facilities and Brachytherapy Services	KHCC, Amman, JO	March, 2017
Training Course	Regional Training Course on Molecular imaging (SPECT/CT and PET-CT and the use of peptide receptor radionuclide therapy for NET	KHCC, Amman, JO	November, 2015
Meeting	Strengthening Nuclear medicine applications through education and training to help fighting non-communicable disease	KHCC, Amman, JO	September, 2019
Learning Module	A guide to FDG PET/CT in clinical oncology	KHCC, Amman, JO	2015
C7-RAS-6.067-001	Regional training course on Nuclear Medicine oncology for nuclear medicine specialists	KHCC, Amman, JO	September, 2015

The main focus of these IAEA regional regional training courses and workshops hosted by KHCC was to enhance the management of non-communicable and communicable diseases through capacity building under the IAEA 'Training Curriculum for Nuclear Medicine Physicians' and strengthening nuclear medicine applications in ARASIA states parties through education and training to fight non-communicable diseases.

Outcomes of the collaborative activities

- Increased capacity and skills of personnel working in nuclear medicine, radiology, and medical physics in IAEA Member States.
- Enhanced capacity building in the region and some IAEA Member States.
- Strengthened nuclear medicine, radiology, medical physics, and as warranted

human nutritional health practice in State Parties through IAEA guidance and training events.

- Improved clinical research in nuclear medicine, radiology, medical physics, and as warranted human nutritional health and care capacity in State Parties.
- Improved Patient Care through best-practice and evidence-based medicine.
- Strengthened professional skills of radiologists, nuclear medicine physicians, medical physicists, and as warranted nutritionists.
- Improved patient care through QUANUM or QUAADRIL peer-review missions and IAEA Collaborating Centres to increase synergy.
- Improved understanding of the development and trends of nuclear medicine infrastructure and radiology.
- The total number of participants, including physicians and technologists, who received sponsorship from the IAEA, in nuclear medicine training activities at the King Hussein Cancer Center from 213 to 2023, is as follows:

Activity	Participants	Period
Fellowship in Nuclear Medicine Field	120	2013 - 2023
Scientific Visit	12	
Workshops and Conferences	102	

Various IAEA RTCs and regional workshops hosted by KHCC.

The First Congress of Arab Society of Nuclear Medicine (ARSNM)

The IAEA was instrumental in the founding of the Arab Society of Nuclear Medicine (ARSNM) and the success of the first ARSNM congress, which was held in Amman, Jordan in collaboration with the King Hussein Cancer Center (KHCC), by sponsoring international experts to lecture at the congress and hosting an IAEA RTCs and Regional Workshop on Clinical Applications on Targeted Imaging and Therapy in Nuclear Medicine (Theranostics). In addition, IAEA has consistently collaborated with KHCC and Jordan Atomic Energy Commission (JAEC) to ensure the success of national and regional nuclear medicine conferences organized by the Jordanian Society of Nuclear Medicine (JOSNM).

The first Congress of the Arab Society of Nuclear Medicine and the 15th Asia Oceania Congress of Nuclear Medicine and Biology, held in Jordan with the collaboration and support of KHCC and the IAEA Research & Publications.

Research & Publications

KHCC has participated in several Coordinated Research Projects (CRPs) (e.g. E13401, E13402, E33038, E14046) conducted by the IAEA that have resulted in numerous notable publications, in addition to numerous other collaborative research projects published in highly impactful peer-reviewed journals including:

- Konert T, Vogel WV, Paez D, ……, Al-Ibraheem A, Thorwarth D, Hanna GG. Introducing FDG PET/CT-guided chemoradiotherapy for stage III NSCLC in low- and middle-income countries: preliminary results from the IAEA PERTAIN trial. Eur J Nucl Med Mol Imaging. 2019 Oct;46(11):2235-2243. doi: 10.1007/s00259-019-04421-5.
- Cerci JJ, Fanti S, Lobato EE, …., Al-Ibraheem A, Hourani M, …, Paez D. Diagnostic Performance and Clinical Impact of 68Ga-PSMA-11 PET/CT Imaging in Early Relapsed Prostate Cancer After Radical Therapy: A Prospective Multicenter Study (IAEA-PSMA Study). J Nucl Med. 2022 Feb;63(2):240-247. doi: 10.2967/jnumed.120.261886.
- Al-Ibraheem A, Abdlkadir AS, Mohamedkhair A, Mikhail-Lette M, Al-Qudah M, Paez D, Mansour AH. Cancer diagnosis in areas of conflict. Front Oncol. 2022 Dec 22;12:1087476. doi: 10.3389/fonc.2022.1087476.
- Al-Ibraheem A, Hirmas N, Fanti S, Paez D, Abuhijla F, Al-Rimawi D, Al-Rasheed U, Abdeljalil R, Hawari F, Alrabi K, Mansour A. Impact of 18F-FDG PET/CT, CT and EBUS/TBNA on preoperative mediastinal nodal staging of NSCLC. BMC Med Imaging. 2021 Mar 17;21(1):49. doi: 10.1186/s12880-021-00580-w.
- Al-Ibraheem A, Abdlkadir AS, Al-Adhami D, Hejleh TA, Mansour A, Mohamad I, Juweid ME, Al-Rasheed U, Al-Hajaj N, Laban DA, Estrada-Lobato E, Saraireh O. The Prognostic and Diagnostic Value of [18F]FDG PET/CT in Untreated Laryngeal Carcinoma. J Clin Med. 2023 May 17;12(10):3514. doi: 10.3390/jcm12103514. PMID: 37240619; PMCID: PMC10218884.
- Pascual TNB, Paez D, Iagaru A, Gnanasegaran G, Lee ST, Sathekge M, Buatti JM, Giammarile F, Al-Ibraheem A, ..., Scott AM. Guiding principles on the education and practice of theranostics. Eur J Nucl Med Mol Imaging. 2024 Jul;51(8):2320-2331. doi: 10.1007/s00259-024-06657-2. Epub 2024 Mar 8. PMID: 38453729; PMCID: PMC11178594.
- Mikhail-Lette M, Cordero L, Lievens Y, Al-Ibraheem A, …., Scott A, Paez D, Giammarile F, Veduta A, Minoshima E, Vichare S, Abdel-Wahab M. Six country vignettes: Strengthening radiotherapy and theranostics. J Cancer Policy. 2024 Jun;40:100471. doi: 10.1016/j.jcpo.2024.100471. Epub 2024 Mar 29. PMID: 38556128.

IAEA support to KHCC

The nuclear medicine department at KHCC has received substantial support from the IAEA through the cost-sharing project to install the first SPECT/CT and the support to obtain the EARL certificate from the European Association of Nuclear Medicine (EANM), which has designated the department as a Center of Excellence for PET/CT services since 2015.

The first SPECT/CT in Jordan, installed at KHCC in 2019, was part of a cost-sharing project supported by the IAEA.

With technical and equipment support from the IAEA's Coordinated Research Project, the Department of Nuclear Medicine has been recognized as a Center of Excellence by the EARL from the EANM.


EARL PET/CT | PET/MR
Accreditation 2022

THIS IS TO CERTIFY THAT THE

King Hussein Cancer Centre Amman al Jubeiha
Department of Nuclear Medicine
Scanner: Siemens Biograph mCT Flow 11012

is granted accreditation according to the requirements and specifications indicated in the EARL accreditation user manual for the following oncology isotope imaging and accreditation program:

^{18}F standards 2, ^{68}Ga

PET/CT | PET/MR scanner accreditation ensures similar performance of the systems within a multicentre setting by harmonising reconstructions for quantification of PET/CT | PET/MR scans. Accredited PET/CT | PET/MR centres of excellence can compare, exchange and combine PET/CT | PET/MR findings, including SUVs, since data are collected and processed in a standardised manner. The regular submission and approval of QC data, as required by EARL, is a condition for the maintenance of the accreditation.

Date of Print: Q2-2022

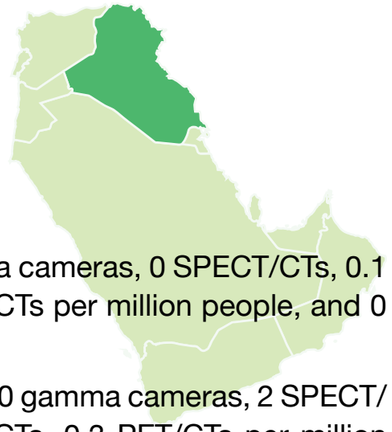
Jolanta Kunikowska
EANM President 2021-2022

Ivalina Hristova
Programme Director

ACCREDITED CENTRE OF EXCELLENCE ·2022· RESEARCH4LIFE an EANM initiative PET/CT · PET/MR

Status of Nuclear Medicine in ARASIA State Parties

IRAQ



Facilities and Equipment:

In 2016, there were 6 nuclear medicine centers, 5 gamma cameras, 0 SPECT/CTs, 0.1 gamma cameras per million people, 0 PET/CTs, 0 PET/CTs per million people, and 0 cyclotron facilities in Iraq.

As of 2023, there are now 15 nuclear medicine centers, 20 gamma cameras, 2 SPECT/CTs, 0.5 gamma cameras per million people, 12 PET/CTs, 0.3 PET/CTs per million people, and 5 cyclotron facilities in the country. This represents a significant increase in the number of nuclear medicine centers, gamma cameras, SPECT/CTs, PET/CTs, and cyclotron facilities in Iraq over the past five years. The number of gamma cameras and PET/CTs per million people has increased significantly, indicating that Iraq has made progress in the field of nuclear medicine.

The increase in the number of nuclear medicine facilities and equipment in Iraq is likely due to:

- The country's efforts to improve its healthcare infrastructure and increase access to medical services.
- Additionally, ARASIA's programs and technical assistance may have played a role in supporting Iraq's progress in the field of nuclear medicine.

So overall, the statistics suggest that Iraq has made significant strides in the peaceful use of nuclear energy, particularly in the area of nuclear medicine, over the past few years. However, there is still much work to be done to further develop the country's technical capabilities and enhance its scientific knowledge in this field.

Human resources:

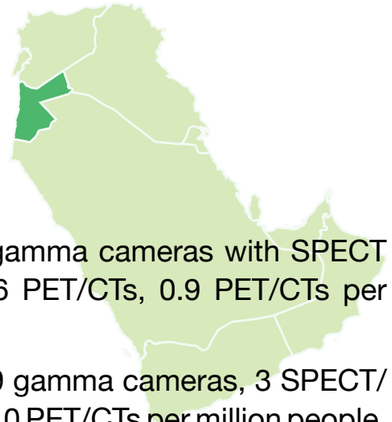
Iraq has witnessed notable developments in its human resources dedicated to nuclear medicine between 2016 and 2023. In 2016, the country had 5 radiopharmacists / radiochemists, 21 medical physicists specializing in nuclear medicine, 10 technologists, and 11 nuclear medicine physicians. However, as of 2023, Iraq has experienced significant growth in these professional categories. The count of radiopharmacists and radiochemists remains unchanged at 5, indicating a consistent workforce dedicated to the preparation and handling of radiopharmaceuticals. Remarkably, the number of medical physicists dedicated to nuclear medicine has risen to 40, reflecting a substantial expansion in the expertise available for quality assurance, radiation safety, and dosimetry within the field. Additionally, the number of technologists has increased to 20, highlighting an improved capacity for performing various imaging procedures. Furthermore, the count of nuclear medicine physicians has reached 20, representing a reinforced presence of specialized medical practitioners in the domain of nuclear medicine.

The significant increase in the number of medical physicists dedicated to nuclear medicine strengthens the implementation of:

- Radiation safety protocols.
- Quality control measures.
- Precise dosimetry.
- Enhancing the overall safety and efficacy of nuclear medicine procedures.

With a larger pool of technologists, Iraq is better equipped to operate and maintain imaging equipment, ensuring efficient imaging procedures and the acquisition of high-quality diagnostic data.

JORDAN



Facilities and Equipment:

In 2016, Jordan had 17 nuclear medicine centers, 14 gamma cameras with SPECT capabilities, 2.3 gamma cameras per million people, 6 PET/CTs, 0.9 PET/CTs per million people, and 2 cyclotron facilities.

As of 2023, Jordan has 17 nuclear medicine centers, 19 gamma cameras, 3 SPECT/CTs, 2 gamma cameras per million people, 11 PET/CTs, 1.0 PET/CTs per million people, and 2 cyclotron facility. This represents an increase in the number of nuclear medicine centers, gamma cameras, SPECT/CTs, PET/CTs, and cyclotron facilities in Jordan over the past five years. Notably, the number of SPECT/CTs has increased from 0 to 3, indicating that Jordan has made progress in this area of nuclear medicine. The number of gamma cameras and PET/CTs per million people has remained relatively stable, indicating that the increase in the total number of these facilities is largely due to population growth. In 2019, KHCC installed its first digital PET/CT device, making it one of the earliest such devices to be used in the Middle East region. KHCC is recognized as a leading oncology center in the Middle East and surrounding areas. This new technology provides faster imaging, reduced noise levels, improved contrast, and uniform detection of lesions throughout the axial field of view. In accordance with its policy to promote nuclear oncology and theranostics knowledge and practice both locally and internationally, KHCC provides training, residency, and fellowship programs for Jordanian and Arab trainees. Many IAEA-sponsored fellows from different Arab countries are pursuing their career goals by meeting the residency and fellow training program requirements at KHCC. Additionally, outpatient nuclear medicine clinics have undergone significant expansion in recent years due to the introduction of new theranostic agents at KHCC, which has resulted in a corresponding rise in patient referrals. This has generated substantial interest among experienced nuclear medicine physicians seeking to practice at KHCC and qualify for the specialized theranostic training and fellowship programs that are offered.

Jordan has been an active member of ARASIA, and this progress in the field of nuclear medicine may be due in part to the organization's support and technical assistance. Overall, the statistics suggest that Jordan has made steady progress in the peaceful use of nuclear energy, particularly in the area of nuclear medicine, over the past few years. However, there is still room for improvement in terms of expanding access to these technologies and increasing scientific knowledge in the field.

Human resources:

Jordan has made notable advancements in its human resources dedicated to nuclear medicine between 2016 and 2023. In 2016, the country had 5 radiopharmacists/radiochemists, 20 medical physicists specializing in nuclear medicine, 34 technologists, and 29 nuclear medicine physicians. However, as of 2023, Jordan has experienced significant growth in these professional categories. The count of radiopharmacists/radiochemists has increased to 8, indicating a strengthened workforce involved in the preparation and handling of radiopharmaceuticals. Furthermore, the number of medical physicists dedicated to nuclear medicine has risen to 28, showcasing the expanded expertise available for ensuring radiation safety, quality assurance, and accurate dosimetry in nuclear medicine practice. The count of technologists has also seen substantial growth, reaching 44, signifying an increased capacity for performing imaging procedures and managing imaging equipment. Additionally, the number of nuclear medicine physicians has reached 42, highlighting the increased presence of specialized medical practitioners in the field of nuclear medicine.

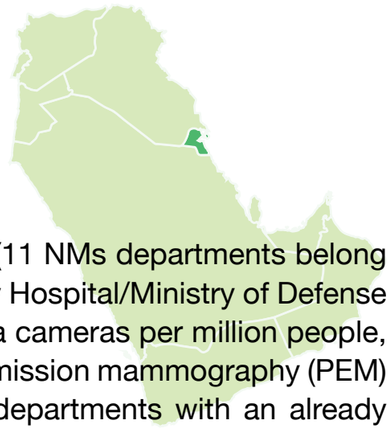
The Jordan Research & Training Reactor (JRTR) is a part of Jordan's peaceful nuclear program and is operated by the Jordan Atomic Energy Commission (JAEC). It is the country's first nuclear critical facility. It was built as an advanced model of open pool type reactor in collaboration with Korean Atomic Energy & Research Institute (KAERI) and Daewoo Engineering Consortium (KDC) and is considered the safest research reactor model.

It is a nuclear reactor with a capacity of 5 MWt that can be expanded to 10 MWt. It produces NaI-131 in both dosage forms; oral solution and capsules for diagnostic and therapeutic uses, which adequately covers the product's local and regional needs.

JRTR provides Terbium and Holmium irradiation services to international radioisotope companies. In the near future, R&D is underway to create new radiopharmaceutical isotopes for therapeutic and diagnostic purposes, such as Lu-177 and Tc-99m.

In summary, Jordan's progress in expanding its human resources in the field of nuclear medicine demonstrates the country's commitment to advancing healthcare services, promoting patient safety, and elevating the quality of diagnostic and therapeutic procedures. These developments have the potential to enhance patient outcomes, strengthen diagnostic accuracy, support effective treatment strategies, and contribute to the overall growth and advancement of nuclear medicine in Jordan.

KUWAIT



Facilities and Equipment:

In 2016, Kuwait had 12 nuclear medicine (NM) centers (11 NMs departments belong to Ministry of Health (MOH) and 1 belongs to the Military Hospital/Ministry of Defense (MOD), 30 gamma cameras, 6 SPECT/CTs, 10.3 gamma cameras per million people, 6 PET/CTs, 1.7 PET/CTs per million people, 1 positron emission mammography (PEM) and 2 cyclotron facilities. In 2023, MOH had 11 NM departments with an already existing NM department that belongs to the Ministry of Defense and a recently established NM service within the private sector. In total, the NM services in Kuwait include 13 departments, with 20 gamma cameras, 26 SPECT/CTs, 14 PET/CTs, 1 PET/MR, 1 PEM, 3 dedicated gamma cameras for cardiac and breast imaging and 2 cyclotron facilities.

The decision to establish nuclear medicine in every new hospital in Kuwait was made by the Ministry of Health (MOH) to ensure access to nuclear medicine services for the population as quickly as possible. However, there is a shortage of staff in various categories and specialties, which can impact the efficient functioning of the facilities.

To ensure safety and risk management, Kuwait has implemented several measures, including a safety and risk management program at the center level, radiation safety local rules from the Radiation Safety Officer (RSO)/NM Physics Unit, an updated safety plan from the Kuwait Cancer Control Center (KCCC), a disaster and evacuation plan for the NM department, and approved policies and procedures from the MOH. Regular maintenance, quality assurance, and quality control of equipment are also conducted. Internal and external audits are mandatory to achieve high-quality patient services.

The accreditation program in Kuwait plays a crucial role in training staff across different categories and fields, with a focus on safety and the quality of patient services. The MOH provides opportunities for citizen employees to receive training locally or internationally, including postgraduate studies, board programs, and fellowships. Each council has its own budget for local workshops and conferences, and staff are sent to international conferences, workshops, and training courses in collaboration with the International Atomic Energy Agency. The disposal of radioactive waste is strictly regulated by the physics unit within the department, following the MOH's requirements and the Radiation Safety Local Rules of the NM department.

The ARASIA program is supportive and adds value by improving human resources through educational programs, training courses, fellowships, workshops, and conferences. The government of Kuwait is committed to achieving and sustaining the highest quality standards in nuclear medicine practice, and with the support of the IAEA, seeks to enhance the quality of services provided to patients. Previous collaborations between the institute and the IAEA have included projects, training courses, conferences, workshops, scientific visits, virtual meetings, and continuing medical education (CME) activities, all contributing to the establishment of NM departments with high-quality services.

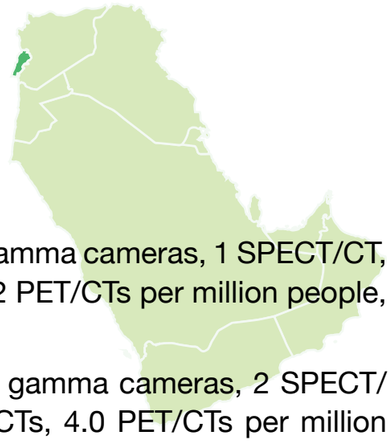
Human resources:

In 2016, Kuwait had 10 radiopharmacists/radiochemists, 10 medical physicists, 150 technologists, and 50 nuclear medicine physicians. By 2023, the number of radiopharmacists/radiochemists increased to 11, the number of physicists also increased to 11, while the number of technologists increased from 186 to 219 and physicians from 50 to 68.

The increase in medical physicists reflects their crucial role in ensuring radiation safety and quality assurance. Advancements in technology and diagnostic capabilities in nuclear medicine may have raised the need for additional personnel, such as radiopharmacists/radiochemists, to support the development and safe administration of radiopharmaceuticals. Also the rising number of technologists indicates a focus on expanding the technical workforce, while the increase in nuclear medicine physicians highlights a growing need for specialized expertise in interpretation and treatment that is supported by having a local board for Kuwait Nuclear Medicine.

These changes suggest a dynamic landscape in Kuwait's nuclear medicine sector, influenced by the abovementioned healthcare policies and technologies.

LEBANON



Facilities and Equipment:

In 2016, Lebanon had 27 nuclear medicine centers, 27 gamma cameras, 1 SPECT/CT, 6.2 gamma cameras per million people, 10 PET/CTs, 2.2 PET/CTs per million people, and 2 cyclotron facilities.

In 2023, Lebanon has 27 nuclear medicine centers, 27 gamma cameras, 2 SPECT/CTs, 6.2 gamma cameras per million people, 18 PET/CTs, 4.0 PET/CTs per million people, and 2 cyclotron facilities. The increase in the number of PET/CTs from 10 to 18 and PET/CTs per million people from 2.2 to 4.0 between 2016 and 2023 may indicate a growing demand for advanced imaging services in the country. This could be due to several factors, including an aging population, increased awareness of the benefits of early disease detection and diagnosis, and advances in medical technology.

However, there are also several implications of this increase:

- One potential concern is the cost of these advanced imaging services, which can be prohibitively expensive for many patients, especially in a country with a struggling economy like Lebanon.
- This may contribute to health disparities and limit access to care for those who cannot afford it.
- Another potential implication is the need for trained professionals to operate and interpret the results of PET/CT scans. As the number of PET/CT machines increases, so does the demand for skilled technicians and radiologists who can accurately interpret the scans and provide appropriate treatment recommendations. It will be important for the healthcare system in Lebanon to ensure that there is an adequate supply of trained professionals to meet this growing demand.

Overall, while the increase in PET/CTs in Lebanon is a positive development in terms of providing advanced imaging services to patients, it also highlights the need to address issues of cost and access to care, as well as the importance of investing in healthcare education and training to meet the growing demand for skilled professionals in this field.

Human resources:

Between 2016 and 2023, Lebanon's human resources in the field of nuclear medicine have shown slight changes. In 2016, the country had 4 radiopharmacists/radiochemists, 50 technologists, and 15 nuclear medicine physicians. As of 2023, these numbers have experienced modest increases, with 5 radiopharmacists/radiochemists, 57 technologists, and 18 nuclear medicine physicians with no medical physicist dedicated for nuclear medicine.

The changes in Lebanon's human resources in the field of nuclear medicine between 2016 and 2023 can be attributed to several factors:

1. Increased recognition of the importance of nuclear medicine services: Over the years, there has been a growing understanding of the role of nuclear medicine in diagnosis, treatment, and management of various medical conditions. This increased recognition may have led to a greater emphasis on developing and expanding nuclear medicine services in Lebanon, which in turn requires a larger workforce.
2. Growing demand for nuclear medicine services: The demand for nuclear medicine services has likely increased due to factors such as an aging population, rising incidence of chronic diseases, and advancements in medical imaging technology. As the demand for these services grows, there is a need to expand the human resources in the field to ensure timely and efficient delivery of care.
3. Increasing demand for Theranostics, particularly for prostate cancer: Theranostics is a rapidly evolving field that combines diagnostics and therapy using radiopharmaceuticals. It has shown promising results in the management of certain cancers, including prostate cancer. The increase in human resources in nuclear medicine may be driven by the rising demand for Theranostics and the need for specialized professionals to administer these treatments.
4. Advancements in technology and diagnostic capabilities: The field of nuclear medicine has witnessed significant advancements in imaging technology and diagnostic capabilities in recent years. These advancements may have created the need for additional personnel, such as radiopharmacists/radiochemists, who are responsible for the development, production, and safe administration of radiopharmaceuticals used in nuclear medicine procedures.
5. Government initiatives and healthcare support aimed at improving healthcare services, including nuclear medicine, which played a role in attracting more professionals to the field and encouraging its growth.

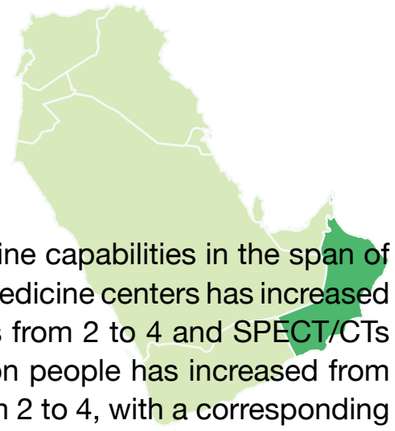
Overall, the modest increases in the number of radiopharmacists/radiochemists, technologists, and nuclear medicine physicians in Lebanon between 2016 and 2023 can be attributed to the growing recognition of the importance of nuclear medicine services, increased demand for these services, and advancements in technology and diagnostic capabilities. These factors have likely driven the need to expand the nuclear medicine workforce to meet the healthcare needs of the population and ensure the safe and effective delivery of nuclear medicine services.

In addition, the absence of a medical physicist dedicated to the field of nuclear medicine is a notable concern. The involvement of a medical physicist is crucial for ensuring the safe and effective use of radiation in diagnostic and therapeutic procedures. Given the importance of this role, it is imperative for the authorities and relevant healthcare

institutions to provide support and take appropriate measures to implement this recommendation.

In summary, Lebanon's nuclear medicine sector has seen slight changes in its human resources between 2016 and 2023. The addition of personnel in specific areas indicates a potential response to growing demand and technological advancements in the field. These changes can contribute to improved patient care, safety, and accessibility to nuclear medicine services. Regular evaluation of workforce requirements, training opportunities, and strategic planning can ensure the continued growth and development of Lebanon's nuclear medicine sector, ultimately benefiting the healthcare system and the well-being of the population. This can be achieved through advocacy campaigns, educational programs, and discussions emphasizing the role and responsibilities of medical physicists in ensuring radiation safety and quality control in nuclear medicine.

OMAN



Facilities and Equipment:

Oman has made notable advances in its nuclear medicine capabilities in the span of seven years from 2016 to 2023. The number of nuclear medicine centers has increased from 2 to 4, accompanied by a rise in gamma cameras from 2 to 4 and SPECT/CTs from 2 to 3. Oman's ratio of gamma cameras per million people has increased from 1.3 to 1.5, and the availability of PET/CTs increased from 2 to 4, with a corresponding rise in PET/CTs per million people from 0.5 to 0.8. This indicates a growing demand for advanced imaging services in the country.

Oman continues to operate and maintain one 11 MeV cyclotron facility for radiopharmaceutical production.

These developments in Oman's nuclear medicine infrastructure are due to its commitment to enhancing healthcare services and quality through:

- Improved diagnostic capabilities.
- Expansion of the local theranostic and therapeutic services with ongoing plans to introduce new tracers and therapies.
- More precise treatment planning.
- Increased accessibility to advanced imaging techniques.
- Decentralization of the nuclear medicine services.

Human resources:

During the 2016 to 2023 period, human resources in nuclear medicine have progressed noticeably in terms of number and capability.

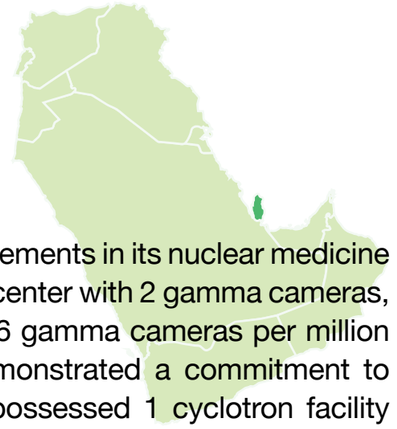
In 2016, the country had 3 radio pharmacists/radiochemists, 8 medical physicists working in nuclear medicine, 15 technologists, and 7 nuclear medicine physicians.

As of 2023, Oman has witnessed a noteworthy increase in all these four categories. The number of radio pharmacists/radiochemists has risen to 7, indicating a growing workforce specializing in the preparation and handling of radiopharmaceuticals. The number of medical physicists dedicated to nuclear medicine has increased to 14, reflecting a stronger emphasis on ensuring quality assurance and radiation safety in this field. Oman has also seen a rise in the number of technologists to 27, who play a crucial role in performing various diagnostic imaging procedures. Furthermore, the number of nuclear medicine physicians has expanded to 17, highlighting the increased availability of specialized medical practitioners in this domain.

All the nuclear medicine centers in Oman have benefited from participation in several national and regional IAEA technical cooperation projects which lead to the

strengthening and improvement of their capabilities for diagnosis and treatment. An IAEA Quality Management Audit in Nuclear Medicine Practices (QUANUM) audit of the nuclear medicine departments is planned to be conducted during the 2024-2025 IAEA technical cooperation programme cycle. Quality Management Manuals of the nuclear medicine departments have been prepared, improved and finalized, based on findings and recommendations made by earlier IAEA expert missions, in preparation for audits and accreditation.

QATAR



Facilities and Equipment:

Between 2016 and 2023, Qatar has made notable advancements in its nuclear medicine capabilities. In 2016, the country had 1 nuclear medicine center with 2 gamma cameras, 1 SPECT, 1 SPECT/CT and 1 PET/CT. With a ratio of 1.6 gamma cameras per million people and 0.4 PET/CTs per million people, Qatar demonstrated a commitment to enhancing healthcare accessibility. Additionally, Qatar possessed 1 cyclotron facility for the production of radiopharmaceuticals. Fast forward to 2023, Qatar has further expanded its nuclear medicine infrastructure. The number of nuclear medicine centers has increased to 2, including a pediatric dedicated hospital, accompanied by 5 SPECT/CTs, 3 PET/CTs and a dedicated Positron Emission Mammography (PEM) capable of doing PEM-guided breast biopsy. The ratio of 1.8 gamma cameras per million people (all upgraded to SPECT/CTs) indicates continued efforts to improve imaging capabilities and the introduction of PEM indicate the interest of Qatar to have an efficient diagnostic and follow up as a response to the increase in Breast Cancer cases in the region. Qatar has maintained its cyclotron facility and introduced a new state of the art centralized radiopharmacy, ensuring a consistent supply of radiopharmaceuticals for diagnostic and therapeutic purposes. These advancements can be attributed to Qatar's healthcare investments and commitment to technological advancements.

The implications of advancements include:

- Improved diagnostic accuracy and growth in awareness toward benefit of early diagnosis.
- Enhanced treatment planning and especially with the use of dedicated scanners such as PEM.
- Expanded access to advanced therapies especially those related to I131, Y90 and Sr89.
- Qatar's nuclear medicine developments also attract international collaborations, support research and innovation and this is clear from publications and outputs related to IAEA and Qatar National Research Fund (QNRF) projects.

Moreover, several measures have been implemented in order to ensure safety in accordance to the Qatar Decree Law No. 31 of 2002 on Radiation Protection including hospital based safety programs with a special focus on NM related radiations safety and waste management. Regular maintenance, quality assurance, and quality control for equipment as well as for radiopharmaceuticals are also conducted. These are based on international guidelines and are documented and included in the Standard Operating Procedures. They are also proved through hospital Joint Commission International (JCI) accreditation.

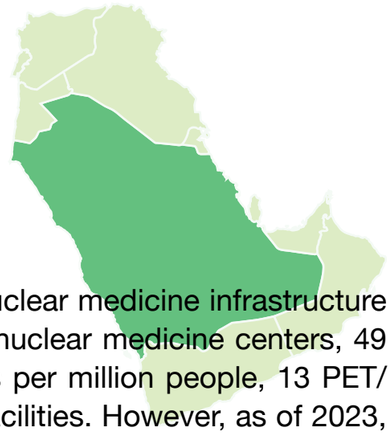
Qatar and the associated hospitals also ensure that appropriate training is implemented for all staff ranging from local, regional and international training to participation in workshop and conferences. Part of these conferences/training/expert missions are supported by IAEA through national and ARASIA programs. Historically, the IAEA provided continuous support to Qatar through the provision of expertise during the initiation of the PET/CT center at the Hamad Medical Corporation in Qatar in 2011.

Human resources:

Between 2016 and 2023, Qatar's human resources in the field of nuclear medicine have experienced slight changes. In 2016, the country had 3 radiopharmacists/radiochemists, 1 medical physicist dedicated to nuclear medicine, 13 technologists, and 5 nuclear medicine physicians. As of 2023, these numbers have slightly increased, with 4 radiopharmacists/radiochemists, 4 medical physicists dedicated to nuclear medicine, 19 technologists, and 6 nuclear medicine physicians.

In summary, Qatar's nuclear medicine sector has seen changes in its human resources between 2016 and 2023. The additions in specific areas signify a response to the growing demand for nuclear medicine services and advancements in the field. These changes can contribute to improved patient care, safety, and accessibility to nuclear medicine services. Regular evaluation of workforce requirements, training opportunities, and strategic planning can ensure the continued growth and development of Qatar's nuclear medicine sector, ultimately benefiting the healthcare system and the well-being of the population.

SAUDI ARABIA



Facilities and Equipment:

Saudi Arabia has witnessed substantial growth in its nuclear medicine infrastructure between 2016 and 2023. In 2016, the country had 41 nuclear medicine centers, 49 gamma cameras, 34 SPECT/CTs, 2.8 gamma cameras per million people, 13 PET/CTs, 0.4 PET/CTs per million people, and 6 cyclotron facilities. However, as of 2023, Saudi Arabia has expanded its capabilities with 68 nuclear medicine centers, 100 gamma cameras, 62 SPECT/CTs, 3.03 gamma cameras per million people, 33 PET/CTs, 1 PET/CT per million people, and 7 cyclotron facilities.

The increase in the number of nuclear medicine centers, gamma cameras, SPECT/CTs, and PET/CTs signifies a significant investment in expanding diagnostic and therapeutic capabilities across the country. It suggests a commitment to improving access to advanced imaging and treatment modalities for various medical conditions. The higher number of gamma cameras and PET/CTs per million people indicates an effort to enhance the availability and utilization of these imaging technologies, leading to more accurate diagnoses and better patient outcomes. The increase in cyclotron facilities reflects a focus on local production, reducing dependence on imported radiopharmaceuticals, and promoting self-sufficiency in this critical aspect of nuclear medicine practice.

Possible causes for these advancements may include Saudi Arabia's recognition of the value of nuclear medicine in improving healthcare services and patient care. It could also be driven by a growing demand for nuclear medicine procedures due to an aging population, increased prevalence of chronic diseases, and the country's focus on healthcare infrastructure development.

Moreover, Saudi Arabia has seven cyclotrons with large spectrum of Energy going from 11 to 30 MEV to cover the national demand for diagnostic and therapy including but not limited to Iodine 123, Iodine 124, Cu 64 and Zr 89 based radiopharmaceuticals.

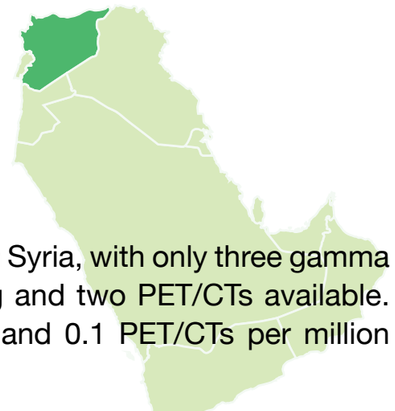
Human resources:

There has been a significant shift in the number of professionals working in nuclear medicine between 2016 and 2023. In 2016, Saudi Arabia had 7 radiopharmacists/radiochemists, 60 medical physicists dedicated to nuclear medicine, 172 technologists, and 79 nuclear medicine physicians. However, as of 2023, the number of radiopharmacists/radiochemists has decreased to 6, while the number of medical physicists dedicated to nuclear medicine has increased to 72. Moreover, there has been a substantial rise in the number of technologists, reaching 372, and nuclear medicine physicians, reaching 176.

The number of radiopharmacists/radiochemists is still very low to cover the national demand to ensure safe use of radiopharmaceutical products and accurate quality control. On the other hand, the increase in medical physicists may indicate a recognition of their critical role in ensuring the safe and effective use of nuclear medicine technologies.

Overall, the changes in the number of professionals dedicated to nuclear medicine in Saudi Arabia reflect a strategic response to the evolving healthcare needs of the population. The increased focus on expanding the workforce and improving access to nuclear medicine services holds the potential to positively impact patient outcomes and contribute to the advancement of medical practice in the country.

SYRIA



Facilities and Equipment:

In 2016, there were only four nuclear medicine centers in Syria, with only three gamma cameras one of which is dedicated to cardiac imaging and two PET/CTs available. This translates to a low ratio of 0.2 gamma cameras and 0.1 PET/CTs per million people, with only one cyclotron facility.

In 2023, the number of centers remains the same but the equipment increased from 3 gamma cameras to 5 and no changes in number of PET/CTs. This mild improvement may be related to the current circumstances in the country.

The ongoing Syrian conflict, which began in 2011, is a significant factor that could have contributed to the lack of progress in the country's healthcare system, including nuclear medicine. According to the United Nations, the conflict has resulted in the loss of healthcare providers, and the destruction of healthcare infrastructure, making it more challenging to maintain existing facilities and construct new ones. The economic sanctions further restrict the country's ability to import medical equipment and supplies.

The consequences of the limited availability of nuclear medicine in Syria can have severe implications for patient care, including:

- Missed or delayed diagnosis and treatment.
- Patients with cancer, for instance, may be deprived of access to PET/CT scans, a critical diagnostic tool used in cancer management, which can lead to delayed diagnosis and a poor prognosis.
- Moreover, with only two PET/CTs in the country, patients in remote areas may have limited access to this diagnostic tool, resulting in inadequate treatment and poor patient outcomes.

In conclusion, the lack of adequate nuclear medicine services can have severe implications for patient care and should be addressed to improve the healthcare system's overall quality.

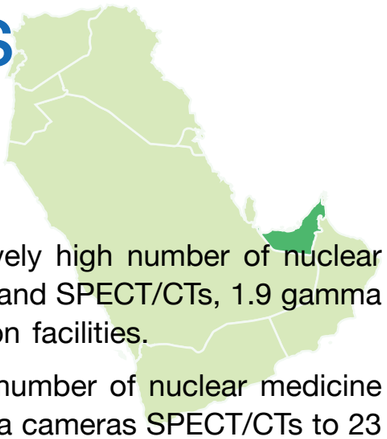
Human resources:

Between 2016 and 2023, Syria's human resources in the field of nuclear medicine have remained stable. In 2016, the country had 5 radiopharmacists/radiochemists, 25 medical physicists dedicated to nuclear medicine, 10 technologists, and 10 nuclear medicine physicians. As of 2023, these numbers have not shown any significant changes, with Syria still having 5 radiopharmacists/radiochemists, 25 medical physicists, 10 technologists, and 10 nuclear medicine physicians.

While stability in these numbers indicates the presence of a workforce capable of fulfilling the requirements of nuclear medicine services, it is essential to consider the impact of the ongoing conflict in the country. The possible causes for the lack of growth or changes in human resources in Syria's nuclear medicine sector could be attributed to the challenging circumstances faced by the country. The limited availability of resources, including training programs and professional development opportunities, could have also contributed to the unchanged numbers.

While the stable workforce is commendable given the circumstances, it raises concerns about the capacity to meet the increasing demand for nuclear medicine services. Efforts to address the challenges faced by the healthcare system in Syria, including the provision of resources, training opportunities, and support for the nuclear medicine sector, are crucial to ensure improved accessibility and quality of care in the future.

UNITED ARAB EMIRATES



Facilities and Equipment:

In 2016, the United Arab Emirates (UAE) had a relatively high number of nuclear medicine centers, with 13 centers, 18 gamma cameras and SPECT/CTs, 1.9 gamma cameras per million people, 4 PET/CTs, and 3 cyclotron facilities.

However, in 2023, there has been an increase in the number of nuclear medicine centers to 15 with additional 5 ongoing projects, gamma cameras SPECT/CTs to 23 and PET/CTs to 10, and the number of cyclotron facilities remains the same at 3 with implementation of three new facilities dedicated for therapy.

One possible cause of this increase in the number of SPECT/CTs and PET/CTs in the UAE may be the growing prevalence of chronic diseases such as cancer and cardiovascular diseases. The government has made efforts to promote awareness and screening for these conditions, which may have led to the increased demand for advanced imaging modalities. Additionally, the UAE is known for its medical tourism industry, and the increase in the number of advanced imaging facilities may be driven by the demand from international patients seeking high-quality medical care.

The implications of this increase in advanced imaging facilities in the UAE are generally positive. With the addition of more SPECT/CTs and PET/CTs, patients in the UAE will have better access to accurate diagnoses and more effective treatment options. The availability of cyclotron facilities also allows for the production of radiopharmaceuticals used in nuclear medicine imaging, which will further enhance the diagnostic capabilities of the country's healthcare system. Overall, the UAE's investment in nuclear medicine technology reflects its commitment to providing high-quality healthcare to its citizens and patients from around the world.

Human resources:

Between 2016 and 2023, the United Arab Emirates (UAE) has maintained a consistent level of human resources in the field of nuclear medicine. In 2016, the country had 2 radiopharmacists/radiochemists, 2 medical physicists dedicated to nuclear medicine, 45 technologists, and 15 nuclear medicine physicians and nuclear radiologists. As of 2023, these numbers slightly increased, with the UAE still having 2 radiopharmacists/radiochemists, 12 medical physicists, 45 technologists, and 18 nuclear medicine physicians and nuclear radiologists.

The stability in the numbers of radiopharmacists/radiochemists, medical physicists, technologists, and nuclear medicine physicians signifies a balanced workforce capable of meeting the demands of nuclear medicine services. This steadfastness ensures a solid foundation for the delivery of high-quality patient care, contributing to the advancement and reliability of nuclear medicine practices in the UAE.

YEMEN

Facilities and Equipment:

In Yemen, there has been no progress in the availability of nuclear medicine and imaging technologies from 2016 to 2023. In 2016, Yemen had 4 nuclear medicine centers and 5 gamma cameras, with a very low ratio of 0.2 gamma cameras per million people, and no SPECT/CTs, PET/CTs, or cyclotron facilities were available. Unfortunately, in 2023, the situation has not improved, and the lack of access to advanced diagnostic and treatment tools persists. Yemen continues to struggle with a civil war that has resulted in a humanitarian crisis, leaving the country with limited resources to invest in healthcare infrastructure.

The ongoing conflict in Yemen has resulted in a severe shortage of medical equipment, supplies, and trained healthcare professionals, further exacerbating the healthcare system's struggles. The lack of nuclear medicine and imaging technologies is a significant problem for patients in need of diagnosis and treatment for conditions such as cancer, heart disease, and other illnesses. The lack of PET/CTs and SPECT/CTs, in particular, limits the ability of physicians to accurately diagnose and treat these diseases. Without these technologies, patients may need to travel to other countries to receive treatment, which can be prohibitively expensive and often impossible due to ongoing conflicts and political instability in the region.

In conclusion, the lack of progress in Yemen's nuclear medicine and imaging technology availability highlights the ongoing healthcare crisis in the country. The ongoing conflict and limited resources have prevented the country from investing in healthcare infrastructure, leaving patients with limited access to advanced diagnostic and treatment tools. As the conflict persists, it is essential to address the urgent needs of the healthcare system in Yemen to provide patients with the necessary care and support.

Human resources:

Due to the ongoing conflict in Yemen, it has been challenging to develop and maintain healthcare infrastructure, including nuclear medicine. As of 2016, Yemen had 2 radiopharmacists/radiochemists, 3 medical physicists dedicated to nuclear medicine, 6 technologists, and 6 nuclear medicine physicians. As of 2023, the number of radiopharmacists increased to 5, however, unfortunately this has been without significant changes in the number of medical physicists and technologists. Additionally, the number of nuclear medicine physicians decreased from 6 to 2. However, there are 4 radiologists supporting the nuclear medicine community.

The conflict has led to a shortage of equipment, supplies, and staff, and many medical professionals have left the country. This lack of resources and personnel can result in a delay in the diagnosis and treatment of diseases that could benefit from nuclear medicine procedures, such as cancer and heart disease. Additionally, the conflict has disrupted the distribution and supply of radiopharmaceuticals, which are essential for performing nuclear medicine procedures, leading to further challenges in patient care. Until there is stability in the country and significant investment in healthcare infrastructure, it is unlikely that Yemen's nuclear medicine capabilities will improve.

Conclusion

Overall, there is a need for continued efforts to increase access to nuclear medicine resources and to promote collaboration and information sharing among countries in the ARASIA State Parties. This is a focus of ARASIA technical cooperation with the IAEA. Through joint regional projects with the IAEA and collaborative initiatives, ARASIA is actively working to improve the quality of nuclear medicine and radiation therapy services in the region, and to address the disparities in access to these technologies between ARASIA states parties. The IAEA supports the development and safe use of nuclear technologies in healthcare, via transfer of technical knowledge and expertise, contributing to the overall improvement of healthcare services and outcomes for people in the ARASIA state parties.

What the IAEA initiative Rays of Hope brings to the table is viable, concrete, practical options. Countries do not need other plans and speeches. What they need is radiotherapy units, trained personnel, concrete solutions," Mr Rafael Mariano Grossi, IAEA Director General.

"We must all work together to tackle a growing cancer burden around the world, especially in developing countries with little or no access to essential medical services required for this disease. Under its Rays of Hope initiative, the IAEA is intensifying its activities to bring cancer care to those that need it the most. Joining forces with key stakeholders in both the public and private sectors will help leverage our efforts and save countless lives."

Rafael Mariano Grossi, Director General of the International Atomic Energy Agency

Glossary

131-I MIBG (meta-iodobenzylguanidine): is a radiopharmaceutical used in nuclear medicine for diagnostic and therapeutic purposes. It consists of a molecule called MIBG labeled with radioactive iodine-131 (131-I).

18 F – FDG Fluorodeoxyglucosea: is a radiopharmaceutical, specifically a radiotracer, used in the medical imaging modality positron emission tomography.

225Ac- actinium -225: a radioactive isotope of the chemical element actinium.

68Ga DOTATIC: Gallium DOTATOC is a radiopharmaceutical used in nuclear medicine for the imaging such as Neuroendocrine, Neuroblastoma..etc..

68Ga PSMA: Gallium-68 prostate-specific membrane antigen is a radiopharmaceutical used in nuclear medicine for the imaging of prostate cancer.

68Ga-FAPI: Gallium-68-labeled Fibroblast Activation Protein Inhibitor.

ACGME-I: Accreditation Council for Graduate Medical Education International.

Ammonia: Myocardial perfusion imaging using ammonia as a tracer to evaluate blood flow to the heart.

ARASIA: Co-Operative Agreement For Arab States In Asia For Research, Development And Training Related To Nuclear Science And Technology.

ARSNM: Arab Society of Nuclear Medicine.

AUBMC: American University of Beirut medical center.

BMT: Bone marrow transplants.

BSGC: Breast Specific Gamma Camera.

C-11 methionine: A PET scan using a carbon-11-labeled methionine tracer for imaging brain tumors.

CAP: college of American pathologists.

CCPC: Joint commission international clinical Care program.

CRPs: Coordinated Research Projects.

EANM: European Association of Nuclear Medicine.

F-choline: PET/CT scan using a fluorine-labeled choline tracer for imaging prostate cancer.

F-DOPA: Fluorodihydroxyphenylalanine (F-DOPA) PET scan for imaging neuroendocrine tumors and certain brain conditions such as Parkinson disease and brain tumors.

Florbetaben: A PET scan using a florbetaben tracer for imaging beta-amyloid plaques in the brain, which is helpful in the diagnosis of Alzheimer's disease.

FLT: Fluorothymidine (FLT) PET imaging for assessing cell proliferation in tumors.

Ga-JR-11: Gastrin-releasing peptide receptor (GRPR) imaging using a gallium-labeled JR-11 tracer for neuroendocrine tumors.

GRPR- Gastrin Releasing peptide receptor.

IAEA: International Atomic Energy Agency.

Iodine-131: Radioactive isotope of iodine.

JAEC: Jordan Atomic Energy Commission.

JCIA: Joint Commission International Accreditation.

JOSNM: Jordanian Society of Nuclear Medicine.

JRTR: The Jordan research and training reactor.

KCCC: Kuwait Cancer Control Center.

KHCC: King Hussein Cancer Center.

LU-177- lutetium -177.

MAGNET: certificate of excellence from the American nurses credentialing cente

MOH: Ministry Of Health.

Na-F: Sodium fluoride (Na-F) PET/CT scan for evaluating bone metabolism and detecting bone metastases.

Neuroendocrine tumors: A group of rare tumors that originate from neuroendocrine cells.

NM: Nuclear Medicine.

PEM: Positron Emitting Mammography.

Pentixafor: This is a PET/CT scan using a CXCR4 receptor-targeted tracer for imaging certain types of cancers.

PET: Positron Emission Tomography.

PET-CT: Positron Emission Tomography with Computed Tomography.

PRLT: PSMA radioligand therapy.

PRRT: Peptide receptor radionuclide therapy.

QUAADRIL: Quality Assurance Audit for Diagnostic Radiology Improvement and Learning.

QUANUM: Quality Management Audits in Nuclear Medicine.

Radiopharmaceuticals: Group of Pharmaceutical Drugs Containing Radioactive Isotopes.

RRC: Regional Resource Cancer.

RTCs: Regional training courses.

Samarium/Strontium: A therapy by samarium-153 or strontium-89 for palliative treatment of bone metastases.

SNMMI: Society of Nuclear medicine and Molecular imaging

SPECT: Single Photon Emission Computed Tomography.

SPECT-CT: Single Photon Emission Computed Tomography with Computed Tomography.

SSDL: Secondary Standards Dosimetry Laboratory.

Tb-161: Terbium-161 - a radioactive isotope of the chemical element terbium.

Theranostic: Combination of Two Words, Therapeutic (Thera) And Diagnostic (Nostic).

Therasphere (Yttrium-90): A targeted radiotherapy treatment using radioactive microspheres for the treatment of liver cancer/ metastases.

TRT: Targeted radionuclide therapy.

UAE: United Arab Emirates.