Summary of the IAEA Technical Meeting on Radiation Protection Challenges in Modern Nuclear Medicine

28–30 April 2025, Vienna

The IAEA Technical meeting was held in a hybrid format from 28 to 30 April 2025 in Vienna. 62 participants from a wide spectrum of health disciplines and professions involved in the medical use of ionizing radiation, as well as the medical industry, regulatory bodies, educational and research institutions, and experts, representing 35 IAEA Member States as well as 8 international organizations, professional bodies, and safety alliances, participated at the meeting.

The meeting agenda and the list of countries and organizations represented at the meeting are provided in Annexes 1 and 2, respectively.

Meeting objectives and expected output

Objectives:

- To discuss the status of modern practices in diagnostic and therapeutic nuclear medicine.
- To identify challenges in the radiation protection of patients in modern diagnostic and therapeutic nuclear medicine, and to provide recommendations for synchronizing the actions of different stakeholders in upgrading the existing guidance and radiation protection practices

Expected output:

- Conclusions offering advice on specific actions and recommendations, notably the development of new IAEA safety report and relevant education and training materials on radiation protection of patients in modern nuclear medicine.

The following report summarizes the findings and conclusions from the meeting.

Findings of the meeting

The rapid development of new radiopharmaceuticals for diagnosis and treatment has led to an increase in the number and variety of imaging procedures and radionuclide treatments targeting new molecular targets.

In addition, on a global scale, conventional PET/CT and SPECT/CT continue to expand in availability and utilization, driven by increasing clinical demand. This is reflected, for example, in the significant rise in the number of procedures involving auxiliary CT in PET/CT and SPECT/CT.

In parallel, emerging technologies, such as digital PET/CT, long axial field-of-view (LAFoV) PET/CT, and digital SPECT/CT, are about to enter the clinical arena. Furthermore, artificial intelligence (AI) is being increasingly applied in nuclear medicine, offering promising opportunities to optimize imaging procedures and improve the accuracy and speed of dosimetry calculations, thereby enhancing radiation protection.

However, due to the dynamic nature of these developments, guidelines for specific management are often lacking. Combined with staff shortages and limited training opportunities in many member states, this poses a challenge to radiation protection in the near future. The situation is further complicated by the limited availability of new equipment and new types of radiopharmaceuticals in many member states.

Main challenges

The following (major) radiation protection challenges were identified during the technical meeting:

- Regulations, Recommendations and Guidelines
  - Many existing regulations do not include the latest types of radionuclides/ radiopharmaceuticals or the latest development of imaging equipment.
  - There is no standardized procedure across countries for discharging patients after radionuclide therapies. Current discharge criteria often rely on exposure model calculation that involve several assumptions; however, many parameters define the potential exposure of the family members or public.
  - The methodology for assessing compliance with relevant recommendations, both locally and nationally, needs further development.

- Radiation Protection
  - Radiation protection in the nuclear medicine department is often not being performed optimally.
  - There are challenges in optimizing (modulating) the protocols of radionuclide therapies.
  - The optimization of CT doses and corresponding diagnostic reference levels (DRLs) in SPECT and PET requires more attention.
  - Patient Dosimetry
    - The dose estimation in pediatric patients in nuclear medicine diagnostics needs more attention.
    - Efforts to harmonize SPECT/CT image quantification related to patient dosimetry are underway and require further support.
    - The practice of patient dosimetry is still not implemented routinely in clinical practice, which is not in line with international requirements. Individualized patient dosimetry for radionuclide therapies remains challenging, especially for alpha emitters because of their complex decay schemes and low administered activity. For many radionuclide therapies, the relationship between absorbed dose and the corresponding biological effect is unclear which impose further challenges in radiation protection.
    - Both commercial and non-commercial AI tools can help to overcome some of the challenges and may promote the adoption of patient dosimetry in clinical practice. However, AI is, with some exceptions such as organ segmentation, not yet mature enough for routine clinical applications. Both big data and transparent AI model would be helpful to improve the accuracy and trustworthiness of AI-based methodology.

- Staff and Training
  - There is a shortage of qualified nuclear medicine professionals in many member states.
  - There is a need to develop and upgrade education and training materials related to radiation protection in new nuclear medicine modalities and practises.
  - Large language models and AI-based consultation are increasingly being used—explicitly or implicitly—in training. Therefore, enhancing the regularization and professional standards of AI-driven consultation is essential for its precise and trustworthy application in radiation protection of patients.

Meeting conclusions and recommendations

This meeting was an excellent opportunity for sharing information between the experts, representatives of the international organizations, invited speakers, and participants from Member States and the IAEA on the status and challenges of radiation protection of patients in modern diagnostic and therapeutic nuclear medicine. It also served to assess the need for the development of additional guidance and tools.

The emerging trends outlined above present new challenges in the radiation protection of patients in modern nuclear medicine. At the same time, they highlight the persistence of long-lasting challenges, such as the continuing need to develop or revise existing guidance. Emphasis was placed on the importance of collaborative efforts among multiple stakeholders to provide appropriate guidance for radiation protection.

Based on the discussions held during the meeting, the following conclusions and recommendations were reached.

It was noted during the meeting that a wide range of interest groups are involved in addressing these issues, including international organizations (such as IAEA, ICRP, etc.), international and national associations and regulatory authorities (represented in Europe by HERCA, for example), scientific societies (e.g., EANM, SNMMI, AAPM, EFOMP, etc.), as well as commercial stakeholders such as equipment manufacturers and suppliers of pharmaceuticals and radionuclides.

Diagnostic Nuclear Medicine:

- Conducting a survey of daily practices of patient management and radiation protection in diagnostic NM across member states is needed to improve personalisation in diagnosis.
- For pediatric NM, a revision of the existing guidelines is necessary and requires immediate attention with adequate allocation of resources.
- The development of AI-based low-dose protocols for PET and SPECT is another step towards optimisation.
- For DRLs of the CT part of hybrid systems, no or only sparse information is available in the member states. Monitoring the current status in the member states will provide valuable information for optimisation.
- Updating existing IAEA reports and materials is needed, in particular with respect to new radiopharmaceuticals used in clinical trials and practice.

Therapeutic Nuclear Medicine:

- Conducting a survey of daily practices of patient management and radiation protection in therapeutic NM across member states is needed to improve personalization of treatments, particularly regarding new radiopharmaceuticals.
- The development of open-source datasets from activity quantification and dosimetry in therapeutic NM would help to verify the accuracy of the available commercial dosimetry software solutions.
- The development of reliable, simplified dosimetry protocols for absorbed dose verification in the region of interest would be of value to address the lack of available technical resources in many member states.
- The development of harmonized risk assessment tools for the public after patient administration or discharge is needed.
- The criteria for patient release in relation to new radiopharmaceuticals need to be updated to help member states harmonise practice and to align it with relevant authorities' requirements.
- Updating existing IAEA reports and materials is needed, in particular with respect to new radiopharmaceuticals used in clinical trials and practice.

ANNEX 1. Meeting agenda

MONDAY, 28 April 2025

8:30 – 9:45	Registration at the UN Pass Office [VIC GATE 1]	
10:00 – 10:30	**Session 1: Opening session** ***Objective:*** *Introductions, welcome, and logistics* Opening address Expectations from the meeting and scope Overview of the TM topics	H. Vandenhove, Director/NSRW M. Pinak/NSRW/RSM O. Holmberg/NSRW/RPOP C. Rizk, Co-Scientific Secretary V. Gershan, Co-Scientific Secretary
10:30 – 12:30	**Session 2: Setting the scene** ***Objective:*** *Identifying the background information about challenges in Modern Nuclear Medicine*	Meeting Chair: Michael Lassmann Rapporteur: Rui Qiu
10:30 – 11:00	Overview of the Radiation Protection Challenges in Modern Nuclear Medicine, by the Meeting Chair	Michael Lassmann
11:00 – 11:10	WHO's role in medical radiation protection	Ferid Shannoun (WHO online)
11:10 – 11:30	*Break*	
11:30 – 12:50 (10 min +2 min discussion)	1. Overview of NM imaging practices in Europe 2. Overview of NM therapy practices in Europe 3. Overview of modern NM practices in USA 4. The hot problems in NM 5. Clinical trials in Imaging, therapy and theranostics 6. Status on the regulatory requirements	1. Michael Lassmann 2. Jens Kurth 3. Homer Macapinlac 4. Kuangyu Shi 5. Desire Deandreis 6. Ritva Bly
12:50 – 13:00	Discussion	All
13:00 – 14:00	*Lunch break*	
14:00 – 15:30	**Session 3: Presentation by Organizations** **Objective***: To include newer guidelines in NM developed or issues on radiation protection identified in technologies and procedures added in last five years*	Session chair: Ritva Bly Session rapporteur: Jens Kurth
15 minutes each organization followed by 2–3 mins for discussion.	ICRP recent activities related to NM ESR recent activities related to NM HERCA recent activities related to NM EFRS recent activities related to NM Occupational radiation protection in the event of the death of a nuclear medicine patient (ASNR) WFNMB recent activities related to NM	Augusto Giussani (ICRP) Clemens Cyran (ESR) Dariusz Kluszczyński (HERCA) Ana Geão (EFRS) Célian MICHEL (ASNR) Lizette Louw, (WFNMB- online)
15:30 – 15:50	*Coffee break*	
15:50 – 17:35	**Session 4: Presentations by the IAEA sections and participating member states**	Session chair: Vesna Gershan Session rapporteur: Chadia Rizk
8 min each	IAEA/RSM/RPOP recent activities related to NM Recent activities by the NMDI section of the IAEA to promote the culture of radiation safety in NM. IAEA/NAHU/DMRP recent activities related to NM IAEA/NAPC -RCRT activities supporting Member States in Radiopharmaceuticals	Chadia Rizk, NSRW/RSM Anita Brink, NAHU Peter Knoll, NAHU Aruna Korde, IAEA/NAPC
4 min each (ppt template prepared)	Algeria, Brazil, Bulgaria, Chile, Estonia, Greece, Iraq, Kazakhstan, Lithuania, Malaysia, Malta, Morocco, Pakistan, Russian Federation, Tunisia, Uzbekistan	

TUESDAY, 29 April 2025

09:00 – 10:30	**Session 5: New technologies and procedures in diagnostic NM**	Session chair: Desire Deandreis Session rapporteur: Kuangyu Shi
09:00 – 09:30	New technologies and procedures in diagnostic Nuclear Medicine	Jens Kurth
09:30 – 10:00	Which type of examinations, when, and why?	Homer Macapinlac
10:00 – 10:30	Discussion	
10:30 – 11:00	*Coffee break*	
11:00 – 12:30	**Session 6: Reducing the patient radiation doses in diagnostic NM**	Session chair: Jens Kurth Session rapporteur Desire Deandreis
11:00 – 11:30	Low-dose PET imaging with AI	Kuangyu Shi
11:30 – 12:00	Optimization of protocols and DRLs for CT used attenuation correction.	Michael Lassmann
12:00 – 12:30	Discussion	All
12:30 – 13:30	*Lunch break*	
13:30 – 15:30	**Session 7: Radiation Protection Issues New technologies and procedures in therapeutic NM**	Session chair: Homer Macapinlac Session rapporteur: Jens Kurth
13:30 – 14:00	Efforts to harmonize SPECT quantification	Michael Lassmann
14:00 – 14:30	Opportunities and challenges of activity quantification and dose calculation methods for therapeutic nuclear medicine	Rui Qiu
14:30 – 15:00	Challenges in optimizing the treatment protocols	Desire Deandreis
15:00 – 15:30	*Coffee break*	
15:30 – 17:00	**Session 8: Assessment of patient radiation doses and risks in therapeutic NM**	Session chair: Rui Qiu Session rapporteur: Michael Lassmann
15:30 – 16:00	Patient-friendly dosimetry for radiopharmaceutical therapy using AI	Kuangyu Shi
16:00 – 16:30	Criteria for release of patients	Jens Kurth
16:30 – 17:00	Discussion	All

WEDNESDAY, 30 April 2025

9:00 – 10:30	**Session 9: Pathways for optimizing radiation protection in nuclear medicine**	Session chair: Jens Kurth Session rapporteur: Homer Macapinlac
9:00 – 9:30	Existing practices and beyond	Michael Lassmann
9:30 – 10:00	New AI technologies, opportunities and challenges of LLM in radiation protection practices and patient counselling in nuclear medicine	Kuangyu Shi
10:00 – 10:30	Discussion	
10:30 – 11:00	*Coffee Break*	
11:00 – 12:30	**Session 10: Closing session** ***Objective:*** *Meeting report, summary, closing*	Session chair: Ola Holmberg
11:00 – 11:45	Identified challenges	Session rapporteurs (~ 9 x 5 min each)
11:45 – 11:55	Trends observation	Jens Kurth
11:55 – 12:25	Meeting summary and conclusion	Michael Lassmann
12:25 – 12:30	Meeting closing	Ola Holmberg

ANNEX 2. List of speakers, IAEA Member States and international organizations represented in the meeting.

A) Invited speakers:
- Dr Ritva Bly, STUK, Finland
- Dr Desire Deandreis, Gustave Roussy, CANCER Campus GRAND PARIS, France
- Dr Jens Kurth, University of Medicine Rostock, Germany
- Dr Michael Lassmann, University Hospital Würzburg, Germany
- Dr Homer Macapinlac, MD Anderson Cancer Center, Houston, USA
- Dr Rui Qiu, Tsinghua University, Beijing, China
- Dr Kuangyu Shi, University Hospital Bern, Switzerland

B) Participating Member States:
Algeria; Armenia; Belarus; Brazil; Bulgaria; Chile; China; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Iraq; Jordan; Kazakhstan; Kenya; Lithuania; Malaysia; Malta; Morocco; Namibia; Norway; Pakistan; Poland; Romania; Russian Federation; Slovakia; Slovenia; Switzerland; Tunisia; Uruguay; USA; Uzbekistan

C) International organizations:
- European Federation of Radiographer Societies (EFRS)
- European Society of Radiology (ESR)
- Heads of the European Radiological protection Competent Authorities (HERCA)
- International Commission on Radiological Protection (ICRP)
- Nuclear Safety and Radiation Protection Authority (ASNR)
- World Federation of Nuclear Medicine and Biology (WFNMB)
- World Health Organization (WHO)

D) International Atomic Energy Agency (IAEA)
- IAEA – Division of Human Health – Nuclear medicine and diagnostic imaging section
- IAEA – Division of human health – Dosimetry and medical radiation physics section
- IAEA – Division of physical and chemical sciences – Radiochemistry and radiation technology section