

Questionnaire on the Evaluation of Tailored Training and Experience Requirements for Different Categories of Radiopharmaceuticals

1. What is the fundamental knowledge that is necessary for a physician to administer any radiopharmaceutical under Title 10 of the *Code of Federal Regulations* (10 CFR) 35.390?

Below is a draft list that the U.S. Nuclear Regulatory Commission (NRC) staff has developed. Please add/delete topics from this list.

- a. Radiation physics
 - i. Structure and properties of atoms
 - ii. Radiation and radioactivity
 - Characteristics of radioactivity
 - Radioactive decay (simple and complex), half-lives, energies
 - Calculation of radioactive decay and activity remaining
 - Primary radionuclides and contaminants
 - iii. Interaction of radiation with matter (direct and indirect)
 - Radiological properties of low energy photons, beta emissions, alpha emissions, and mixed emissions
 - iv. Radionuclide production
 - v. Units of radiation and radioactivity
- b. Instrumentation
 - i. Operation and use of instrumentation (e.g., gas-filled detectors [ion chambers, survey meters, and dose calibrators], sodium iodide detectors [well counters]) and advantages and disadvantages for measuring and detecting different radionuclides and mixed radionuclides.
 - ii. Dosage and dose measurements
 - iii. Instrumentation to monitor and measure unit dosage without modification or adjustment, unit dosage with adjustment, unit dosage with modification, multi-dosage, kit preparation, generator elution
 - iv. Frequency of calibration
 - v. Operation and use of personnel monitoring devices
 - vi. Routine quality assurance parameters (including calculations) for detection and measurement of radioactivity
- c. Radiation protection for protection of workers, family members, public, and patient as it relates to the regulations in 10 CFR Parts 19, 20, and 35
 - i. Radiation protection associated with dose measurements and handling (unit dosage with modification, multi-dosage, kit preparation, generator elution)
 - ii. Performing calculations necessary to comply with regulations (e.g., patient release, medical events)
 - iii. Maintaining doses as low as reasonably achievable (ALARA), including external and internal exposures
 - iv. Basic shielding (e.g., syringe shields, aprons)
 - v. Protective clothing/devices to include the lens of the eye
 - vi. Surveys and monitoring

- vii. Dosimeters
 - viii. Minimizing and clean-up of contamination and spills (e.g., when handling unit dosage without modification or adjustment, unit dosage with adjustment, unit dosage with modification, multi-dosage, kit preparation, generator elution)
 - ix. Ordering, receiving, and unpacking radiopharmaceutical
 - x. General understanding of radiation safety officer (RSO) responsibilities including their authority to stop work
 - xi. Understanding public and occupational dose limits
 - xii. Waste control and radioactive storage
 - xiii. Radiation protection for patient to prevent unwanted exposure
 - Patient identity verification
 - Appropriate use of a written directive
 - Written directives verification
 - Properly performing radiopharmaceutical therapy delivery equipment
 - Minimizing and clean-up of contamination and spills
 - xiv. Signage
 - xv. Appropriate occupational dose guidance for the pregnant worker
 - xvi. Application of guidance for the nursing mother receiving radiopharmaceuticals
- d. Mathematics pertaining to the use and measurement of radioactivity
- i. Decay equations (simple and complex)
 - ii. Half value layers
 - iii. Exposure calculations (internal and external)
 - iv. Calculations associated with instrumentation
 - v. Radiation dose (including external and internal dosimetry)
 - vi. Converting activity to dose
 - vii. Organ/tissue uptake to dose
 - viii. Calculations necessary to comply with regulations (e.g., patient release, medical events, etc.)
 - ix. Unit dosage with adjustment, unit dosage with modification, multi-dosage, kit preparation, generator elution
- e. General patient release determination
- i. Transportation and release location
 - ii. Patient specific parameters, such as living and working conditions
 - iii. Exposure to sensitive populations – pregnant women and children
 - iv. Radiation effects due to low energy photons, beta emissions, alpha emissions
 - v. Combined radiation effects from mixed emissions and mixed half-lives and decay chains
 - vi. Pharmacological effects of specific drugs and resulting radiation doses, route of administration, and route of elimination
 - vii. Pharmacological effects on normal adults, pregnant women, fetuses, nursing infants, nursing women, and compromised patients and resulting radiation doses, differing routes of administration, and routes of elimination

- f. Chemistry of byproduct material for medical use
 - i. Original and final chemical form
 - ii. Generators
 - iii. Kit preparation
 - iv. Interaction with environment, spills, release to environment
- g. Radiation biology
 - i. Chemical and physical effects of ionizing radiation of alpha emissions, beta emissions, and low energy photons on biological systems (molecular and cellular damage)
 - ii. Chemical and physical effects of ionizing radiation from mixed emissions and mixed half-lives and decay chains on biological systems
 - iii. Comparison of relative risks of low level radiation with other health risks
 - iv. Biological effects of high dose radiation (acute, late, fatal)
 - v. Biological effects of low dose radiation (acute, late)
 - vi. Therapeutic use of radionuclides including mechanisms of action of particulate radiation
 - vii. Pharmacological effects of specific drugs and resulting radiation doses, route of administration and route of elimination
 - viii. Pharmacological effects on normal adults, pregnant women, fetuses, nursing infants, nursing women, and compromised patients and resulting radiation doses, differing routes of administration, and routes of elimination
 - ix. 4Rs – repair, redistribution, repopulation, and reoxygenation
- h. Medical events
 - i. Definition of a medical event (including patient intervention)
 - ii. Determination of a medical event occurrence
 - iii. Evaluation of the medical consequences of a medical event
 - iv. Root cause analysis and determination of appropriate corrective actions
 - v. Controls and programs to prevent medical events
- i. NRC requirements
 - i. General understanding of 10 CFR Parts 19, 20, and 35
 - ii. Dose limits in 10 CFR Parts 20 and 35
 - iii. Reporting requirements who, when, and where to report – in 10 CFR Parts 20 and 35
 - iv. Training requirements
 - v. Recordkeeping requirements
 - vi. Licensee procedures including (written directive procedures and safety procedures for each use)
 - vii. Need for amendments
 - viii. Need for notifications
 - ix. Need for change or transfer of control
 - x. Need for license termination and decommissioning
 - xi. Guidance for appropriate 10 CFR 35.1000 uses
 - xii. Appropriate waste and transportation requirements
 - xiii. Security and control of license material, and access control

2. What additional knowledge is necessary for a physician to administer specific types of radiopharmaceuticals under 10 CFR 35.390? Below is a draft list that NRC staff has developed. Please add/delete topics from this list.
- a. Indication of use and normal/abnormal response to the treatment
 - b. Knowledge of clinical dose and risks of prescribing a different dose
 - c. Use of dose blockers, if necessary
 - d. Route of administration
 - i. Ability to determine administration under special patient conditions such as gastrostomy, tracheostomy, renal failure, dialysis, liver failure, incontinence, unable to swallow, ostomies, body tubes/catheters, etc.
 - ii. How to perform administration
 - iii. Patient risks associated with route of administration
 - iv. Radiation protection for workers associated with route of administration
 - e. Specific risks associated with toxicity of the radiopharmaceutical (i.e., minor differences between prescribed and administered activity can result in different consequences for patient)
 - f. Specific risks associated with the type of radiation emitted (alpha, beta, gamma, low energy photon)
 - g. Specific risks associated with the delivery method of the drug to the target (if the radionuclide needs to be tagged to a chemical component, what happens if it isn't tagged or tagged incorrectly)
 - h. Medical event specific to a radiopharmaceutical
 - i. Prevention (QA/QC on any necessary equipment used to ensure appropriate dose/dosage is delivered)
 - ii. Evaluation
 - iii. Reporting
 - iv. Medical intervention or response if a medical event occurs
 - i. Post verification (to determine dosage and if medical event occurred)
 - i. Appropriate modality (e.g. imaging)
 - ii. Understanding artifacts
 - j. Patient release instructions specific to a radiopharmaceutical
 - i. When to provide discussion and instructions
 - ii. Transportation, and release location
 - iii. Patient specific parameters, such as living and working conditions
 - iv. Exposure to sensitive populations – pregnant women, nursing mother and child, and children

- v. Radiation effects due to low energy photons, beta emissions, alpha emissions
 - vi. Combined radiation effects from mixed emissions and mixed half-lives and decay chains
 - vii. Pharmacological effects of specific drugs and resulting radiation doses, route of administration, and route of elimination
 - viii. Pharmacological effects on normal adults, pregnant women, fetuses, nursing infants, nursing women, and compromised patients and resulting radiation doses, differing routes of administration, and routes of elimination
- k. Radiation protection specific to radiopharmaceutical
- i. Unique or additional handling concerns
 - ii. Unique ordering, receiving, and unpacking concerns
 - iii. Calculation, measurement, and preparation of radiopharmaceutical dose
 - iv. Disposal of radiopharmaceutical
 - v. Shielding specific to a radiopharmaceutical
 - vi. Use of procedures to contain spilled radioactive material and use of proper decontamination procedures
 - vii. Dosimetry
 - viii. Volatility
 - ix. Circumstances which require a call to the RSO and/or the regulator
 - x. What to do in the event of medical emergency or if the patient dies or cremation is planned
 - xi. Unique protective clothing or shielding
 - xii. Remote handling devices, if any
3. How should the physician acquire the knowledge topics listed above? Classroom/laboratory training and supervised work experience (including clinical experience)? Please provide an estimate for the number of hours or clinical experience needed for the knowledge topics listed above.
4. How should a physician's knowledge in the topics listed above and ability to function independently be evaluated?
- a. Exam?
 - b. Both a written exam and practical exam?
 - c. Attestation by a qualified authorized user?
 - d. How would you structure a competency model to demonstrate knowledge of the fundamental knowledge areas?
 - e. Who should administer the written exam and/or practical exam or oversee the competency model – the regulator, medical specialty board, or professional societies?