



Components of Preparedness

Domain I: Radiation Physics & Detection – 7%

Domain II: Radiation Safety & Regulations – 13%

Domain III: Pharmaceutical & Radiopharmaceutical Agents – 25%

Domain IV: Instrument Operations & Quality Control – 15%

Domain V: Clinical Procedures – 40%

The **NMTCB Components of Preparedness** provide a description of the concepts, tasks, knowledge, and skills an individual needs to successfully understand and perform the necessary duties for an entry-level nuclear medicine technologist. Components of preparedness statements are published by NMTCB to assist students, program directors, and item writers. Each task is keyed to the 2017 Job Task Analysis Survey published by the NMTCB, which is the basis for the NMTCB nuclear medicine exam.

The **NMTCB Components of Preparedness** document was updated by NMT subject matter experts through a rigorous job practice analysis study and validated by NMT professionals working in the field through an extensive survey instrument. The entry level NMT tasks and the knowledge needed to perform such tasks are extensively researched and grouped into the following functional content areas:

Domain I: Radiation Physics and Detection

A Physical properties

- 1 Radioactive materials
 - a. Modes of decay
 - i. Gamma emitters
 - ii. Beta emitters
 - iii. Alpha emitters
 - iv. Positron emitters
 - 2 X-ray production
 - a. Bremsstrahlung
 - b. Characteristic x-ray

B Measurement of radioactivity and decay calculations

C Interactions of radiation with matter

D Radiation detector types and basic principles

E Counting statistics

Domain II: Radiation Safety and Regulations

- A Biological effects of radiation exposure**
- B Protection techniques and calculations**
 - 1 Time
 - 2 Distance (inverse square law)
 - 3 Shielding (shielding equations)
- C Monitoring protocols and requirements (e.g., timing and frequency)**
 - 1 Radiation surveys (area monitoring) including:
 - a. Survey meters and well counters
 - b. Choice of radiation detection devices (e.g., Geiger Counters, sodium iodide detectors)
 - c. Frequency and limits of wipe surveys
 - 2 Personal monitoring devices
 - 3 Personal protective equipment (e.g., lab coat, gloves, syringe shields)
 - 4 Effective dose equivalent limits for:
 - a. Radiation workers
 - b. Pregnant radiation workers
 - c. General public
- D Practice and adhere to ALARA**
- E Nuclear Regulatory Commission (NRC)**
 - 1 Posting warning and informational signs delineating restricted and unrestricted areas
 - 2 Surveying, inspecting and inventorying radioactive materials
 - 3 Responding to adverse events
 - a. Trigger levels and monitoring methods
 - b. Radiation exposure
 - c. Radiation spills
 - d. Protection during adverse events
 - e. Personnel, patient and/or public decontamination
 - f. Area/equipment decontamination
 - 4 Adhere to radioactive waste storage requirements
 - 5 Dispose of radioactive materials (e.g., liquids, solids, gasses, contaminated materials)
 - 6 Identify recordable and reportable events
 - 7 Maintain records as required for:
 - a. Receipt, storage and disposal of radioactive materials
 - b. Radiation monitoring and reporting
 - c. Equipment calibration and maintenance
 - d. Staff, patient, occupational and public exposure
 - e. Nuclear medicine diagnostic and therapeutic procedures
- F Department of Transportation (DOT) - radiopharmaceutical transport**
 - 1 Use of shielding containers
 - 2 Labeling requirements (e.g., transportation index, name, concentration, expiration date/time, total activity, assay date/time)

- 3 Package monitoring/receiving/returning
- G Environmental Protection Agency (EPA)**
- H Occupational Safety and Health Administration (OSHA)**
- I Health and Human Services (HHS)/Health Insurance Portability and Accountability Act (HIPAA)**
 - 1 Protecting patient rights and privacy
 - 2 Maintaining patient records
 - 3 Releasing information to authorized parties
- J Knowledge of institutional and departmental accreditation organizations**

Domain III: Pharmaceutical and Radiopharmaceutical Agents

- A Elute radionuclide generator, perform and evaluate quality control tests**
 - 1 Types of generators (e.g., $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$, $^{82}\text{Sr}/\text{Rb}82$, etc.,)
 - a. Elution
 - b. Generator yield – volume and activity
 - c. Quality control procedures
 - i. $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ (^{99}Mo breakthrough and Al +3 content)
 - ii. $^{82}\text{Sr}/^{82}\text{Rb}$ (measured activity and levels of ^{82}Sr & ^{85}Sr)
 - 2 Dose calibrator operation / units of radioactivity
- B Prepare radiopharmaceutical kits , perform quality control, and evaluate results**
 - 1 Radiopharmaceutical kits
 - a. Preparation techniques including particle size and number
 - b. Activity and volume limitations
 - c. Activity calculations
 - 2 Radiopharmaceutical quality control
 - a. Visual inspection - color and clarity
 - b. Radiochemical purity
 - 3 Labeling kits
 - 4 Storage of kits before and after reconstitution
- C Understand the characteristics (i.e., mechanism of localization), indications, contraindications and administration of diagnostic radiopharmaceuticals**
 - 1 Tc99m labeled radiopharmaceuticals
 - a. Tc99m sodium pertechnetate
 - b. Tc99m oxidronate/HDP
 - c. Tc99m medronate/MDP
 - d. Tc99m pentetate/DTPA
 - e. Tc99m macroaggregated albumin/MAA
 - f. Tc99m sulfur colloid
 - g. Tc99m disofenin/mebrofenin (Choletec®)
 - h. Tc99m mertiatide/MAG3
 - i. Tc99m pyrophosphate/PYP
 - j. Tc99m sestamibi/MIBI (Cardiolite®)

- k. Tc99m tetrofosmin (Myoview®)
 - l. Tc99m succimer/DMSA
 - m. Tc99m exametazime/HMPAO (Ceretek®)
 - n. Tc99m bicisate/ECD (Neurolite®)
 - o. Tc99m labeled RBCs
 - p. Tc99m HMPAO tagged WBCs
 - q. Tc99m tilmanocept (Lymphoseek®)
- 2 Iodine labeled radiopharmaceuticals
- a. I-123 sodium iodide
 - b. I-131 sodium iodide
 - c. I-123 MIBG
 - d. I-131 MIBG
 - e. I-123 loflupane (DaTscan®)
- 3 Indium labeled radiopharmaceuticals
- a. In-111 Pentetate (DTPA)
 - b. In-111 chloride
 - c. In-111 oxine labeled WBCs
 - d. In-111 pentetretotide (Octreoscan®)
- 4 Miscellaneous diagnostic radiopharmaceuticals
- a. Tl201 thallos chloride
 - b. Ga67 gallium citrate
 - c. Xe133 gas
- 5 Positron Emission Tomography
- a. F-18 FDG
 - b. F-18 Florbetaben (Neuraceq®)
 - c. F-18 Florbetapir (Amyvid®)
 - d. F-18 Flutemetamol (Vizamyl®)
 - e. F-18 Sodium Fluoride (NaF)
 - f. Rb82 chloride
 - g. N13 ammonia
 - h. Ga-68 Dotatate
- D Understand the characteristics (i.e., mechanism of localization), indications, contraindications and administration of therapeutic radiopharmaceuticals**
- 1 Sr89 chloride (Metastron®)
 - 2 Sm153 EDTMP lexidronam (Quadramet®)
 - 3 I-131 sodium iodide
 - 4 Y90 ibritumomab tiuxetan (Zevalin®)
 - 5 Y90 microspheres (SIR-Spheres®, TheraSphere®)
 - 6 Ra223 Radium dichloride (Xofigo®)
 - 7 I-125 Seeds
- E Understand the indications, contraindications, and administration of interventional and adjunct pharmaceutical agents used in conjunction with nuclear medicine procedures**

- 1 dipyridamole (Persantine®)
- 2 adenosine
- 3 dobutamine
- 4 aminophylline
- 5 regadenoson (Lexiscan®)
- 6 captopril
- 7 enalaprilat
- 8 furosemide (Lasix®)
- 9 insulin
- 10 acetazolamide
- 11 cholecystokinin/sincalide/CCK
- 12 morphine
- 13 cimetidine/ranitidine/famotidine
- 14 ACD solution
- 15 heparin
- 16 contrast media (oral and IV)
- 17 Lugol's solution/SSKI
- 18 Thyroid Stimulating Hormone (TSH)
- 19 Lidocaine
- 20 Lidocaine (EMLA) cream
- 21 atropine
- 22 recombinant human TSH (Thyrogen®)

F Label blood components with radiopharmaceutical according to protocol

- 1 Labeling procedures
 - a. Required lab equipment and supplies
 - b. Anticoagulants and other additives
 - c. Chemical reactions
 - d. Cell washing
 - e. Required radiopharmaceuticals
 - f. Method: *invivo* or *invitro*
- 2 Calculation of labeling efficiency and administered dosage
- 3 Reinjection patient and sample verification

G Understand the routes of administration

- 1 Administration modes
- 2 Administration techniques (e.g., bolus, venipuncture, IV)

H Prepare and administer non-radioactive agents

- 1 Follow aseptic technique
- 2 Adverse side-effects and treatment
- 3 Antidote medications
- 4 Interventional pharmaceuticals
- 5 Non-radioactive agents (e.g., ACD solution, heparin, contrast media, TSH, atropine, etc.,)

Domain IV: Instrument Operations and Quality Control**A Non-imaging equipment, components and operation**

- 1 Perform and evaluate quality control on well counters and probes
 - a. Calibrate and perform quality control on the sodium iodide scintillation detector
 - b. Conduct a gamma ray spectra and pulse height analysis
 - c. Apply formulas (e.g., energy resolution, sensitivity, Chi-square statistics, etc.,)
- 2 Determine operational status of survey meter
 - a. Survey meter operations and components
 - b. Survey meter quality control
- 3 Perform and evaluate dose calibrator constancy, accuracy, linearity, and geometry tests

B Imaging equipment, components, and operation

- 1 Gamma Camera quality control
 - a. Uniformity
 - b. Spatial resolution and linearity
 - c. Visual image quality
 - d. Phantoms
 - e. Artifacts
 - f. Assess system sensitivity
 - g. Pulse height analysis
- 2 SPECT and SPECT/CT imaging system
 - a. Attenuation correction
 - b. SPECT camera quality control
 - i. Center of rotation
 - ii. Field uniformity requirements
 - iii. Pixel calibration
 - iv. 3-D uniformity and resolution (e.g., Jaczak phantom)
 - v. Artifacts
- 3 PET and PET/CT imaging systems
 - a. Application of attenuation corrections
 - b. PET quality control (e.g., daily blank scan, normalization scan, 2-D/3-D well counter, artifacts, etc.)
- 4 CT imaging systems
 - a. Co-registration of images
 - b. CT quality control (e.g., contrast and spatial resolution, noise, uniformity, artifacts, etc.,)
- 5 Computer equipment (e.g., monitors, matrix sizes, printers, etc.,)
- 6 Networking and information systems (i.e., PACS and RIS)

C Auxiliary equipment

- 1 Laboratory equipment (e.g., pipette, fume hoods)

- 2 Patient care equipment
 - a. Intravenous infusion pump
 - b. ECG monitor
 - c. Pulse oximeter
 - d. Defibrillator
 - e. Glucose meter
 - f. Blood pressure equipment
- 3 Non-imaging equipment
 - a. Xenon delivery system and trap
 - b. Aerosol delivery system
 - c. Treadmill

Domain V: Clinical Procedures

A Knowledge and performance of nuclear medicine procedures

- 1 Pulmonary
 - a. Radioaerosol ventilation
 - b. Gas ventilation
 - c. Perfusion
 - d. Perfusion/Ventilation quantitation
- 2 Bone/Musculoskeletal scans
 - a. Limited
 - b. Whole-body
 - c. 3-phase
 - d. 4-phase
 - e. SPECT
 - f. NaF PET
- 3 Oncology
 - a. Ga67 tumor imaging, planar and SPECT
 - b. Monoclonal antibody imaging
 - c. Peptide imaging
 - d. Breast imaging
 - e. Lymphoscintigraphy/sentinel lymph node localization
 - f. Tumor imaging, PET
 - g. Neuroendocrine tumor imaging
- 4 Infection
 - a. Ga67 infection imaging
 - b. Tagged WBC imaging
- 5 Renal/Genitourinary
 - a. Cystogram, direct
 - b. Effective renal plasma flow (ERPF)
 - c. Glomerular filtration rate (GFR)

- d. Renal anatomy, planar, SPECT
 - e. Renal flow
 - f. Renogram (Lasix® and ACE inhibitors)
- 6 Endocrine
- a. Adrenal imaging
 - b. Parathyroid imaging, planar and SPECT
 - c. Thyroid imaging
 - d. Thyroid uptake
 - e. Whole body survey for thyroid metastases
- 7 Hematopoietic
- a. Bone marrow imaging
- 8 Cardiovascular
- a. Myocardial perfusion, planar
 - b. Myocardial perfusion, SPECT, attenuation and non-attenuation
 - c. Myocardial perfusion, gated SPECT
 - d. First pass for EF and wall motion
 - e. Gated cardiac blood pool, rest
 - f. Gated cardiac blood pool, stress
 - g. Gated cardiac blood pool, SPECT
 - h. Cardiac shunt
 - i. Cardiac CT SPECT
 - j. MIBG
 - k. Myocardial viability (thallium, FDG)
 - l. Cardiac PET
- 9 Gastrointestinal
- a. Gastric emptying (liquid/solid)
 - b. Gastroesophageal reflux
 - c. Gastrointestinal bleeding
 - d. Hemangioma
 - e. Hepatobiliary with and without GBEF
 - f. Peritoneal venous shunt patency
 - g. Liver-lung shunt mapping (arterial)
 - h. Liver-spleen imaging, planar and SPECT
 - i. Meckel's diverticulum
- 10 Central Nervous System
- a. Brain flow, brain death
 - b. Brain imaging, planar and SPECT
 - c. Dopamine receptor DaT scan
 - d. Cisternogram
 - e. CSF leak
 - f. CSF shunt patency
 - g. Brain PET

- 11 Radionuclide Therapy
 - a. Thyroid
 - b. Metastatic bone
 - c. Monoclonal antibody therapy (Zevalin®)
 - d. Embolic radiotherapy (labeled microspheres)
 - 12 CT Imaging Procedures
 - a. Attenuation correction /anatomical localization
 - b. Diagnostic
- B Schedule patient studies to accommodate sequencing of multiple procedures and special orders**
- 1 Schedule the camera time
 - 2 Schedule multiple radionuclide procedures for a single patient
 - 3 Schedule same-day multiple modality procedures for a single patient
- C Procure supply of radiopharmaceuticals, considering license possession limits and schedule**
- D Instruct patient, family, and personnel concerning procedures and precautions**
- E Receive, prepare, and provide care to patient**
- 1 Protect patient information and privacy according to the Healthcare Insurance Portability and Accountability Act (HIPPA)
 - 2 Perform basic patient care (e.g., vital signs, basic first aid)
 - 3 Practice correct patient transferring techniques
 - 4 Use and accommodate patient support devices
 - a. Intravenous infusion pump/lines
 - b. Supplemental oxygen
 - c. Foley catheter and drainage bag
 - d. ECG monitor
 - 5 Receive and prepare patient, verify patient identification and written orders for study
 - 6 Perform pre-examination screening including review of:
 - a. Verify patient preparations and identify contraindications
 - b. Medical history
 - c. Current medications
 - d. Allergic and adverse reaction history
 - e. Review relevant lab values
 - 7 Verify that informed consent has been obtained
- F Select and administer prescribed radiopharmaceutical**
- 1 Verify patient identification
 - 2 Calculate appropriate volume to deliver prescribed dosage when needed.
 - 3 Administer radiopharmaceutical using appropriate route and technique
- G Monitor and assess patient condition**
- H Implement emergency procedures (e.g., in case of fainting, seizure, cardiopulmonary arrest, etc.)**
- I Prepare equipment and perform examinations**

- 1 Position patient using anatomical markers and immobilization techniques
- 2 Establish imaging parameters for data acquisition
- J Evaluate image quality**
 - 1 Normal and abnormal scan patterns
 - 2 Identify artifacts and causes
 - 3 Co-registration of images (SPECT/CT and PET/CT)
 - 4 Repeat study and/or perform additional views
- K Perform post-procedure assessment**
- L Provide patient / caregiver education concerning discharge instructions and cautions**
- M Process and evaluate computer generated data**
 - 1 Data storage, transfer and retrieval
 - 2 Image formation (static, dynamic, ERNA, list mode)
 - 3 Image reconstruction (SPECT, PET)
 - 4 Image enhancement (e.g., filters, matrix, intensity, etc.)
 - 5 Quantitative analysis
 - a. Regions of interest and quantification
 - b. Curve generation and analysis
 - c. Image normalization and subtraction
 - 6 Display formatting (image size, number of images, intensity adjustments)
- N Prepare and perform cardiac monitoring and/or assist with stress testing**
 - 1 Basic electrocardiography (ECG)
 - a. Cardiac conduction system
 - b. Components of a normal ECG wave form
 - c. Recognizing and responding to changes on a resting or stress ECG
 - 2 ECG lead placements
 - 3 Treadmill stress techniques (i.e., Bruce and modified Bruce) and bicycle stress techniques
 - a. Contraindications
 - b. Duration/termination parameters
 - 4 Pharmacological stress protocols
 - a. Contraindications
 - b. Timing of pharmacological stress agent
 - c. Timing of radiopharmaceutical injection
 - d. Duration/termination parameters
 - e. Drug side-effects and appropriate treatment
 - f. Reversal agents and techniques
- O Obtain samples and/or data for non-imaging studies**
 - 1 Data specimen collection techniques, including timing, methods, containers, and storage
 - 2 Background correction
 - 3 External counting techniques
- P Calculate and evaluate the results of non-imaging studies**

- 1 Error analysis
 - 2 Calculations
- Q Prepare, survey, and clean radiotherapy administration and/or isolation room**