ACPSEM POSITION ON THE ROLES AND RESPONSIBILITIES OF THE QUALIFIED MEDICAL PHYSICIST

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INTRODUCTION

Medical Physics is the branch of physics that is associated with the practice of medicine. The essential responsibility of the Qualified Medical Physics Specialist (QMPS) in clinical practice is to assure the safe and effective delivery of radiation to achieve the diagnostic or therapeutic result as prescribed in patient care. The clinical practice of Medical Physics is focused on accuracy, safety and quality in radiation oncology, medical imaging, image-guided medical procedures, and medical radiation safety, as well as on innovative research and development in the aforementioned disciplines and the dissemination of scientific and technical information for the professional development of healthcare workers involved in these disciplines.

The QMPS works collaboratively with physician colleagues, biomedical engineers, radiographers, radiation therapists, nurses and others, often providing supervision and oversight of staff to ensure that all radiation producing and related equipment remains safe and suitably calibrated, that radiation dose determinations are accurate, and that all imaging modalities are functioning at their optimal levels. The QMPS ensures that all such equipment, policies and procedures are in compliance with the relevant state and national legislation and in keeping with published standards. The QMPS's primary professional responsibility is to the patient's and the staff's safety and welfare.

QMPSs working in clinical, research or educational environments are crucial to the delivery of quality radiation therapy, performance of quality medical imaging, and protection of patients, healthcare workers and the general public from the potentially harmful effects of radiation and other physical phenomena such as magnetic fields and ultrasound. As such, QMPSs serve a vital role in the delivery of high quality healthcare in these areas that is in the interests of the local, national and international communities.

QMPSs have a unique combination of education and training in physics principles, radiation physics applications, dosimetry planning, radiobiological principles, human anatomy and oncology principles, as well as safety analysis and quality control methods. To attain this knowledge, the usual education and professional career structure for a Medical Physicist in Australasia begins with an undergraduate qualification majoring in physics, followed by a postgraduate degree in medical physics degree (Masters level or higher) and completion of the Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) Training Education and Assessment Program (TEAP). Upon completion of the 3 to 5 year TEAP program, Medical Physicists become ACPSEM certified.

A fully trained Medical Physicist demonstrates competence by successfully obtaining admission to the ACPSEM Register of Qualified Medical Physics Specialists. An ACPSEM certified Medical Physicist is eligible for direct admission to the ACPSEM Register of Qualified Medical Physics Specialists.

SCOPE

This document describes the position of the ACPSEM in regard to the roles and responsibilities of the practising Qualified Medical Physics Specialist in the areas of:

- Radiation Oncology Medical Physics,
- Nuclear Medicine Medical Physics, and
- Radiology Medical Physics.

Furthermore, it is the position of the ACPSEM, that the roles and responsibilities described in this document must only be conducted either by, or under the direct supervision of, a Qualified Medical Physics Specialist.

ASSOCIATED DOCUMENTATION

The roles and responsibilities defined herein are based on IAEA human health service series report number 25, with consideration for ARPANSA radiation protection series reports numbers 14 and 14.1 – 14.3 and the Australasian context.

DEFINITIONS

Medical Physics is that branch of physics that is associated with the practice of medicine. The term Medical Physics, as it is used here, includes:

- Radiation oncology medical physics
- Nuclear medicine medical physics, and
- Radiology medical physics

Radiation includes both ionizing and non-ionizing radiation such as electromagnetic radiation, particulate radiation, and ultrasound. These modalities, used for diagnostic or therapeutic purposes when prescribed by a properly qualified practitioner, are herein described as radiological procedures.

The Practice of Medical Physics means the use of principles and accepted protocols of physics to assure the correct quality, quantity, and placement of radiation during the performance of a radiological procedure.

Medical Specialist means a doctor of medicine who is licensed to practice their medical specialty and who either prescribes or utilizes radiological procedures for other persons.

Quality Assurance consists of activities designed to assure adequate quality, precision and accuracy in the use of radiation and reproducibility of the procedures and systems used.

Qualified Medical Physics Specialist (QMPS) is an individual who is competent to practice independently in one or more of the subfields of medical physics demonstrated through admission to the ACPSEM Register of Qualified Medical Physics Specialists. A QMPS may be also referred to as a Qualified Expert.

Medical Physicist is a health professional, with specialist education and training in the concepts and techniques of applying physics in medicine and practices in one or more subfields (specialities) of medical physics.

ROLES AND RESPONSIBILITIES OF THE QUALIFIED MEDICAL PHYSICS SPECIALIST

The use of radiation technology in medicine continues to change rapidly. The research and development work in medical physics has provided a significant contribution for many of the new technologies developed for diagnosis and treatment techniques. With proper education, training, depth of experience and skills, the QMPS plays a key role improving the quality, safety and outcome for patient care in the clinic. The QMPS should routinely participate in the department's clinical task groups who are developing or implementing improved clinical techniques. To provide the most appropriate support skill for the medical specialists and other allied health staff working in the clinical department, the QMPS should have an in-depth, broad area of experience and knowledge which spans not only the physics and technical aspects, but also the anatomical, physiological, histopathological and radiobiological aspects. This can be in the clinical management for a wide range of patient cases undergoing treatment or diagnostic procedures.

The breadth of this field coupled with the depth of knowledge required of the QMPS means that subspecialisation into the main areas of Medical Physics practice is required. There are three areas of specialisation:

- Radiation oncology medical physics,
- Nuclear medicine medical physics, and
- Radiology medical physics.

Whilst the radiation oncology medical specialist focuses on the medical care of the patient receiving radiation treatment and the radiation therapist focuses on the planning and treatment of that patient, the QMPS must focus on ensuring that the equipment accurately directs the beams and delivers the intended dose to the radiotherapy patient; that new methods are safely implemented to eventually become a routine technique; and that continual monitoring of the techniques leads to further improvements in the patient's quality of treatment and long term outcome.

Similarly, whilst the radiology or nuclear medicine medical specialist focuses on the medical care of the patient, and the radiographer and nuclear medicine technologists focus on the imaging of the patient, the QMPS must focus on ensuring that all the hospital's radiation imaging equipment provides an optimal image with the least associated patient dose.

The monitoring of new techniques and equipment (in addition to routine medical physics services) is an important on-going task for the QMPS to oversee as medical practices continue to change and improve for patient care. Experience has also shown that whilst the manufacturer initially designs, develops and tests new technology for imaging and therapeutic purposes, equipment with innovative concepts may have technical design problems; may not necessarily operate optimally; or may even have program software problems under certain conditions which can lead to serious patient or staff safe care issues. QMPS input significantly contributes to minimising these risks. As new techniques in imaging and therapy become accepted as an approved routine procedure for the radiographers or radiation therapists to carry out, the QMPS progresses on to work on other new innovations that need to be introduced by a clinical task group. Many of these projects eventually become patient trials with controlled protocols for assessment.

This document summarises the tasks for which medical physicists are uniquely qualified. Additionally, medical physicists participate in many procedures in the clinic not listed here, depending on the specifics of clinic operation. A scope of practice consistent with the aforementioned practice guidelines for the different sub-specialties of medical physics is outlined below. More detailed descriptions of the roles and responsibilities of the qualified expert are provided in Appendices I-IV.

The scope of practice of the QMPS may include, but is not limited to:

General (See Appendix I for more details)

- Provide technical supervision of equipment operation and maintenance
- Maintain records demonstrating technical compliance with regulatory authority and accrediting body standards and requirements
- Participate in or undertake research and development either individually or as part of a broader clinical team
- Participate in education and training programs
- Provide supervision of and participate in radiation protection and safety programs
- Establishment, implementation, and supervision of quality assurance programs
- Drive optimization of physical aspects of diagnostic and therapeutic procedures

For Radiation Oncology Medical Physics(See Appendix II for more details)

- Develop equipment specifications for radiation therapy treatment, brachytherapy, simulation, and radiation measurement
- Develop procedures for the initial and continuing evaluation of radiation therapy treatment, brachytherapy, simulation, and radiation measurement equipment
- Provide evidence of compliance of equipment for radiation therapy treatment, brachytherapy, simulation, and radiation detection, with regulatory and accreditation agency rules and recommendations
- Measure and characterize medical radiation from radiation therapy treatment, brachytherapy, and simulation equipment prior to clinical utilization
- Perform acceptance testing, evaluation and commissioning of equipment used for external-beam therapy, brachytherapy, simulation, treatment-planning, and radiation detection; acceptance testing and evaluation of their associated computer systems, algorithms, data, and output
- Approve radiation oncology technical procedures prior to clinical use
- Develop and/or evaluate, in conjunction with the medical practitioner, policies and procedures related to the appropriate therapeutic use of radiation
- Develop and/or evaluate, with the medical practitioner, the dosimetric component of patients' treatment plans
- Review of radiation oncology dosimetry information noted in patient records
- Develop and manage a comprehensive Quality Management Program that monitors, evaluates, and optimizes radiation oncology processes
- Develop and/or evaluate a comprehensive clinical radiation safety program in radiation oncology
- Direct the Radiation Oncology Physics program to include the technical direction of staff responsible for treatment planning, machine maintenance and repair and other physics support staff.
- Provide consultation on patient or personnel radiation dose and associated risks
- Provide radiation oncology physics and radiation dosimetry training for medical practitioners and other health-care providers
- Provide consultation to assure accurate radiation dose delivery
- Provide institutional consultation on program development in radiation oncology
- Plan and specify thickness, material, and placement of shielding needed to protect patients, workers, the general public and the environment from radiation produced incidentally to diagnosis or treatment of humans
- Assess and evaluate installed shielding designed to protect patients, workers, and the general public from radiation produced incident to diagnosis or treatment of humans
- Use imaging procedures as they pertain to the simulation, treatment planning and treatment delivery in therapeutic radiologic procedures.
- Participate in informatics development and direction

- Apply other medical applications of physics as appropriate to safely carry out therapeutic radiologic procedures
- Develop and apply Medical Health Physics procedures associated with the practice of Therapeutic Radiology

For Nuclear Medicine Medical Physics (See Appendix III for more details)

- Develop nuclear imaging and radioactivity measurement equipment specifications
- Develop procedures for the initial and continuing evaluation of nuclear imaging and radioactivity measurement equipment
- Provide evidence of compliance of nuclear imaging and radioactivity measurement equipment with regulatory, professional and accreditation agency rules and recommendations
- Measure and characterize of medical radiation from radiopharmaceuticals prior to clinical utilization
- Perform acceptance testing, evaluation and commissioning of nuclear imaging and radioactivity measurement equipment and their associated computer systems, algorithms, data, and output
- Evaluate nuclear imaging and radioactivity measurement procedures prior to clinical use
- Develop and/or evaluate of policies and procedures related to the appropriate clinical use of radiation for nuclear imaging, radiopharmaceutical therapy and/or radioactivity measurement purposes
- Review of radiopharmaceutical dosimetry information noted in patient records
- Develop and manage of a comprehensive Quality Management Program that monitors, evaluates, and optimizes nuclear imaging, radiopharmaceutical therapy and radioactivity measurement processes
- Develop and/or evaluate a comprehensive clinical radiation safety program in nuclear medicine
- Provide consultation on patient or personnel radiation dose and associated risks
- Provide institutional consultation on program development in medical nuclear imaging and radiopharmaceutical therapy
- Provide medical nuclear physics training for medical practitioners and other health-care providers
- Provide consultation to assure an optimized balance between image quality and patient dose
- Plan and specify thickness, material, and placement of shielding needed to protect patients, workers, the general public and the environment from radiation produced incident to diagnosis or treatment of humans
- Assess and evaluate installed shielding designed to protect patients, workers, and the general public from radiation produced incident to diagnosis or treatment of humans
- Participate in informatics development and direction
- Apply other medical applications of physics as appropriate to safely carry out nuclear medicine procedures
- Develop and apply Medical Health Physics procedures associated with the practice of Nuclear Medicine

For Radiology Medical Physics (See Appendix IV for more details)

- Develop specifications for imaging equipment and diagnostic radiation detectors
- Develop procedures for the initial and continuing evaluation of imaging equipment and diagnostic radiation detectors
- Provide evidence of compliance of imaging equipment with regulatory and accreditation agency rules and recommendations
- Measure and characterize of medical radiation from imaging equipment prior to clinical utilization
- Perform acceptance testing, evaluation and commissioning of imaging equipment and/or their associated computer systems, algorithms, data, and output
- Develop and/or evaluate of policies and procedures related to the appropriate clinical use of radiation for imaging purposes

- Review diagnostic imaging dosimetry information noted in patient records
- Develop and manage of a comprehensive Quality Management Program that monitors, evaluates, and optimizes imaging processes
- Consult in the development and/or evaluation of a comprehensive clinical radiation safety program in diagnostic imaging
- Consult on patient or personnel radiation dose and associated risks
- Provide diagnostic imaging physics training for medical practitioners and other health-care providers
- Provide consultation to assure an optimized balance between image quality and patient dose
- Provide institutional consultation on program development in diagnostic imaging
- Plan and specify of thickness, material, and placement of shielding needed to protect patients, workers, the general public and the environment from radiation produced incident to diagnosis or treatment of humans
- Assess and evaluate of installed shielding designed to protect patients, workers, the general public and the environment from radiation produced incident to diagnosis or treatment of humans
- Participate in informatics development and direction
- Apply other medical applications of physics as appropriate to safely carry out diagnostic radiologic procedures
- Develop and apply Medical Health Physics procedures associated with the practice of Diagnostic Radiology

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APPENDIX I

ROLES AND RESPONSIBILITIES COMMON TO ALL QUALIFIED MEDICAL PHYSICS SPECIALTIES

The main functions and responsibilities of the QMPS which are common to *all* medical physics specialties are described below:

(a) *Technical supervision of equipment operation and maintenance*: QMPSs supervise the preventive and corrective maintenance, repair and calibration of the diagnostic, therapeutic and measuring equipment, and are responsible for documenting the relevant information. They collaborate with service engineers in developing and maintaining a quality management program for all of the equipment, so as to make it possible for the equipment to operate optimally.

(b) *Records and documentation*: QMPSs provide the documentation needed and maintain the records of their area of work, providing evidence of the compliance of equipment and procedures with the appropriate regulatory and accreditation authorities' rules and recommendations. In addition, QMPSs are responsible for the documentation of QA, equipment calibration, independent dosimetry audits and any other medical physics policies and procedures.

(c) *Clinical computing and networking*: QMPSs have the knowledge and skills to assist in the clinical use of information systems, e.g. reviewing/processing computer workstations or record and verify systems, and to perform basic computer system management and administrative tasks, apply image data processing techniques, e.g. image reconstruction, registration and fusion,. They are familiar with the core concepts and use of record and verify systems, picture archiving and communication systems, radiology information systems and hospital information systems. They are also knowledgeable on how to store, handle or distribute patient images and data between different workstations. They collaborate with computer engineers for the verification of network integration and data transfer to ensure that all systems are functional and that patient data integrity is maintained, and patient data are protected against unauthorized access and breach of privacy.

(d) *Research and development*: QMPSs evaluate new technologies and investigate the adoption of new procedures, assisting in the training of clinical staff for their implementation. They support the physical and technical aspects of clinical research and often have a leading role in the medical research team, particularly in centres of high technological complexity. QMPSs play an important role in clinical protocols used in applied research. They carry out research and development in medical physics and instrumentation, monitor current advances in specific areas of research, and design project plans with milestones, experimental methodology and estimated time frames.

(e) *Education and training*: QMPSs play a key role in the academic education and clinical training of medical physicists. They also lecture and develop educational material for medical practitioners, therapists, radiographers and nurses, as well as for students, residents and technical maintenance staff. In addition, they may also provide ongoing mentoring or clinical supervision of professionals, based on the requirements for their continued professional education and development.

(f) *Calibration and verification of measurement instruments*: QMPSs are responsible for the calibration of the instruments they use or are responsible for following recommended standards or codes of practice and keeping appropriate calibration records. They are responsible for developing procedures to determine the stability of the instruments for clinical use.

APPENDIX II

ROLES AND RESPONSIBILITIES SPECIFIC TO THE RADIATION ONCOLOGY QUALIFIED MEDICAL PHYSICS SPECIALIST

The main responsibilities and functions of QMPSs in radiation oncology are described below:

(a) *Installation design, technical specification, and acceptance and commissioning of equipment, including the establishment of criteria for acceptable performance.*

(i) QMPSs are an essential part of the team for the installation, design and shielding of new or modified radiation therapy rooms, ensuring that all safety requirements are complied with. They calculate and provide the thickness, material composition and placement of the shielding needed to protect patients, staff and the general public, thus ensuring that all requirements of safety and functionality are met. They also verify the adequacy of the shielding after installation.

(ii) QMPSs have a leading role in preparing equipment specifications according to the needs of the radiation therapy facility, and they participate in the tender evaluation and purchase recommendation of the equipment. They analyse the functional requirements for clinical use, and specify the necessary conditions for integration, compatibility and connectivity to existing equipment of the equipment to be purchased.

(iii) Following the installation of new equipment, QMPSs are responsible for specifying the basic standards to be applied for its acceptance and subsequent commissioning. They ensure that all units and systems function according to their technical specification and provide advice on any deviation of equipment performance from acceptable criteria, including guidance on decommissioning when appropriate. QMPSs also have, often in collaboration with computer engineers, responsibility for the verification of the computer systems and algorithms associated with the new equipment, and for ensuring that they are adequate for safe and effective clinical use.

(b) *Technical supervision of equipment operation and maintenance*: QMPSs are responsible for authorizing the clinical use of radiation equipment after a maintenance procedure. For this purpose, they perform QC measurements of particular complexity after preventive or corrective maintenance, to ensure that the function of the equipment has not been affected by any alteration made during maintenance or repair. By verifying the proper function of the equipment, they aim to ensure optimal performance as well as patient and staff safety

(c) *Radiation safety and protection of patients, staff and the general public*: QMPSs have responsibilities in the development and implementation of a clinical radiation safety program for the radiation protection of the patient in radiation therapy. In the majority of cases however, they also have responsibilities with respect to radiation safety of the staff and the public, as it pertains to the radiation therapy service and infrastructure. QMPSs are responsible for developing the procedures needed for testing the integrity of the equipment and accessories, for the proper operation of interlocks and other safety aspects.

(d) *Patient radiation dosimetry*: QMPSs are responsible for establishing procedures for the calculation and verification of the radiation dose to the patient. Their duties include dosimetry measurements using ionization chambers and other detectors for the reference and relative determination of absorbed dose from external beam radiation therapy and brachytherapy sources, development of methods to analyse the results of dose measurements, and verification of the accuracy of dose distributions delivered to patients. Tasks related to patient dosimetry include:

(i) Acceptance testing and commissioning of radiation generators, radioactive sources and treatment planning systems (TPSs): QMPSs are responsible for the acceptance testing, commissioning and acquisition of all of the data needed for the clinical use of the imaging and treatment units (part of the commissioning process for entry into service).

(ii) Treatment planning and dose calculations: Medical physicists perform or supervise the calculations and measurements necessary for optimizing the dose distribution in the patient and ensure their proper application for the different types of treatment. These can either be manual or computer calculations and/or in-phantom measurements. QMPSs are also responsible for the validation of image and data transfer to and from the TPS. Often, they also perform administrator duties for the TPS, applying system security policies, enabling data protection, import and export of data, backups, data storage and archival, system upgrades/updates, etc.

(iii) Patient dose verification: QMPSs are responsible for patient specific dose verification measurements. They establish tolerances and action levels. This includes relevant in vivo dosimetry measurements using appropriate detectors.

(iv) Additional tasks in brachytherapy: Subsequent to the calibration of the radioactive sources used for brachytherapy, but still as a component of the commissioning process, QMPSs are responsible for the comparison with the manufacturer's calibration certificates, resolving any discrepancy that may arise. To initiate treatments with manual after-loading implants, they are responsible for the transfer of the sources from the shielded safe to the patient's room, and for the necessary radiation survey after the sources have been inserted into the applicators. They make periodic QC measurements to ensure that the computer controlled movements of the source are accurate. QMPSs are responsible for producing policies and procedures to ensure the safety and protection of patients, staff and members of the public for this type of source. They develop an emergency action plan, indicating the steps to be followed in the case that a source is lost or the computerized brachytherapy treatment system fails. When decommissioning a brachytherapy unit or sources, medical physicists are responsible for their radioactive waste disposal after removal of the source from the equipment.

(e) *Optimization of physical aspects of therapeutic procedures*: QMPSs have responsibilities for optimizing the physical and technical aspects of the therapeutic procedures used in their radiation therapy facility. This includes assisting in the selection of the appropriate positioning and immobilization aids for optimization of patient treatment plans according to the delivery techniques envisaged, overseeing the manufacture, QC and verification of beam shaping devices, performing the QA of the intensity modulation used for each treatment, defining the imaging protocols used for treatment planning and image guided radiation therapy (IGRT), and developing the methodologies used in the determination of set-up margins.

(f) *Quality management of the physical and technical aspects of radiation therapy*: QMPSs participate as team members in establishing a quality management program and have responsibility for the physical and technical aspects. Related tasks are:

(i) Developing institutional policies and procedures related to the use of radiation, which includes responsibility for documenting and implementing new policies and procedures, or updating existing ones.

(ii) Establishing QA programs and performing QC of all of the radiation generators (all radiation therapy imaging and treatment units), TPSs, radiation therapy networks, e.g. record and verify systems, and dosimetry equipment (ionization chambers and other detectors, electrometers, phantoms, scanners, etc.): One of the major tasks of QA in radiation therapy is the calibration of radiation sources. QMPSs are responsible for performing the calibration of radiation units and brachytherapy sources according to well established dosimetry protocols or codes of practice, and for ensuring compliance of radiation therapy equipment with national and international regulations and recommendations. They also verify the accuracy of the TPS and

perform QC of individual treatment plans using independent dose calculation methods or systems.

(iii) Performing risk assessments and identifying potential radiation emergencies, such as incidents resulting from equipment malfunction, human error or loss of radioactive sources: QMPSs develop plans of action to be followed in the event of such occurrences and carry out drills to verify that they can be implemented correctly. In general, QMPSs try to find ways to minimize the risk in each case, adopt mandatory peer review processes, follow continuous quality improvement methods and participate in external audits whenever possible.

(iv) Investigating unintended or accidental medical exposures: QMPSs have responsibilities in analysing all incidents related to equipment failure, accident, error or other unsolicited event which could result inpatients receiving an exposure that was significantly different, higher or lower, from that prescribed. QMPSs provide consultation on the doses received by patients or personnel and on their associated risks, and recommend measures to minimize the likelihood of accidents happening again.

(g) *Collaboration with other clinical professionals*: QMPSs are key members of the team of clinical professionals, including medical practitioners, therapists and nursing staff, that work together in the treatment of malignant diseases. The contribution of QMPSs in this respect includes:

(i) Consultation with radiation oncology medical practitioners on patient cases, in order to establish the optimal treatment technique including patient positioning and immobilization aids and accessories, and beam modifiers that may be needed and manufactured for the best outcome: QMPSs provide treatment plan assessments and proposals on how to optimize them.

(ii) Collaboration with the technology staff in the set-up, correct treatment delivery and dosimetry of patients: Advanced treatment modalities, especially during initial implementation, may require more intensive collaboration, e.g. intensity modulated radiation therapy (IMRT) and image guided radiation therapy (IGRT). Some modalities, e.g. stereotactic radiosurgery and permanent prostate seed implant brachytherapy, require the physical presence of the MPS during the procedure.

(iii) Comprehensive quality management systems require the input of the QMPS in regular peer review meetings, e.g. image review and new patient planning conferences.

APPENDIX III

ROLES AND RESPONSIBILITIES SPECIFIC TO THE NUCLEAR MEDICINE QUALIFIED MEDICAL PHYSICS SPECIALIST

The main responsibilities and functions of QMPSs in nuclear medicine are listed below:

(a) *Installation design, technical specification, acceptance and commissioning of equipment, including the establishment of criteria for acceptable performance*: Within the technical specification, acceptance commissioning and supervision of the proper operation of the installation and its equipment, and the establishment of criteria for its acceptable performance, the following roles and duties must be considered:

(i) QMPSs are an essential part of the design team for new installations. They are responsible for shielding and installation designs of new or modified nuclear medicine facilities, ensuring that all safety requirements are complied with. They calculate and provide the thickness, material composition and placement of shielding needed to protect patients, staff and the general public, and design the system for the management of isotopes and radioactive wastes, thus ensuring that all requirements of safety and functionality are met. They also verify the adequacy of the shielding after installation.

(ii) QMPSs have a leading role in preparing equipment specifications according to the needs of the nuclear medicine facility, and they participate in the tender evaluation and purchase recommendation of the equipment. They analyse the functional requirements for clinical use, and specify the necessary conditions for integration, compatibility and connectivity to existing equipment of the equipment to be purchased.

(iii) Following the installation of new equipment, QMPSs are responsible for specifying the basic standards to be applied for its acceptance and subsequent commissioning. They ensure that all units and systems function according to their technical specification and provide advice on any deviation of equipment performance from acceptable criteria, including guidance on decommissioning when appropriate. QMPSs also have, often in collaboration with computer engineers, responsibility for the verification of the computer systems; they assist medical practitioners in evaluating imaging or diagnostic algorithms for their safe and effective clinical use.

(b) *Radiation safety and protection of patients, staff and the general public*: QMPSs have responsibilities in the development and implementation of a clinical radiation safety program for the radiation protection of the patient in nuclear medicine. In the majority of cases, however, they also have responsibilities with respect to the radiation safety of the staff and the public, as it pertains to the nuclear medicine service and infrastructure. QMPSs are responsible for developing the procedures needed for testing the integrity of equipment and radioactive sources and for the proper operation of the equipment. They establish policies and procedures for the safe transport of these radionuclides, for precautions in the case of contamination or spillage of unsealed radionuclides, and for the management of radioactive waste as required by regulations. QMPSs have responsibilities with respect to discharging the patient after radionuclide therapy, based on the potential exposure of the public. They have responsibilities for communicating with the patients to provide instructions that can further minimize the exposure of relatives and the public after discharge.

(c) *Patient internal dosimetry*: QMPSs are responsible for establishing procedures for the calculation and verification of the radiation dose received by different internal organs, as well as the total effective dose to the patient, resulting from the administration of radionuclide activity. They are also

responsible for verifying the accuracy of such calculations. Tasks related to patient dosimetry include:

(i) Activity measurements and calculation of absorbed doses: QMPSs use activity distribution data and internal dosimetry methodology to estimate the dose absorbed by patients during different clinical procedures. This requires the use of manual or computerized models and/or in-phantom measurements. Judgement with respect to the applicability of the models used and the ability to synthesize new models is necessary, as well as knowledge to estimate dosimetry uncertainties.

(ii) Specific patient dose calculations: QMPSs are responsible for the measurement and/or calculation of individual patient dose, as well as foetal doses in cases where patients are found to be pregnant; this is particularly important in therapeutic applications where dosimetry needs to be done for each patient. They also establish tolerances and make judgements on the appropriateness of the measured data, including advice to the medical practitioner and the patient on any associated risks, especially those related to the induction of cancer.

(d) *Dose Estimations for Clinical Trials and Research*: QMPS are responsible to provide dose reports and risk assessments to institutional research and ethics committees for clinical trials and research which include imaging procedures involving ionising radiation such as radiology and nuclear medicine procedures.

(e) *Optimization of the physical aspects of diagnostic procedures*: QMPSs have responsibilities for the optimization of the physical aspects of the imaging systems (gamma cameras, single photon emission computed tomography (SPECT), positron emission tomography (PET), the latter two often combined with computed tomography (CT), etc.). They are responsible for the development and maintenance of a quality management program for all imaging equipment, so as to produce images of optimal quality while minimizing the radiation dose delivered to patients. QMPSs are also responsible for the equipment and instrumentation needed to ensure proper QC, optimal image quality, monitoring of patient exposure, and determination of dose to individual organs from different nuclear medicine imaging procedures, as well as for the use of the appropriate guidelines and techniques. They can also assist medical practitioners in the evaluation of examination efficacy and participate in image quality and perception studies.

(f) *Radionuclide Therapy: Nuclear Medicine QMPS* play a key role in the development, implementation, delivery, verification and maintenance of radionuclide therapy techniques*:*

(i) Ensuring the accuracy of the measured radioactivity;

(ii) Ensuring the preparation of in-patient treatment facilities for each patient;

(iii) Ensuring the safety of staff during the administration of the radiopharmaceutical;

(iv) Ensuring the removal of any radioactive contamination of the treatment facilities following the discharge of the patient;

(v) The measurement of absorbed dose to the tumour(s) and to critical organs and determination of the activity to be administered from tracer dose administrations of the radionuclide, accounting for physical effects such as attenuation, scatter and partial volume effects;

(vi) Providing advice on the appropriate radiation safety precautions to ensure that the patient's relatives and friends do not receive radiation doses in excess of the appropriate dose constraints' and

(vii) Development of procedures and protocol for safe and effective introduction and use of novel radionuclide therapy technique. This may include advanced techniques such as Monte Carlo based dose calculations.

(g) *Quality management of the physical and technical aspects of nuclear medicine*: QMPSs participate as team members in establishing a quality management program and have responsibility for physical and technical aspects. Related tasks comprise:

(i) Developing institutional policies and procedures for the continuous optimization of radiation use, which includes responsibility for writing new policies and procedures, or updating existing ones.

(ii) Establishing QA programs ensuring that policies and procedures are in place, with appropriate elements of good practice for handling of radioactive material, for radiation protection of patients, and for QC and regulatory compliance of equipment.

(iii) Performing risk assessments and identifying potential radiation emergencies, such as incidents resulting from equipment malfunction, human error, radioactive spill or losses of radioactive sources: QMPSs develop action procedures to be followed in the event of such occurrences and carry out drills to verify that procedures can be implemented correctly. In general, QMPSs try to find ways to minimize the risk in each case, adopt mandatory peer review processes, follow continuous quality improvement methods and participate in voluntary external audits whenever possible.

(iv) Investigating unintended or accidental medical exposures: QMPSs have responsibilities in analysing all incidents related to equipment failure, accidents, errors or other unsolicited events which could result in patients receiving an exposure significantly different from that intended. QMPSs provide consultation on the doses received by patients or personnel and on the associated risks, and recommend measures to minimize the chances for accidents to happen again.

(h) *Collaboration with other clinical professionals*: QMPSs are key members of the team of clinical professionals, including medical practitioners, nuclear medicine technologists , radiopharmaceutical scientists and nursing staff, that work together for the diagnosis and/or treatment of patients. The contribution of medical physicists in this respect includes:

(i) Consultations with nuclear medicine medical practitioners on special cases where diagnostic tests or treatment require additional actions to those routinely established: The collaboration between the medical practitioners and the medical physicists helps in establishing the optimal approach for each case.

(ii) Assistance and provision of advice to nuclear medicine technologists in the implementation of new clinical procedures, being key members of the team responsible for the introduction of new imaging or therapeutic procedures in the institution: QMPSs are also responsible for developing methods for QA of the new procedures.

APPENDIX IV

ROLES AND RESPONSIBILITIES SPECIFIC TO THE RADIOLOGY QUALIFIED MEDICAL PHYSICS SPECIALIST

The main responsibilities and functions of QMPSs in diagnostic and interventional are listed below:

(a) *Installation design, technical specification, acceptance and commissioning of equipment, including the establishment of criteria for acceptable performance*: Within the technical specification, acceptance, commissioning and supervision of the proper operation of equipment, and the establishment of criteria for its acceptable performance, the following roles and duties must be considered:

(i) QMPSs are an essential part of the design team for new installations. They are responsible for shielding and installation design of new or modified radiology rooms, ensuring that all safety and legislative requirements are complied with, including dose limits. They calculate and provide the thickness, material composition and placement of shielding needed to protect patients, staff and the general public, and supervise the construction, thus guaranteeing that all requirements of safety and functionality are met. They also verify the adequacy of the shielding after installation.

(ii) QMPSs have a leading role in preparing equipment specifications and they participate in the tender evaluation and purchase recommendation of equipment. They perform analysis of the technical and functional requirements for clinical use, and specify conditions for integration, compatibility and connectivity of the equipment to be purchased.

(iii) Following the installation of new equipment, or after any significant change or service, QMPSs are responsible for specifying the basic standards to be applied for its acceptance and subsequent commissioning. They ensure that all units and systems function according to their technical specifications and provide advice on any deviation of equipment performance from acceptable criteria, including guidance on decommissioning when appropriate. QMPSs also have, often in collaboration with computer engineers, responsibility for the verification of the computer systems; they assist medical practitioners in evaluating imaging or diagnostic algorithms for their safe and effective clinical use.

(b) *Radiation safety and protection of patients, staff and the general public* :QMPSs have responsibilities in the development and implementation of a clinical radiation safety program for the radiation protection of patients in areas where DIR equipment is used. In the majority of cases, however, the QMPS also has responsibilities with respect to the radiation safety of the staff and the public, as it pertains to the radiology service and infrastructure (e.g. stewardship for development of Radiation Management Plans). QMPSs are responsible for developing procedures for testing the integrity of the equipment and accessories (including personal protective equipment), for the proper operation of dosimetry equipment and other safety features. They also participate in the investigation of incidents involving radiation and they provide the appropriate reports and documentation.

(b) *Patient dosimetry*: QMPSs are responsible for establishing procedures for the calculation and verification of the radiation dose received by the patient. Their duties include dosimetry measurements as well as the development of methods to analyse the results of the measurements and verify the accuracy of doses delivered to patients. In special cases, duties also involve individual patient dose calculations. Tasks related to patient dosimetry include:

(i) Measurements and calculation of absorbed doses: QMPSs use data acquired during commissioning and information from dosimetry measurements to estimate the absorbed dose

to patients during different clinical procedures (including MGD (mammography) and CTDIvol or DLP (CT)). This requires the use of analytical calculations, computerized models or in-phantom measurements. Judgement with respect to the applicability of the models used and the ability to synthesize new models is necessary, as well as knowledge to estimate dosimetry uncertainties.

(ii) Specific patient dose calculations: QMPSs are responsible for the measurement and/or calculation of individual patient doses for research ethics applications and incidents and foetal doses in cases where a patient is found to be pregnant. This may include detailed measurements and the use of software to calculate effective dose. They establish tolerances and make judgements on the appropriateness of the measured data, including advice to the medical practitioner and the patient on any associated risks, especially those related to the induction of cancer.

(iii) Patient dose estimations to establish diagnostic reference levels (DRLs), or to verify conformity with recommended DRLs by national or international regulations: QMPSs have responsibilities in reviewing procedures and equipment when DRLs are consistently exceeded in standard procedures. It may also be appropriate to set warning and notification levels for interventional procedures (e.g. angiography and cardiology).

(c) O*ptimization of physical aspects of diagnostic and interventional procedures*: QMPSs have responsibilities in the optimization of the physical and technical aspects of the different processes used to produce medical images and the necessary imaging equipment (analogue and digital x-ray units, CT, angiography units, etc.). They also assist medical practitioners in the evaluation of examination efficacy and participate in image quality and perception studies.

(d) *Quality management of the physical and technical aspects*: QMPSs participate as team members in establishing a quality management program and have responsibility for the physical and technical aspects. They are primarily responsible for developing and implementing procedures for the initial and continuing evaluation of the DIR equipment as well as for the calibration of dosimetry equipment. Related tasks comprise:

(i) Developing institutional policies and procedures for the continuous optimization of radiation use, which includes responsibility for writing new policies and procedures, or updating existing ones.

(ii) Establishing a QA program for verifying, setting and accepting the initial reference values of parameters for optimal image quality and the initial reference state of the imaging equipment: This includes developing and implementing QC, ensuring that periodic QC measurements are carried out for the x-ray units and associated equipment for image visualization, processing, storage and printing. QMPSs are also responsible for ensuring compliance of the imaging equipment with government and accreditation agency regulations and recommendations.

(iii) Performing risk assessments and identifying possible radiation emergencies, such as incidents resulting from equipment malfunction or human error: QMPSs develop action procedures to be followed in the event of such occurrences and carry out drills to verify that procedures can be carried out correctly.

(iv) Investigating unintended or accidental medical exposures, such as sentinel events in interventional radiology: QMPSs provide consultation on the doses received by patients or personnel and on the associated risks, and recommend measures to minimize the chances for accidents to happen again.

(e) *Collaboration with other clinical professionals*: QMPSs are key members of the team of clinical professionals, including radiological medical practitioners and other clinical specialists, radiographers and nursing staff, that work together for the diagnosis and treatment of patients. The contribution of medical physicists in this respect includes:

(i) Consultations to medical practitioners on special patient cases that may be encountered during diagnostic or interventional procedures that require additional actions to those routinely established: The collaboration between the medical practitioners and the QMPSs helps in establishing the optimal approach for each case.

(ii) Assistance and providing advice to the radiology personnel in the implementation of new clinical procedures, being key members of the team responsible for the introduction of new clinical procedures in the institution: QMPSs are also responsible for developing methods for QA of the new procedures.

In addition to the above described roles and responsibilities of the QMPS in diagnostic and interventional radiology, QMPSs working in medical imaging, due to their knowledge, training and professional focus, can contribute to the delivery of quality and performance of medical imaging, and protection of healthcare workers, patients and the general public from the potentially harmful effects associated with other physical phenomena such as magnetic fields and ultrasound.