The 'Medical Imaging' Physicist in the Emerging World: Challenges and Opportunities

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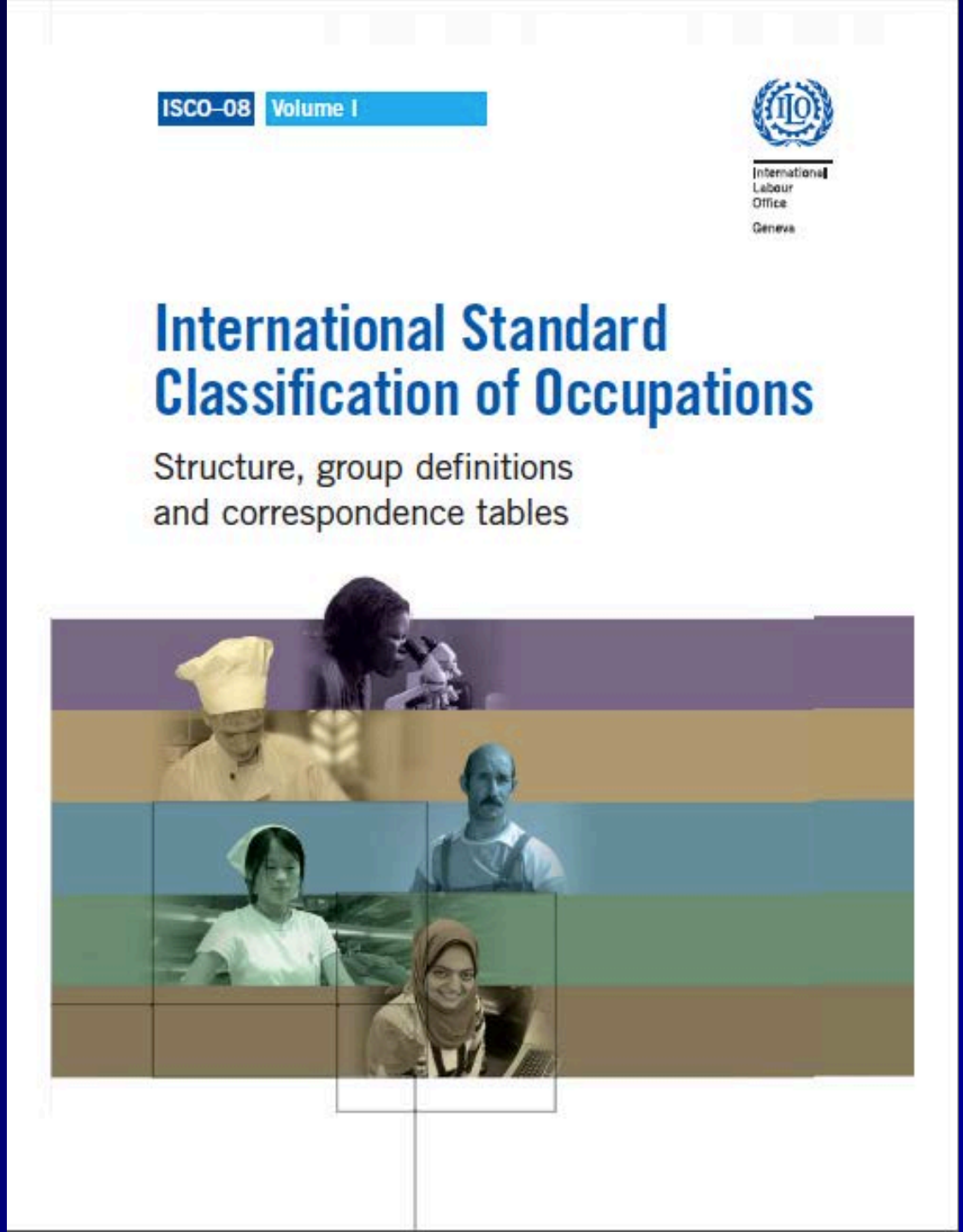
Washington DC, USA



Medical Physicist

Radiation Protection Expert*

***In the US, Health Physicist**

Unit Group 2111

Physicists and Astronomers

Physicists and astronomers conduct research and improve or develop concepts, theories and operational methods concerning matter, space, time, energy, forces and fields and the interrelationship between these physical phenomena. They apply scientific knowledge relating to physics and astronomy in industrial, medical, military or other fields.

Tasks include –

(a) conducting research and improving or developing concepts, theories, instrumentation, software and operational methods related to physics and astronomy;

(b) conducting experiments, tests and analyses on the structure and properties of matter in fields such as mechanics, thermodynamics, electronics, communications, power generation and distribution, aerodynamics, optics and lasers, remote sensing, medicine, sonics, magnetism and nuclear physics;

Examples of the occupations classified here:

- Astronomer
- Medical physicist
- Nuclear physicist
- Physicist

Some related occupations classified elsewhere:

- Radiation oncologist – 2212
- Radiologist – 2212
- Specialist physician (nuclear medicine) – 2212
- Radiographer – 3211

Note

It should be noted that, while they are appropriately classified in this unit group with other physicists, medical physicists are considered to be an integral part of the health workforce alongside those occupations classified in Sub-major Group 22: Health Professionals and others classified in a number of other unit groups in Major Group 2: Professionals.

(d) applying principles, techniques and processes to develop or improve industrial, medical, military and other practical applications of the principles and techniques of physics or astronomy;

(e) ensuring the safe and effective delivery of radiation (ionizing and non-ionizing) to patients to achieve a diagnostic or therapeutic result as prescribed by a medical practitioner;

(f) ensuring the accurate measurement and characterization of physical quantities used in medical applications;

(g) testing, commissioning and evaluating equipment used in applications such as imaging, medical treatment and dosimetry;

(h) advising and consulting with medical practitioners and other health care professionals in optimizing the balance between the beneficial and deleterious effects of radiation;

(i) observing, analysing and interpreting celestial phenomena and developing methods, numerical models and techniques to extend knowledge of fields such as navigation, satellite communication, space exploration, celestial bodies and cosmic radiation;

(j) developing, implementing and maintaining standards and protocols for the measurement of physical phenomena and for the use of nuclear technology in industrial and medical applications;

(k) preparing scientific papers and reports.

ISCO-08

IOMP Policy Statement No. 1

The Medical Physicist: Role and Responsibilities

- Medical physicists are professionals with education and specialist training in the concepts and techniques of applying physics in medicine. Medical Physicists work in clinical, academic or research institutions.

IOMP Policy Statement No. 1

The Medical Physicist: Role and Responsibilities

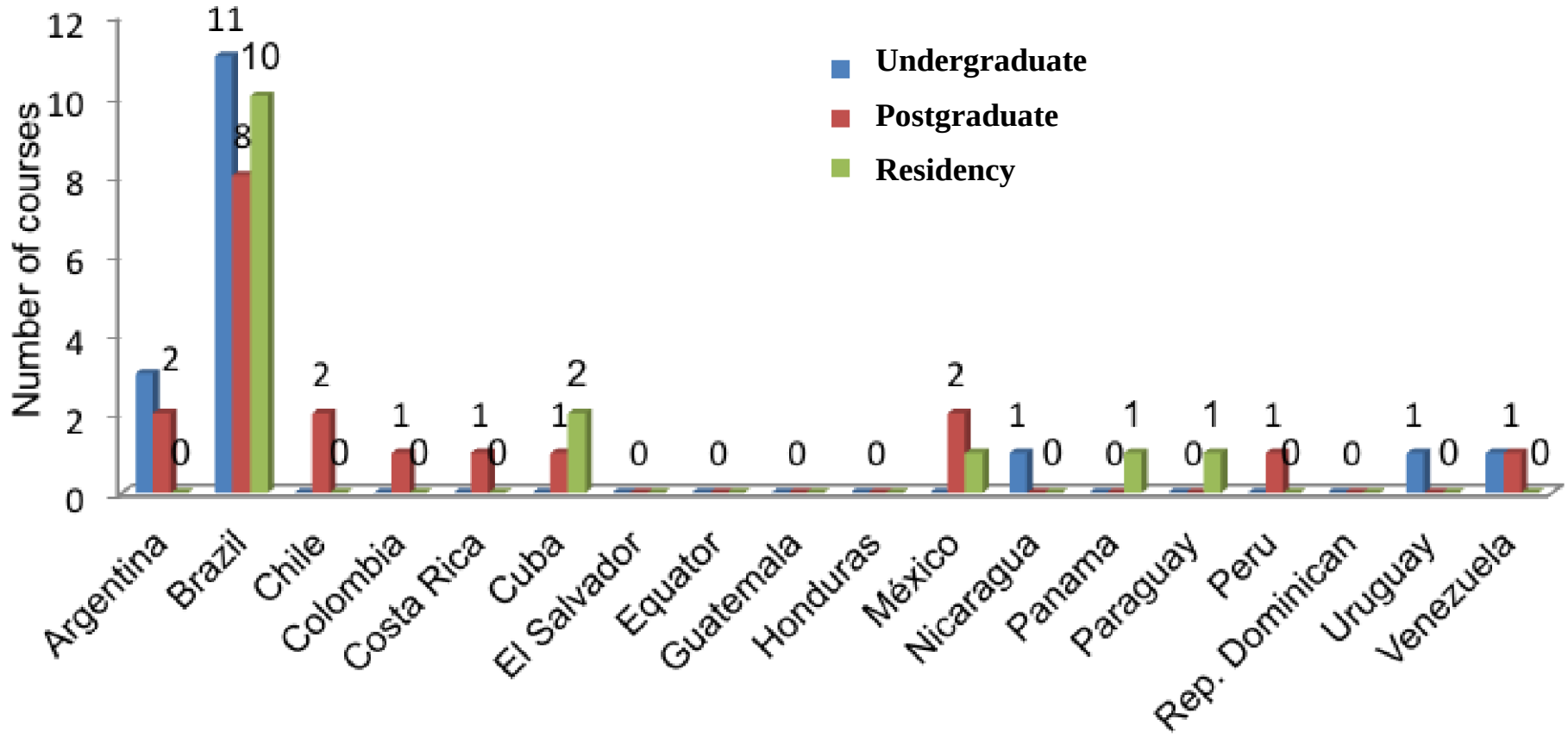
- Medical physicists working in a clinical environment are health professionals, with education and specialist training in the concepts and techniques of applying physics in medicine, competent to practice independently in one or more of the subfields (specialties) of medical physics.

IOMP Policy Statement No. 2

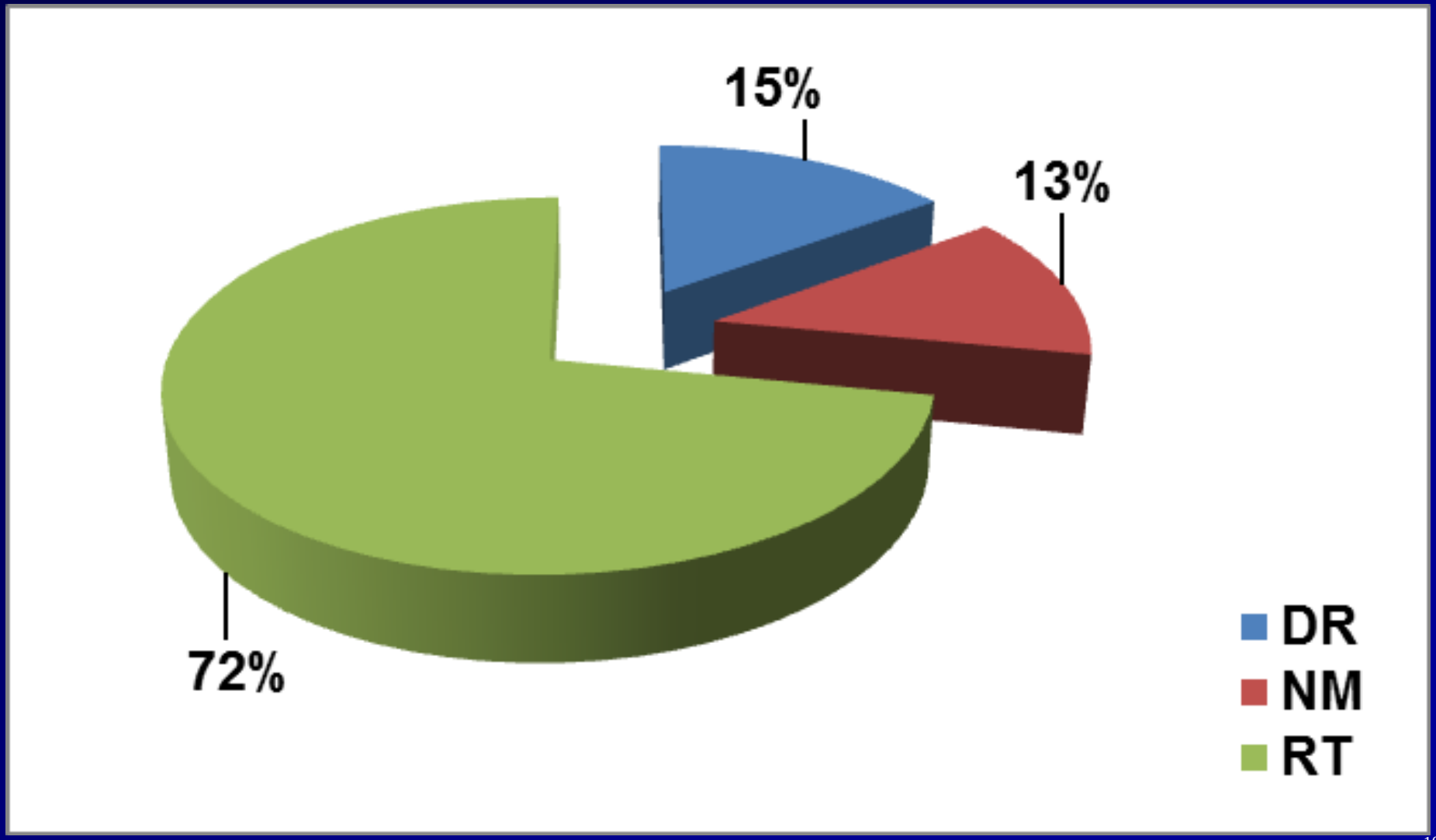
Basic Requirements for Education and Training of Medical Physicists

- The minimum **educational qualification** for a medical physicists is a university degree or equivalent (level corresponding to a **master's degree**) majoring in medical physics or an appropriate science subject.
- Medical physicists who have clinical responsibilities should have received (additionally to their education) a clinical competency training, preferably in the form of a formal **residency** or an equivalent clinical training program, for a duration appropriate to their roles and responsibilities. **(2 year minimum).**

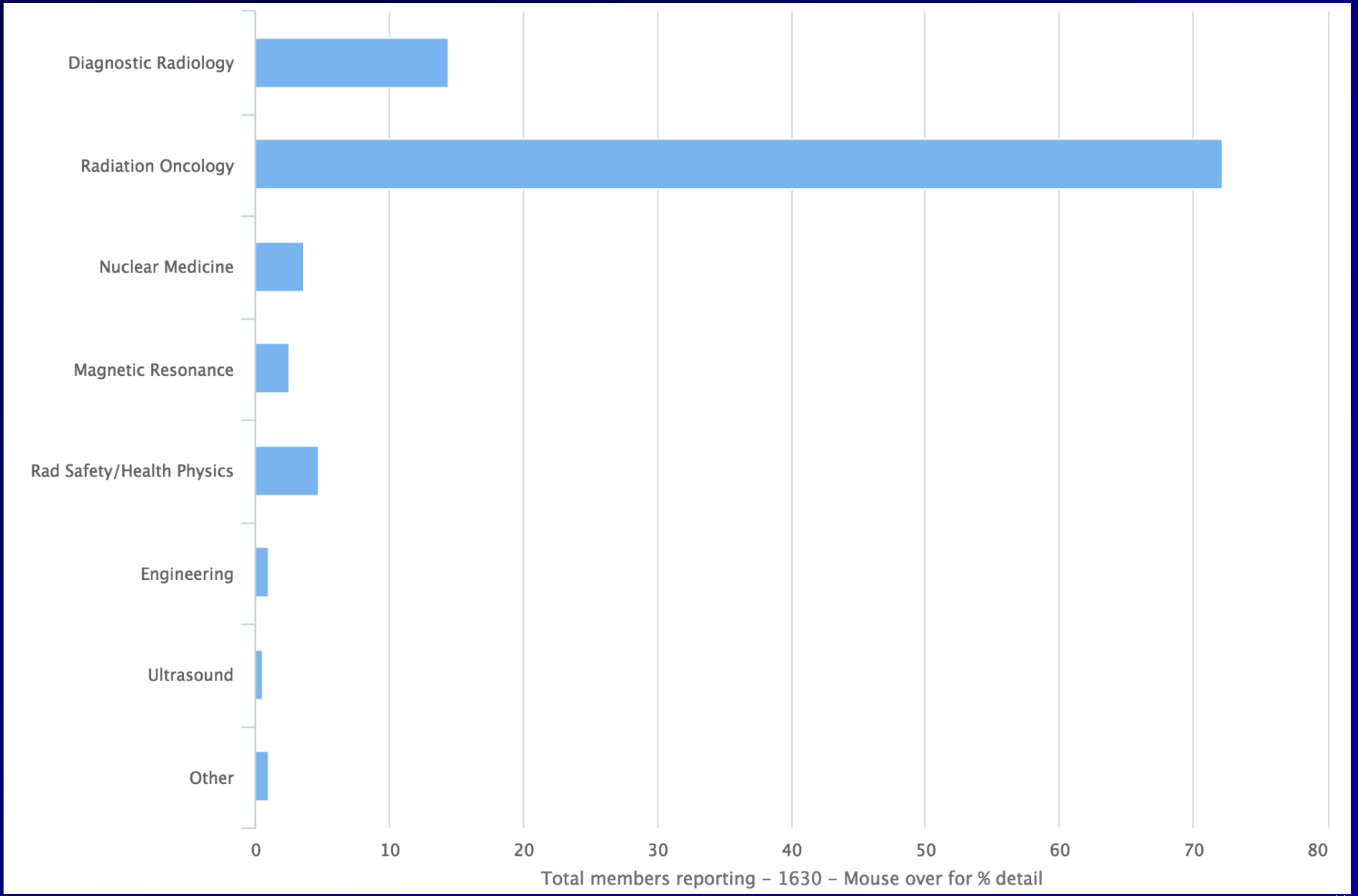
Medical Physics Education in Latin America (2011-2012)



Medical Physicists in Latin America (2011-2012)



Medical Physicists in the USA (2015)



Pathways to Empower Medical Imaging Physicists in the Emerging World

- Legislation/Regulations
- Accreditation Programs

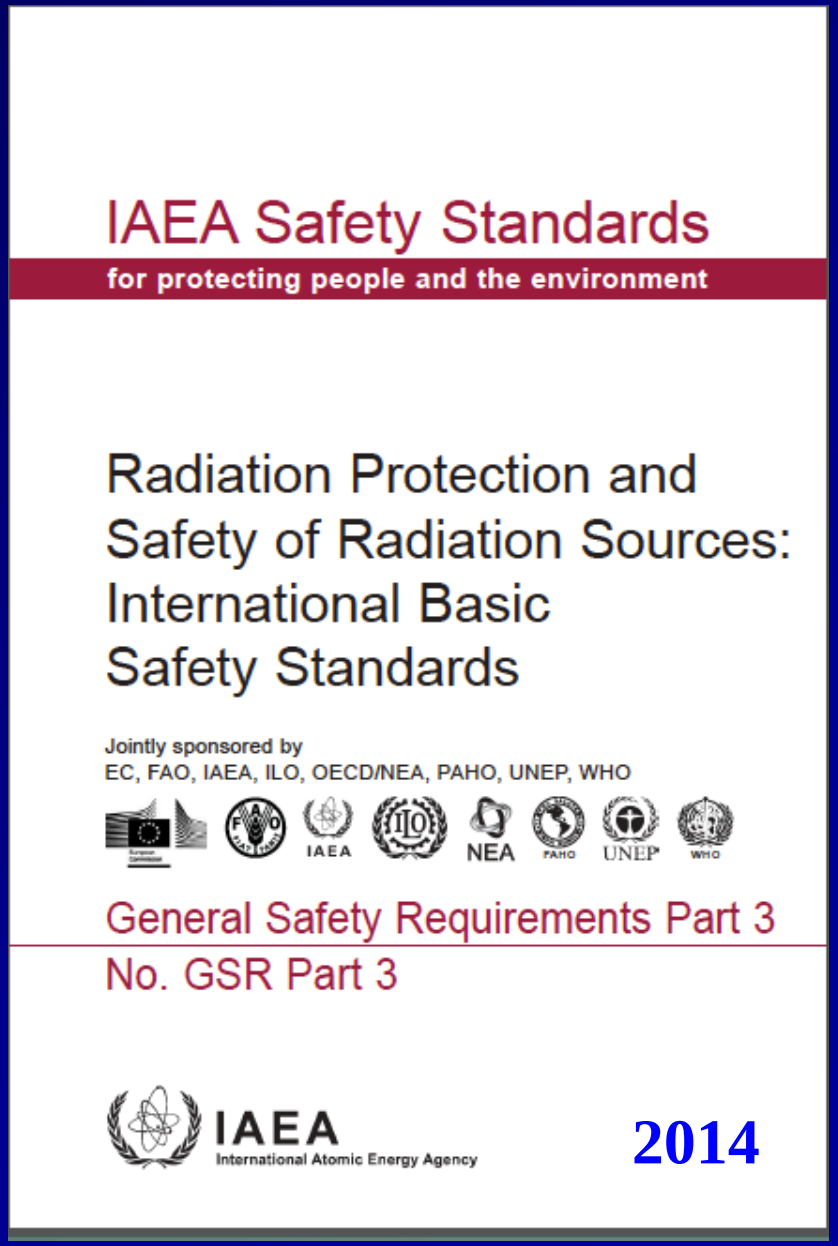
BSS Contents

1. Introduction

REQUIREMENTS

2. General Requirements for Protection and Safety
3. Planned Exposure Situations
4. Emergency Exposure Situations
5. Existing Exposure Situations

SCHEDULES



Responsibilities

PRINCIPAL

- Registrants or licensees, or the person or organization responsible for facilities and activities for which notification only is required;
- Employers in relation to occupational exposure
- Radiological medical practitioners in relation to medical exposure
- Those persons or organizations designated to deal with emergency exposure situations or existing exposure situations.

OTHER PARTIES

a) Suppliers of sources, providers of equipment and software, and providers of consumer products;

b) Radiation protection officers

c) Referring medical practitioners

d) Medical physicists

e) Medical radiation technologists

f) Qualified experts or any other party to whom a principal party has assigned specific responsibilities;

g) Workers other than workers listed in a)–f);

h) Ethics committees.

Medical Physicist

Classified by the International Labor Organization as a profession in the International Standard Classification of Occupations-08 (ISCO-08)

A *health professional*, with specialist education and training in the concepts and techniques of applying physics in medicine, and competent to practise independently in one or more of the subfields (specialties*) of medical physics.

***(e.g. diagnostic radiology, radiation therapy, nuclear medicine)**

IOMP Policy Statement No. 1

Medical Physics Specialties

- Radiation Oncology Physics
- Medical Imaging Physics
- Nuclear Medicine Physics
- Medical Health Physics (Radiation Protection in Medicine)
- Non-ionizing Medical Radiation Physics
- Physiological Measurements

Left to Right: Kin Yin Cheung (AFOMP), Pablo Jiménez (PAHO), Cari Borrás (WHO), Stelios Christofides (EFOMP), Hans Svensson (IOMP).

Medical Physicists, BSS Technical Meeting, IAEA, 2007

Competence of persons is normally assessed by the State by having a formal mechanism for registration, accreditation or certification…

States that have yet to develop such a mechanism need to assess the education, training and competence of any individual proposed by the licensee to act as a medical physicist and to decide, on the basis either of international standards or standards of a State where such a system exists, whether such an individual can undertake the functions of a medical physicist, within the required specialty.

Medical Exposure: Application of the system for protection and safety

- Justification
- Optimization of protection
  - Design and Operational Considerations
  - Calibration, Clinical Dosimetry and QA
- Pregnant or breast-feeding women
- Release of patients after radionuclide therapy
- Unintended and accidental medical exposures
- Radiological review and records

For diagnostic radiological procedures and image-guided interventional procedures,

the requirements of these Standards for medical imaging, calibration, dosimetry and quality assurance, including the acceptance and commissioning of medical radiological equipment, as specified in … are fulfilled by or under the oversight of or with the documented advice of a medical physicist, whose degree of involvement is determined by the complexity of the radiological procedure and the associated radiation risks

Operational considerations

For diagnostic radiological procedures and image guided interventional procedures, the radiological medical practitioner, in cooperation with the medical radiation technologist, the medical physicist, and if appropriate with the radiopharmacist or radiochemist, shall ensure that the following are used:

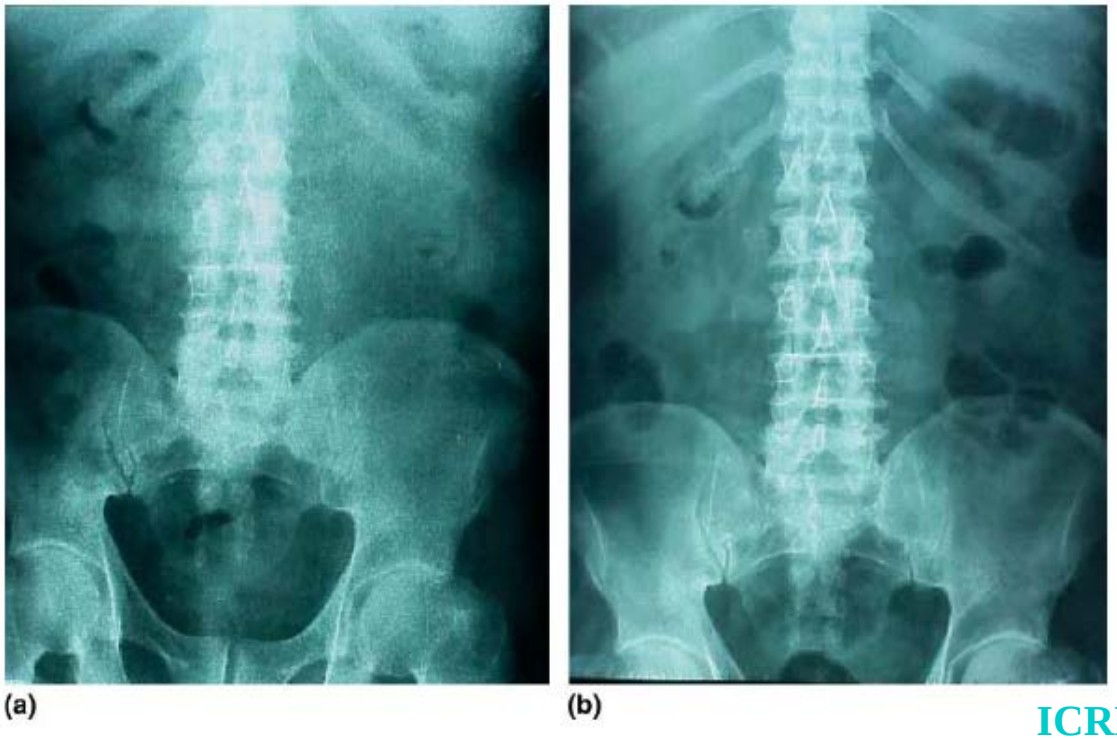
Operational considerations

(a) Appropriate medical radiological equipment and software and also, for nuclear medicine, appropriate radiopharmaceuticals;

Operational considerations

b) **Appropriate techniques and parameters to deliver a medical exposure of the patient that is the minimum necessary to fulfill the clinical purpose of the procedure, with account taken of relevant norms of acceptable image quality established by relevant professional bodies and relevant diagnostic reference levels established in accordance with ...**

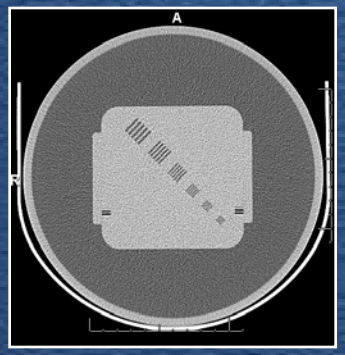
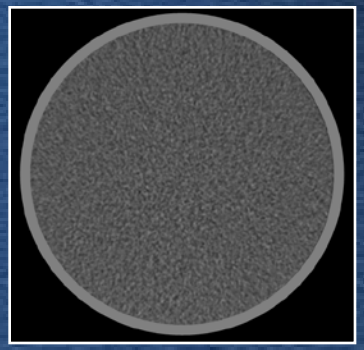
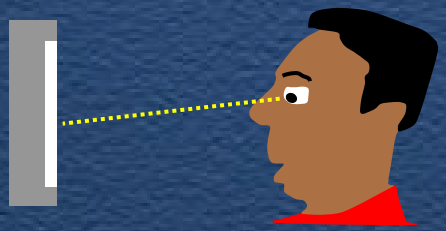
Relative Exposure Index: 1.15
Image too noisy



Relative Exposure Index: 1.87
Image of sufficient quality

ICRP 93

CT image quality evaluation

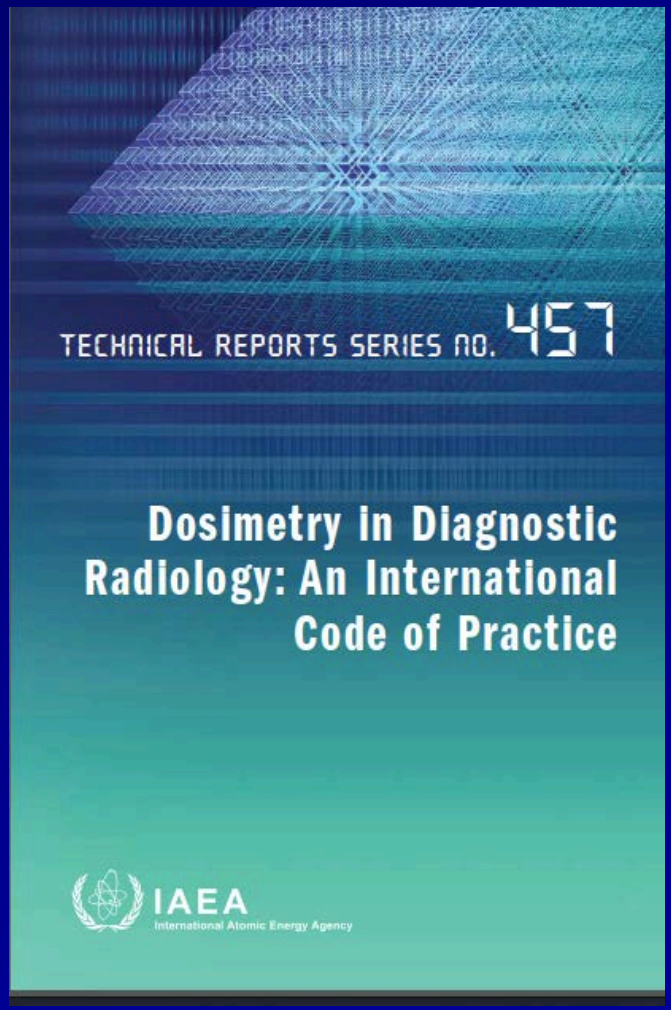
	Old Era	New Era
phantom	 complicated	 basic
analysis	 simple	$MTF(f) = \frac{\int_{-\infty}^{\infty} LSF(x)\ e^{-2\pi i f x}\ dx}{\int_{-\infty}^{\infty} LSF(x)\ dx}$ more sophisticated
results	perfunctory	useful & quantitative

J. Boone RSNA 2009

Calibration

The medical physicist (MP) shall ensure that:

a) All sources giving rise to medical exposure are calibrated in terms of appropriate quantities using internationally accepted or nationally accepted protocols;



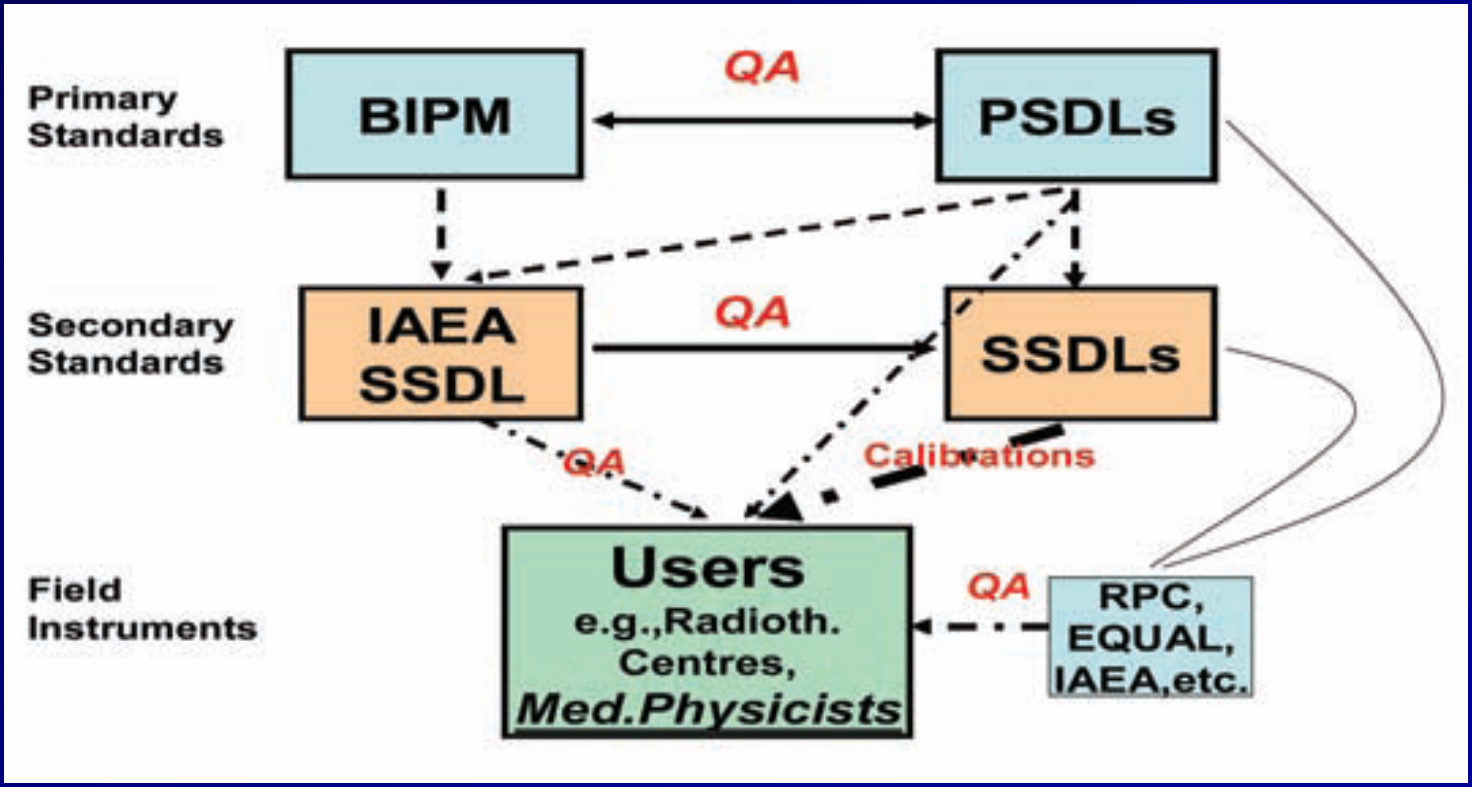
Calibration

The medical physicist (MP) shall ensure that:

b) Calibrations are carried out at the time of commissioning a unit prior to clinical use, after any maintenance procedure that could affect the dosimetry and at intervals approved by the regulatory body;

Calibration - MP

d) **Calibration of all dosimeters used for dosimetry of patients and for the calibration of sources, is traceable to a standards dosimetry laboratory.**



Dosimetry of Patients

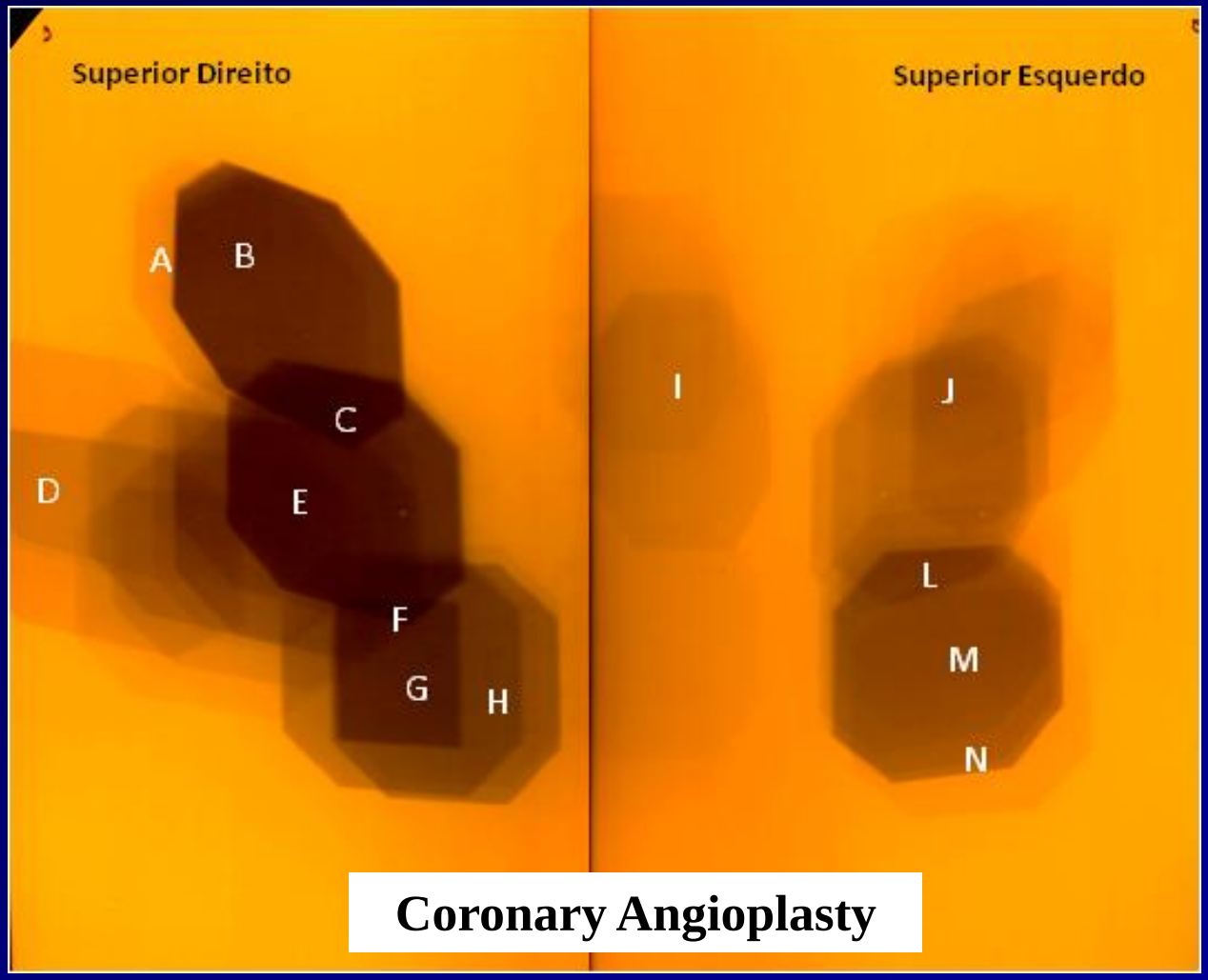
Registrants and licensees shall ensure that dosimetry of patients is performed and documented by or under the supervision of a medical physicist, using calibrated dosimeters and following internationally accepted or nationally accepted protocols, including dosimetry to determine the following:

Dosimetry of Patients – MP

a) For diagnostic medical exposures, typical doses to patients for common radiological procedures;

b) For image-guided interventional procedures, typical doses to patients;

In Interventional Exams, Maximum Skin Dose Can Be Determined With Radiochromic Film

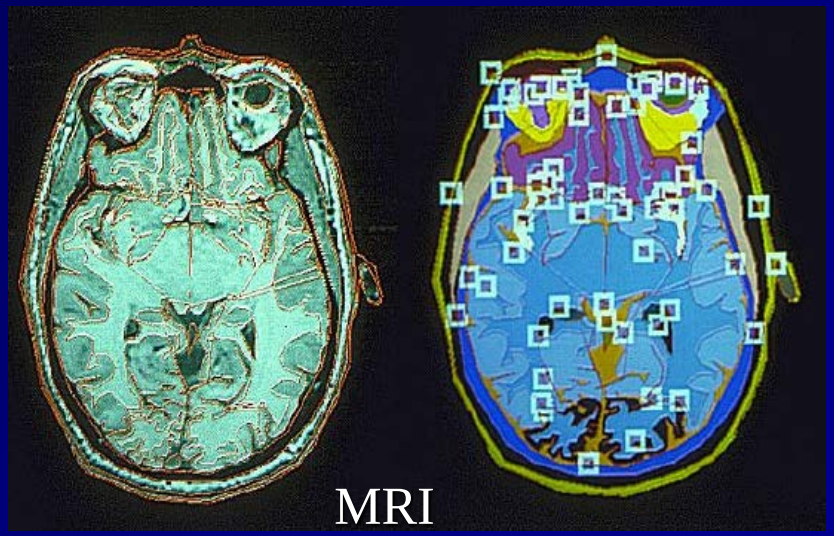


Coronary Angioplasty

Loc	Dose (Gy)
A	0,34
B	1,81
C	3,54
D	0,46
E	3,54
F	1,97
G	1,26
H	0,65
I	0,31
J	1,20
L	1,03
M	0,19
N	0,03

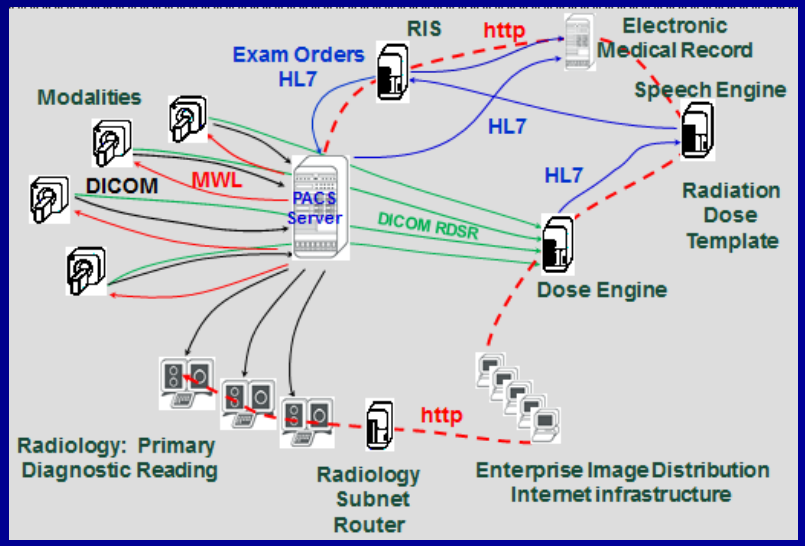
Methods for Determining Organ and Tissue Doses (ICRU 74, 2005)

- Measurements in physical phantoms
- Monte Carlo radiation transport calculations
  - Mathematical phantoms
  - Special features of the active bone marrow
  - Voxel phantoms



Radimetrics eXposure: Dose calculation engine

- Receives CT study
- Extracts patient dose metric information
- Pushes dose metrics to radiology report
- Maintains database
- Provides dashboards

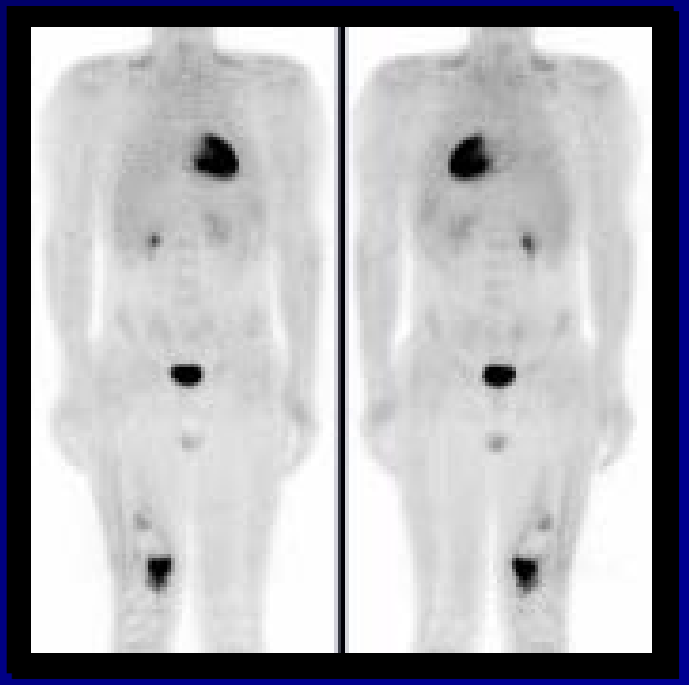


JA Seibert 2013

Quantificação em PET com (^{18}F)FDG

SUV

Standardized Uptake Values



$$SUV = \frac{(atividade\_média/ml)_{tecido}}{(atividade\_total\_injetada/ml)_{corpo\_inteiro}}$$

$$SUV_{massa} = \frac{(atividade\_média/ml)_{tecido}}{(atividade\_total\_injetada/massa\_do\_paciente(g))}$$

Dificuldades na quantificação:

1. Correções e aquisição das imagens
2. Características próprias do paciente e da biodistribuição do radiofármaco.

L.Pozzo

Dose per unit administered activity: Organs receiving the highest radiation dose (adults)

Radiopharmaceutical	First Organ Dose			Second Organ Dose			Third Organ Dose		
	mGy/MBq	Organ	rad/mCi	mGy/MBq	Organ	rad/mCi	mGy/MBq	Organ	rad/mCi
Methyl-C-11 Thymidine	3.20E-02	Liver	1.18E-01	3.10E-02	Kidney	1.15E-01	5.50E-03	Gallbladder	2.04E-02
2-C-11 Thymidine	1.10E-02	Kidney	4.07E-02	5.20E-03	Liver	1.92E-02	3.40E-03	Heart	1.26E-02
O-15 Water	1.90E-03	Hrt Wall	7.03E-03	1.70E-03	Kidneys	6.29E-03	1.60E-03	Liver	5.92E-03
F-18 Fluoro-deoxyglucose	1.60E-01	Bladder	5.92E-01	6.20E-02	Heart	2.29E-01	2.80E-02	Brain	1.04E-01
Rb-82	3.80E-02	Thyroid	1.41E-01	2.00E-02	Adrenals	7.40E-02	1.80E-02	Kidneys	6.66E-02

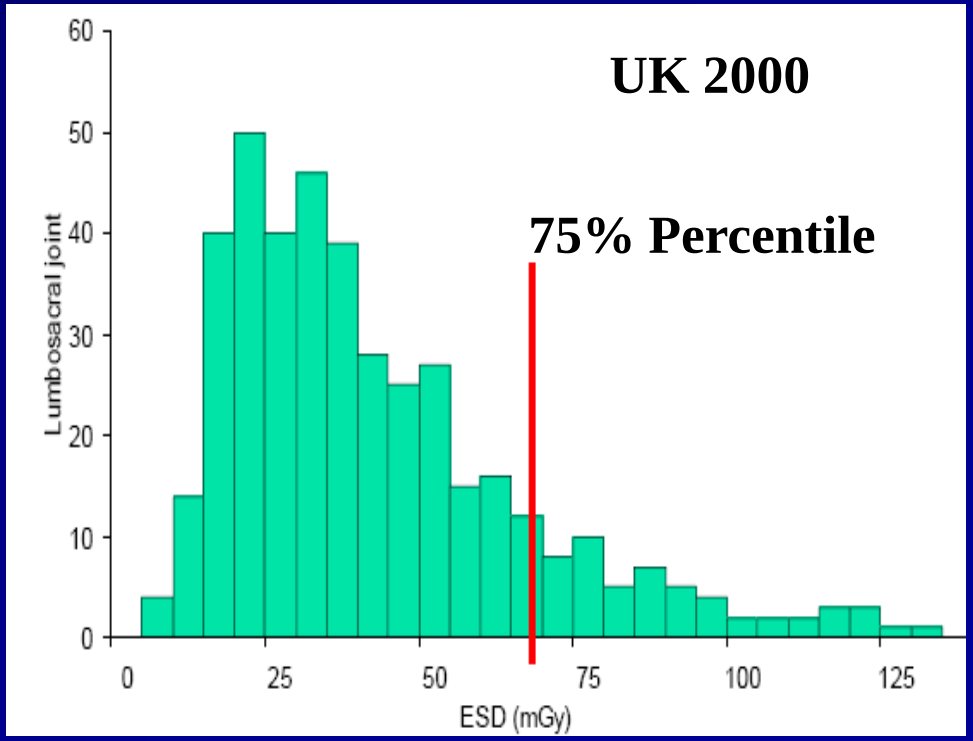
http://www.doseinfo-radar.com/RADAR-INT-NM.htm

To Optimize Patient Radiation Protection

The best way is to establish

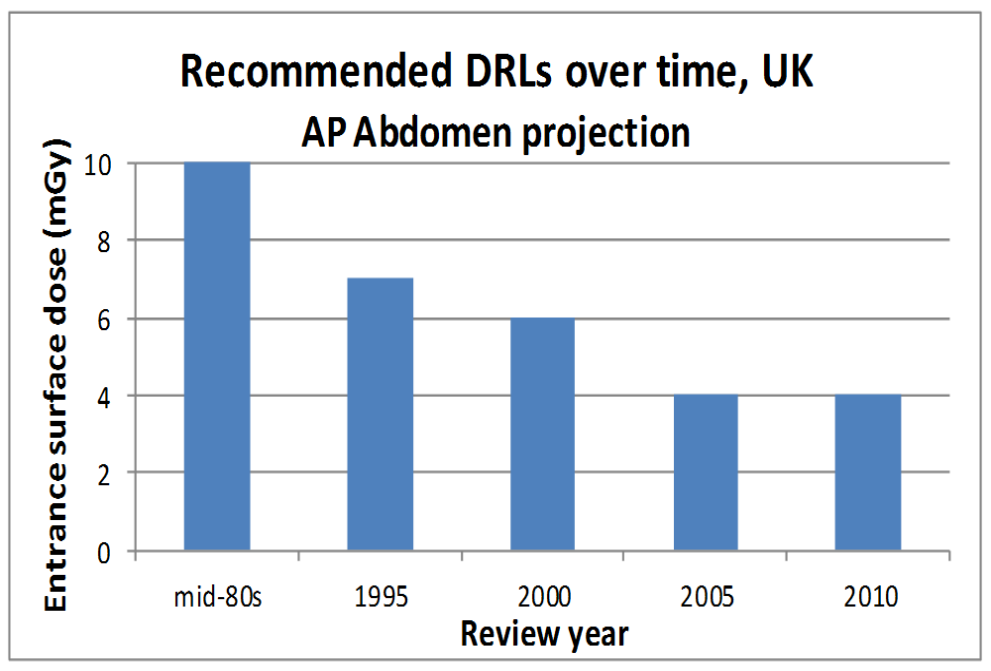
Diagnostic Reference Levels (DRL)

… derived from the data from wide scale quality surveys … for the most frequent examinations in diagnostic radiology...



Diagnostic Reference Levels

Registrants and licensees shall ensure that:



a) **Local assessments, on the basis of the measurements required in … are made at approved intervals for those radiological procedures for which diagnostic reference levels have been established**

Diagnostic Reference Levels

Registrants and licensees shall ensure that:

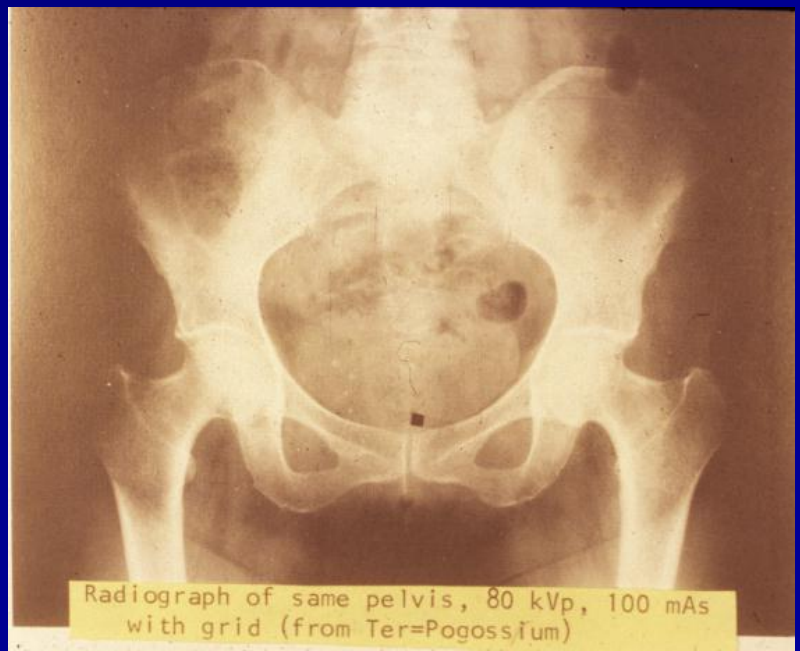
b) A review is conducted to determine whether the optimization of protection and safety for patients is adequate, or whether corrective action is required, if for a given radiological procedure:

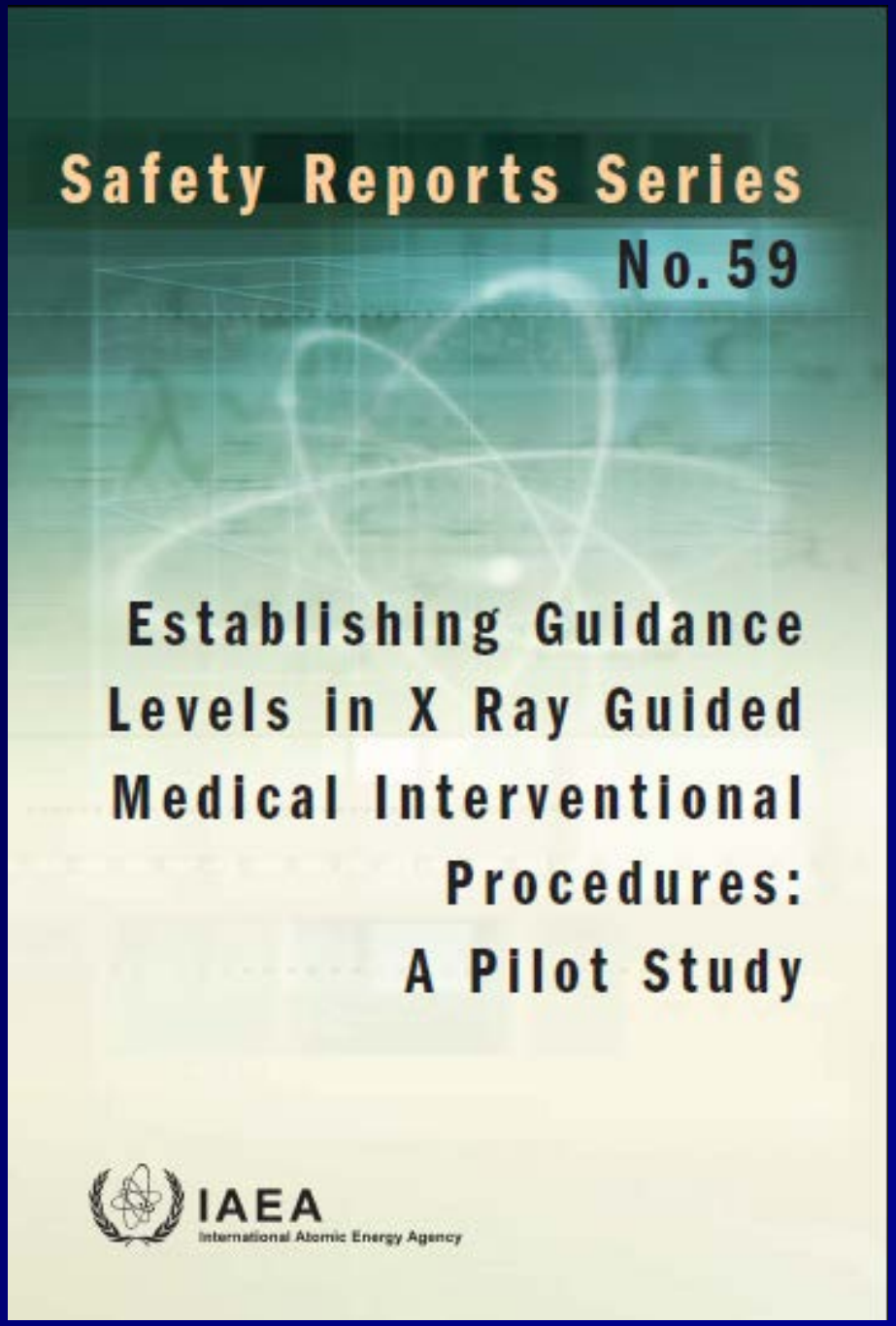
i. typical doses or activities exceed the relevant diagnostic reference level; or

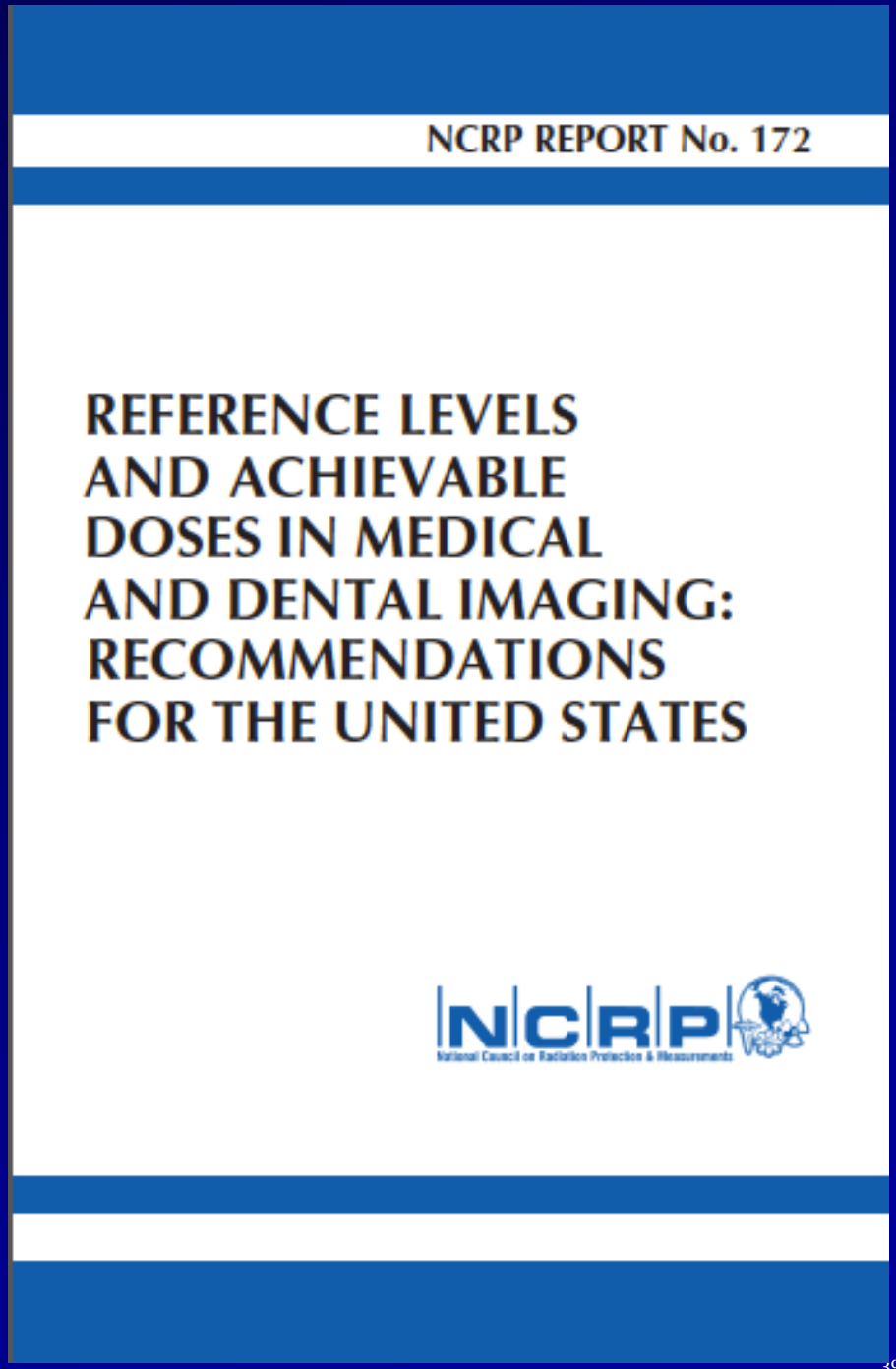
Diagnostic Reference Levels

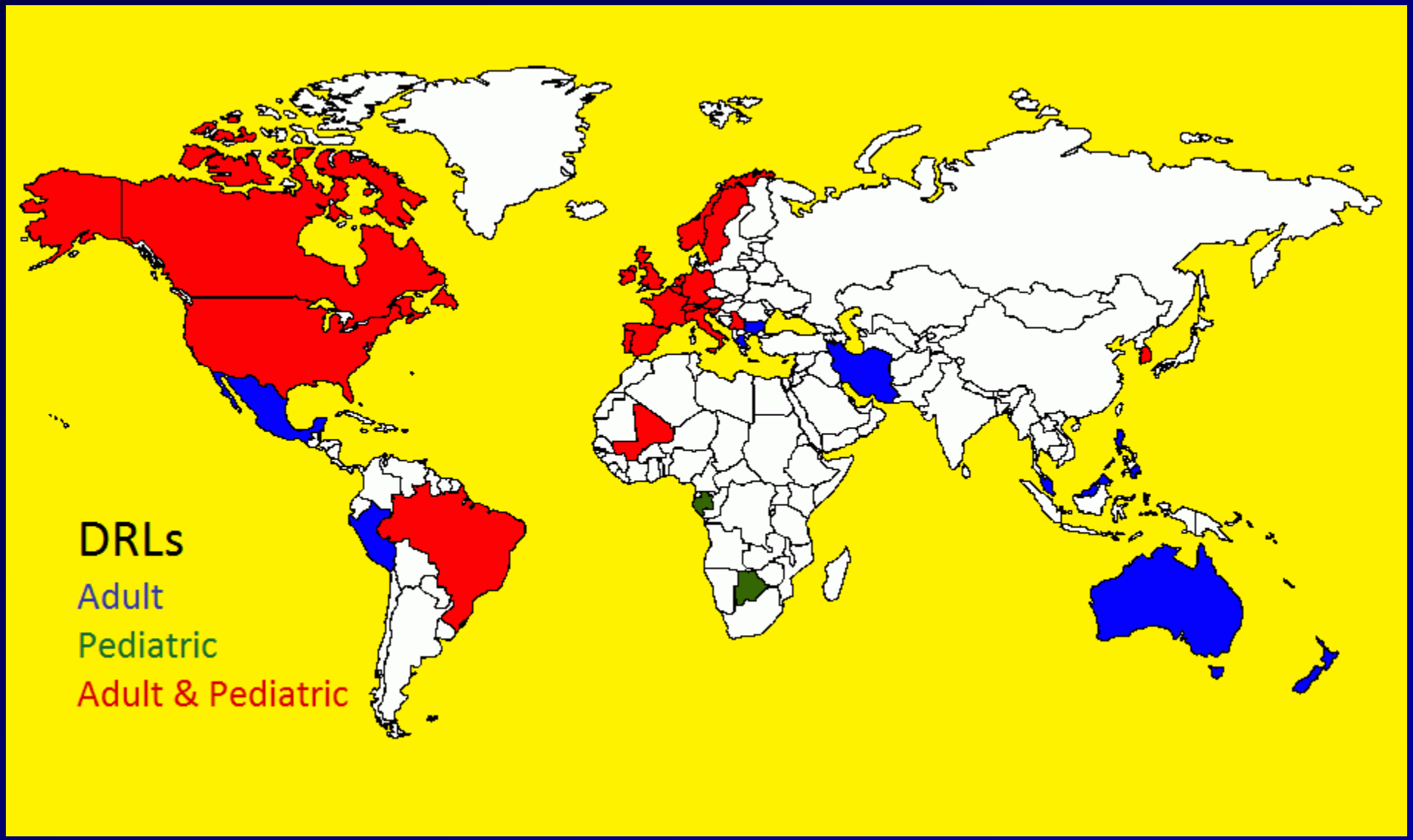
b) A review is conducted … if, for a given radiological procedure:

ii. typical doses or activities fall substantially below the relevant diagnostic reference level and the exposures do not provide useful diagnostic information or do not yield the expected medical benefit to the patient.




Safety Reports Series
No. 59
Establishing Guidance Levels in X Ray Guided Medical Interventional Procedures: A Pilot Study
IAEA
International Atomic Energy Agency


NCRP REPORT No. 172
REFERENCE LEVELS AND ACHIEVABLE DOSES IN MEDICAL AND DENTAL IMAGING: RECOMMENDATIONS FOR THE UNITED STATES
NCRP
National Council on Radiation Protection & Measurements



www.eu-alara.net/index.php/surveys-mainmenu-53/36-ean-surveys/156-drls.html
www.hc-sc.gc.ca/ewh-semt/pubs/radiation/safety-code_35-securite/index-eng.php
NCRP 172
C J Martin et al. Approaches to aspects of optimisation of protection in diagnostic radiology in six continents. IOP PUBLISHING, J. Radiol. Prot. (33), 4, 2013

Country or Region	Diagnostic RL (R, M, F, CT, NM)*		Interventional RL
	Adult (A)	Pediatric (P)	Types (A, P)
Europe			
European Commission	R, M, CT	R, CT	
Austria	R, F, M, CT	R, F, CT	
Belgium	R ,F, M, CT	R, F, CT	
Bulgaria	R ,F, M, CT		
France	R, M, CT, NM	R	2
Germany	R, F, NM	R, F	2 A, 1 P
Greece	M, CT, NM	?	
Ireland	R ,F, CT		
Italy	R, M, CT, NM	R, NM	
Netherlands	R ,F, M, CT	R ,F, CT	?
Norway	R ,F, M, CT	R ,F, CT	
Portugal	R ,F, M, CT	R ,F, CT	
Spain	R ,F, M, CT	R ,F, CT	
Sweden	R,M, CT, NM	R ,F, CT	
Switzerland	R, M, CT	CT, NM	(8 + 4) A
United Kingdom	R, F, CT, NM	R, F, CT	5 A

Quality Assurance for Medical Exposures

Registrants and licensees, in applying the requirements of these Standards in respect to management systems, shall establish a comprehensive programme of quality assurance for medical exposures with the active participation of medical physicists, radiological medical practitioners, medical radiation technologists and, for complex nuclear medicine facilities, radiopharmacists and radiochemists, and in conjunction with other health professionals as appropriate. Principles established by the World Health Organization, the Pan American Health Organization and relevant professional bodies shall be taken into account .

Quality Assurance for Medical Exposures

Registrants and licensees shall ensure that programmes of quality assurance for medical exposures include, as appropriate to the medical radiation facility:

a) Measurements of the physical parameters of medical radiological equipment by, or under the supervision of, a medical physicist:

Quality Assurance for Medical Exposures

i. At the time of **acceptance and commissioning** of the equipment prior to its clinical use on patients;

ii. **Periodically thereafter**;

iii. **After any major maintenance** that could affect protection and safety of patients;

iv. After any installation of new software or modification of existing software …

Quality Assurance for Medical Exposures

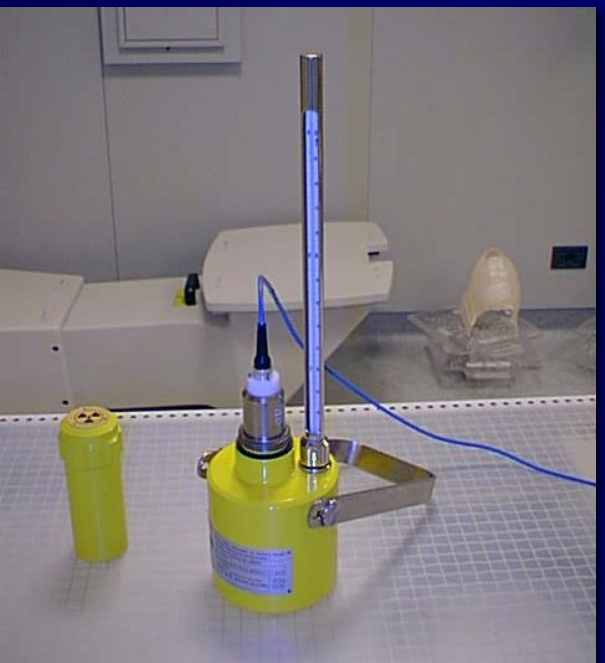
b) **Implementation of corrective actions** if measured values of the physical parameters in a) are outside established control tolerance limits;

c) **Verification of the appropriate physical and clinical factors** used in radiological procedures;

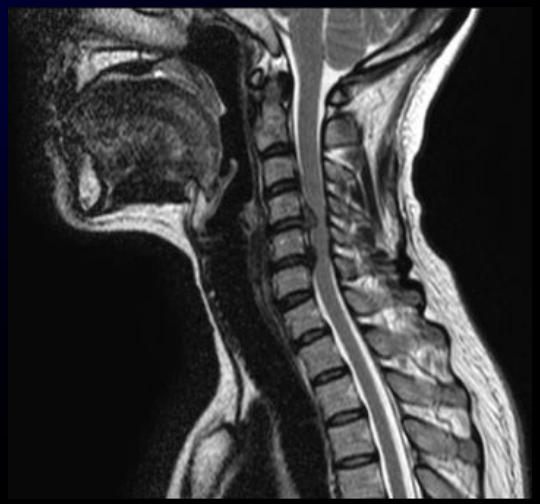
Quality Assurance for Medical Exposures

d) **Maintaining records of relevant procedures and results;**

e) **Periodic checks of the calibration and conditions of operation of dosimetry equipment and monitoring equipment.**



Medical Physicists are Needed in Non-Ionizing Radiation Imaging



Pathways to Empower Medical Imaging Physicists in the Emerging World

- Legislation/Regulations
- Accreditation Programs
- Commercial Pressure?

Top 10 Most Expensive Capital Items - March 2015

Tracks prices of the 10 most expensive capital items purchased during the month by hospitals and other provider organizations.

Common Name	Category	Avg. Cost	One Month Change	12 Month Change
Angio	Radiographic/Fluoroscopic Systems, Angiography/Interventional	$1,084,978	8.3%	-13.8%
Cardiac Mapping	Stereotactic Systems, Image-Guided, Cardiac Mapping/Ablation	$223,107	2.3%	3.3%
CT Radiotherapy Simulation System	Radiotherapy Simulation Systems, Computed Tomography-Based	$550,930	-11.2%	8.9%
CT Scanner	Scanning Systems, Computed Tomography	$732,275	-11.4%	-20.9%
Digital Mammo	Radiographic Systems, Digital, Mammographic	$429,451	3.5%	21.4%
Digital X-Ray	Radiographic Systems, Digital	$222,701	-4.6%	4.4%
Linac	Radiotherapy Systems, Linear Accelerator	$2,707,640	3.5%	-0.1%
MRI	Scanning Systems, Magnetic Resonance Imaging	$1,245,330	-15.9%	-25%
PET/CT	Scanning Systems, Computed Tomography/Positron Emission Tomography	$1,437,612	-1.6%	-3.4%
Radiosurgery	Stereotactic Systems, Image-Guided, Radiosurgical, Linear Accelerator	$2,487,500	-25.4%	-27%

Get more analysis on this technology pricing data from the source, ECRI Institute. | Disclaimer