KETUA PENGARAH KESIHATAN MALAYSIA
Kementerian Kesihatan Malaysia
Aras 12, Blok E7, Kompleks E
Pusat Pentadbiran Kerajaan Persekutuan
62590 PUTRAJAYA
Tel.: 03-8000 8000

Ruj Kami: KKM.600-36/6/4 JLD4(43)
Tarikh : 25/04/2025

Semua Pengarah Kesihatan Negeri
Semua Pengarah Hospital
Semua Pegawai Kesihatan Daerah
Semua Pegawai Pergigian Daerah

Semua Pemegang Lesen
Di bawah Akta Perlesenan Tenaga Atom 1984 (Akta 304)
Bagi Maksud Perubatan

YBhg. Datuk/Dato'/Datin/Tuan/Puan,

SURAT PEKELILING KETUA PENGARAH KESIHATAN MALAYSIA BIL.14/2025

MALAYSIA NATIONAL DIAGNOSTIC REFERENCE LEVEL (DRL) FOR RADIOLOGY AND ORAL AND MAXILLOFACIAL RADIOLOGY (OMFR) 2025

Dengan hormatnya saya merujuk kepada perkara tersebut di atas.

2. Dimaklumkan bahawa Kementerian Kesihatan Malaysia (KKM) telah menyediakan *Malaysia National Diagnostic Reference Level (DRL) for Radiology and Oral and Maxillofacial Radiology (OMFR) 2025* sebagai satu panduan kepada semua fasiliti perubatan yang menggunakan perkhidmatan radiologi dan perkhidmatan oral dan maksilofasial radiologi.

3. Hal ini adalah selaras dengan Peraturan 54 dalam Peraturan-peraturan Perlesenan Tenaga Atom (Perlindungan Sinaran Keselamatan Asas) 2010 di bawah Akta Perlesenan Tenaga Atom 1984 (Akta 304). DRL yang disediakan ini digunakan sebagai panduan supaya:

(a) tindakan pembetulan diambil sebagaimana yang perlu jika dos jatuh dengan banyaknya di bawah nilai DRL dan dedahan itu tidak memberikan maklumat diagnostik yang berguna dan tidak menghasilkan faedah perubatan yang dijangkakan kepada pesakit; dan

..2/-

(b) kajian semula dipertimbangkan jika dos melebihi nilai DRL bagi memastikan perlindungan optimum terhadap pesakit dan mengekalkan aras amalan baik yang sesuai.

4. Di samping itu, dokumen ini turut memperkenalkan nilai *achievable dose* untuk diguna pakai bersama nilai DRL kebangsaan. Nilai ini dapat memberikan maklumat tambahan bagi membantu dalam mengoptimumkan kualiti imej dan dos pesakit.

5. Oleh yang demikian, bersama-sama ini dilampirkan pekeliling *Malaysia National Diagnostic Reference Level (DRL) for Radiology and Oral and Maxillofacial Radiology (OMFR) 2025* untuk rujukan dan panduan.

6. Pekeliling ini adalah berkuatkuasa mulai tarikh surat ini dikeluarkan.

7. Sekiranya terdapat sebarang pertanyaan berkaitan dengan Pekeliling ini, pihak YBhg. Datuk/Dato'/Datin/Tuan/Puan boleh menghubungi Bahagian Kawalselia Radiasi Perubatan, KKM di talian 03-8892 4727 atau emel kepada nurmazaina@moh.gov.my/ najibah.ar@moh.gov.my.

Sekian, terima kasih.

"MALAYSIA MADANI"

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

(DATUK DR MUHAMMAD RADZI BIN ABU HASSAN)

MALAYSIA NATIONAL DIAGNOSTIC REFERENCE LEVEL (DRL)

FOR RADIOLOGY AND ORAL AND MAXILLOFACIAL RADIOLOGY

2025

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Medical Radiation Surveillance Division
Ministry of Health Malaysia
Level 3 & 4, Block E3, Complex E, Precinct 1
Federal Government Administrative Centre
62590 Putrajaya, Malaysia
Tel: +603-8892 4727
E-mail: bkrp@moh.gov.my

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The committee sincerely thanks all the appointed local coordinators for their valuable contribution to the success of this study. Their dedication in gathering the necessary data efficiently and accurately showed great organizational and leadership skills. We also wish to express our heartfelt thanks to all the healthcare facilities that contributed their data to this important study. Without their collaboration and willingness to share crucial information, the development of the Malaysia National DRL would not have been possible.

The committee would also like to express our sincere gratitude to all those who contributed at any stage of the research process, from the creation of the research proposal to the finalization of this report.

1. Introduction and Background of the Establishment of the Diagnostic Reference Level (DRL)

The International Atomic Energy Agency (IAEA) Safety Standards: General Safety Requirements Part 3 (GSR Part 3) define diagnostic reference level (DRL) as:

"a level used in medical imaging to indicate whether, in routine conditions, the dose to the patient or the amount of radiopharmaceuticals administered in a specified radiological procedure for medical imaging is unusually high or unusually low for that procedure."

The International Commission on Radiological Protection (ICRP) Publication 135 defines a DRL as a form of investigation level used as a tool to aid in optimisation of protection in medical exposure of patients in diagnostic and interventional procedures. It is used in medical imaging involving ionizing radiation to indicate whether the radiation dose used for a specific procedure under routine conditions is unusually high or low.

DRL is established for standard procedures based on groups of "standard-sized" patients rather than individual exposures. All individuals who carry out medical radiological procedures should be familiar with the important role of DRL in optimisation. The radiation metric used as a DRL quantity should be easily measurable or readily available. Whenever possible, DRL should be based on clinical tasks.

The concept of DRL is well established and has been widely accepted for many years in the country. Knowledge of trends in medical radiation exposure from the use of diagnostic radiology and their distribution in the Malaysian population is a useful guide on where best to optimize our efforts in order to protect the population in a cost-effective manner. It is also needed in reviewing the Malaysian DRL established in 2013, which is recommended as a guide for medical exposure from various examinations, to avoid unnecessary high patient doses.

Currently, the Atomic Energy Licensing Act 1984 (Act 304) regulates the use of ionizing radiation in Malaysia, including medical applications. All imaging equipment in diagnostic radiology have to undergo annual quality control (QC) tests according to recommendations made by Ministry of Health (MOH). The Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010 [P. U. A (46)] (BSRP 2010) made under the Act 304 defines medical exposure as the exposure incurred by:

i. a patient as part of his medical or dental investigative or diagnostic procedures or treatment;
ii. a person who knowingly assists in the support and comfort of patients, other than a person who is occupationally exposed; or

ii. a person who knowingly assists in the support and comfort of patients, other than a person who is occupationally exposed; or
iii. a volunteer in a medical research programme that involves radiation exposure.

Regulations 5, 42(1), 48(1)(a-b), and 54 of the BSRP 2010 further require the medical institutions to comply with the requirements of medical exposure, namely for diagnostic radiology practices, to ensure that:

i. the exposure of patients is at the minimum level required in order to achieve the intended diagnostic objective; and
ii. the relevant information from previous examinations is taken into account in order to avoid unnecessary additional examinations.

The main objective of Medical Radiation Exposure Study in Malaysia, conducted from 2007 to 2009, was to develop a national database of patient dose in diagnostic imaging with the view of establishing DRL for Malaysia. The study was carried out under actual clinical settings, and did not consider the potential factors that might affect the dose measured. These factors include exposure parameters and performance of the machine. Furthermore, the proposed DRL was based on the third quartile value of the dose distribution collected in the study. However, the study was limited to:

i. adult patients older than 16 years; and
ii. conventional imaging modalities general x-ray, dental x-ray and 2-dimensional (2D) mammography.

The first guidelines on "Malaysian Diagnostic Reference Levels (DRLs) in Medical Imaging (Radiology)" were published in 2013. It was set for the following examinations:

i. eight routine x-ray examination types for general radiography (twelve projections);
ii. eleven examination types for fluoroscopy and interventional radiology;
iii. eight examination types for computed tomography (CT) scan;
iv. three groups of breast thickness for mammography;
v. two examination types for bone mineral densitometry (BMD); and
vi. intraoral and panoramic examinations for dental radiology.

In view of rapid and new developments in diagnostic radiology, it is important that their impact on population exposure and the national DRL (NDRL) is kept under regular review. The MOH, therefore, is initiating a review of the current national DRL and population exposure in diagnostic radiology. "Report on Medical Radiation Exposure for the Development of Malaysian Diagnostic Reference Levels (DRL) in Diagnostic Radiology, Oral and Maxillofacial Radiology, and Nuclear Medicine," is published in 2025.

2. Objective

The primary objective is to review the Malaysian DRL in 2013 and establish new national DRL value in view of promoting the basis of optimisation procedures in diagnostic radiology.

The objective of this document is to fulfill the Section 54 of Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010 [P. U. A (46)] (BSRP 2010) to establish and publish new national DRL, including details of the review of these new national DRL and guidance on the establishment, review and use of DRL.

This document is also to be used as a guidance for the licensee to establish their own facilities DRL in accordance with national DRL.

Furthermore, to guide and assist the authority to monitor in the regular dose audit compliance and practices review for promoting improvement in patient protection.

3. Dosimetric Data

DRL quantities assess the amount of ionizing radiation used for a medical imaging procedure, not absorbed dose to a patient or organ. DRL quantities should be appropriate to the specific study being performed, and to the specific size of the patient. DRL quantities should also:

i. be appropriate to the imaging modality being evaluated;
ii. assess the amount of ionizing radiation applied to perform a medical imaging task; and
iii. be easily measured or determined.

Table 1: The DRL quantities and units used in this national DRL

Modality	Quantities used in this National Protocol	Unit
X-ray Radiography	Entrance Surface Air Kerma ($K_{a,e}$)	mGy
	Air Kerma-Area Product (P_{KA})	mGy.cm^2
Mammography	Mean Glandular Dose (D_G)	mGy
Dental intra-oral	Incident Air Kerma ($K_{a,i}$)	mGy
Dental panoramic	Air Kerma-Area Product (P_{KA})	mGy.cm^2
Fluoroscopy and C-arm fluoroscopy	Air Kerma-Area Product (P_{KA})	Gy.cm^2
	Air Kerma at the Patient Entrance Reference Point ($K_{a,r}$)	mGy
Angiography	Air Kerma-Area Product (P_{KA})	Gy.cm^2
	Air Kerma at the Patient Entrance Reference Point ($K_{a,r}$)	mGy
CT Scan	Computed Tomography Dose Index (Volume) ($CTDI_{vol}$)	mGy
	Dose-Length Product (DLP_t)	mGy.cm
Cone-beam CT (depending on availability of the quantity)	Air Kerma-Area Product (P_{KA})	mGy.cm^2
Bone densitometry	Air Kerma-Area Product (P_{KA})	mGy.cm^2
	Entrance Surface Air Kerma ($K_{a,e}$)	mGy

4. Establishment and Review of National DRL

ICRP Publication 135 defines a national DRL as DRL value set in a country based on data from all or a representative sample of healthcare facilities in that country. A DRL is defined for a specified clinical imaging task. National DRL values are defined as the 75th percentile (third quartile, Q3) of the distribution of the median values of the appropriate DRL quantity observed at each healthcare facility obtained from national surveys.

There are four steps needed to set national DRL:

i. The most commonly performed routine diagnostic examinations are identified and a lexicon defined; for each imaging modality, reference dose quantity or quantities are accepted and identified and measuring method is standardized;

ii. Determined sampling size and select healthcare facilities. In each healthcare facility, dose measurements are performed following the standardized methods; median dose from the patient sample is estimated for each examination and set as a facility dose, usually by a medical physicist;

iii. Facility doses from all or a representative sample of facilities in the country are centrally collected and statistically analysed; DRL should be based on doses measured in various types of hospitals, clinics, and practices representing the typical practice in the country or region; and

iv. Finally, for diagnostic radiology, national DRL are usually set at the rounded 75th percentile of the median distribution of typical doses from each healthcare facility.

A summary on steps in setting national DRL is shown in Figure 1.

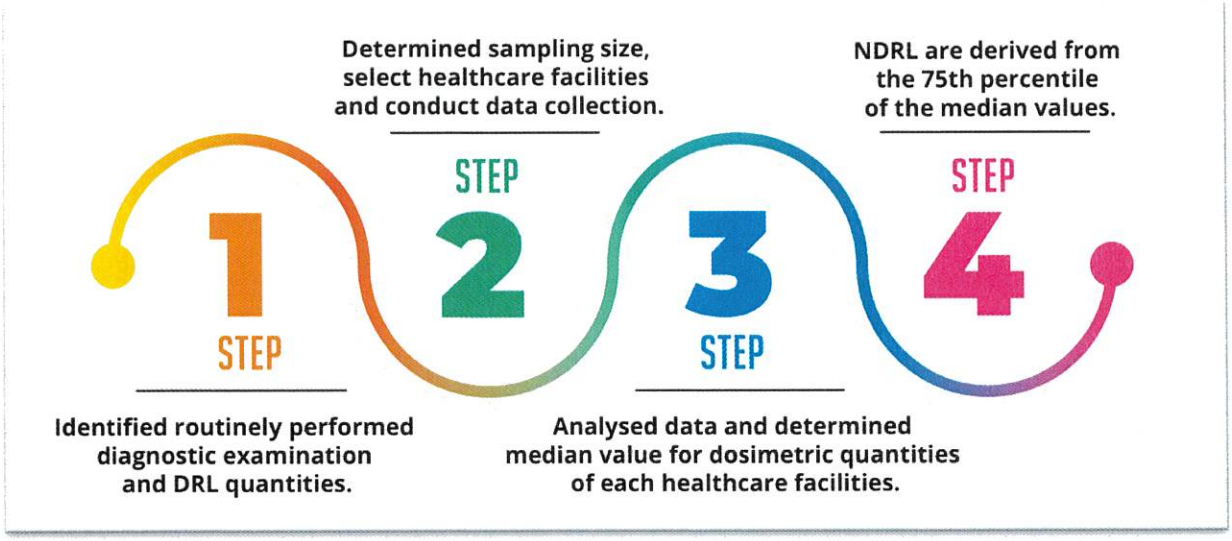

Figure 1: Steps in setting national DRL

A summary of sampling size of healthcare facilities involved in data collection are listed in Table 2.

Table 2: Summary of sampling size of healthcare facilities involved in data collection

Healthcare Facilities
i. Government hospitals
ii. Private hospitals
iii. University hospitals
iv. Ministry of Defence (MinDef) hospitals*
v. Private radiological clinics
vi. General practitioners (GP) clinics
vii. Government health Clinics*
viii. Specialist clinics

Dental Facilities
i. Government hospitals or dental clinics
ii. Private hospitals or dental clinics
iii. University hospitals
iv. Ministry of Defence** (MinDef) hospitals or dental clinics

*Refers to *Klinik Kesihatan (KK)*

**Refers to *Pusat Perubatan Angkatan Tentera (PPAT)* and *Hospital Angkatan Tentera (HAT)*

5. National DRL (NDRL) 2025

The national DRL 2025 has been developed by qualified and experienced radiology and dental personnel through committee appointed by Director General of Health:

i. Steering Committee for the Medical Radiation Exposure Study for the Development of the Malaysia National Diagnostic Reference Level (DRL) *[Jawatankuasa Induk Kajian Medical Radiation Exposure Study Bagi Pembangunan Malaysia Nasional Diagnostic Reference Level (DRL)]*
ii. Working Group Committee for the Medical Radiation Exposure Study Data Collection in the Development of the Malaysia National Diagnostic Reference Level (DRL) [*Jawatankuasa Kumpulan Kerja Pengumpulan Data Kajian Medical Radiation Exposure Study Bagi Pembangunan Malaysia Nasional Diagnostic Reference Level (DRL)]*

The national DRL is developed based on the 75th percentile and the 50th percentile is taken as an achievable dose (Adult: Table 3 – 8, Paediatric and neonates: Table 9 – 12, and Dental and Maxillofacial Radiology: Table 13 – 15).

The median values of the national DRL survey distribution represents what can be accomplished with radiology practice that optimises dose management of dosimetric quantities with respect to clinical image quality goals. Hence, the concept of achievable dose (AD) was introduced and is defined as a level of a DRL quantity 'achievable by standard techniques and technologies in widespread use, without compromising adequate image quality'. These median values provide additional information that can assist in optimising image quality and patient dose.

Important notes: *DRL values shall not be used for individual patients or as trigger (alert or alarm) levels for individual patients or individual examinations. (ICRP 135)*

Table 3: National DRL and achievable dose for adult in general radiography

Types of Procedures	$K_{a,e}$ (mGy)		P_{KA} (mGy.cm^2)	
	NDRL	Achievable Dose	NDRL	Achievable Dose
Chest PA	0.2	0.1	120	91
Chest AP	0.8	0.5	250	191
Abdomen AP	4.1	3.4	2060	1382
Pelvis AP	3.1	2.5	2040	1790

Types of Procedures	$K_{a,e}$ (mGy)		P_{KA} (mGy.cm^2)	
	NDRL	Achievable Dose	NDRL	Achievable Dose
Cervical AP	1.6	1.2	300	231
Cervical LAT	1.1	0.5	350	277
Lumbo-sacral AP	5.4	3.0	1500	1135
Lumbo-sacral LAT	7.3	4.2	2800	1941
Thoracic spine AP	4.0	2.5	760	684
Thoracic spine LAT	6.2	3.5	1800	1156

Table 4: National DRL and achievable dose for adult in fluoroscopy

Types of Procedures	$K_{a,r}$ (mGy)		$P_{K,A}$ (Gy.cm^2)	
	NDRL	Achievable Dose	NDRL	Achievable Dose
All Peripheral Procedures - Antegrade Ureteric Stenting	7.7	3.4	4.1	2.1
Biliary Intervention - ERCP	9.2	5.7	5.9	3.6
Biliary Intervention - PTBD and Antegrade Biliary Stenting	8.8	2.4	NA	NA
Hysterosalpingogram	5.2	2.3	3.0	1.3
Long Bones Fracture - Intramedullary Nails	6.4	1.8	1.0	0.2
Nephrostomy	4.6	1.8	5.7	0.6

Table 5: National DRL and achievable dose for adult in angiography

Types of Procedures	$K_{a,r}$ (mGy)		P_{KA} (Gy.cm^2)	
	NDRL	Achievable Dose	NDRL	Achievable Dose
Head				
Cerebral Embolisation – Aneurysm	3200	1629	310	177
Cerebral Embolisation - AVM/AVF	4700	919	390	195
Cerebral Digital Subtraction Angiography (DSA)	940	389	190	81
Thorax				
All Thoracic Procedure - Bronchial Artery Embolisation	320	270	89	39
All Thoracic Procedure - Central Venoplasty	110	41	21	10
All Thoracic Procedure - SVC Stenting	98	33	42	13
Abdomen				
All Abdominal Embolisation Procedure Except Hepatic	1100	581	340	194
All Pelvic Procedure - Illiac Artery Stenting	290	97	110	19
Hepatic Embolisation	1500	698	340	184
Extremities				
Peripheral Venoplasty	55	36	15	9.3
Percutaneous Transluminal Angioplasty (PTA) - Lower Limb	120	70	40	22
Percutaneous Transluminal Angioplasty (PTA) - Upper Limb	34	17	11	5.8

Types of Procedures	$K_{a,r}$ (mGy)		P_{KA} (Gy.cm^2)	
	NDRL	Achievable Dose	NDRL	Achievable Dose
Cardiac				
Coronary Angiography (CA) + Percutaneous Intervention (PCI)	2200	1636	170	90
Coronary Angiography (CA) - Complex	1200	610	80	50
Coronary Angiography (CA) - Simple	480	342	44	27
Percutaneous Intervention (PCI) - Complex	2800	2269	200	171
Percutaneous Intervention (PCI) - Simple	1300	873	160	99

Table 6: National DRL and achievable dose for adult in CT scan

Types of Examinations	$CTDI_{vol}$ (mGy)		DLP (mGy.cm)	
	NDRL	Achievable Dose	NDRL	Achievable Dose
Abdomen and Pelvis (Routine)	16	13	810	661
Brain (Routine - Single Phase)	50	46	960	854
Coronary (Prospective Gating)	54	35	880	326
Neck - Cervical Spine	18	12	490	386
Neck - Soft Tissue	14	11	400	356
Paranasal Sinuses (PNS)	28	13	430	226
Renal Studies - CTU (for Renal Stone)	13	8.2	500	387
Thorax (Routine)	8.2	6.6	310	259

Types of Examinations	$CTDI_{vol}$ (mGy)		DLP (mGy.cm)	
	NDRL	Achievable Dose	NDRL	Achievable Dose
Thorax, Abdomen, and Pelvis (TAP)	16	9.4	820	692

Table 7: National DRL and achievable dose for adult in mammography

Types of Examinations	D_G (mGy)	
	NDRL	Achievable Dose
Full Field Digital Mammography – CC View	1.6	1.5
Full Field Digital Mammography – MLO View	1.8	1.5
Digital Breast Tomography – CC View	1.9	1.8
Digital Breast Tomography – MLO View	2.3	2.1

Table 8: National DRL and achievable dose for adult in BMD

Types of Examinations	$K_{a,e}$ (mGy)		P_{KA} (mGy.cm^2)	
	NDRL	Achievable Dose	NDRL	Achievable Dose
Lumbar spine	0.67	0.15	30	20
Single hip (L/R)	0.72	0.15	23	15

Table 9: National DRL for paediatric in general radiography

Types of Examinations	Age Group	NDRL	
		$K_{a,e}$ (mGy)	P_{KA} (mGy.cm^2)
Chest AP	1 month to < 4 years	0.17	45
	4 to < 10 years	0.23	70
	10 to < 14 years	0.24	175

Types of Examinations	Age Group	NDRL	
		$K_{a,e}$ (mGy)	P_{KA} (mGy.cm^2)
	14 to < 18 years	0.64	170
Chest PA	1 month to < 4 years	0.1	30
	4 to < 10 years	0.08	50
	10 to < 14 years	0.15	85
	14 to < 18 years	0.19	100
Abdomen AP	1 month to < 4 years	0.23	105
	4 to < 10 years	0.7	395
	10 to < 14 years	1.2	960
	14 to < 18 years	3.6	1550
Pelvis AP	1 month to < 4 years	0.25	450
	4 to < 10 years	0.4	405
	10 to < 14 years	1.1	1165
	14 to < 18 years	2.9	1290

Table 10: National DRL for neonatal general radiography

Type of Examinations	NDRL	
	$K_{a,e}$ (mGy)	P_{KA} (mGy.cm^2)
Chest and abdomen	0.1	40
Chest AP	0.13	30
Abdomen AP	0.14	25

Table 11: National DRL for paediatric in fluoroscopy

Types of Procedures	NDRL	
	$K_{a,r}$ (mGy)	P_{KA} (Gy.cm^2)
Distal Loopogram	0.98	1.9
Lower Gastrointestinal	1.6	0.21
Micturating Cystourethrogram (MCUG)	1.2	0.55
Upper Gastrointestinal	2.7	0.50

Table 12: National DRL for paediatric in CT scan

Types of Examinations	Age Group	NDRL	
		$CTDI_{vol}$ (mGy)	DLP (mGy.cm)
Brain	Less than 1 month	30	455
	1 month to < 4 years	34	600
	4 to < 10 years	42	795
	10 to < 14 years	50	955
	14 to < 18 years	52	985
Chest	Less than 1 month	4.0	90
	1 month to < 4 years	4.0	75
	4 to < 10 years	2.8	80
	10 to < 14 years	6.9	240
	14 to < 18 years	6.8	295
Abdomen	Less than 1 month	NA	NA

Types of Examinations	Age Group	NDRL	
		$CTDI_{vol}$ (mGy)	DLP (mGy.cm)
	1 month to < 4 years	4.8	165
	4 to < 10 years	5.5	235
	10 to < 14 years	9.5	565
	14 to < 18 years	16	775
Chest & Abdomen	Less than 1 month	NA	NA
	1 month to < 4 years	10	320
	4 to < 10 years	9.1	345
	10 to < 14 years	NA	NA
	14 to < 18 years	12	590

Table 13: National DRL for adult and paediatric in dental intraoral

Types of Patients	Types of Examination	NDRL
		$K_{a,i}$ (mGy)
Adult	Intraoral periapical (IOPA) anterior	1.4
	Intraoral periapical (IOPA) posterior	1.5
	Bitewing	1.8
	Occlusal (true/standard/oblique)	3.6
Paediatric	Intraoral periapical (IOPA) anterior	1.0
	Intraoral periapical (IOPA) posterior	1.1
	Bitewing	1.1
	Occlusal (true/standard/oblique)	2.0

Table 14: National DRL for adult and paediatric in dental panoramic tomographic examinations

Types of Patients	Types of Examination	NDRL
		P_{KA} (mGy.cm^2)
Adult	Dental Panoramic Tomograph (DPT)	130
	Lateral cephalometric	30
Paediatric	Dental Panoramic Tomograph (DPT)	110
	Lateral cephalometric	30

Table 15: National DRL for adult and paediatric in dental CBCT

Types of Patients	Types of Examinations	NDRL
		P_{KA} (mGy.cm^2)
Adult	Dentoalveolar (small)	450
	Maxillofacial (medium)	1800
	Skull (large)	2500
Paediatric	Dentoalveolar (small)	400
	Maxillofacial (medium)	1800
	Skull (large)	2500

6. Local DRL (LDRL)

Local DRL (LDRL) is tailored to the practices, equipment, and patient populations of a specific institution or locality. It can be developed for situations such as:

i. National DRL is not available for the identified procedures; or
ii. National DRL is available but local equipment or techniques have enabled a greater degree of optimisation.

National DRL for radiology examinations is based on the 75th percentile value of the distribution of the dosimetric quantities with a minimum sample size of 30 per examination from the healthcare facilities. The establishment of local DRL shall follow similar methods as establishment of national DRL shown in Figure 1.

7. Facility DRL (FDRL)

Facility DRL (FDRL) refers to typical values in ICRP 135 and established by the median of the distribution of the data for a DRL quantity for a clinical imaging procedure. Facility DRL is a basis to form local DRL.

7.1 Establishment of facility DRL

Facility DRL need to be established, regularly reviewed and used, taking corrective action where necessary. If facility DRL exceed or are substantially lower than national DRL values, an investigation must be conducted by the radiological team to ensure optimal practices and intended outcomes are delivered. Both national DRL and facility DRL are to be reviewed when new technologies are introduced, or a medical radiological procedure is changed to ensure that there is adequate optimisation of the procedures to protect patients.

The process for establishing facility DRL is detailed in Figure 2.

7.2 Application of facility DRL

As part of the radiation protection programme, licensee of healthcare facilities must ensure that radiation workers that conduct medical exposures are informed of the role of DRL as a part of optimisation. DRL do not replace professional judgement in connection with individual medical exposures but rather aid in the optimisation of medical exposures.

The first step in using facility DRL is for individual room median values to be compared with the national DRL value. When a DRL value is identified as being consistently exceeded, an investigation of equipment and practices must be conducted immediately to ensure optimisation of safety and protection of patients. When the investigation determines the reason that the DRL is consistently exceeded, corrective actions must be taken without undue delay.

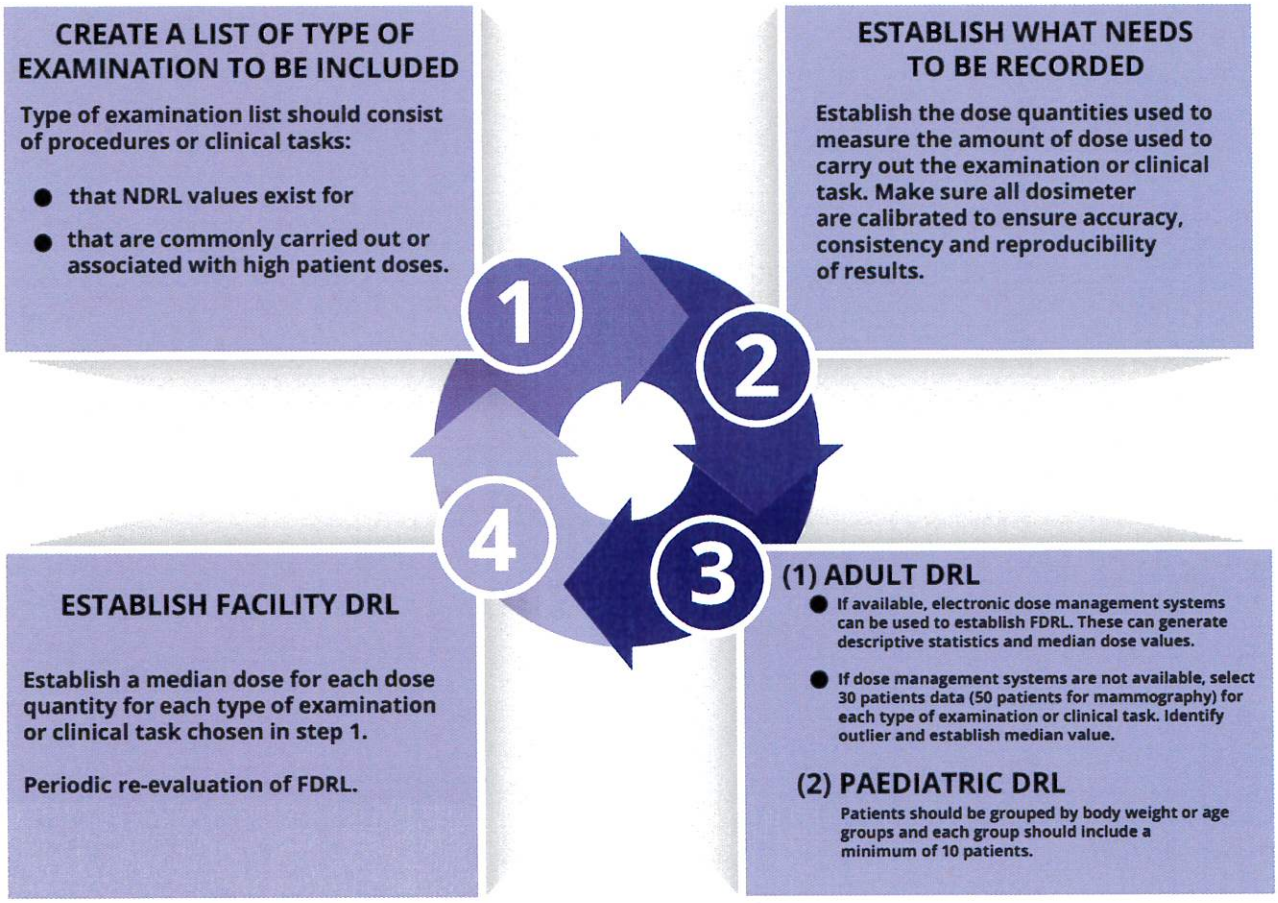

Figure 2: The process for establishing facility DRL

7.3 Review of facility DRL

The development of DRL is a cyclical process and facility DRL must be regularly reviewed. Generally, facility DRL should be reviewed periodically. DRL should also be reviewed when new technologies are introduced, or a medical radiological procedure is changed to ensure that there is adequate optimisation of medical radiological procedures to protect patients.

Figure 3 illustrates the workflow involved in the audit cycle and optimisation process, outlining the key stages from initial data collection through to the implementation of improvements.

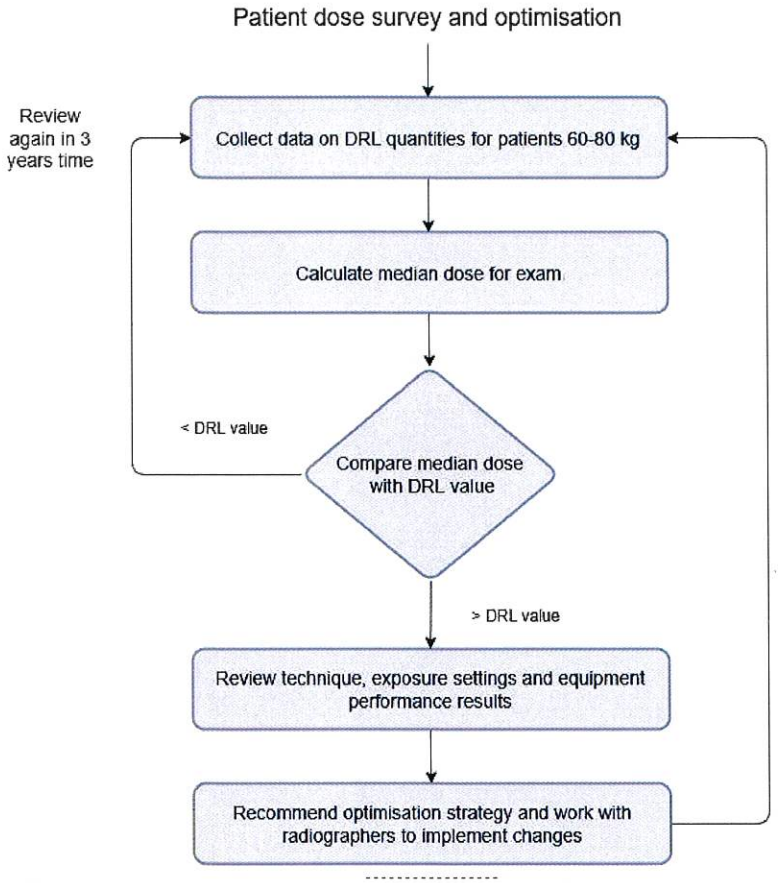

Figure 3: Workflow for audit cycle and optimisation process

7.4 Corrective action for facility DRL

An investigation of equipment and practices must be conducted immediately and corrective actions taken if facility DRL consistently exceeds the national DRL or local DRL. Corrective action based on optimisation of protection should include a review of equipment performance, the settings used, and the study protocols. The factors most likely to be involved are survey methodology, equipment performance, procedure protocol, operator skill, and procedure complexity.

When facility DRL value is substantially below the Achievable Dose (AD), image quality might be affected adversely. Image quality should be prioritised when the study protocol is reviewed.

Meanwhile, Figure 4 presents the decision tree developed to guide corrective actions for the facility DRL. This structured approach helps users systematically identify the necessary actions when comparing facility DRL to national DRL and select the appropriate steps.

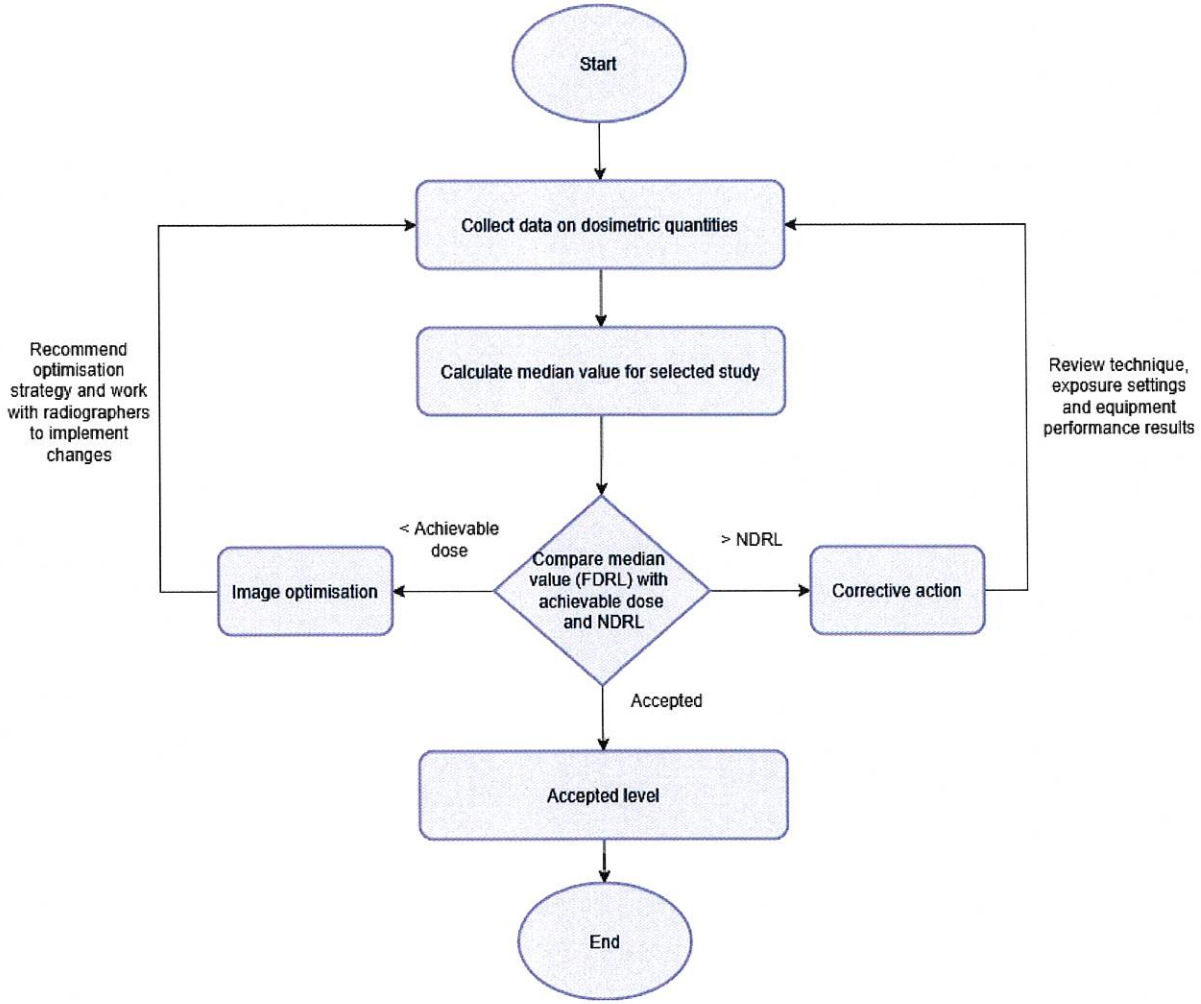

Figure 4: Decision tree for corrective active action for facility DRL

8. Recommendation

The recommendations from the DRL survey focus on improving radiation dose management, enhancing patient safety, and ensuring consistent practices across healthcare facilities in Malaysia. The key overarching themes are:

i. Regular revision of national DRL
   a. Periodic updates of national DRL, to align with technological advancements and evolving clinical practices.

ii. Comprehensive data collection
   a. Standardize data collection procedures to minimize inconsistencies and improve accuracy.

b. Incorporate advanced metrics (e.g. SSDE, procedural complexity) and include newer technologies like dual-energy scanners and AI-driven noise reduction.

iii. Facility DRL
   a. Encourage healthcare facilities to develop and maintain their own DRL, enabling benchmarking and alignment with local or national standards.
   b. Continuous recording and analysis of patient dose data for ongoing optimisation.

iv. Local DRL
   a. Encourage establishment of local DRL for examinations that this survey is not able to make recommendations for national DRL.

v. Collaboration among stakeholders
   a. Establish multidisciplinary teams comprising radiologists, medical physicists, and radiographers to drive DRL development and implementation.
   b. Promote clear communication and collaboration across facilities to unify practices.

vi. Education and awareness
   a. Enhance training and education programs for radiation workers to ensure a deeper understanding of DRL and clinical dosimetry.
   b. Raise awareness about balancing radiation exposure with diagnostic image quality to prioritize patient safety.

vii. Technology and innovation
   a. Leverage advancements in imaging technology and AI to reduce radiation exposure without compromising diagnostic accuracy.
   b. Include specific parameters for newer technologies in data collection and analysis.

viii. Balancing dose and image quality
   a. Emphasize protocols that balance minimal radiation exposure with optimal diagnostic image quality, ensuring patient safety and effective outcomes.

This holistic approach integrates technical, operational, and educational improvements to strengthen the foundation of dose optimisation and patient safety in radiological practices across Malaysia.

9. Conclusion

National DRL values are set for common diagnostic radiology examinations and procedures in Malaysia. These allow licensees to compare their facility DRL, representative of patient dose, to the national DRL. Where facility DRL are deemed too high or too low, an immediate investigation into the cause is required. Corrective actions identified must be recorded. Licensees shall ensure that healthcare professionals and individuals that conduct medical exposures are informed of national DRL and facility DRL to facilitate patient dose optimisation.

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Appendix 1: Glossary of Terms

Achievable dose (AD)
A dose that serves as a goal for optimisation efforts. This dose is achievable by standard techniques and technologies in widespread use, while maintaining clinical image quality adequate for diagnostic purposes. The achievable dose is set at the median value of the dose distribution.

Air kerma-area product (P_{KA})
The integral of the air kerma free-in-air (i.e. in the absence of backscatter) over the area of the x-ray beam in a plane perpendicular to the beam axis. Another acronym used for this quantity is KAP (measured in $mGy.cm^2$). The older terminology is 'dose-area product', which was abbreviated as DAP.

Air kerma at the patient entrance reference point ($K_{a,r}$)
The air kerma at a point in space located at a fixed distance from the focal spot (see Patient entrance reference point) cumulated from a whole x-ray procedure, expressed in Gy. Other terminology refers to this quantity as 'reference air kerma' or 'cumulative air kerma' and acronym used is CAK. This quantity is referred to in older medical publications as 'cumulative dose', 'reference air kerma' and 'reference point air kerma'.

Computed tomography dose index (volume) ($CTDI_{vol}$)
The weighted CTDI, $CTDI_w$, normalised by the helical pitch. $CTDI_w$ is an estimate of the average dose over a single slice in a CT dosimetry phantom, measured in mGy.

Diagnostic reference level (DRL)
A diagnostic reference level is a form of investigation level used as a tool to aid in optimisation of protection in the medical exposure of patients for diagnostic and interventional procedures. It is used in medical imaging with ionising radiation to indicate whether, in routine conditions, the amount of radiation used for a specified procedure is unusually high or low for that procedure.

Dose-length product (DLP)
A parameter used as a surrogate measure for energy imparted to the patient in a computed tomography scan of length L. The DLP unit is mGy.cm.

DRL quantity
A commonly and easily measured or determined radiation metric (e.g. $K_{a,e}$, $K_{a,i}$, $CTDI_{vol}$, DLP, P_{KA}, $K_{a,r}$, and D_G) that assesses the amount of ionising radiation used to perform a medical imaging task. The quantity or quantities selected are those that are readily available for each type of medical imaging modality and medical imaging task.

Entrance-surface air kerma ($K_{a,e}$)
Air kerma on the central x-ray beam axis at the point where the x-ray beam enters the patient or phantom (includes backscattered radiation). The older acronym used is either ESAK or the older term ESD, which is measured in mGy.

Facility DRL (FDRL)
The median of the distribution of the data for a DRL quantity for a clinical imaging procedure. The distribution includes data collected from a particular healthcare facility that has several x-ray rooms.
Facility DRL can be used:

i. as a guide to encourage further optimisation in a facility by providing a facility comparator, in a similar manner to national DRL or local DRL; or
ii. for a single facility to provide a comparator linked to a new technology or technique.

Incident air kerma ($K_{a,i}$)
Air kerma from the incident beam on the central x-ray beam axis at the focal-spot-to-surface distance (does not include backscattered radiation). The older acronym used is IAK, which is measured in mGy.

Local DRL (LDRL)
A DRL for an x-ray procedure set within a few healthcare facilities in Malaysia for a defined clinical imaging task, based on the 75th percentile value of the distribution of the appropriate DRL quantity in a reasonable number (e.g.10–20) of x-ray rooms in a local area. Local DRL may be set for procedures for which no national DRL is available, or where there is a national value but local equipment or techniques have enabled a greater degree of optimisation to be achieved so that a value less than the corresponding national DRL can be implemented.

Mean glandular dose (D_G)
In mammography, D_G is the mean absorbed dose in the glandular tissue of the breast. Glandular tissue is the radiosensitive tissue of the breast. D_G is calculated from either the incident air kerma ($K_{a,i}$) or the entrance-surface air kerma ($K_{a,e}$) used for the specific mammography examination. The conversion from $K_{a,i}$ to D_G is a

function of beam quality (i.e. half value layer), anode material, filtration, breast thickness, and breast composition. The conversion from $K_{a,e}$ to D_G is a function of all these factors as well as adjustment for the backscatter factor from breast tissue. D_G is also called 'average glandular dose' (AGD) (measured in mGy).

Medical exposure

Radiation exposure incurred:

i. by patients as part of their own medical or dental diagnosis or treatment;
ii. by persons, other than those occupationally exposed, knowingly, while voluntarily helping in the support and comfort of patients; and
iii. by volunteers in a programme of biomedical research involving their exposure.

National DRL (NDRL)

National DRL value set in Malaysia based on data from a representative sample of healthcare facilities. A national DRL is defined for a specified clinical imaging task. National DRL values are usually defined as the third quartile (75th percentile) of the distribution of the median values of the appropriate DRL quantity observed at each healthcare facility.

Neonatal

A neonatal patient is a newborn baby receiving medical care, typically within the first 28 days of life.

Appendix 2: List of Committee Member

The Steering Committee for the Medical Radiation Exposure Study for the Development of the Malaysia National Diagnostic Reference Level (DRL) [Jawatankuasa Induk Kajian Medical Radiation Exposure Study Bagi Pembangunan Malaysia Nasional Diagnostic Reference Level (DRL)]

1.	Dr. Norzaini Rose binti Mohd. Zain Head of National Clinical Radiology Expertise KKM (Chairman & Investigator)	Institut Kanser Negara (Radiologi)
2.	Dr. Zunaide bin Kayun@Farni Former Director	Bahagian Kawalselia Radiasi Perubatan
3.	En. Bazli bin Sapiin Director	Bahagian Kawalselia Radiasi Perubatan
4.	Dr. Rosminah binti Md. Kassim Radiologist	Hospital Kuala Lumpur
5.	Dr. Zulkifli Zaki bin Abdul Ghani Radiologist	Hospital Sungai buloh
6.	Brig Jen (Dr) Fazil bin Ibrahim Radiologist	Hospital Angkatan Tentera Tuanku Mizan
7.	Datuk Dr. Abd Kahar bin Abdul Ghapar Cardiologist	Hospital Sultan Idris Shah
8.	En. Mohammad Azwin bin Abdul Karim Medical Physicist	Hospital Kuala Lumpur
9.	Pn. Mary Oomen Kochummen Radiographer	Hospital Tuanku Azizah
10.	Prof. Madya Dr. Noramaliza binti Mohd Noor University representative	Hospital Pengajar UPM
11.	Prof. Madya Dr. Muhammad Khalis bin Abdul Karim University representative	Universiti Putra Malaysia
12.	Dr. Noor Diyana binti Osman University representative	Institut Perubatan & Pergigian Termaju, USM
13.	Prof. Dr. Norlisah binti Mohd Ramli Association representative	College of Radiology (CoR)
14.	Dr. Long Tuan Mastazamin bin Long Tuan Kechik Association representative	Malaysia Medical Association (MMA)
15.	En. Sawal bin Masait Association representative	Malaysian Society of Radiographers (MSR)

Working Group Committee for the Medical Radiation Exposure Study Data Collection in the Development of the Malaysia National Diagnostic Reference Level (DRL) [*Jawatankuasa Kumpulan Kerja Pengumpulan Data Kajian Medical Radiation Exposure Study Bagi Pembangunan Malaysia Nasional Diagnostic Reference Level (DRL)]*

General X-ray & Bone Densitometer

1.	Dr. Azlina binti Abdul Manan Radiologist	Hospital Tengku Ampuan Rahimah
2.	En. Mohd Fairoz bin Mohd Yusuff Medical Physicist	JKN Melaka
3.	Pn. Nornasrifah binti Mohamad Nor Medical Physicist	JK Wilayah Persekutuan
4.	Pn. Mutia Suhaibah binti Abdullah Medical Physicist	JKN Kelantan
5.	Pn. Noorhidayah binti Che Mat Medical Physicist	Hospital Sultanah Bahiyah
6.	Pn. Siti Sarah binti Yusof Medical Physicist	Hospital Tuanku Ja'afar
7.	Pn. Emma Idayu binti Mohammed Kamal Ariffin Medical Physicist	Hospital Sultan Ismail
8.	Pn. Khadijah binti Hamzah Medical Physicist	Hospital Al-Sultan Abdullah, UiTM Puncak Alam
9.	Pn. Nor Hasnida binti Mat Desa Radiographer	Bahagian Pembangunan Kesihatan Keluarga
10.	Pn. Khairun Nisa'a binti Khairul Zaman Radiographer	Hospital Shah Alam

Conventional Fluoroscopy, Interventional Radiology & Interventional Cardiology

1.	Prof Madya Dr Khairul Azmi bin Ab Kadir Radiologist	Pusat Perubatan Universiti Malaya
2.	Prof Dr. Ahmad Sobri bin Muda Radiologist	Hospital Pengajar UPM
3.	Dr. Melisa Lim Seer Yee Radiologist	Hospital Kuala Lumpur
4.	Prof Madya Dr. Nur Yazmin binti Yaacob Radiologist	Hospital Canselor Tuanku Muhriz UKM

5.	Dr. Mohd Rizal bin Roslan Radiologist	Hospital Selayang
6.	Dr. Hafisyatul Aiza binti Zainal Abidin Cardiologist	Fakulti Perubatan Universiti Teknologi MARA Sungai Buloh
7.	Col (Dr) Mohd Rafizi bin Mohamed Rus Cardiologist	Hospital Angkatan Tentera Tuanku Mizan
8.	Dr. Jayamalar Thurairajasingam Orthopedic	Hospital Sultan Ismail
9.	Dr. Zamri bin Ab Rahman Orthopedic	Hospital Shah Alam
10.	Pn. Hazlina binti A. Majid Medical Physicist	JKN Perak
11.	En. Sim Kwan Tack Medical Physicist	JKN Sarawak
12.	Juslia Apau Medical Physicist	JKN Sabah
13.	En. Bakhtiar bin Mohd Ramadhan Medical Physicist	Hospital Sultan Idris Shah
14.	Pn. Wan Nurul Aini binti Wan Ibrahim Medical Physicist	Hospital Sultanah Zahirah
15.	Ts. Wan Nur Ain binti Wan Ghazali Medical Physicist	Hospital Sungai Buloh
16.	En. Muhd Zaidi bin Ab Rahman Radiographer	Institut Jantung Negara
17.	En. Fazlishah bin Abd Wahab Radiographer	Hospital Kuala Lumpur
18.	En. Muhammad Mudzakir bin Zainal Alam Radiographer	Hospital Al-Sultan Abdullah, UiTM Puncak Alam

CT Scanner

1.	Dr. Rofiah binti Ali Radiologist	Hospital Sungai Buloh
2.	Dr. Kama Azira binti Awang @ Ramli Radiologist	Hospital Sultan Idris Shah
3.	Dr. Sarawana Chelwan Muniandy Radiologist	Hospital Kuala Lumpur
4.	Dr. Hanim binti Mohd Taha Radiologist	Hospital Selayang

5.	En. Nik Mohd Bukhari bin Nik Ab Rashid Medical Physicist	JKN Johor
6.	Ts. Wilfred Intang Medical Physicist	JKN Sabah
7.	Pn. Siti Norsyafiqah binti Mohd Mustafa Medical Physicist	Institut Kanser Negara
8.	Pn. Nor Naimah binti Yahaya Medical Physicist	Hospital Tuanku Fauziah
9.	Pn. Roslina binti Ismail Medical Physicist	Hospital Raja Permaisuri Bainun
10.	Pn. Suratey binti Sulaiman Medical Physicist	Hospital Selayang
11.	Pn. Eng Kae Yann Medical Physicist	Hospital Pulau Pinang
12.	Pn. Faeezah binti Harun Medical Physicist	Hospital Kuala Lumpur
13.	Pn. Zaidah binti Maspin Radiographer	Hospital Kuala Lumpur
14.	Pn. Mazli bin Mohd Zin Radiographer	Hospital Canselor Tuanku Muhriz UKM

Mammography

1.	Prof. Dr. Kartini binti Rahmat Radiologist	Pusat Perubatan Universiti Malaya
2.	Dr. Zahurin binti Ismail Radiologist	Institut Kanser Negara
3.	Pn. Nurain binti Borhan Medical Physicist	JKN Selangor
4.	Pn. Nor Hamimah binti Md Non Medical Physicist	JKN Pahang
5.	Pn. Puteri Afini binti Mohd Razak Medical Physicist	Hospital Melaka
6.	Pn. Sharmila binti Mohd Imran Medical Physicist	Hospital Ampang
7.	Pn. Aminah binti Mohamed Medical Physicist	Pusat Perubatan Universiti Malaya
8.	Pn. Fitrina Yusrin binti Yusof Medical Physicist	Kulliyyah of Medicine, Universiti Islam Antarabangsa Malaysia
9.	Pn. Roslaili binti Mohamed Radiographer	Hospital Canselor Tuanku Muhriz UKM

10.	Pn. Rohafiza binti Mohamad Noor Radiographer	Hospital Kuala Lumpur

Paediatric

1.	Prof. Dr. Hamzaini bin Abd Hamid Radiologist	Hospital Canselor Tuanku Muhriz UKM
2.	Dr. Che Zubaidah binti Che Daud Radiologist	Hospital Tunku Azizah
3.	Dr. Caroline Judy Westerhout Radiologist	Pusat Perubatan Universiti Malaya
4.	Prof. Madya Dr. Hasyma binti Abu Hassan Radiologist	Fakulti Perubatan Dan Sains Kesihatan Universiti Putra Malaysia (UPM)
5.	Prof. Dr. Azian binti Abd Aziz Radiologist	Universiti Islam Antarabangsa Malaysia (UIAM)
6.	Pn. Nurul Ezuahani binti Samad Fatimi Radiographer	Hospital Tunku Azizah

Oral and Maxillofacial Radiology (OMFR)

1.	Prof. Dr. Norliza binti Ibrahim University Professor	Fakulti Pergigian Universiti Malaya
2.	Prof. Dr. Phrabhakaran a/l K. N. Nambiar University Professor	Fakulti Pergigian Universiti MAHSA
3.	En. Muhammad Emi Azlee bin Shohini Medical Physicist	JKN Negeri Sembilan
4.	Pn. Nurhizwani binti Hilmi Medical Physicist	JKN Terengganu
5.	Pn. Nurul Hafiza binti Mohamed Salleh Medical Physicist	JKN Perak
6.	Pn. Noor Hasyifah binti Abdullah Medical Physicist	Hospital Sultan Idris Shah
7.	Pn. Nafizatul Khairiah binti Mohd Shamsuri Medical Physicist	Hospital Shah Alam
8.	Ts. Nik Kamarullah bin Ya Ali Medical Physicist	Hospital Universiti Sains Malaysia
9.	En. Ahmad Aziz Farhan bin Rosli Radiographer	Fakulti Pergigian UiTM Sungai Buloh

Secretariat

1.	Pn. Nurmazaina binti Md Ariffin Senior Principal Assistant Director (Principal Investigator)	Bahagian Kawalselia Radiasi Perubatan
2.	Dr. Tan Hun Yee Senior Assistant Director (Investigator)	Bahagian Kawalselia Radiasi Perubatan
3.	Pn. Nur Ashmira binti Aznan Senior Assistant Director (Investigator)	Bahagian Kawalselia Radiasi Perubatan
4.	Pn. Najibah binti Abdul Rahman Senior Assistant Director (Investigator)	Bahagian Kawalselia Radiasi Perubatan

Statistical Advisor

1.	Professor Dr Karuthan a/l Chinna	Faculty of Business and Management, UCSI University

Team for Development of DRL Web Application

1.	Ts. Dr. Adi Izhar bin Che Ani	UiTM Cawangan Pulau Pinang
2.	Dr. Mohammad Nizam bin Ibrahim	UiTM Cawangan Pulau Pinang
3.	Ir. Ts. Dr. Samsul bin Setumim	UiTM Cawangan Pulau Pinang
4.	En. Mohd Ikmal Fitri bin Maruzuki	UiTM Cawangan Pulau Pinang
5.	Ir. Dr. Mohd Firdaus bin Abdullah	UiTM Cawangan Pulau Pinang
6.	Dr. Siti Juliana binti Abu Bakar	UiTM Cawangan Pulau Pinang