



National Diagnostic Reference Level Fact Sheet

What is the definition of a Diagnostic Reference Level?

A Diagnostic Reference Level (DRL), is defined by the International Commission on Radiological Protection (ICRP)¹, as;

“a form of investigation level, applied to an easily measured quantity, usually the absorbed dose in air, or tissue-equivalent material at the surface of a simple phantom or a representative patient.”

The ICRP recommends the establishment of diagnostic reference levels as a tool for optimising the radiation dose delivered to patients in the course of diagnostic and/or therapeutic procedures. The Council of the European Union² defines DRLs as;

“dose levels in medical radiodiagnostic practices or, in the case of radio-pharmaceuticals, levels of activity, for typical examinations for groups of standard-sized patients or standard phantoms for broadly defined types of equipment. These levels are expected not to be exceeded for standard procedures when good and normal practice regarding diagnostic and technical performance is applied.”

The ARPANSA national DRL is the 75th percentile (third quartile) of the spread of the median³ doses of common protocols as recorded from data submitted to the National Diagnostic Reference Level Service. A local facility reference level (FRL) is defined as the median value of the spread of doses for common protocols surveyed at the local radiology facility. The development of DRLs will be derived from the ongoing data submitted to the National DRL Service, which it is assumed, have produced images of acceptable diagnostic quality as defined by the reporting specialist.

What is the objective of DRLs?

The objective of a diagnostic reference level is to help avoid excessive radiation dose to the patient that does not contribute additional clinical information value to the medical imaging task⁴.

- Typically, diagnostic reference levels are used as investigation levels (i.e. as a quality assurance tool), they are advisory and **NOT** a dose limit, therefore should not be applied to individual patients.
- The application of a FRL is for the local imaging facility to establish a reference dose for their common imaging protocols that can be used for internal and external comparison.
- DRLs can also be used for international comparative dosimetry.

What are the applications of DRLs?

DRLs, together with an optimisation process, help reduce unnecessary patient doses and the consequent radiation risks.

A diagnostic reference level can be used to:

- improve local, regional, or national distributions of observed doses for a general medical imaging task, by reducing the frequency of unjustified high or low dose values
- promote a narrower range of doses that represent good practice for a more specific medical imaging task
- promote an optimum range of doses for a specified medical imaging protocol
- provide a common dose metric for the comparison of FRLs between facilities, protocols and modalities
- assess the dose impact of the introduction of new protocols
- provide compliance with the relevant state and territory regulatory requirements⁵.

Appropriate local review and action is required when the doses observed are **consistently** outside the selected diagnostic reference level, unless clinically justified. However this elevated dose with clinical justification should be an exception rather than the norm across multiple DRLs.

How are DRLs used?

FRLs can be used to:

- define local facility doses for common procedures
- compare FRLs with other similar protocols
- compare with other imaging facilities' FRLs
- compare with regional or national DRLs
- provide a comparative dose metric for optimisation strategies
- comply with state and territory regulatory requirements.

DRLs are used to:

- compare against FRLs
- compare with international DRLs
- comply with state and territory regulatory requirements.

What are the regulatory requirements?

State and territory regulatory bodies require implementation of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Code of Practice (RPS 14)⁵ which requires the development and application of diagnostic reference levels.

The ARPANSA Code of Practice (RPS 14), Section 3.1.8 states that

*“the Responsible Person **must** establish a program to ensure that radiation doses administered to a patient for diagnostic purposes are:*

- a) Periodically compared with diagnostic reference levels (DRLs) for diagnostic procedures for which DRLs have been established in Australia; and*
- b) If DRLs are consistently exceeded, reviewed to determine whether radiation has been optimised.”*

In addition, the ARPANSA Safety Guide⁶, Section 7.8, suggests that

“as part of the QA program, patient dose surveys are undertaken periodically to establish that the doses are acceptable when compared with published DRLs.”

The Department of Health & Ageing (DoHA) Diagnostic Imaging Accreditation Scheme (DIAS), the Royal Australian & New Zealand College of Radiology (RANZCR) Quality and Accreditation Program and the Australian College on Healthcare Standards (ACHS) EQulP 5 Accreditation Standards all require compliance with state and territory regulation which in turn requires compliance with the ARPANSA Code of Practice (RPS.14)⁵.

What measurement quantities are commonly used?

From a practical perspective, the DRL should be expressed as an easily measured patient dose-related quantity for the specified imaging platform, for example, multi-detector computed tomography (MDCT):

MDCT examinations – volume computed tomography dose index (CTDI_{vol} , mGy)^{7,8} and the dose-length product (DLP, mGy.cm)^{7,8}. New CT scanners in accordance with Australian Standards, AS/NZS 32002.44⁹, should display the CTDI_{vol} and/or the DLP on the operator’s console after the selection of technique factors and prior to the initiation of x-rays. Average CTDI_{vol} and total DLP should be available at the end of the scan procedure⁸.

Fluoroscopic examinations – dose area product (DAP, mGy.cm²), screening time (sec), number of acquired frames^{7,8}.

General Radiographic examinations (film-screen CR & DR) – either entrance skin dose (ESD, mGy)⁷ or the dose area product (DAP, mGy.cm²)⁸.

Mammography – the mean glandular dose (MGD, mGy)^{7,8}.

Nuclear Medicine – adult reference activity (MBq)⁸.

Estimating Effective Dose (mSv) from DRL assessment

As seen above, different imaging modalities have different basic dose metrics. To compare these dose metrics and gain some information on the radiation dose delivered and the consequent population statistical risk it is useful to convert the individual DRL dose metrics into approximate effective dose (ED, mSv).

MDCT – DLP to ED¹⁰

Fluoroscopy & Radiography – DAP to ED¹¹

Nuclear Medicine – Activity to ED¹²

Mammography – MGD to ED¹³

It should be noted that these effective dose conversions are to be used **with caution**. They should not be applied to an individual but rather are statistical estimates of a dose and risk to a population who may receive that dose.

Australian National DRLs (NDRL)

ARPANSA, in collaboration with other stakeholders, has developed the National DRL Service which facilities can use to compare their doses with the national DRLs and from which dose data will be used to develop and update national DRLs.

Due to its significantly higher population dose contribution, the National DRL Service will initially be applied to MDCT. This will be followed by interventional fluoroscopic procedures, nuclear medicine, mammography and general radiography & fluoroscopy.

The ARPANSA NDRL project will initially give emphasis to the higher dose modalities. ARPANSA will provide an easy to use tool for all modalities but until these are developed and distributed each facility is encouraged to undertake paper based local surveys to establish their own FRLs as soon as possible.

Australian national DRLs for adult and paediatric MDCT are now available and are shown in Tables 1a-c.

Table 1a: Australian Adult (15+ years) MDCT DRLs

Australian Adult (15+ years) MDCT Diagnostic Reference Levels		
Adult Protocol	DLP (mGy.cm)	CTDI_{vol} (mGy)
Head	1000	60
Neck	600	30
Chest	450	15
AbdoPelvis	700	15
ChestAbdoPelvis	1200	30
Lumbar Spine	900	40

For more information see *Adult DRLs information* on ARPANSA's website (<http://www.arpansa.gov.au/services/ndrl/adult.cfm>)

Table 1b: Australian Child (5-14 years) MDCT DRLs

Australian Child (5-14 years) MDCT Diagnostic Reference Levels		
Child Protocol	DLP (mGy.cm)	CTDI_{vol} (mGy)
Head	600	35
Chest	110	5
AbdoPelvis	390	10

Table 1c: Australian Baby/Infant (0-4 years) MDCT DRLs

Australian Baby (0-4 years) MDCT Diagnostic Reference Levels		
Baby Protocol	DLP (mGy.cm)	CTDI_{vol} (mGy)
Head	470	30
Chest	60	2
AbdoPelvis	170	7

For more information see *Paediatric DRLs information* on ARPANSA's website (<http://www.arpansa.gov.au/services/ndrl/paediatric.cfm>)

Examples of UK and European DRLs

Table 2: UK & EU MDCT DRLs¹⁴

Comparison of Head, Chest, and Abdominal CT Dose Values with DRLs Given in European Guidelines (Table 6)

Examination	Mean Value	3 rd -Quartile Value	United Kingdom Study (3 rd -Quartile Value)	European DRL
Head CT				
CTDI _w (mGy)	39	47	66	60
DLP (mGy – cm)	544	527	787	1050
Chest CT				
CTDI _w (mGy)	9.3	9.5	17	30
DLP (mGy – cm)	348	447	488	650
Abdominal CT				
CTDI _w (mGy)	10.4	10.9	19.0	35
DLP (mGy – cm)	549	696	472	780

Note: Data are mean and 3rd quartile values for the examinations performed in the entire patient sample.
CTDI_w – weighted CT dose index.

Table 3: Recommended diagnostic reference doses for general radiography for individual radiographs on adult patients¹⁵

Radiograph	ESD per radiograph (mGy)	DAP per radiograph (Gy cm ²)
Skull AP/PA	3	-
Skull LAT	1.5	-
Chest PA	0.2	0.12
Chest LAT	1	-
Thoracic spine AP	3.5	-
Thoracic spine LAT	10	-
Lumbar spine AP	6	1.6
Lumbar spine LAT	14	3
Lumbar spine LSJ	26	3
Abdomen AP	6	3
Pelvis AP	4	3

Note: Adult is defined as a person of average size (70 to 80 kg)

**Table 4: Recommended diagnostic reference doses for fluoroscopic/
interventional examinations on adult patients¹⁵**

Examination	DAP per exam (Gy.cm ²)	Fluoroscopy time per exam (mins)
Barium (or water soluble) swallow	11	2.3
Barium meal	13	2.3
Barium follow through	14	2.2
Barium (or water soluble) enema	31	2.7
Small bowel enema	50	10.7
Biliary drainage/intervention	54	17
Femoral angiogram	33	5
Hickman line	4	2.2
Hysterosalpingogram	4	1
IVU	16	-
MCU	17	2.7
Nephrostogram	13	4.6
Nephrostomy	19	8.8
Retrograde pyelogram	13	3
Sialogram	1.6	1.6
T-tube cholangiogram	10	2
Venogram (leg)	5	2.3
Coronary angiogram	36	5.6
Oesophageal dilation	16	5.5
Pacemaker implant	27	10.7

Table 5: Recommended fluoroscopic/interventional diagnostic reference doses for complete examinations on paediatric patients¹⁵

Examination	Standard age (y)	DAP per exam (Gy.cm ²)
MCU	0	0.4
	1	1.0
	5	1.0
	10	2.1
	15	4.7
Barium meal	0	0.7
	1	2.0
	5	2.0
	10	4.5
	15	7.2
Barium swallow	0	0.8
	1	1.5
	5	1.5
	10	2.7
	15	4.6

Table 6: Recommended diagnostic reference levels for CT examinations (CTDI_{vol} and DLP)¹⁶

Patient group	Scan region	CTDI _{vol} (mGy) single slice/ multi slice	DLP (mGy.cm) Single slice/ multi slice	
Adults	Brain	55/65	760/930	
	Abdomen (liver metastases)	13/14	460/470	
	Abdomen &pelvis (abscess)	13/14	510/560	
	Chest, abdomen & pelvis (lymphoma staging or follow up)	22/26	760/940	
	Chest (lung cancer)	10/13	430/580	
	Chest Hi-res	3/7	80/170	
Children	Head	30	270	
0-1 yr old	Thorax	12	200	
5 year old	Head	45	470	
	Thorax	13	230	
	10 year old	Head	50	620
		Thorax	20	370

Dose values for adults relate to the 16cm diameter CT dosimetry phantom for examinations of the head and the 32cm diameter CT dosimetry phantom for examinations of the trunk.

All dose values for children relate to the 16 cm diameter CT dosimetry phantom.

Table 7: Recommended diagnostic reference level for mammography for a typical adult patient

For film screen examinations using a grid, the mean glandular dose (MGD) is 2 mGy based on the 4.2 cm acrylic American College of Radiologists phantom¹⁷.

Additionally for Digital Mammography, the MGD shall be ≤ 1 mGy for 2.0 cm PMMA (2.3 cm 50% adipose, 50% glandular breast) and ≤ 4.5 mGy for 6.0 cm PMMA (6.5 cm 50% adipose, 50% glandular breast)¹⁸

Table 8: Sample Australian nuclear medicine DRLs

Procedure Name	Nuclide	Chemical Form	Route of Administration	Most Common Activity ¹⁹ (Mode) (MBq)	Adult Reference Activity ¹⁹ (MBq)	Effective whole body dose ²⁰ (mSv)
Bone Scan	Tc-99m	MDP, HDP	iv	800	900	5.1
Myocardial perfusion – 2 day stress/rest (stress)	Tc-99m	MIBI	iv	600	900	7.1
Myocardial perfusion – 2 day stress/rest (rest)	Tc-99m	MIBI	iv	600	840	7.6
Thyroid	Tc-99m	pertechnetate	iv	200	200	2.6
Lung perfusion	Tc-99m	MAA	iv	200	200	2.2
Renal scan	Tc-99m	MAG3	iv	300	350	2.5

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