

IAEA QUESTION AND ANSWERS

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1. Why do we need DRLs in medical imaging?

Surveys of dose estimates from different imaging modalities highlight the substantial variations in dose between some healthcare facilities for same examination or procedure and similar patient group (adults or children of defined sizes). Such observations indicate the need for standardization of dose and reduction in variation in dose without compromising the clinical purpose of each examination or procedure. Examination-specific or procedure-specific DRLs for various patient groups can provide the stimulus for monitoring practice to promote improvements in patient protection.

2. What is the purpose of DRLs?

DRLs should be set for representative examinations or procedures performed in the local area, country or region where they are applied. National DRLs (NDRLs) should be set on the basis of wide scale surveys of the median doses representing typical practice for a patient group (e.g. adults or children of different sizes) at a range of representative healthcare facilities for a specific type of examination or procedure. NDRLs are commonly set at the third quartile values (the values that splits off the highest 25% of data from the remaining 75%) of these national distributions [IPEM, 2004]. As such, NDRLs are not optimum doses, but nevertheless they are helpful in identifying potentially unusual practice (healthcare facilities where median doses are among the highest 25% of the national dose distribution). DRLs can be also established for a region within the country or, in some cases, regions of several countries. They can also be used to set updated values for new technologies that may allow lower dose levels to be achieved. Where no national or regional DRLs are available, DRLs can be set based on local dosimetry or practice data, or can be based on published values that are appropriate for the local circumstances.

3. How to set DRLs?

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4. Who is responsible for setting and updating DRLs?

The government has a responsibility to ensure that DRLs are established for the country [Requirement 34, [GSR Part 3](#), 2014]. The processes and steps towards establishing DRLs are likely to involve many players, including the imaging facilities, the health authority, the professional bodies, and the regulatory body. In particular there should be collective 'ownership' of the DRLs in deciding on what procedures and what size groups will be used, how the data will be collected, who will manage the data, and when the DRLs should be reviewed and updated. In some countries, a national governmental body administers the national patient dose database that underpins the establishing of DRLs. In other countries, this role may be taken by the regulatory body or a professional body. There is no preferred custodian: what is important is that a patient dose database (for DRLs) is established and maintained, DRL values are set, these are promulgated through the regulatory processes, and a process for periodic review is established. It may be more appropriate to take a regional rather than a national approach to DRLs.

5. Which dose quantities are used for setting DRLs?

- 1 DRLs should be set in terms of the practical dose quantities used to monitor practice. These dose metrics should be easily measurable. The following are commonly used terms [ICRP 2001, IAEA 2007]:
 - For radiography, air kerma-area product (PKA) and entrance surface air kerma (K_a,e) are recommended DRL quantities.

- For fluoroscopy and interventional radiology procedures, air kerma-area product (PKA) is the recommended primary DRL quantity. Air kerma at patient entrance reference point ($K_{a,r}$), fluoroscopy time and number of images are recommended as useful additional DRL quantities (a multiple DRL).
- For CT, volume computed tomography dose index (CTDI_{vol}) and dose length product (DLP) are recommended quantities.
- For mammography and breast tomosynthesis, the recommended DRL quantity is one or more of incident air kerma ($K_{a,i}$), entrance surface air kerma ($K_{a,e}$), or mean glandular dose (DG), with the choice of quantity depending on local practices.
- For dental intra-oral radiography, the recommended quantity is incident air kerma ($K_{a,i}$), and PKA for dental panoramic radiography.
- For nuclear medicine, DRLs are set in activity administered to patient, and/or in administered activity per kg of body mass.

The above dosimetric quantities, their symbols and closely similar quantities are summarized in the following table:

Quantities suitable for setting DRLs				
Quantity	Recommended symbols	Recommended unit	Other common symbols used in literature	Closely similar quantity
Entrance surface air kerma	$K_{a,e}$	mGy	ESAK	Entrance-surface dose (ESD)*
Incident air kerma	$K_{a,i}$	mGy	IAK	
Incident air kerma at the patient entrance**	$K_{a,r}$	Gy	CAK (Cumulative air kerma)	
Air kerma-area product	P_{KA}	mGy.cm ² (radiography and dental), Gy.cm ² (fluoroscopy)	KAP	Dose-area product (DAP)*
Mean glandular dose	D_G	mGy	MGD, AGD	
<p>*Because “air kerma” and “dose in air” are numerically equal in diagnostic radiology energy range.</p> <p>**Also names “cumulative dose”, “reference air kerma” and “reference point air kerma” have been used in the literature</p>				

These quantities are not patient doses that can allow estimation of risk to individuals, but are dose indicators characterizing radiation exposure for the purposes of comparison of practice. There is no merit in setting DRLs in terms of other dose quantities, such as effective dose, that are derived from the well-defined monitoring quantities by coefficients that could vary depending on the particular dose model adopted.

6. How are DRLs used by a healthcare facility?

For each diagnostic imaging system typical levels of dose in related quantities for each type of examination or procedure (and associated clinical indication) should be determined as the median values observed for representative samples of patients of a particular group (adults and children of defined sizes). Mean rather than median was earlier recommended, but the recent recommendations favor median values. These median doses should be compared with the relevant DRLs. Clinical protocols for performing a particular examination or procedure should be reviewed if the comparison shows that the facility's typical dose exceeds the DRL, or that the facility's typical dose is substantially below the DRL and it is evident that the exposures are not producing images of diagnostic usefulness or are not yielding the expected medical benefit to the patient. The resulting actions aimed at improving optimization of protection and safety will usually, but not necessarily, result in lower facility typical doses for the examination or procedure.

7. Do DRLs apply to individual patients?

No, DRLs are general guideline for clinical operations and do not apply directly to individual patients and examinations. DRLs relate to typical practice for a specific examination or procedure and to some extent to clinical conditions (e.g., CT of brain in relation to acute stroke) and patient group (e.g., by age or weight, especially for children), as summarized by median doses observed for a sample of patients. Values of the dose quantities for specific examinations or procedures on

individual patients can be expected to vary somewhat according to patient physique and clinical needs, and so these individual doses should not be compared directly with relevant DRLs, whose purpose is to promote general improvements in overall practice for the examination or procedure. However, an investigation could be considered when doses for a group of individuals are consistently exceeding a DRL, with a view to reviewing and as necessary revising examination or procedure technique for optimized patient protection [[GSR Part 3](#), 2014].

8. What can be done for individual patients?

Individual procedures performed with particular imaging equipment should be optimized according to the specific clinical task and body dimensions of the patient. In that individualization optimization process, the DRL can be used as a starting point and as a benchmark to compare (but not to dictate) the individual applied dose to the operational-based dose values (DRLs). Automatic dose tracking tools may help in the optimization process.

9. What is the difference between national DRLs (NDRLs) and local DRLs (LDRLs)?

NDRL for each examination or procedure and patient group are set on the basis of distributions of the typical (median) doses observed in wide scale (national) surveys, commonly by adopting the third quartile value to provide investigation levels for unusual practice (doses in top 25%). LDRLs represent the typical local practice at a single large centre or group of healthcare facilities, set as the third quartile of the median doses determined from samples of patients in the different healthcare facilities of the group.

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10. Which examinations should have DRLs?

DRLs are intended to promote improvements in patient protection by allowing comparison of current practice. National and local DRLs should

(ideally) be set for each examination or procedure, for each clinical indication and each patient group (adults and children of defined sizes). The examinations or procedures included should represent at least the most frequent examinations performed in the region for which dose assessment is practicable, with priority given to those that result in the highest patient radiation dose. In order to allow meaningful comparison of truly similar examinations or procedures conducted for similar purpose and requiring similar technique, it is crucial to specify detailed descriptions of the examination or procedure, including a clinical indication (such as CT abdomen in relation to liver metastases), rather than simply broad categories of examination or procedure (such as CT abdomen). This usefully allows the comparison of 'apples with apples' rather than a mixed bag of fruit. For interventional practices the complexity of the procedures should be taken into account.

11. How should we account for patient size?

The technique factors required for an examination or procedure and the resulting dose are dependent on patient size and each healthcare facility should establish specific protocols for each patient group as part of optimized practice. Protocols for paediatric examinations can, for example, be developed for patients grouped by ranges of weight or cross-sectional area, reflecting necessary changes in optimized technique. See for more details [here >>](#)

12. Are DRLs effective in improving patient radiation protection?

DRLs have already proved useful as a tool in support of dose audit and practice review for promoting improvements in patient protection. Their application since 1989 in the UK within a coherent framework for managing patient dose has been instrumental in promoting increased awareness of dose and helping to reduce unnecessary x-ray exposure. UK national DRLs for conventional X ray examinations on adult patients, for example, have typically fallen by a factor of two over the last 20 years owing to improvements in imaging practice.

13. Where should I start in the absence of well-established national and local support for DRLs (as, for example, a small facility in a less-resourced country)?

- 1 The priority for a medical facility might be to estimate typical patient dose quantities in relation to present practice for a few common examinations on adult patients, according to the following steps:
 - Record displayed values of radiation dose quantity for samples of 10 or more typical adult patients undergoing procedures for common clinical indications. For example, for CT, consider including examinations of head (e.g. in relation to acute stroke), chest (e.g. in relation to lung cancer) and abdomen (e.g. in relation to acute abdominal pain).
 - Verify the accuracy, and if necessary, apply correction factors, of the displayed values of radiation dose quantities.
 - Calculate for each type of examination the median values of dose quantities (e.g. CTDI_{vol} and DLP for CT); these are your typical dose levels (but not your local DRLs that are set for a group of imaging systems or a group of hospitals).
 - Compare your typical dose levels (median values) with published DRLs for a similar practice in the absence of local or national DRLs, in order to provide a broad indication of your relative performance and urgency of need for improvement in your imaging technique.
 - Comparison of typical dose levels (median values) to DRLs is not sufficient, by itself, for optimisation of protection. Image quality or, more generally, the diagnostic information provided by the examination (including the effects of post-processing), must be evaluated as well.
 - If your values are below published DRL, this does not necessarily indicate satisfactory performance. Imaging techniques should

always be reviewed for potential reduction in their levels of dose without compromising the clinical purpose of the examination.

- If your values are above DRL, there is a more urgent need to investigate whether simple changes can be made to the imaging settings selected for an examination in order to reduce values of radiation dose quantities whilst still providing the required clinical information.
- Levels of dose should be reassessed following revision of imaging technique in order to allow further comparisons (see steps above).

14. What are the potential pitfalls in comparing your typical dose values (medians) with published DRLs?

Published DRLs can prove useful in allowing comparison of median dose values in your facility, for a particular imaging system, although potential problems in this process include the following:

- Published DRLs values from other countries (with potentially different imaging practices and technology) may not be relevant to your particular circumstances.
- The types of examination or procedure specified for the published DRLs (as being with or without detailed clinical indications) may not be directly relevant to your particular practice.
- Published dose values may not have been obtained using the same methodology (e.g. total values or values per projection or per series) or in relation to the same standard condition like CT dosimetry phantom (diameter of 16 cm or 32 cm), or may be given in different dose quantity or unit.
- Published DRLs values may not be expressed in a different dose quantity or dose unit.
- The patient sample (number of patients and their body size) in the published survey may be different.

- Advances in technology, such as post-processing and iterative reconstruction in CT, will need to be taken into account when updating DRLs.

References

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- [IAEA. Dosimetry in Diagnostic Radiology: An International Code of Practice. IAEA, 2007](#)

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