



# European Society of Paediatric Radiology Computed Tomography and Dose Task Force: European guidelines on diagnostic reference levels for paediatric imaging

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## Abstract

The recent European Council Directive 2013/59/EURATOM requires the establishment of diagnostic reference levels (DRLs) to optimise radiation dose in diagnostic and interventional radiology procedures. At the time this directive was enacted, just a few European countries had already set paediatric DRLs and many of these were outdated. For this reason, the European Commission launched a project addressing European Guidelines on Diagnostic Reference Levels for Paediatric Imaging that was awarded to a consortium led by the European Society of Radiology with the collaboration of the European Society of Paediatric Radiology and other European stakeholders involved in the radiation protection of children. The main aims of this project were to establish European DRLs to be used by countries without their own national paediatric DRLs and to provide a consistent method to establish new DRLs in the future. These European guidelines have been very recently endorsed by the European Commission and published in issue N° 185 of the Radiation Protection series. The purpose of this article is to introduce these guidelines to the wide community of paediatric radiologists.

**Keywords** Children · Diagnostic radiology · Diagnostic reference levels · Guidelines · Interventional radiology

## Introduction

Diagnostic reference levels (DRLs) are radiation dose levels in medical radiodiagnostic and interventional radiology procedures for typical examinations in groups of standard-sized patients, or standard phantoms, for broadly defined types of

equipment [1]. DRLs should not be exceeded for standard radiologic procedures when standard good practice is applied. Therefore, DRLs are a very useful tool to help optimise patient dose in diagnostic and interventional radiology procedures. The introduction and usage of DRLs were recommended by the International Commission on Radiological Protection (ICRP) in 1991 [2] and introduced by the European legislation in 1997 through the Medical Exposure Directive 97/43/EURATOM [1]. In 1999, the International Commission published “Radiation Protection 109: Guidance on diagnostic reference levels for medical exposure” [3], highlighting the role of paediatric DRLs and introducing European DRLs for 5-year-old children. The subsequent Council Directive 2013/59/EURATOM [4] strictly stipulated the need for the establishment of national DRLs by the member states, and also for interventional procedures, where appropriate.

Nevertheless, fewer than half of the European countries had established DRLs for at least a limited set of common paediatric examinations at the time directive 2013/59/EURATOM was enacted. In many countries, the available national paediatric DRLs were adopted from other countries or from the old European Commission recommendations. Only a few countries based their own DRLs on

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nationwide patient dose surveys. Moreover, comparison among the available national DRLs was difficult, as there was little consistency within patient groups according to age or weight. Therefore, detailed guidelines were needed for advice on how to carry out future national surveys to establish new national DRLs in order to make them comparable, suitable and, hence, relevant for use at the European level.

The European Commission recognised this need and in December 2013 launched a tender project on European Guidelines on Diagnostic Reference Levels for Paediatric Imaging (PiDRL). This tender project was awarded to a consortium led by the European Society of Radiology (ESR) with the participation of other European stakeholders and professional societies involved in radiation protection in children. This is of particular importance for the European Society of Paediatric Radiology (ESPR). It was a strategic opportunity to unite with other world-class stakeholders including the European Federation of Organisations for Medical Physics, the European Federation of Radiographers Societies, and the Finnish Radiation and Nuclear Safety Authority, along with the Luxembourg Institute of Science and Technology as subcontractor.

This project also relied on an expert advisory panel made up of representatives from the World Health Organisation, the International Atomic Energy Agency, the National Council on Radiation Protection and Measurement, Public Health England, the Cardiovascular and Interventional Radiological Society of Europe, EURATOM and the ICRP.

The aims of the PiDRL project were to:

- Agree on a methodology for establishing and using DRLs for paediatric radiodiagnostic imaging and interventional procedures,
- Update and extend the European DRLs to cover more procedures and include a wider patient age/weight range based on available knowledge, and
- Promote the establishment and use of DRLs in paediatric radiodiagnostic imaging and interventional radiology practices to advance optimisation of radiation protection for children.

The final outcome of this project was the publication of a series of guidelines and recommendations concerning the implementation and use of DRLs in children. These results and recommendations have been endorsed by the European Commission, and very recently made available via publication in issue N° 185 of the Radiation Protection series [5].

The aim of this article is to introduce these guidelines to the wide community of paediatric radiologists.

## Overview of recommendations

Three different types of paediatric DRLs should be implemented:

**Local DRLs.** These DRLs are based on the median values of patient dose distributions for a specific radiologic task in standardised patient groups gleaned from a wide sample of examinations performed within a hospital facility or group of hospitals. Institutions should regularly compare their own local DRLs with national DRLs to ensure they are not significantly higher. Local DRLs should be reviewed frequently.

**National DRLs.** These DRLs should be set by an authoritative body for a specific radiologic task within standardised patient groups. They should be based on national patient dose surveys involving a wide sample of institutions within the country. The national DRLs are based on the third quartile or the 75th percentile of the median values of the distribution of patient doses. National DRLs are important tools for each radiology department within the country to check its local DRLs against the national 75th percentile for a specific imaging procedure and to undertake appropriate actions in case national DRLs are locally exceeded. National DRLs should be updated every 5 years.

**European DRLs.** The most common paediatric imaging examinations are provided by the European Commission within the publication RP 185 [5]. They include plain radiographic examinations of the skull, thorax, abdomen, pelvis and micturating cystourethrography. They also include computed tomography (CT) studies of head, thorax and abdomen. European DRLs were established using the median value of the distribution of the national DRLs for a specific radiologic task in standardised patient groups. European DRLs should be considered preliminary national DRLs in countries where national DRLs based on a specific nationwide survey are not available and used until appropriate national DRLs have been established.

## Paediatric diagnostic reference levels to be set

Paediatric DRLs should be established for examinations that significantly contribute to the collective effective dose of the paediatric patient population. These should include the most common, low-dose examinations and the less common, high-dose examinations. The Radiation Protection 185 publication reports a series of relevant radiologic, fluoroscopic and CT examinations. Particularly, they recommend establishing

new DRLs – as they were not previously available – for radiographic studies of the spine, fluoroscopic studies of the gastrointestinal tract, and for CT studies of paranasal sinuses, inner ear, head for ventricular size, neck, whole body in trauma, chest for cardiovascular angiography and the spine.

## Patient grouping

Generally, the bigger the patient the higher the dose of radiation needed to obtain the same image quality with an appropriate signal-to-noise ratio, so that images are fit for purpose. Consequently, due to the large variation in child size at a given age, weight is a far more relevant parameter than age for patient grouping. Therefore, five weight groups, ranging from less than 5 kg to 80 kg, are recommended for body (chest and abdomen) examinations. However, since head size more closely relates to age than to weight, four age groups, ranging from younger than 3 months to older than 6 years, are recommended for cranial studies. A DRL for each specific imaging study should be established in each particular group.

## Sample size

In order to establish paediatric DRLs, a relevant number of patient dose data should be collected and collated. In general, the higher the variability in patient dose for the same type of examination, the larger the sample size needed to obtain acceptable results. For the setting of national DRLs based on nationwide surveys, each institution involved in the survey should provide a sample of at least 10 patients per procedure type and per patient group for examinations such as radiography and CT.

## Diagnostic reference level quantities

The physical quantities used to establish DRLs should be easily measurable and directly obtainable from the X-ray equipment. A list of primary and additional physical quantities for each radiologic modality is available in the Radiation Protection 185 publication. For CT, volume CT dose index and dose length product should always be referred to a 32-cm phantom for chest, abdomen, trunk and spine examinations, and to a 16-cm phantom for head examinations.

## Interventional radiology procedures and diagnostic reference levels

Over the last two decades, the use of interventional radiology procedures, including interventional cardiology, has been

dramatically increased in children. Interventional procedures can result in high patient radiation doses. Furthermore, some clinical conditions may require several procedures, thus the cumulative dose can be high.

For this reason, article 56 (2) of the directive 2013/59/EURATOM [4] states that “Member states shall ensure the establishment, regular review and use of diagnostic reference levels for radiodiagnostic examinations, having regard to the recommended European diagnostic reference levels where available, *and where appropriate, for interventional radiology procedures*, and the availability of guidance for this purpose.”

No national or European DRLs for paediatric interventional procedures have been set so far, but a few papers (mostly concerning local DRLs in cardiac procedures) have been published in recent years.

The PiDRL consortium performed a small-scale survey on paediatric interventional radiology procedures involving a few European paediatric specialist centres, with the aim to establish the most frequent interventional procedures in children and to report preliminary dose data. Based on the limited information available from this survey and from a few published studies, the PiDRL consortium recommends establishing DRLs for a small set of interventional cardiology procedures in children and the placement of peripherally inserted central catheters. For other procedures, such as sclerotherapy and embolization of vascular malformations in children, further studies are needed to verify the feasibility of establishing DRLs.

## Conclusion

DRLs are a fundamental tool to optimise radiologic studies in children and thus play a pivotal role in radioprotection. The Council Directive 2013/59/EURATOM [4] strictly requires the establishment of national DRLs for the most common radiologic studies. In this regard, the European Guidelines on Diagnostic Reference Levels for Paediatric Imaging provide European DRLs as an interim solution for European countries lacking their own national DRLs and also provide a consistent method for establishing new paediatric DRLs in the years to come. These guidelines also suggest the future establishment of paediatric DRLs for a set of cardiac and non-cardiac interventional procedures. The complete guidelines are freely available for download from the EuroSafe website of the European Society of Radiology [5].

## Compliance with ethical standards

**Conflicts of interest** None

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