



Contract ENER/2010/NUCL/SI2.581237

Study on European Population Doses from Medical Exposure
(Dose Datamed 2, DDM2)

**Supplement to DDM2 Project Report:
Diagnostic Reference Levels (DRLs) in Europe**

FOREWORD

According to Article 4(2) of the Medical Exposure Directive (MED) (97/43/Euratom), Member States shall promote the establishment and the use of diagnostic reference levels (DRLs) for diagnostic examinations in radiology and nuclear medicine and the availability of guidance for this purpose.

Dose Datamed 2 project estimated European population doses from radiodiagnostic procedures based on data collection. In context of that diagnostic reference levels (DRLs) for adult and paediatric x-ray procedures and adult nuclear medicine procedures that countries had set were collected. An electronic questionnaire was sent to national contact persons recognized for the project. This document introduces results of the survey on DRLs as a supplement to the DDM2 Project Report.

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EXECUTIVE SUMMARY

The DDM2 survey was carried out using open questions in electronic questionnaire. X-ray adult and paediatric DRLs and nuclear medicine adult DRLs were collected and the results are shown in this report.

Diagnostic reference levels (DRL) for adult x-ray examinations are established in 72 % of the 36 European countries and in 80 % of EU and EFTA countries (Iceland, Norway and Switzerland). For paediatric x-ray examinations, only 39 % of the countries have established DRLs and 47 % of EU and EFTA countries.

From the adult DRLs, 71 % are based on own national dose surveys in Europe and 81 % in EU and EFTA countries, while the rest are based on published values or recommendations, such as EC recommendations. From paediatric DRLs, 67 % are based on own national dose surveys, while the rest are based on published European guidelines or other publications.

DRLs for adult nuclear medicine (NM) examinations are set in 64 % of the European countries and in 70 % of EU and EFTA countries. From the NM DRLs, 65 % are based on own national dose surveys, while the rest are based on published values.

In this survey it came out that all countries that reported of their own methodology to set DRLs the principal of the 75th percentile was adopted. DRLs were given to normal size patients (70 kg \pm 15 kg) and to paediatric patients typically according to child's age or weight.

Observations in DDM2 suggest that the DRLs in many countries should be revised; they might be based on published values or old data, which do not properly represent current national practices.

INTRODUCTION

According to Council Directive 97/43/Euratom Diagnostic Reference Levels (DRL) are dose levels in medical radiodiagnostic practices or, in the case of radiopharmaceuticals, 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 implementation of DRLs is explained in ICRP 73 and ICRP 103 reports as follows. In practice, the values are selected on the basis of a percentile point on the observed distribution of doses to patients or to a reference patient. The values should be selected by professional medical bodies in conjunction with national health and radiological protection authorities and reviewed at intervals that



represent a compromise between the necessary stability and the long-term changes in the observed dose distributions. The selected values could be specific to a country or region.

In 1999 European Commission published Radiation Protection 109, Guidance on Diagnostic Reference Levels (DRLs) for Medical Exposures. According to that *DRLs should be established both for diagnostic radiology and for nuclear medicine, and if they are consistently exceeded investigation and appropriate corrective action should be taken. Therefore, in diagnostic radiology this level should be higher than the median or mean value of the measured patient doses or doses in a phantom. Given that the curve giving the number of examinations and their doses is usually skewed with a long tail, the level of the 75th percentile seems appropriate.*

Locally it is possible to establish DRLs to compare practices in a hospital or between hospitals on a hospital district. Local DRLs should be more stringent or equal to the national or regional DRLs.

Ideally, the DRLs should be based on the survey of the patient doses, in terms of the same quantity as used for the DRL, in the country, region or hospital where they are to be used as reference values for comparing patient doses determined in the local practice. Therefore, the mean effective doses per x-ray diagnostic procedure, or the mean administered activities per NM procedure, used for the estimation of the collective effective dose to the population in the same country, region or hospital, should on the average bear a clear relationship with the corresponding DRL values. Were it not so, it could be an indication of a non up-to-date DRL or adoption of a generic DRL which does not reflect the patient dose levels in the real practice of the country, region or hospital.

DRLs for several x-ray and NM procedures were collected in the context of the DDM2 questionnaires. This was considered useful because the results of patient dose surveys for the purpose of setting DRLs are often used. The comparison of the DRLs with the mean effective doses used in population dose calculations can provide information to judge the appropriateness of the DRLs and lead to subsequent re-evaluation of their values.

In this report the used country codes are adopted from Eurostat.

DIAGNOSTIC REFERENCE LEVELS FOR X-RAY PROCEDURES

2.1 General

Diagnostic reference levels (DRL) for adult x-ray examinations are established in 72 % of the 36 European countries (25 % have no DRLs and 3 % have not replied) (Fig 2.1). Corresponding figures for EU and EFTA countries (Iceland, Norway and Switzerland) together are 80 %, 17 % and 3 % respectively. From the countries having no adult DRLs, a draft document for DRLs in 10 different types of plain radiography was under approval process in Ukraine 2012.

For paediatric x-ray examinations, only 39 % of the countries have established DRLs (58 % have no DRLs and 3 % have not replied) (Fig 2.2). Corresponding figures for EU and EFTA countries are 47 %, 50 % and 3 % respectively.

From the adult DRLs, 71 % are based on own national dose surveys in Europe and 81 % in EU and EFTA countries (Fig. 2.1), while the rest are based on published values or recommendations, such as EC recommendations; see more details in Table 2.1. In one country, the source of DRL was recorded as unknown. From paediatric DRLs, 67 % are based on own national dose surveys (Fig. 2.2), while the rest are based on published European guidelines or other publications, see more details in Table 2.2. In one country, for one group of examinations, the source of DRL was recorded as unknown.

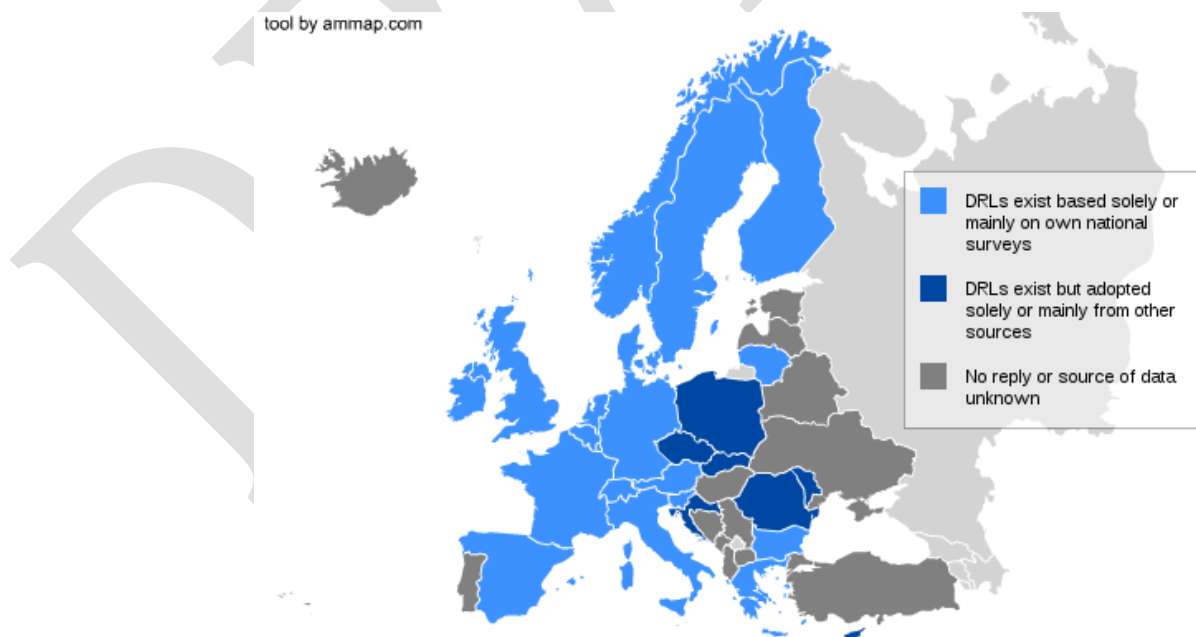


Fig.2.1. Diagnostic reference levels for adult x-ray examinations.



Table 2.1. The basis of DRL values for adult x-ray examinations in European countries.

Country	Symbol	Plain radiography	Mammography	Fluoroscopy	Interventional radiology	Computed tomography
Austria	AT	Own survey	EUREF	Own survey	Own survey	Own survey
Belgium	BE	Own survey				Own survey
Bulgaria	BG	Own survey & other	Own survey	Own survey	Own survey	Own survey
Croatia	HR	IAEA BSS	IAEA BSS			IAEA BSS
Cyprus	CY	EU RP 109	EU RP 109			
Czech Republic	CZ	IAEA BSS & Scandinavian	EU RP 109	Scandinavian recommendations		EU 16262
Denmark	DK	Own survey	Own survey	Own survey		Own survey
Estonia	EE					
Finland	FI	Own survey	Own survey	Own survey	Own survey	Own survey
France	FR	Own survey	Own survey			Own survey
Germany	DE	Own survey	Own survey	Own survey	Own survey	Own survey
Greece	EL		Own survey			
Hungary	HU					
Iceland	IS					
Ireland	IE	Own survey and UK data	EU RP 109	Own survey and UK data	UK data	EU 16262
Italy	IT	EU RP 109	EU RP 109	EU RP 109		
Latvia	LV					
Lithuania	LT	Own survey	Own survey	Own survey		Own survey
Luxembourg	LU	Own survey	EU RP 109	Own survey & EUR 16260 & DE regulation	Own survey & DE regulation	Own survey
Fmr. Yug. Rep. Of Macedonia	MK					
Malta	MT					
Moldova	MD	IAEA BSS	IAEA BSS			IAEA BSS
Montenegro	ME					
Netherlands	NL	Own survey	Own survey			Own survey
Norway	NO	Own survey	Own survey	Own survey		Own survey
Poland	PL	EU RP 109				EU 16262
Portugal	PT					
Romania	RO	EU RP 109	IAEA BSS			
Serbia	RS					
Slovakia	SK	Unknown	Unknown			
Slovenia	SI	Own survey				Own survey
Spain	ES	Own survey	Own survey			
Sweden	SE	Own survey	Own survey	Own survey		Own survey
Switzerland	CH	Own survey	European guidelines	Own survey	Own survey	Own survey
Ukraine	UA					
United Kingdom	UK	Own survey	Own survey	Own survey	Own survey	Own survey



Table 2.2. The basis of DRL values for paediatric x-ray examinations in European countries.

Country	Symbol	Plain radiography	Fluoroscopy	Computed tomography
Austria	AT	Own survey	Own survey	Own survey
Belgium	BE			
Bulgaria	BG			
Croatia	HR			
Cyprus	CY	EU RP 109		
Czech Republic	CZ			
Denmark	DK	Own survey	Own survey	
Estonia	EE			
Finland	FI	Own survey	Own survey	
France	FR	Own survey		Own survey
Germany	DE	Own survey	Own survey	Own survey
Greece	EL			
Hungary	HU			
Iceland	IS			
Ireland	IE	Own survey and UK data	UK data	
Italy	IT	EU RP 109		
Latvia	LV			
Lithuania	LT			
Luxembourg	LU	EUR 16261		
Fmr. Yug, Rep. Of				
Macedonia	MK			
Malta	MT			
Moldova	MD			
Montenegro	ME			
Netherlands	NL	Own survey	Own survey	Unknown
Norway	NO	Own survey		Own survey
Poland	PL	EU RP 109		
Portugal	PT			
Romania	RO	EU RP 109		
Serbia	RS			
Slovakia	SK			
Slovenia	SI			
Spain	ES			
Sweden	SE			
Switzerland	CH	Own survey	Own survey	M. Galanski, HD Nagel (2005/06)
Ukraine	UA			
United Kingdom	UK	Own survey	Own survey	



2.2 DRLs for adult x-ray procedures

2.2.1 Plain radiography

DRLs have been given in terms of either Entrance Surface Dose (ESD) or Entrance Surface Air Kerma (ESAK) or Dose Area Product (DAP) or Air Kerma Area Product (KAP) as summarized in Tables 2.3 and 2.4. Only those DRLs are shown which have been set in more than one country and which have been specified in a comparable way. Some cases in which the DRL was set for two or more projections have been excluded because the information was not exact enough to justify the comparison. The most common value of the DRLs in Europe is recorded when there was more than one similar value, and the countries having this DRL are given; in case of competing options for such values, the lowest values of the options has been recorded. Further, the countries having a DRL that is higher or lower than the most common one are given.

Table 2.3. DRLs given in terms of ESD, mGy. For mammography, the last line with “one projection” is for MGD, mGy (note that compressed breast thicknesses may vary).

Anatomical region	Projections	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
Head, skull, cranium	AP or PA	5,0	2,5-5	2	ES, CZ, IT, MD, RO, SK	-	BE, BG, CH, UK
	LAT	3,0	1-3	3	ES, CZ, CY, IT, MO, RO, SK	-	BE, CH, UK
Chest, thorax	PA	0,3	0,15-0,6	4	CY, ES, FR, IE, LT, RO	BG, CZ, HR, IT, MD, RO, SK	BE, FI, UK
	LAT	1,5	0,75-2	2,7	HR, CY, CZ, ES, IE, IT, RO, SK	LI, MD	BE, FI, FR, CH, UK
Thoracic spine	AP	7	3,5-7	2	HR, CZ, MD, SK	-	IE, LT, UK
	LAT	20	10-20	2	HR, CZ, MD, SK	-	IE, LT, UK
Abdomen	AP or PA	10	4,5-10	2,2	ES, IT, SK	-	BE, FI, FR, IE, UK
Lumbar spine	AP	10	5-10	2	ES, HR, CY, CZ, IT, LT, MD, RO, SK	-	BE, BG, DK, FI, IE, CH, UK
	LAT	30	10-30	3	ES, HR, CY, CZ, IT, MD, SK	-	BE, BG, FI, IE, LT, CH, UK
	LSJ	40	26-46	1,8	ES, CZ, IT, MD, RO	IE	UK
Pelvis	AP	10	3,5-10	2,9	ES, CY, CZ, IT, MO, RO, SK	-	BE, BG, FI, IE, LT, CH, UK
Mammography	CC, MLO or LAT	10	7-12	1,7	CY, ES, DK, FI, IT, LU, RO	BG	EL
	One projection	3	1,5-4	2,7	HR, MD, NO, SK	SE, UK	AT, CZ, FR, DE, LT, NL



Table 2.4. DRLs given in terms of DAP, mGy·cm².

Anatomical region	Projections	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
Head, skull, cranium	AP or PA	650	600-1000	1,7	DE, LU, CH	AT, PL	BE, SI
	LAT	600	500-1000	2	BE, DE, LU, SI	AT, PL	CH
Dental	Panoramic	120	120-200	1,7	FI	FR	-
Chest, thorax	PA	150	120-1000	8,3	SI, CH	AT, BE, BG, CZ, FR, DE, LU, PL	IE, UK
	LAT	600	250-1000	4	LU, CH	AT, CZ, FR, PL	BE, DE, SI
Thoracic spine	AP	1300	1250-2200	1,8	DE, LU, SI	FR, PL	-
	LAT	1700	1200-3200	2,7	DE, LU	FR, PL	SI
Abdomen	AP or PA	3000	2000-8000	4	AT, FI, DE, LU, NL, UK	BE, CZ, FR, IE, PL	SI
Lumbar spine	AP	2300	1500-10000	6,7	DE	BE, BG, CZ, FR, LU, PL, CH	IE, SI, UK
	LAT	4000	2750-8000	2,9	AT	BE, FR, DE, PL, CH	IE, SI, UK
	LSJ	-	2900-3000	1,0	SI, UK	-	IE
Pelvis	AP	2500	2500-7000	2,8	DK, DE, NO, CH	CZ, FI, FR, IE, DE, LU, PL, SI, SE, UK	-

For most of the cases, countries have given DRLs in terms of both ESD and DAP. For mammography, the DRL has been given either in terms of ESD or MGD, and the use of MGD seems to be the majority. For mammography, 56 % of European countries has given DRLs and 60 % of EU and EFTA countries.

Table 2.5. DRLs in EU guideline RP 109.

Anatomic region	Projections	Quantity and unit	DRL from EU RP 109
Head, skull, cranium	AP or PA	ESD, mGy	5
	LAT	ESD, mGy	3
Chest, thorax	PA	ESD, mGy	0,3
	LAT	ESD, mGy	1,5
Lumbar spine	AP	ESD, mGy	10
	LAT	ESD, mGy	30
	LSJ	ESD, mGy	40
Pelvis	AP	ESD, mGy	10
	CC, MLO or LAT	ESD, mGy	10

Most common DRLs using ESD were the same as in EU guideline RP 109 (Table 2.5). However, the variation is quite high, for example for thorax PA it is four fold in range 0,15-0,6 mGy. Most of the countries having lower DRL than the most common value had carried out an own survey and countries having the most common value or higher had adopted a recommended value from RP 109 or from International BSS. On the basis of national patient dose surveys carried out in this project some countries could now update their DRLs based on their own data. Also European recommendations of DRLs could be updated.

The range of the DRLs is usually high: the variation is typically 2-4-fold but at maximum even 20-fold. Figures 2.4. to 2.9 illustrate the variation of the DRL values for a few selected cases.

DRLs for adult x-ray procedures are given to normal size patients (typically 70 ± 15 kg). Most countries that had given DRLs reported that they had given specific guidance to use DRLs. Examples of guidance showed that some countries had included references for the DRLs such as published guidance, reports or results of a national surveys. The concept of DRLs as described in EU RP 109 was adopted with an exception that DRLs were given in one country as guiding values. Only few countries reported to have regular surveys to update the DRLs.

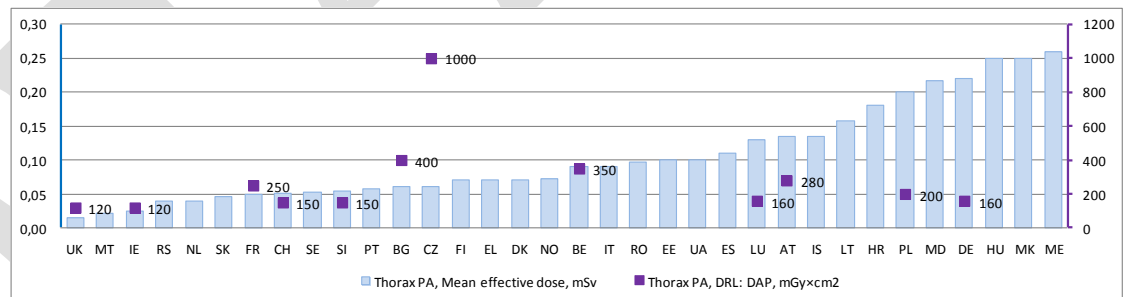


Fig. 2.3. Comparison of DRL values with the mean effective doses for thorax PA plain radiography.

In Fig. 2.3, as an example, the DRLs set in some countries for thorax PA radiography have been compared with the mean (typical) effective doses (E) estimated for this x-ray procedure. Because E is proportional to dose area product (DAP) (within a factor of about 2), a clear relationship between DRLs (given in terms of DAP) and E values could be expected. However, this is not the case for the results of Fig.2.3. In general, the variation in the observed DRLs between countries turned out to be smaller than variation between the corresponding mean effective doses. These observations suggest that the DRLs in many countries should be revised; they might be based on published values or old data, which do not properly represent current national practices.

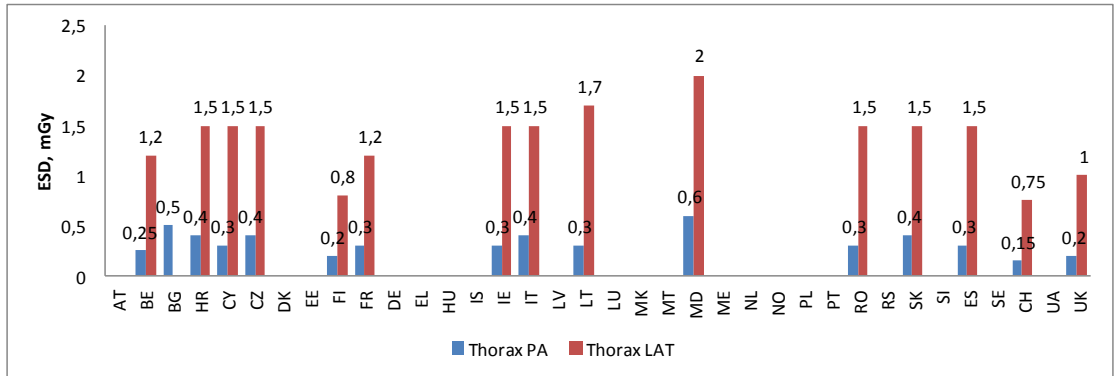


Fig. 2.4. Comparison of DRLs for *thorax plain radiography* in terms of ESD (mGy).

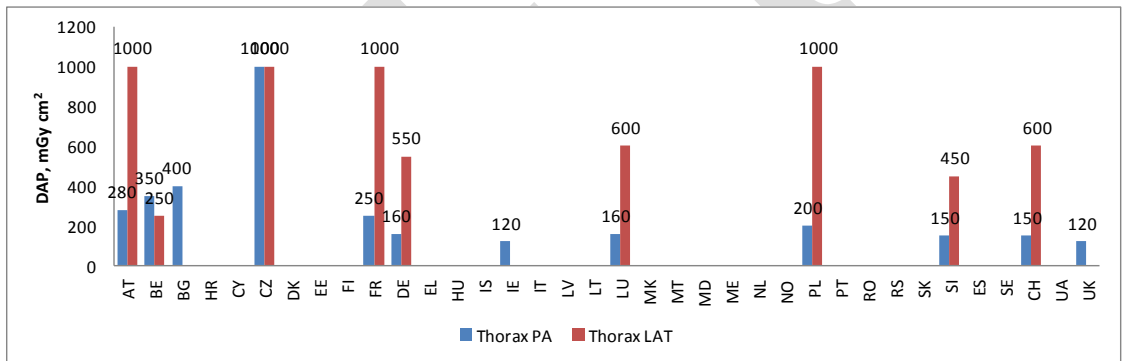


Fig. 2.5. Comparison of DRLs for *thorax plain radiography* in terms of DAP (mGy cm²).

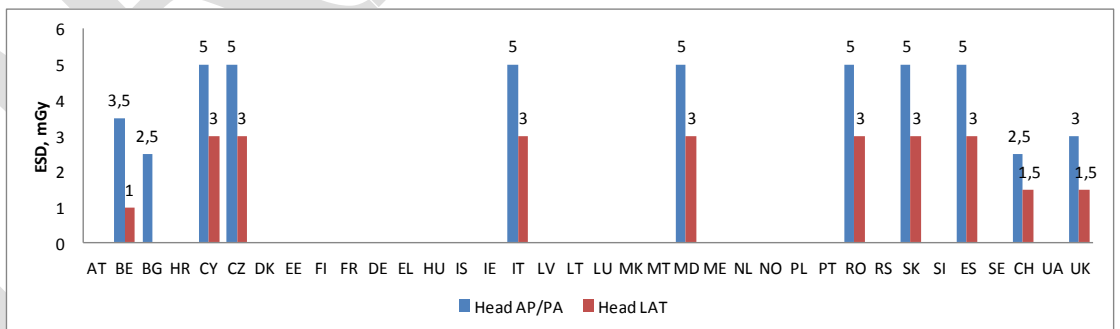


Fig. 2.6. Comparison of DRLs for *head plain radiography* in terms of ESD (mGy).

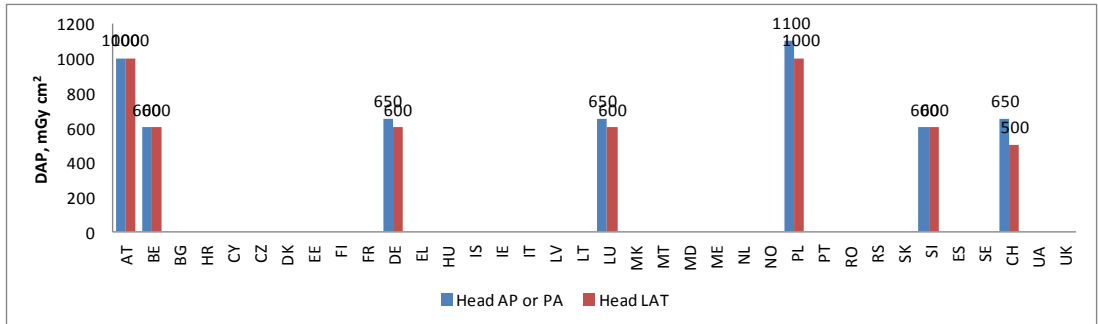


Fig. 2.7. Comparison of DRLs for *head plain radiography* in terms of DAP (mGy cm²).

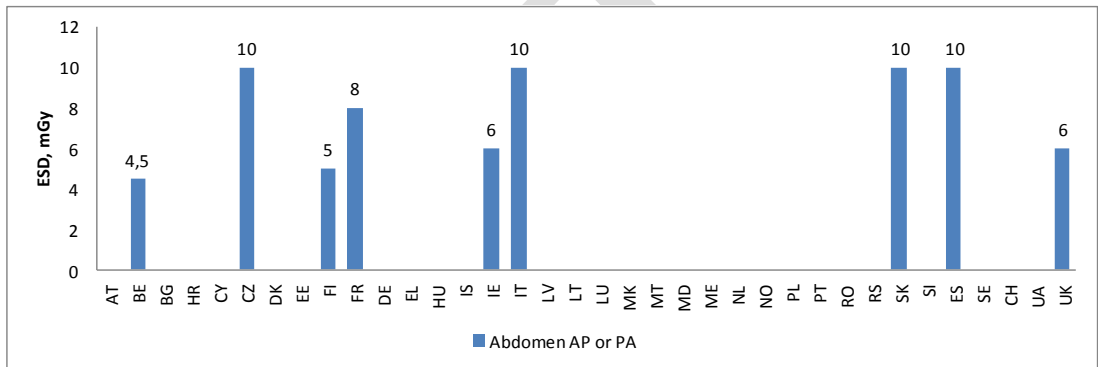


Fig. 2.8. Comparison of DRLs for *abdomen plain radiography* in terms of ESD (mGy).

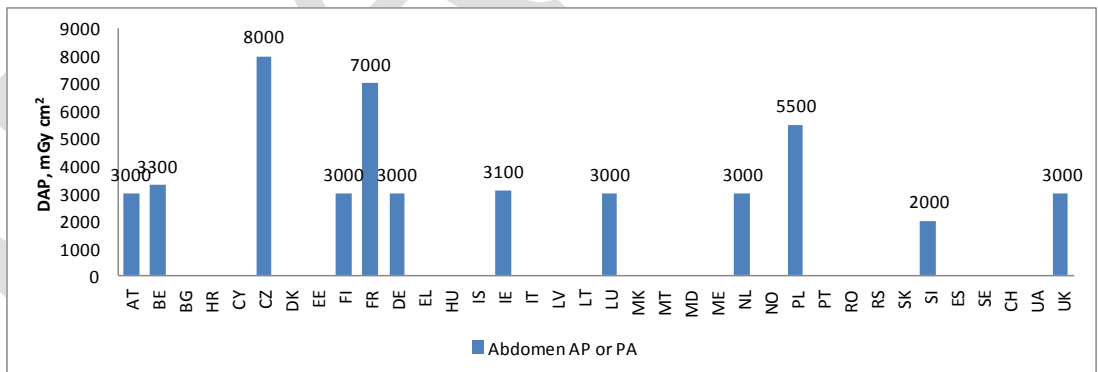


Fig. 2.9. Comparison of DRLs for *abdomen plain radiography* in terms of DAP (mGy cm²).

2.2.2 Fluoroscopy

DRLs have been given in terms of either DAP or (in one case) ESD and in some cases also in terms of fluoroscopy time as summarized in Tables 2.6 and 2.7. Only those DRLs are shown which have been set in more than one country and which have been specified in a comparable way. The most common value of the DRLs is recorded when there was more than one similar value, and the countries having



this DRL are given; in case of competing options or no similar values, the lowest option is recorded. Further, the countries having a DRL that is higher or lower than the most common one are given. The DRLs are compared with those given in EU Guidelines in Table 2.8.

Table 2.6. DRLs for fluoroscopy given in terms of DAP, Gy cm².

Examination or Anatomical region	Most common			Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
	value	Range	Max/min			
Barium meal	18	13-25	1,9	BG, LT	CY, CZ	IE, UK
Small intestine	44	44-65	1,5	DE, LU	AT, IE, UK	-
Barium enema	40	30-60	1,9	BG, NO	CY, CZ, IE, SE	DK, DE, LT, UK
Colon	37	37-50	1,4	LU	FI	-
ERCP	30	19-45	2,4	CH	AT	IE
IVU	20	12-40	3,3	DK, FI, SE	CY, CZ	IE, NO, UK
Phlebography	5	5-5,5	1,1	DE, LU	AT	-
Coronary angiography (CA)	60	23-80	3,5	AT, FI	SE, CH	BG, DE, IE, LU, NO, UK
Lower limb arteriography (LLA)	45	45-200	4,4	BG	LU	-

Table 2.7. DRLs for fluoroscopy given in terms of fluoroscopy time, min, or ESD, mGy.

Examination or Anatomical region	Most common			Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
	value	Range	Max/min			
Fluoroscopy time, min						
Barium meal	2,3	2,3-14,1	6,1	UK	BG	-
Barium enema	2,7	2,7-14,2	5,3	UK	BG	-
Coronary angiography (CA)	6	5,6-8	1,4	UK	FI	-
ESD, mGy						
IVU	10	5-10	2,0	CZ, IT, LU, MD, RO	-	BG, FI

Besides the DRLs in the above tables, DRLs have also been given to the following fluoroscopy examinations: Barium swallow, Oesophagus, Barium follow through, Sialography, T-tube cholangiography, Retrograde pyelography, Nephrostography, Hysterosalpingography, Venography (leg), Angiography carotid artery - 4 vessels, Angiography pulmonary artery, Arteriography aortic iliac vessels, Angdominal angiography (selective), Angiography mesenteric, Angiography renal, Arteriography

pelvic, Pelvi-leg-angiography, Arteriography, Angiography upper limb and Femoral angiography.

Table 2.8. Most common DRLs in terms of DAP [Gy cm^2] compared to DRLs in EU guideline RP 109.

Examination or Anatomical region	Most common value	DRL from EU RP 109
Barium meal	18	25
Barium enema	40	50 or 60
IVU	20	20 or 40

The range of the DRLs is usually high: the variation is typically 2-6-fold. Figures 2.10 to 2.13 illustrate the variation of the DRL values for a few selected cases. Most common values of DRLs compared to those in EU RP 109 are lower for fluoroscopic procedures. (Table 2.8). The data collection in this project shows that there is a need to update RP 109 by revising values and increasing number of DRLs.

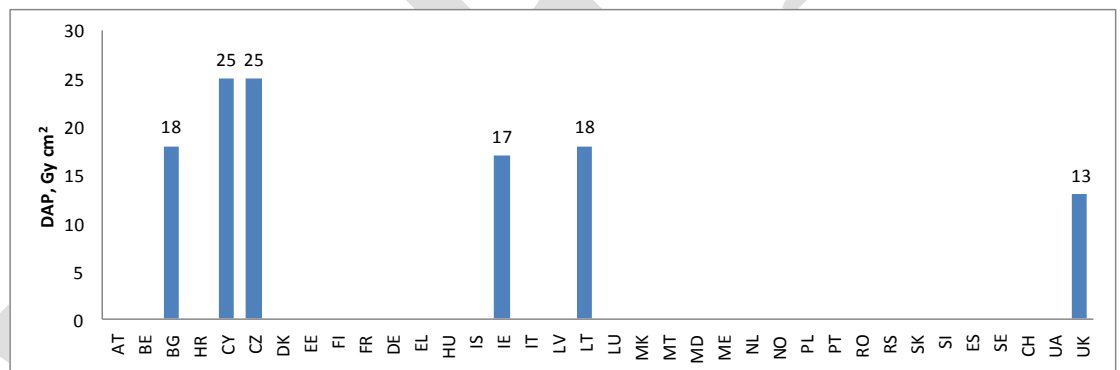


Fig. 2.10. Comparison of DRLs for *barium meal* in terms of DAP ($\text{Gy}\cdot\text{cm}^2$).

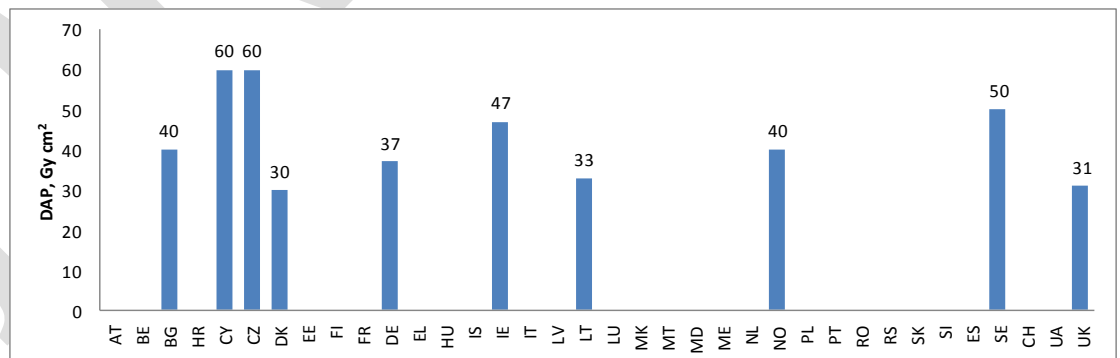


Fig. 2.11. Comparison of DRLs for *barium enema* in terms of DAP ($\text{Gy}\cdot\text{cm}^2$).

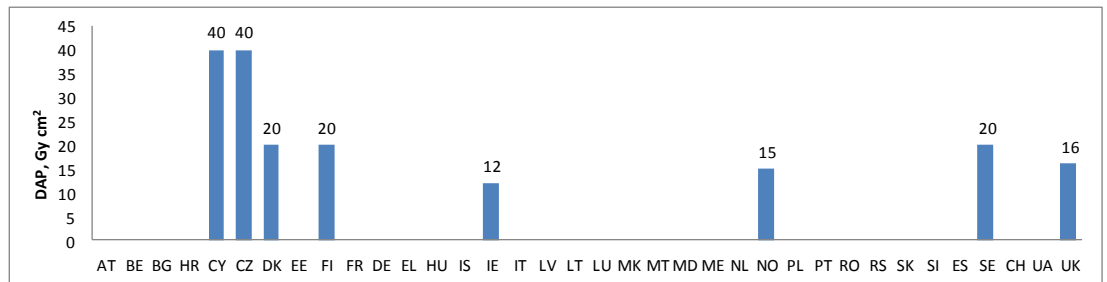


Fig. 2.12. Comparison of DRLs for *IVU* in terms of DAP (Gy·cm²).

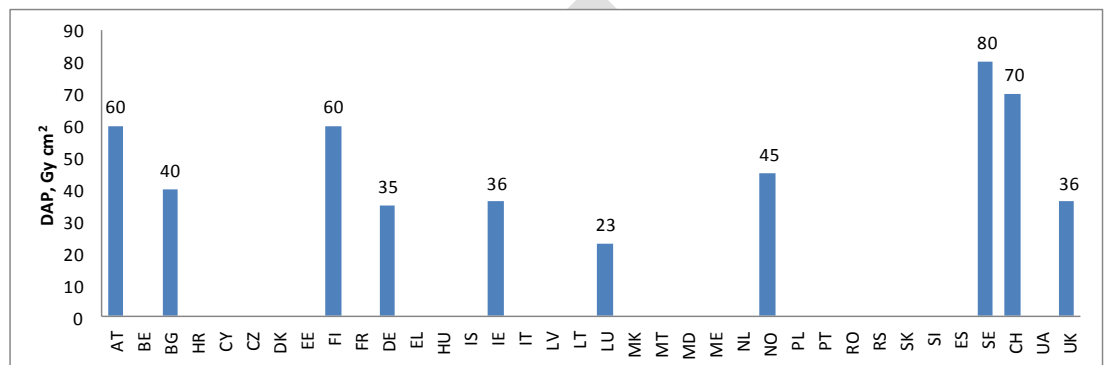


Fig. 2.13. Comparison of DRLs for *Coronary angiography (CA)* in terms of DAP (Gy·cm²).

2.2.3 Interventional radiology

PTCA is the only interventional procedure where several (five) European countries have given DRLs. The values range from 44 to 130 Gy cm², with a ratio max/min 3 (Table 2.9 and Fig. 2.14). Besides this DRL, DRLs have also been given to the following interventional procedures: Cerebral embolisation, PTCA+CA, PTA, Embolisation bronchial arteries, Bile duct drainage/dilatation, TIPS (liver), Hepatic embolisation, Vertebroplasty, Embolisation pelvic arteries and Upper limbs embolisation.

Table 2.9. DRLs for PTCA given in terms of DAP, Gy·cm².

Procedure or Anatomical region	Quantity and unit	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
PTCA	DAP, Gy cm ²	100	44-130	3,0	FI, CH	AT	DE, LU

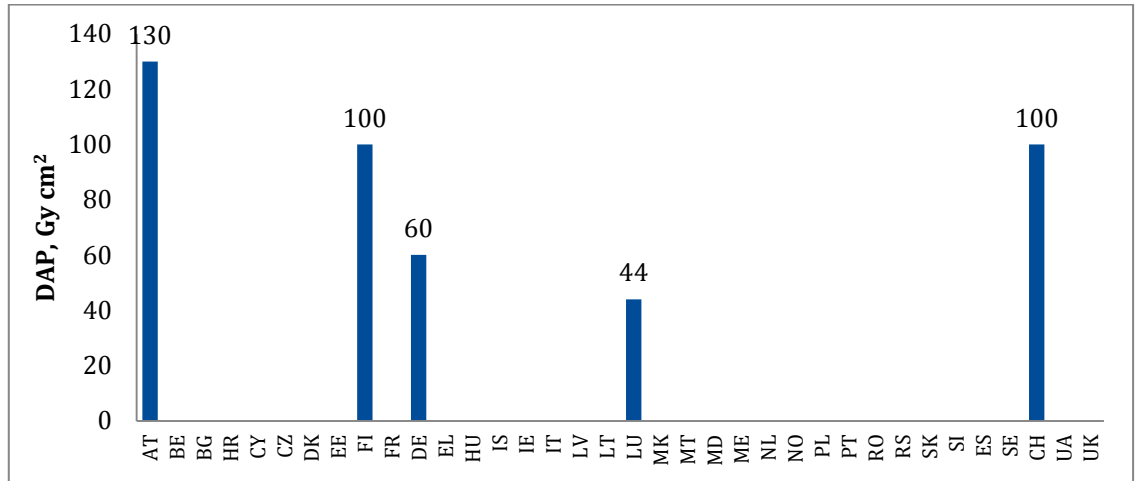


Fig. 2.14 Comparison of DRLs for PTCA in terms of DAP (Gy·cm²).

2.2.4 Computed tomography

DRLs have been given in terms of either DLP (Dose Length Product) or CTDI_{vol} (pitch corrected CT dose index) as summarized in Tables 2.10 and 2.11. Only those DRLs have been shown which have been set in more than one country and which have been specified in a comparable way. The most common value of the DRLs has been recorded when there has been more than one similar value, and the countries having this DRL have been given. Further, the countries having a DRL which is higher or lower than the most common one have been given.



Table 2.10. DRLs given in terms of DLP, mGy·cm.

Anatomical region	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
Head, brain, cranium	1000	760-1300	1,7	BG, FI, LU, NO, CH	AT, BE, DK, FR, IT, PL, SI, SE	DE, LT, UK
Cervical spine	400	400-600	1,5	NO	LU, CH	-
Neck	500	440-500	1,1	DK, CH	-	LU
Chest normal	400	270-700	2,6	BE, DE, NO, CH	AT, BG, DK, FI, FR, IT, LT, PL, SI, SE,	LU
Chest HRCT		80 -300	3,8	UK	DK, PL	-
Upper abdomen		400-740	1,9	CH	AT, DE	-
Abdomen	800	460-1200	2,6	DK, IT, LU, NO	AT, BE, DE, LT	BG, FI, PL, SI, UK
Pelvis	550	450-650	1,4	BG, LT	AT, DK, IT, PL	DE, CH
Lumbar spine	500	300-870	2,9	FI, DE, LU, NO	BE, FR, SE, CH	LT

Table 2.11. DRLs given in terms of CTDI_{vol}, mGy.

Anatomical region	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
Head, brain, cranium	60	50-75	1,5	FI, FR, CH, UK	NO, SE	BG, CR, CZ, IT, MD, SI
Chest normal	10	10-30	3	CH, UK	BG, FI, IT, NO, SI, SE	-
Abdomen	25	13-35	2,7	HR, MD, SE	BG, CZ, IT	FI, NO, SI, CH, UK
Lumbar spine	35	30-55	1,8	HR, CZ, MD	FI, SE	NO, CH

Besides the DRLs given in Tables 2.10 and 2.11, DRLs for the following CT examinations have been given in some countries: sinuses , facial bones, tumour diagnosis, facial bones, sinusitis, sinus, facial bones, heart, cardiovascular, colon, liver and spleen, liver, thorax/abdomen/pelvis, petrous bone, urography and shoulder.

In Figures 2.15 to 2.20 comparisons of DRLs for a few CT examinations has been presented.

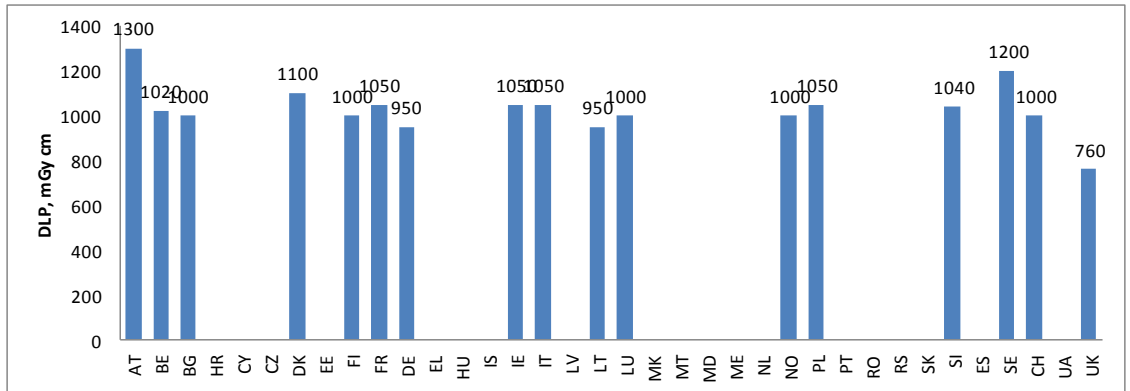


Fig. 2.15. Comparison of DRLs for *CT head* in terms of DLP, mGy cm.

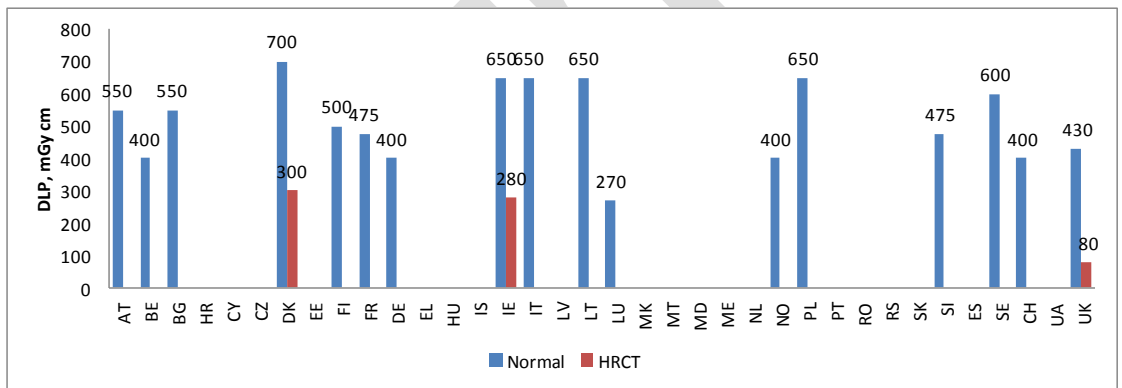


Fig. 2.16 Comparison of DRLs for *CT chest* in terms of DLP, mGy cm.

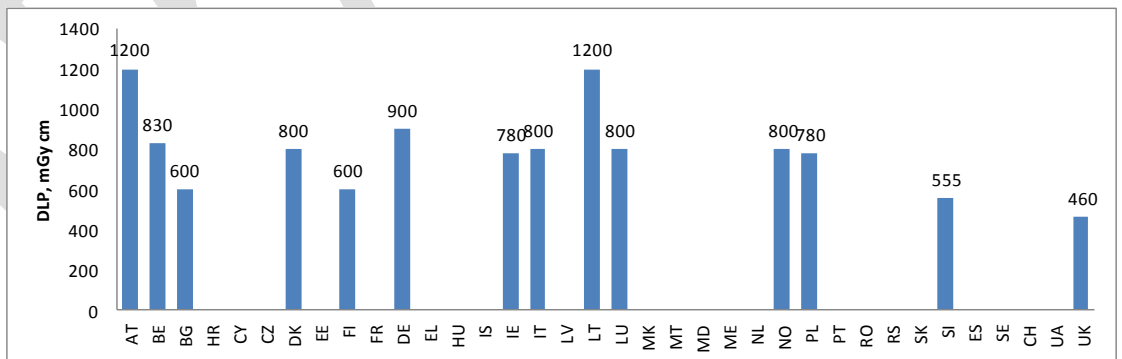


Fig. 2.17 Comparison of DRLs for *CT abdomen* in terms of DLP, mGy cm.

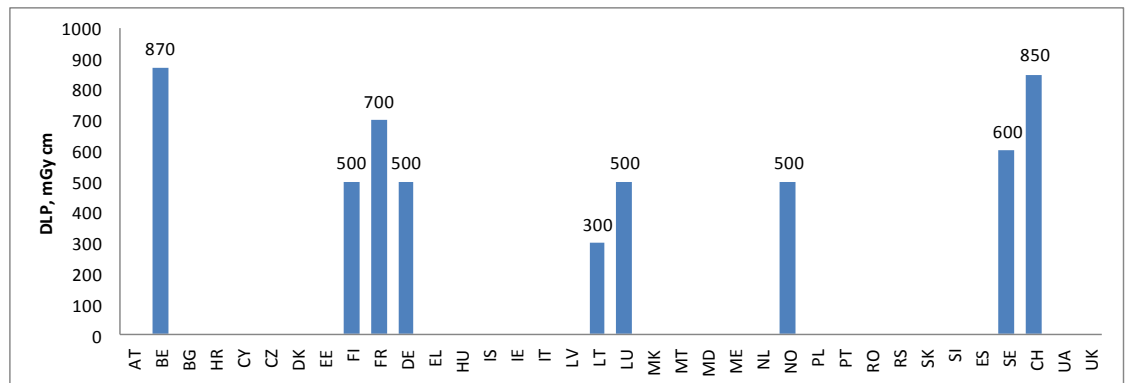


Fig. 2.18 Comparison of DRLs for *CT lumbar spine* in terms of DLP, mGy cm.

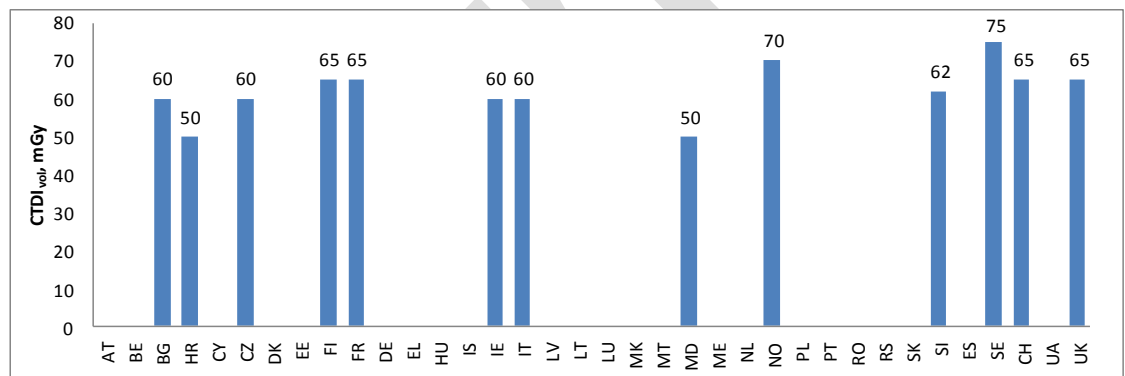


Fig. 2.19 Comparison of DRLs for *CT head* in terms of CTDI_{vol}, mGy.

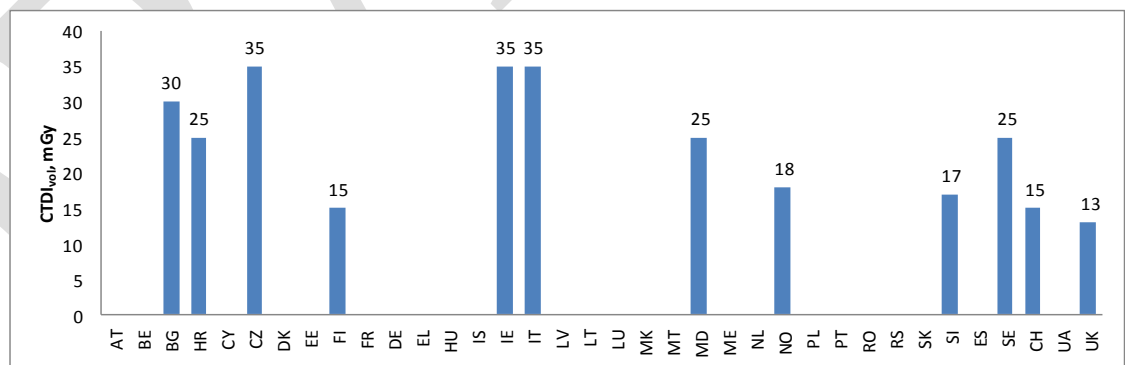


Fig. 2.20 Comparison of DRLs for *CT abdomen* in terms of CTDI_{vol}, mGy.

2.3 DRLs for paediatric x-ray procedures

DRLs for paediatric x-ray procedures are summarized in Tables 2.12 to 2.17. Comparison of a few DRLs is presented in Figures 2.21 to 2.25. Comparison to DRLs in RP109 in Table 2.14 shows that some countries have adopted given examples of DRLs in RP 109. In case of own studies DRLs are even lower.



Table 2.12. DRLs for paediatric plain radiography examinations in terms of ESD, mGy.

Anatomical region	Projection	Age	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
Head	AP/PA	5 years	2	1,5	1,0	CY, IT, LU, PL, RO	-	-
	LAT	5 years	1	1	1,0	IT, LU, PL, RO	-	-
Thorax	AP	Newborn	0,08	0,08	1,0	CY, IT, LU, PL, RO	-	-
	AP	5 years	0,1	0,08-0,1	1,3	CY, IT, PL, RO	-	DK
	PA	5 years	0,1	0,08-0,1	1,3	CY, FR, IT, LU, PL, RO	-	DK, IE
	LAT	5 years	0,2	0,095-0,2	2,1	CY, FR, IT, LU, PL, RO	-	DK
Abdomen		5 years	1	0,33-1	3,0	CY, IT, LU, PL, RO	-	IE
Pelvis	AP	Infants	0,2	0,2-0,27	1,4	CY, IT, LU, PL, RO	IE	-
	AP	5 years	0,9	0,375-0,9	2,4	CY, IT, LU, PL, RO	-	DK, IE

Table 2.13 DRLs for paediatric plain radiography examinations in terms of DAP, mGy cm².

Anatomical region	Projection	Age	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
Head	AP/PA	1 year	200	200-250	1,3	DE	AT	-
	AP/PA	5 years	300	300-350	1,2	DE	AT	-
	LAT	1 year	200	200	1,0	AT, DE	-	-
		5 years	250	250	1,0	AT, DE	-	-
Thorax		Newborn	10,0	10-15	1,5	FR	NL	-
		5 years	50	50	1,0	FR, DE	-	-
	LAT	5 years	40	40-60	1,5	DE	FR	-
	LAT	10 years	60	60-80	1,3	DE	FR	-
Abdomen	AP	1 year	90	90-200	2,2	AT	DE, NL	-
	AP	5 years	250	200-300	1,5	DE, NL	FR	AT
	AP	10 years	350	350-700	2,0	DE	AT, FR	-
Pelvis		5 years	150	150-200	1,3	DE	FR	-
		10 years	250	250-400	1,6	DE	FR	-

Table 2.14. Most common DRLs for paediatric plain radiography examinations in terms of ESD[mGy] compared to DRLs in EU guideline RP 109.

Anatomical region	Projection	Age	Most common value	DRL from EU RP 109
Head	AP/PA	5 years	2	1,5
	LAT	5 years	1	1
Thorax	AP	Newborn	0,08	0,08
	AP	5 years	0,1	0,1
	PA	5 years	0,1	0,1
	LAT	5 years	0,2	0,2
Abdomen		5 years	1	1
Pelvis	AP	Infants	0,2	0,2
	AP	5 years	0,9	0,9

Table 2.15 DRLs for paediatric Micturating Cystourethrography (MCU) in terms of DAP, Gy cm²

Anatomical region	Projection	Age	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
Micturating Cystourethrography (MCU)		0 years	0,3	0,1-0,5	5,0	DK, FI, NL	AT, IE, UK	DE
		1 year	0,9	0,3-1	3,3	DK, FI	IE, UK	AT, DE, NL
		5 years	0,9	0,3-1	3,3	DK, FI	AT, IE, UK	DE, NL
		10 years	0,6	0,6-2,1	3,5	IE, UK	-	AT, DE

Table 2.16 DRLs for paediatric CT examinations in terms of DLP, mGy cm.

Anatomical region	Projection	Age	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
CT brain		0 years	270	270-390	1,4	UK	AT, IE, CH	-
		1 year	270	270-520	1,9	UK	AT, FR, IE, CH	-
		5 years	470	470-600	1,3	AT, FR, IE	-	CH, UK
		10 years	620	620-900	1,5	UK	AT, FR, IE, CH	-
		15 years	900	900-920	18,0	AT	CH	-
CT chest		0 years	12	12-200	16,7	CH	AT, IE, UK	-
		1 year	28	28-200	7,1	CH	AT, FR, IE, UK	-
		5 years	55	55-65	1,2	CH	AT, FR, IE, UK	-
		10 years	105	105-370	3,5	CH	AT, FR, IE, UK	-
		15 years	200	200-205	1,03	AT	CH	-
CT abdomen		1 year	70	70-80	1,1	CH	FR, IE	-
		10 years	240	240-245	1,02	CH	FR, IE	-

Table 2.17 DRLs for paediatric CT examinations in terms of CTDI_{vol}, mGy.

Anatomical region	Projection	Age	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
CT Brain		0 years	20	20-27	1,4	NL	IE, CH	-
		1 year	25	25-33	1,3	NL	IE, CH	-
		5 years	35	35-40	1,1	NL	IE, CH	-

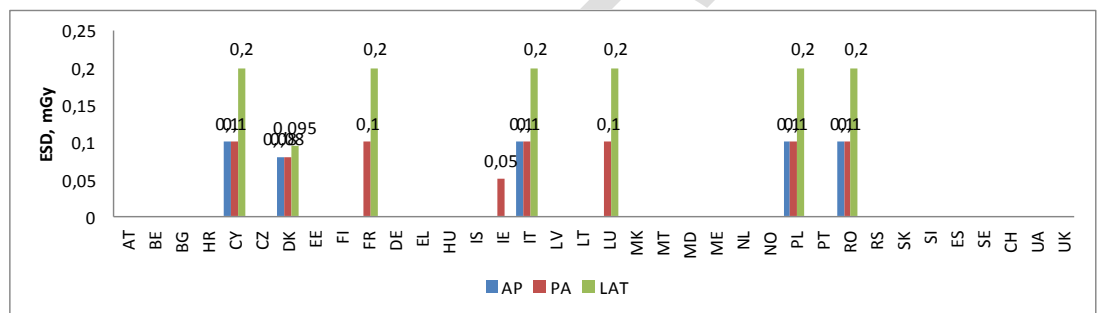


Fig. 2.21 Comparison of DRLs for paediatric *thorax plain radiography* for 5 years old child in terms of ESD, mGy.

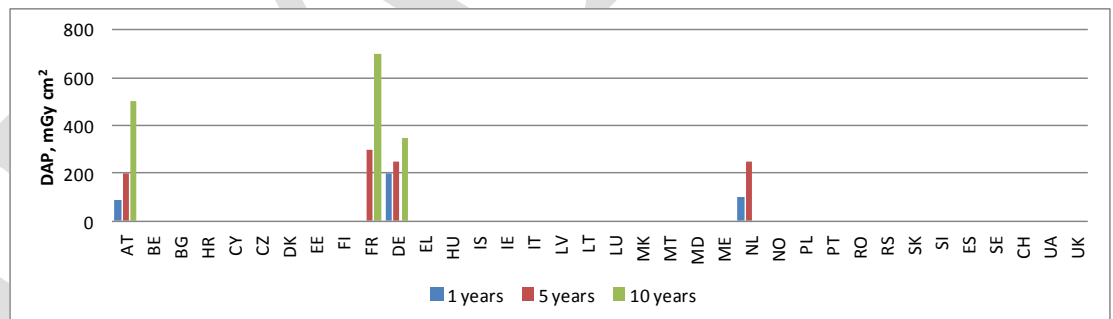


Fig. 2.22 Comparison of DRLs for paediatric *abdomen plain radiography, AP projection*, for 1-10 years old children in terms of DAP, mGy cm².

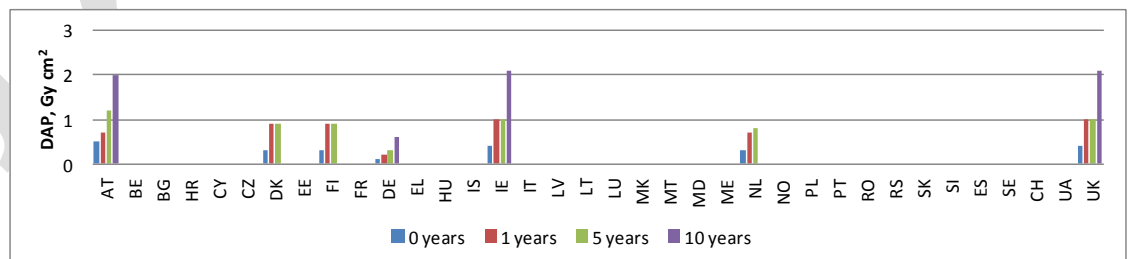


Fig. 2.23 Comparison of DRLs for paediatric *Micturating Cystourethrography (MCU)*, for 0-10 years old children in terms of DAP, Gy cm².

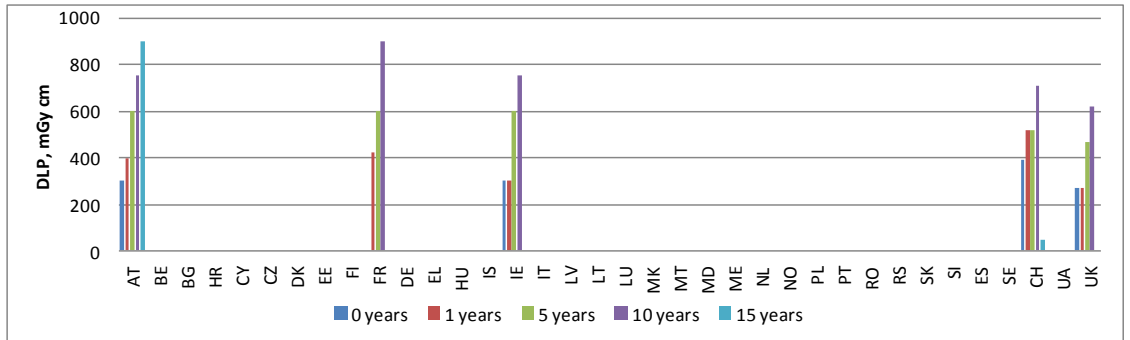


Fig. 2.24 Comparison of DRLs for paediatric *brain CT*, for 1-15 years old children in terms of DLP, mGy cm.

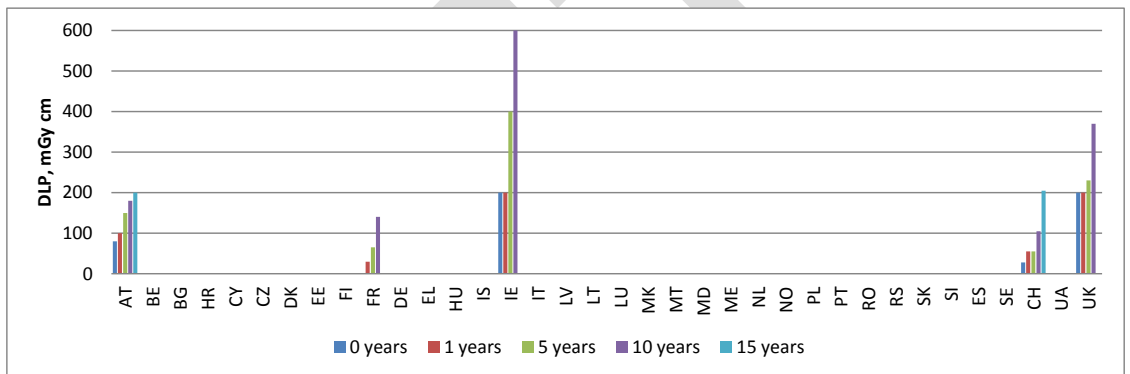


Fig. 2.25 Comparison of DRLs for paediatric *chest CT*, for 0-15 years old children in terms of DLP, mGy cm.

DIAGNOSTIC REFERENCE LEVELS FOR NUCLEAR MEDICINE PROCEDURES

3.1 General

Diagnostic reference levels for adult nuclear medicine (NM) examinations are set in 64 % of the European countries and 36 % have no DRLs (Fig 3.1). Corresponding figures for EU and EFTA countries together are 70 % and 30 % respectively. From the NM DRLs, 65 % are based on own national dose surveys (Fig. 3.1), while the rest are based on published values; see more details in Table 3.1.



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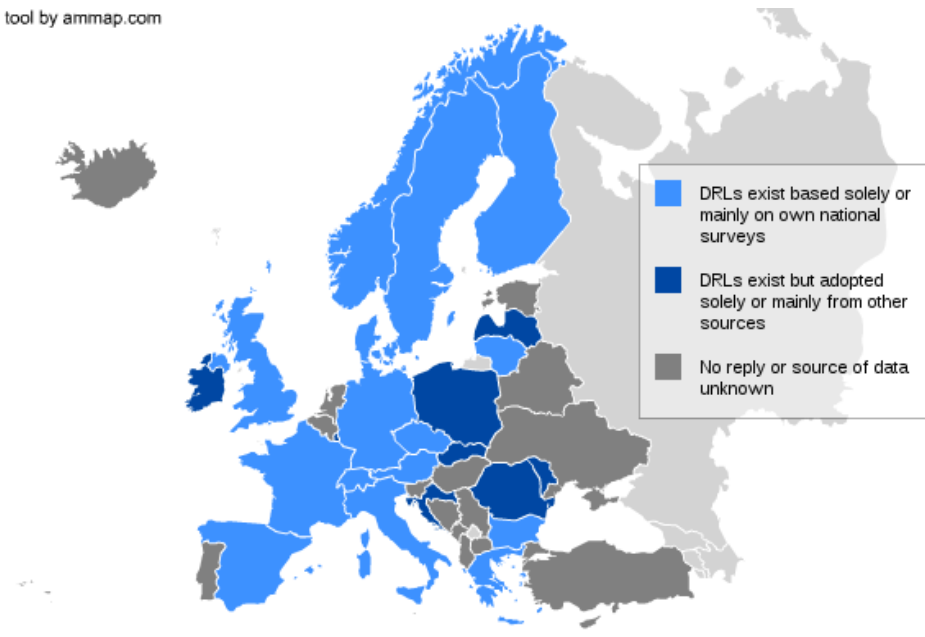


Fig.3.1. Diagnostic reference levels for NM examinations.

3.2 Summary and comparison of the DRLs for NM procedures

The summary of the DRLs for NM procedures given in the European countries is shown in Table 3.2. Comparisons of selected DRL values are presented in Figures 3.2 to 3.17.

All DRLs have been given in terms of administered activity (in MBq). Only those DRLs have been shown which have been set in at least 5 countries and which have been specified in a comparable way. The most common value of the DRLs has been recorded when there has been more than one similar value. The countries having this DRL or a lower value have been shown as well as those countries having a higher value. In case no common value was possible to record, the countries giving the DRL have been shown.

In NM the administered activities are highly dependent of the used procedures. Especially in heart studies there are one day and two days protocols for stress and rest imaging and also variation between these procedures. Therefore it is difficult to compare administered activities without knowing precisely the used protocol. Countries have given a DRL in some cases to the whole protocol with two injections and in some cases DRLs separately to both stress and rest imaging.

There is a large variation between DRLs given by countries and it can be seen already in the DRLs by ten countries in EU RP 109. However, for most common procedures that has only minor variation like for example bone imaging with Tc-



99m phosphonates a European recommendation for DRLs could be driven on basis of this study.

DRLs in NM are based on used administrated activities to normal size patients (typically 70 ± 15 kg). Most countries that had given DRLs reported that they had given specific guidance to use DRLs. Examples of guidance showed that some countries had included references for the DRLs such as published guidance, reports or results of a national surveys. The concept of DRLs as described in EU RP 109 was adopted with an exception that DRLs were given in one country as guiding values. Usefulness of guiding levels in NM should be considered instead of DRLs or additional to DRLs.

Table 3.1. Basis of the setting of national DRLs for NM procedures in European countries.

Country	Basis of DRL
Austria	Own national surveys
Belgium	
Bulgaria	Own national surveys
Croatia	Published values
Cyprus	
Czech Republic	Own national surveys
Denmark	Own national surveys
Estonia	
Finland	Own national surveys
France	Own national surveys
Germany	Own national surveys
Greece	Own national surveys
Hungary	
Iceland	
Ireland	Published values
Italy	Own national surveys
Latvia	Published values
Lithuania	Unknown
Luxembourg	Published values
Fmr. Yug, Rep. Of Macedonia	
Malta	
Moldova	Published values
Montenegro	
Netherlands	
Norway	Own national surveys
Poland	Published values
Portugal	
Romania	Unknown
Serbia	
Slovakia	Unknown
Slovenia	
Spain	Own national surveys
Sweden	Own national surveys
Switzerland	Own national surveys
Ukraine	
United Kingdom	Unknown

Table 3.2 Summary of the DRLs for NM procedures

Procedure	Radiopharmaceutical	Most common value, MBq	Countries with DRL equal to, or lower than, the most common value	Countries with DRL higher than the most common value	Countries with DRL when no common value was identified	Range	Max/min	Comments
Bone imaging	Tc-99m phosphates & phosphonates	600	HR, LT, LV, MD, SK, SE, UK	BG, CZ, ES, FI, FR, DE, EL, IT, LU, NO, PL, RO, CH		500-1110	2,2	no SPECT or no details
Myocardial Perfusion	Tl-201 chloride	110	AT, CZ, FI, FR, DE, CH, IT, UK	EL, ES, IE, LU		75-185	2,5	1st injection or SPECT or no details
Myocardial Perfusion	Tc-99m tetrofosmin	1000	ES, FI, FR, DE, IE, LI, LV, UK	IT, LU, NO, CH, SE		300-1500	5,0	same day or no details
Myocardial Perfusion	Tc-99m MIBI			AT, BG, ES, FR, DE, IE, IT, LT, LU, RO, CH, SE, UK	300-1480	4,9	isonitrile as MIBI
Tumour imaging (PET)	F-18 FDG	400	AT, IE, SE, UK	DK, FI, FR, DE		350-500	1,4	
Thyroid metastases (after ablation, uptake 0%)	I-131 iodide	400	DK, BG, FI, EL, IE, IT, LT, LV, PL, UK	-		90-400	4,4	
Thyroid imaging	Tc-99m pertechnetate	80	FR, DE, IE, PL, RO, CH, UK	AT, BG, CZ, DK, EL, ES, IT, LT, LV, MD, NO, SE		75-222	3,0	
Thyroid imaging	I-123 iodide	20	AT, CZ, FR, IT, LT, LV, PL, RO, SK, CH, UK	DK, ES, LU		10-37	3,7	
MUGA, cardiac bloodpool, cardiac blood flow	Tc-99m erythrocytes	800	AT, CZ, DK, FI, DE, RO, IE, MD, PL, UK	FR, EL, IT, CH		600-1000	1,7	pyrophos. & HAS as erythrocytes
Lung perfusion	Tc-99m MAA	200	AT, BG, CZ, DK, HR, FI, DE, EL, IR, IT, LV, MD, RO, SE, CH, UK	FR, NO, ES		100-296	3,0	200(SPECT)
Renal imaging	Tc-99m DMSA	150	AT, BG, CZ, DK, FI, DE, CH, IE, UK	EL, IT, LT, LV		70-183	2,6	
Renal imaging	Tc-99m MAG3	100	DE, IE, LT, LV, NO, CH, UK	AT, BG, CZ, DK, ES, HR, FI, FR, IT, LU, SE		70-370	5,3	CR renography Tc-99m
Renal imaging	Tc-99m DTPA	200	AT, BG, DE, IT, MD, NO, SE, CH	ES, CZ, DK, HR, FI, FR, EL, IE, LT, LU, LV, UK		150-540	3,6	CR renography Tc-99m
Parathyroid imaging	Tc-99m MIBI	800	BG, CZ, FI, LT, MD, CH, IT, PL	DK, IE, UK		400-900	2,3	
Cerebral blood flow	Tc-99m Exametazime(HMPAO, Ceretec)	500	HR, FR, IE, LT, MD, UK	CZ, DK, ES, FI, DE, IT, LU, NO, PL, RO, SE		500-1110	2,2	
Infection/Inflammation imaging	Ga-67 citrate	150	CZ, IE, IT, UK	AT, EL, LT, LU, ES		110-370	3,4	

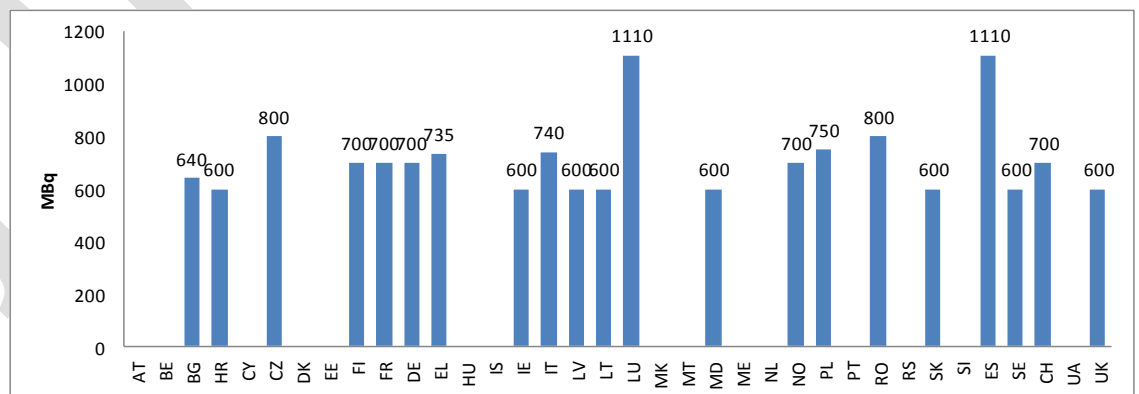


Fig 3.2. Comparison of DRLs for bone imaging, Tc-99m phosphates and phosphonates.

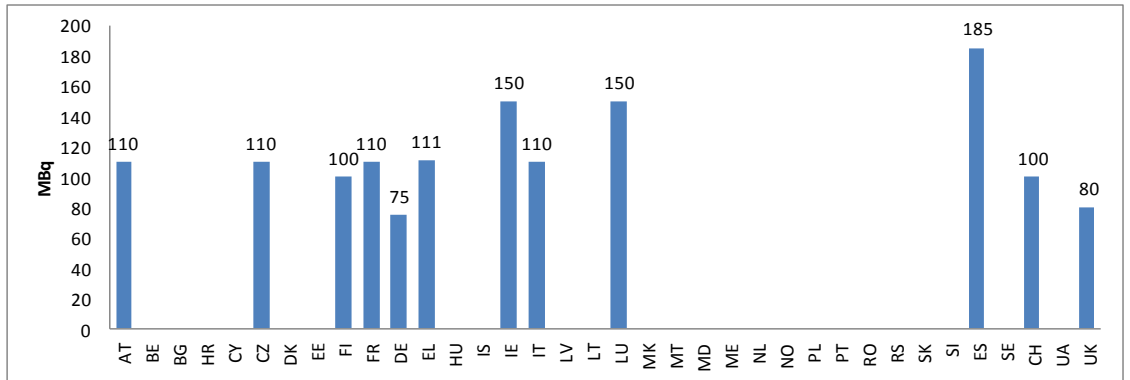


Fig 3.3. Comparison of DRLs for myocardial perfusion, Tl-201 chloride.

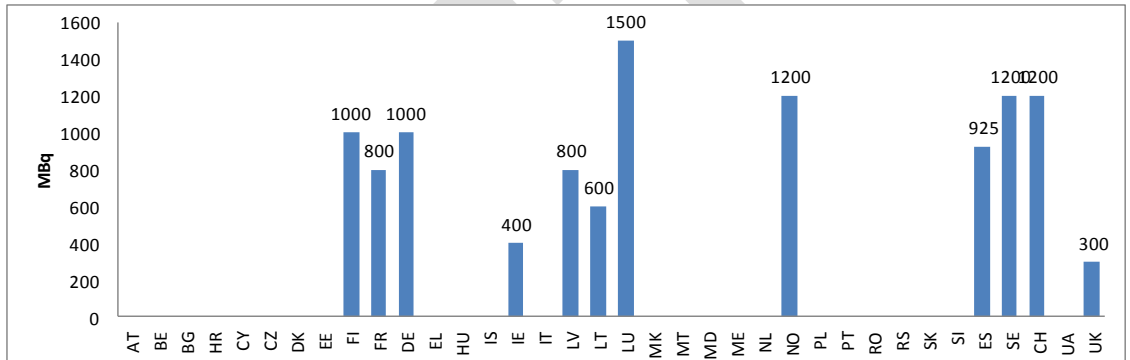


Fig 3.4. Comparison of DRLs for myocardial perfusion, Tc-99m tetrofosmin.

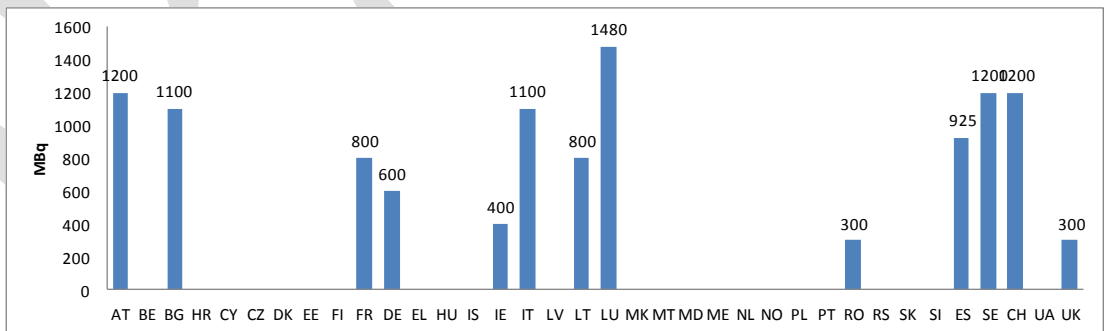


Fig 3.5. Comparison of DRLs for myocardial perfusion, Tc-99m MIBI.

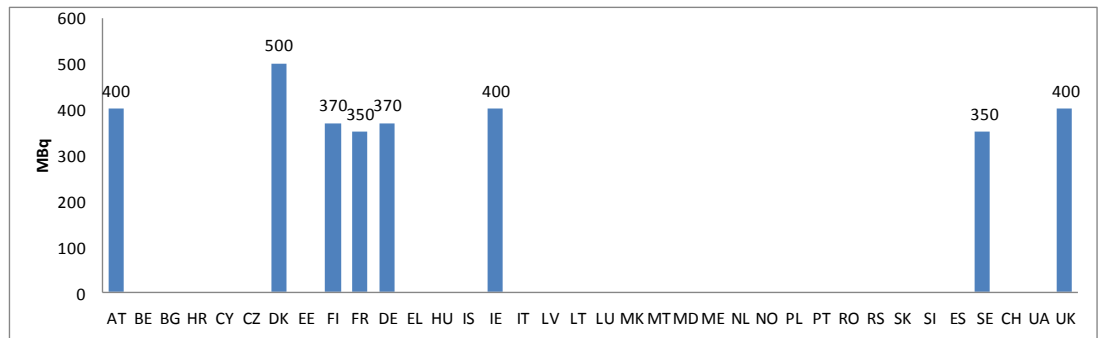


Fig 3.6. Comparison of DRLs for tumour imaging (PET), F-18 FDG.

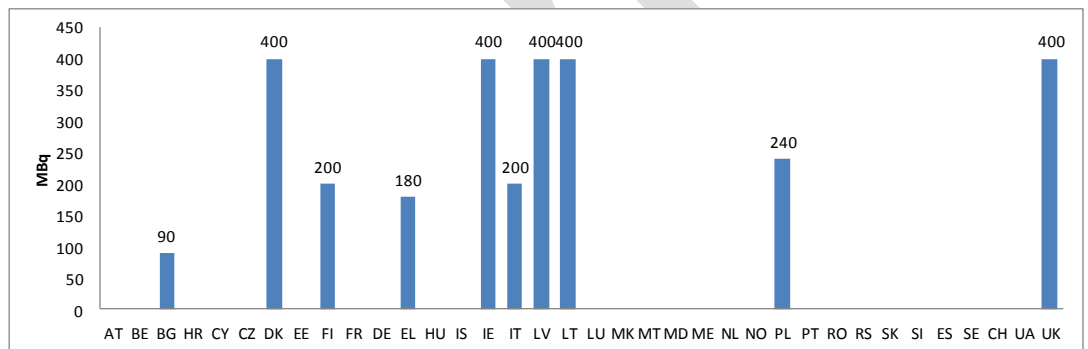


Fig 3.7. Comparison of DRLs for thyroid metastases (after ablation, uptake 0%), I-131 iodide.

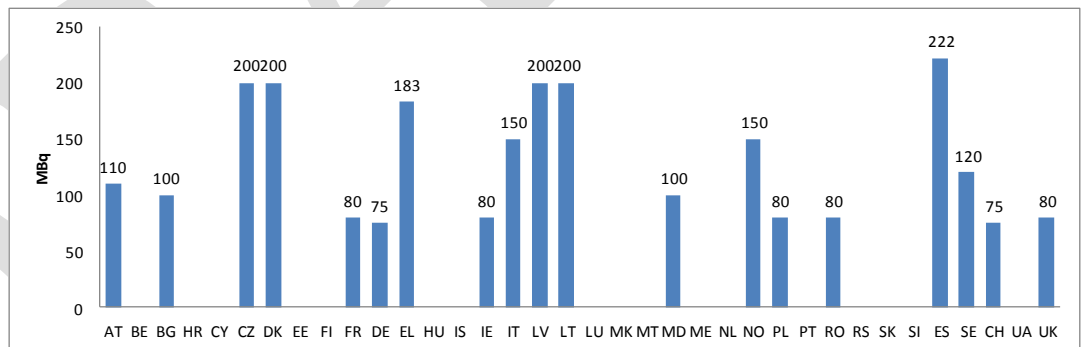


Fig 3.8. Comparison of DRLs for thyroid imaging Tc-99m pertechnetate.

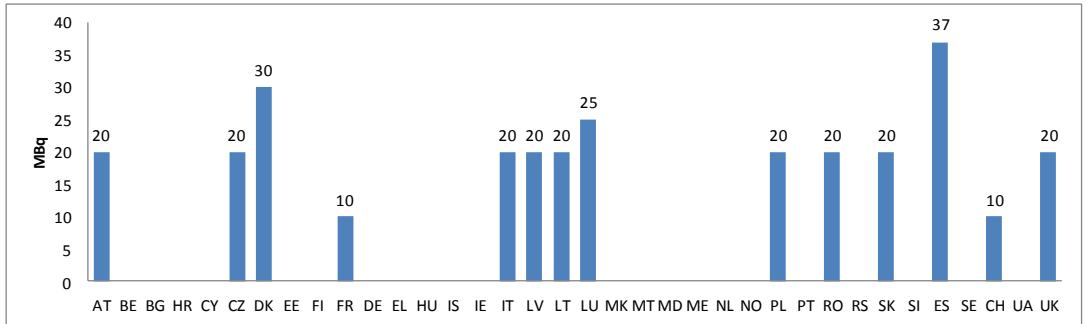


Fig 3.9. Comparison of DRLs for thyroid imaging, I-123 iodide.

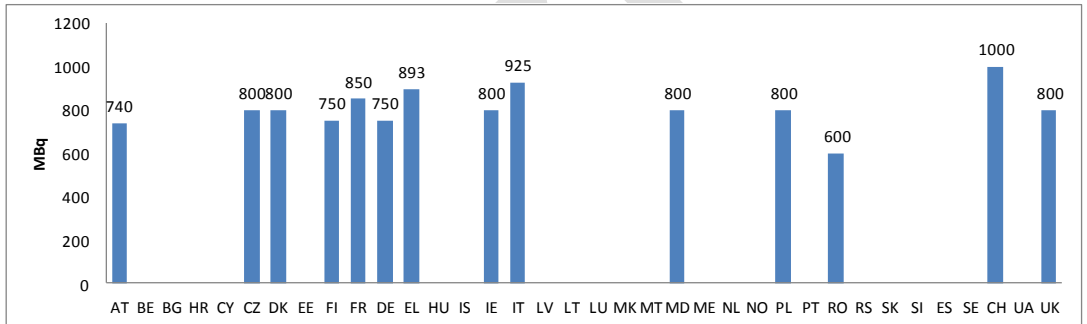


Fig 3.10. Comparison of DRLs for MUGA, cardiac blood pool, cardiac blood flow, Tc-99m erythrocytes.

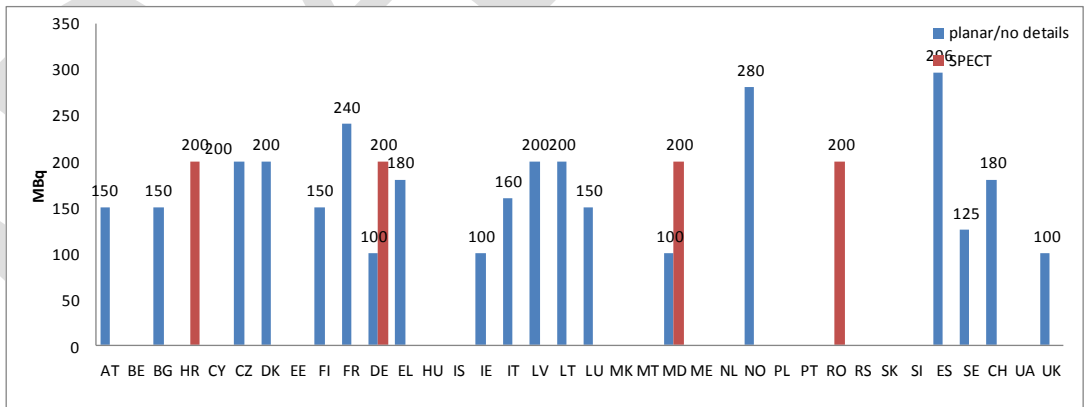


Fig 3.11. Comparison of DRLs for lung perfusion, Tc-99m MAA.

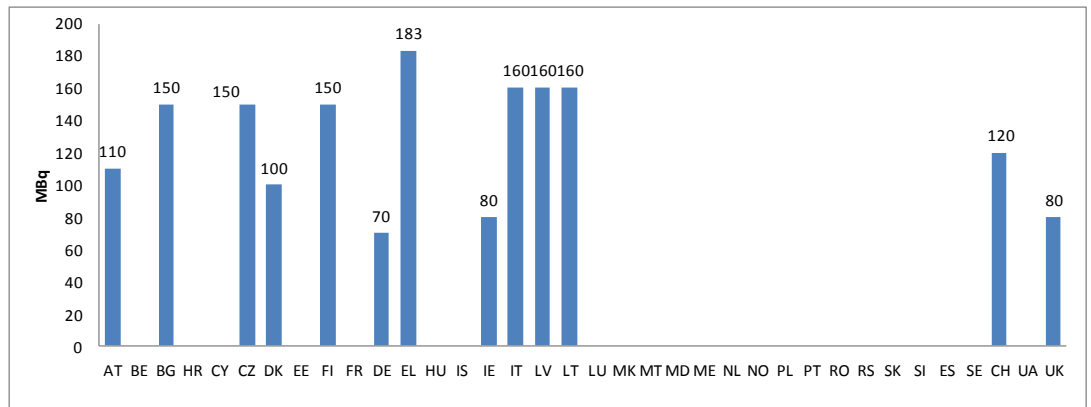


Fig 3.12. Comparison of DRLs for renal imaging, Tc-99m DMSA.

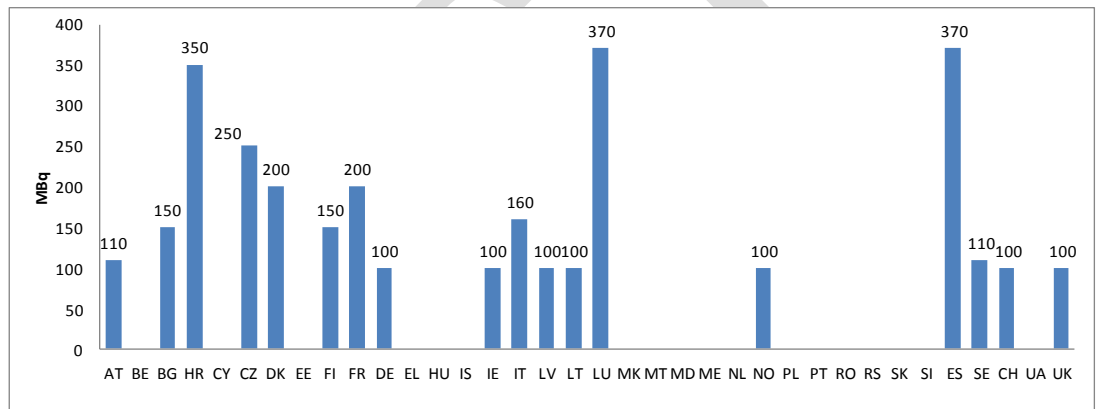


Fig 3.13. Comparison of DRLs for renal imaging, Tc-99m MAG3.

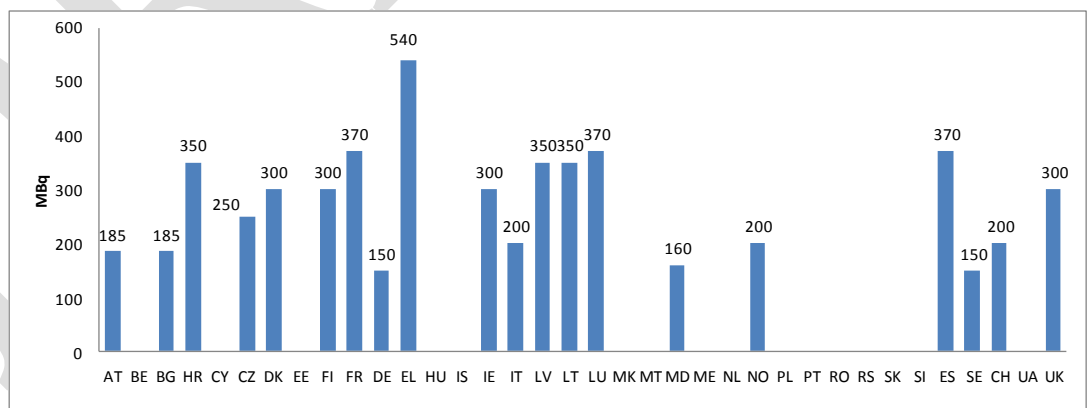


Fig 3.14. Comparison of DRLs for renal imaging, Tc-99m DTPA.

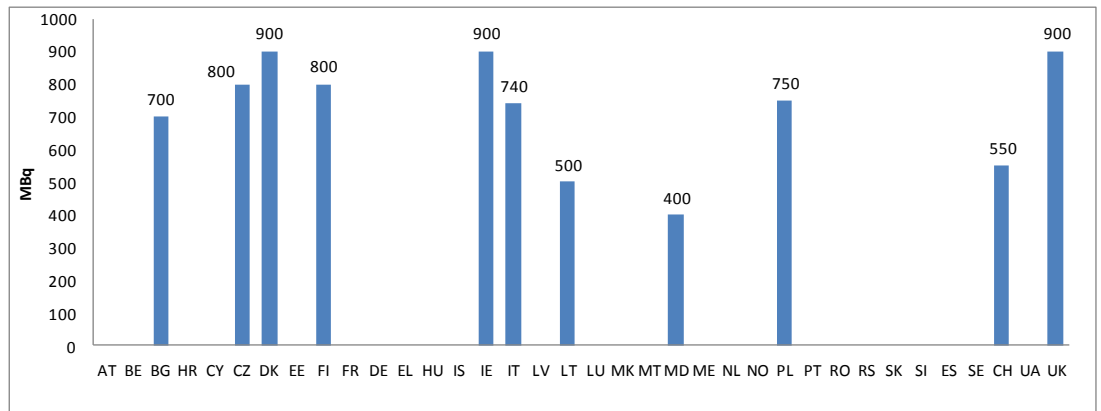


Fig 3.15. Comparison of DRLs for prathyroid imaging, Tc-99m MIBI.

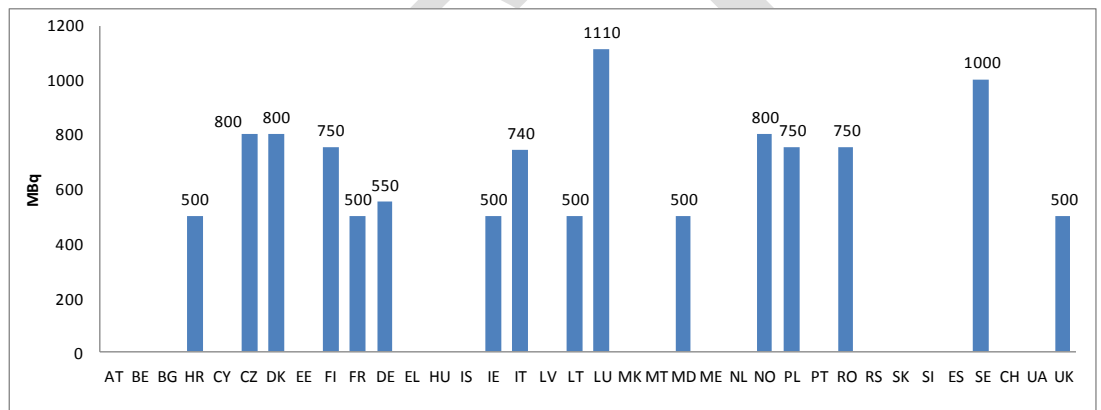


Fig 3.16. Comparison of DRLs for cerebral blood flow, Tc-99m Exametazime (HMPAO, Ceretec).

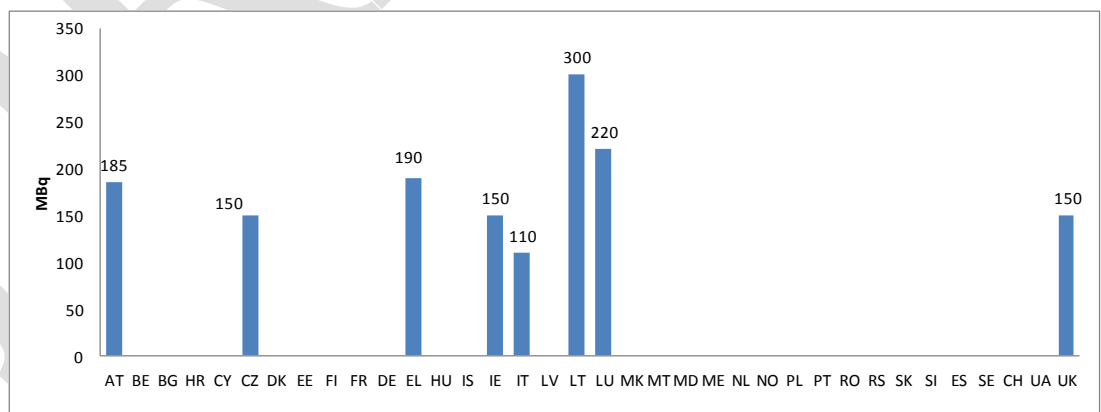


Fig 3.17. Comparison of DRLs for Infection/Inflammation imaging, Ga-67 citrate.