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Diagnostic Reference Levels in Thirty-six European Countries

Part 2/2

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FOREWORD

Luxembourg, December 2014

Ionising radiation has been used in medicine since the discovery of radioactivity and x-rays more than a century ago and is now firmly established as an essential tool for medical diagnosis and therapy. There has been a marked increase in the use of medical x-ray and nuclear imaging in the past decade or so, as new technologies, such as computed tomography and positron emission tomography, have become widespread. These procedures – when medically indicated and properly conducted – provide great benefits to patients; however, the associated radiation exposures have to be monitored and controlled, in view of their potential to cause harmful health effects.

In 2008 the European Commission published "Radiation Protection 154: European Guidance on Estimating Population Doses from Medical X-Ray Procedures" (RP 154). The 2008 publication also contained the results of national medical exposure studies in ten European countries. However, a full evaluation of radiation exposure resulting from medical diagnostic procedures in Europe has not been previously carried out. The present report is therefore intended to fill this gap.

This report provides comprehensive information on 36 European countries regarding frequencies and radiation doses of x-ray and nuclear medicine radiodiagnostic procedures. The information presented in the report is based on national surveys carried out between 2007 and 2010. The average annual effective dose per person in the participating European countries has been calculated to be about 1.1 mSv from all medical imaging. This value represents about half the recent medical radiation dose estimate in Australia and about one-third of that in the United States. The report also shows that radiation doses from medical imaging vary considerably among the different European countries and that there is a trend upwards in many countries; further analyses on a national level are needed to better quantify and understand these differences and trends.

In terms of the significance of the different groups of medical imaging procedures, the report demonstrates that computed tomography alone accounts for more than half of the medical radiation exposure of the European population in 2007-2010. Other x-ray procedures are responsible for most of the remaining population exposure, and nuclear medicine represents only about five percent.

The work undertaken to produce this report has provided several important additional benefits. Most importantly, the project stimulated national efforts to develop and carry out population dose studies, including in some European countries with limited previous experience. The report identified a “Top 7” of the most important nuclear medicine procedures, which is complementary to the RP 154's "Top 20" for x-ray examinations and could be used in future national dose surveys. Finally, a summary of the national diagnostic reference levels (DRLs) is published as Part 2 of this report (only available online).

I believe that the data and the results included in this report will serve as an important reference for authorities, scientists and professionals dealing with radiation protection of patients. High-quality and up-to-date information provides the basis of sound policies, and maintaining and updating our knowledge of the medical radiation exposure of the population should be of utmost importance. This is emphasized in the new European Basic Safety Standards Directive (Council Directive 2013/59/Euratom), which requires that the age and gender distribution of the exposed patient population be taken into account.

The publication of this report in the Commission's Radiation Protection series of publications has been recommended by the Group of Experts established under Article 31 of the Euratom Treaty.

Ivo Alehno

Head of Radiation Protection Unit

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EXECUTIVE SUMMARY

The DDM2 survey was carried out using open questions in an 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 have been established in 72 % of the 36 European countries and in 81 % of EU and EFTA countries (Iceland, Norway and Switzerland). For paediatric x-ray examinations, only 39 % of the countries have established DRLs and 45 % of EU and EFTA countries.

For adult DRLs, 77 % are based on countries' own national dose surveys at least in part in Europe and 83 % in EU and EFTA countries, while the rest are based on published values or recommendations, such as EC recommendations. For paediatric DRLs, 64 % are based on countries' own national dose surveys at least in part, 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, 70 % are based on countries' own national dose surveys at least in part, while the rest are based on published values.

The DRLs for adult x-ray procedures were established at least in part based on surveys in 18 countries and for paediatric x-ray procedures in 10 countries. In those countries that had used published values, DRLs were most commonly adopted from the European guideline RP 109. The DRLs for nuclear medicine were established at least in part based on surveys in 13 countries.

The most common value of the DRLs in Europe was recorded when there was more than one similar value; in case of competing options for such values, the lowest values of the options were recorded. The most common value does not mean that it represents European practice, because there might be differences in the quality of the surveys on which it is based. However, the most common value in this report represents the status of established DRLs in Europe.

More DRLs than presented in the comparative tables were reported to exist in some countries. All reported national DRLs are presented in the Annex 1. In some cases the examination was not explained clearly enough to compare the DRL with other DRLs. This was especially the case in NM heart examinations.

In this survey, it came out that in all countries that reported their own methodology for setting DRLs, the principle of the 75th percentile was adopted for x-ray procedures. For NM procedures the methodology from RP 109 to use DRLs as guiding values was adopted in most of the countries. It is recommended in RP 109 that this level of activity be administered for a certain type of examination in standard situations. In Finland and Greece, DRLs were established using the 75th percentile and were set at levels that are expected not to be exceeded for standard procedures when good and normal practice regarding diagnostic and technical performance is applied. Administrations above these levels would only be considered as good practice in particular circumstances. All DRLs were given for normal size patients (70 kg ± 15 kg) and to paediatric patients typically according to the child's age or weight.

The usefulness of DRLs in NM should be investigated. The DRLs in NM are guiding values according to RP 109 and used as such. This does not encourage to optimize. The administered activities should be optimized for each patient taking into account the whole imaging procedure including available equipment. A recommended value does not represent an optimized activity in all cases. However, it is highly important to have recommendations

for dosage of paediatric patients, such as the European Association of Nuclear Medicine (EANM) has given (Lassmann 2008, Lassmann 2007, Piepsz 1990).

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. A study to evaluate existing surveys and methods that were used to establish DRLs could be carried out in Europe to revise European DRLs. The results of this survey could be used as a baseline for the study. Especially the DRLs for paediatric x-ray examinations should be updated and established. Because of a high variation in paediatric patients' sizes, more attention should be paid to practical methods to use DRLs. If the DRL is fixed to a certain age or weight, it might not be possible to collect a group of patients to compare the DRL with.

This report gives a summary of available DRLs without recommending any values to be used.

1 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 (ICRP 1996), ICRP Supporting Guidance 2 (ICRP 2001) and ICRP 103 (ICRP 2007) 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.

According to Radiation Protection 109 (EC 1999), Guidance on Diagnostic Reference Levels (DRLs) for Medical Exposures, DRLs should be established both for diagnostic radiology and 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 a survey of 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 average bear a clear relationship to 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 for a country to evaluate the appropriateness of the DRLs. For example, if the mean effective dose in a particular procedure is lower than or equal to that in other countries, but the DRL is higher, there may be a need to find out reasons for that and to update DRLs.

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

2 DIAGNOSTIC REFERENCE LEVELS FOR X-RAY PROCEDURES

2.1 General

Diagnostic reference levels (DRL) for adult x-ray examinations have been 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 81 %, 16 % and 3 % respectively. From the countries that have no adult DRLs, a draft document for DRLs in 10 different types of plain radiography was under approval process in Ukraine during the DDM2 project.

For paediatric x-ray examinations, only 39 % of the countries have established DRLs (55 % have no DRLs and 6 % have not replied) (Fig 2.2). Corresponding figures for EU and EFTA countries are 45 %, 49 % and 6 % respectively.

For adult DRLs, 77 % are based on national dose surveys in Europe at least in part and 83 % 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. For paediatric DRLs, 64 % are based on national dose surveys at least in part (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. The country was classified as having DRLs based on its own surveys in situations where at least one DRL in the corresponding group of examinations was based on its own survey.

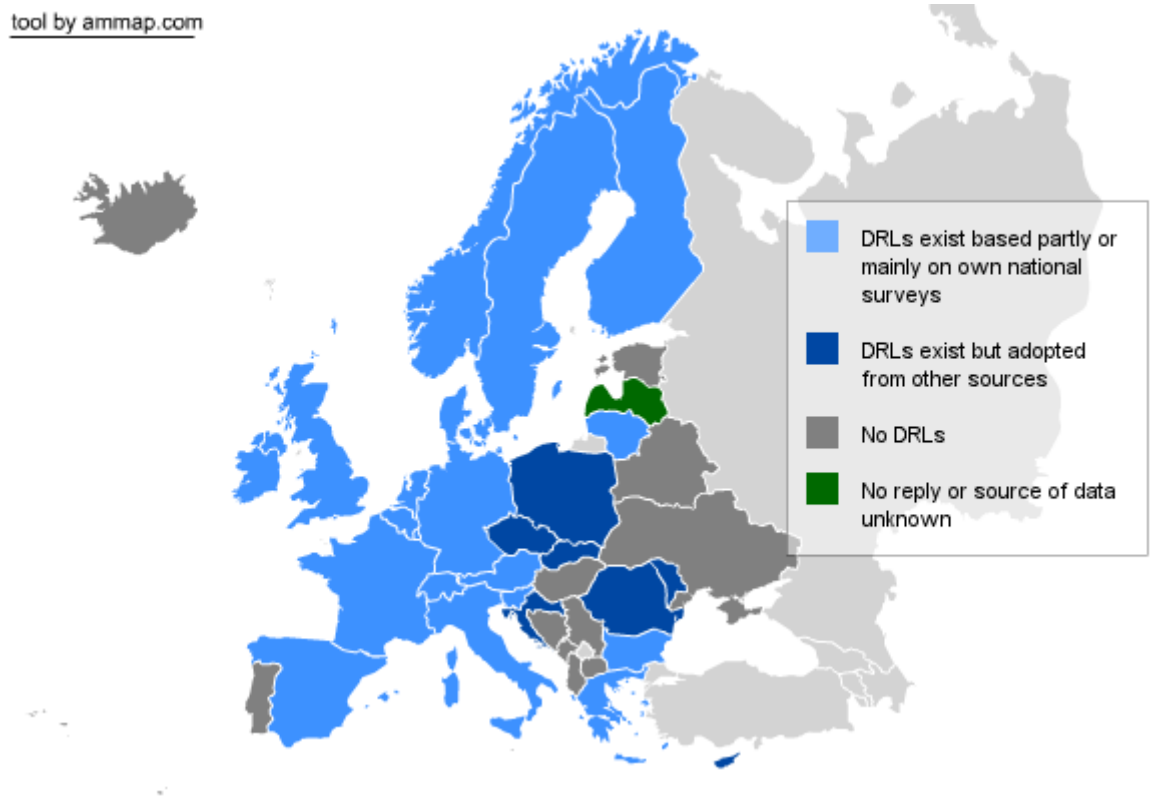

Figure 2.1. Diagnostic reference levels for adult x-ray examinations.

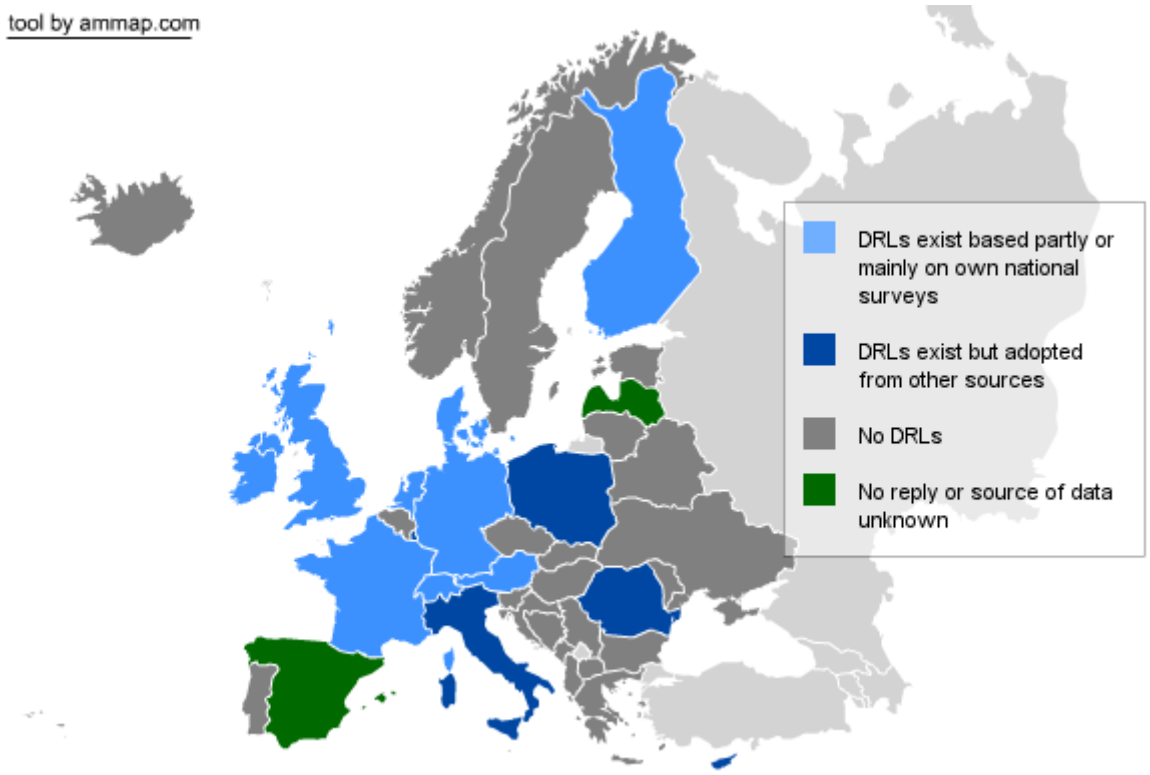

Figure 2.2. Diagnostic reference levels for paediatric x-ray examinations.

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	No DRLs	No DRLs	No DRLs	Own survey
Bulgaria	BG	Own survey & other	Own survey	Own survey	Own survey	Own survey
Croatia	HR	IAEA BSS 115	IAEA BSS 115	No DRLs	No DRLs	IAEA BSS 115
Cyprus	CY	EU RP 109	EU RP 109	No DRLs	No DRLs	No DRLs
Czech Republic	CZ	Own survey & IAEA BSS 115 & Scandinavian recommendations	EU RP 109	Scandinavian recommendations	No DRLs	EUR 16262
Denmark	DK	Own survey	Own survey	Own survey	No DRLs	Own survey
Estonia	EE	No DRLs	No DRLs	No DRLs	No DRLs	No DRLs
Finland	FI	Own survey	Own survey	Own survey	Own survey	Own survey
France	FR	Own survey	Own survey	No DRLs	No DRLs	Own survey
Germany	DE	Own survey	Own survey	Own survey	Own survey	Own survey
Greece	EL	No DRLs	Own survey	No DRLs	No DRLs	No DRLs
Hungary	HU	No DRLs	No DRLs	No DRLs	No DRLs	No DRLs
Iceland	IS	No DRLs	No DRLs	No DRLs	No DRLs	No DRLs
Ireland	IE	Own survey	EU RP 109	Own survey	UK data	Own survey
Italy	IT	EU RP 109	EU RP 109	EU RP 109	No DRLs	No DRLs
Latvia	LV	No DRLs	No DRLs	No DRLs	No DRLs	No DRLs
Lithuania	LT	Own survey	Own survey	Own survey	No DRLs	Own survey
Luxembourg	LU	Own survey	EU RP 109	Own survey & EUR 16260 & DE regulation	Own survey & DE regulation	Own survey
Frmr. Yug, Rep. Of Macedonia	MK	No DRLs	No DRLs	No DRLs	No DRLs	No DRLs
Malta	MT	No DRLs	No DRLs	No DRLs	No DRLs	No DRLs
Moldova	MD	IAEA BSS 115	IAEA BSS 115	No DRLs	No DRLs	IAEA BSS 115
Montenegro	ME	No DRLs	No DRLs	No DRLs	No DRLs	No DRLs
Netherlands	NL	Own survey	Own survey	No DRLs	No DRLs	Own survey
Norway	NO	Own survey	Own survey	Own survey	No DRLs	Own survey
Poland	PL	Own survey	No DRLs	No DRLs	No DRLs	EUR 16262
Portugal	PT	No DRLs	No DRLs	No DRLs	No DRLs	No DRLs
Romania	RO	EU RP 109	IAEA BSS 115	No DRLs	No DRLs	No DRLs
Serbia	RS	No DRLs	No DRLs	No DRLs	No DRLs	No DRLs
Slovakia	SK	Unknown	Unknown	Unknown	No DRLs	Unknown
Slovenia	SI	Own survey	No DRLs	No DRLs	No DRLs	Own survey
Spain	ES	Own survey	Own survey	Own survey	Own survey	Own survey
Sweden	SE	Own survey	Own survey	Own survey	No DRLs	Own survey
Switzerland	CH	Own survey	No DRLs	Own survey	Own survey	Own survey
Ukraine	UA	No DRLs	No DRLs	No DRLs	No DRLs	No DRLs
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	No DRLs	No DRLs	No DRLs
Bulgaria	BG	No DRLs	No DRLs	No DRLs
Croatia	HR	No DRLs	No DRLs	No DRLs
Cyprus	CY	EU RP 109	No DRLs	No DRLs
Czech Republic	CZ	No DRLs	No DRLs	No DRLs
Denmark	DK	Own survey	Own survey	No DRLs
Estonia	EE	No DRLs	No DRLs	No DRLs
Finland	FI	Own survey	Own survey	No DRLs
France	FR	Own survey	No DRLs	Own survey
Germany	DE	Own survey	Own survey	Own survey
Greece	EL	No DRLs	No DRLs	No DRLs
Hungary	HU	No DRLs	No DRLs	No DRLs
Iceland	IS	No DRLs	No DRLs	No DRLs
Ireland	IE	Own survey and UK data	UK data	Own survey
Italy	IT	EU RP 109	No DRLs	No DRLs
Latvia	LV	Not known	Not known	Not known
Lithuania	LT	No DRLs	No DRLs	No DRLs
Luxembourg	LU	EUR 16261	No DRLs	No DRLs
Frmr. Yug, Rep. Of Macedonia	MK	No DRLs	No DRLs	No DRLs
Malta	MT	No DRLs	No DRLs	No DRLs
Moldova	MD	No DRLs	No DRLs	No DRLs
Montenegro	ME	No DRLs	No DRLs	No DRLs
Netherlands	NL	Own survey	Own survey	Unknown
Norway	NO	No DRLs	No DRLs	Own survey
Poland	PL	EU RP 109	No DRLs	No DRLs
Portugal	PT	No DRLs	No DRLs	No DRLs
Romania	RO	EU RP 109	No DRLs	No DRLs
Serbia	RS	No DRLs	No DRLs	No DRLs
Slovakia	SK	No DRLs	No DRLs	No DRLs
Slovenia	SI	No DRLs	No DRLs	No DRLs
Spain	ES	Not known	Not known	Not known
Sweden	SE	No DRLs	No DRLs	No DRLs
Switzerland	CH	Own survey	Own survey	M. Galanski, HD Nagel (2005/06)
Ukraine	UA	No DRLs	No DRLs	No DRLs
United Kingdom	UK	Own survey	Own survey	No DRLs

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) or both 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. In addition, the countries having a DRL that is higher or lower than the most common one are given.

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 have been recorded. The most common value does not mean that it represents European practice, because there might be differences in the quality of the surveys on which it is based.

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	2,5-5	2	CY, CZ, ES, IT, MD, RO, SK	-	BE, BG, CH, UK
	LAT	3	1-3	3	CY, CZ, ES, IT, MD, RO, SK	-	BE, CH, UK
Chest, thorax	PA	0,3	0,15-0,6	4	CY, ES, FR, LT, RO	BG, CZ, HR, IT, MD, SK	BE, CH, FI, UK
	LAT	1,5	0,75-2	2,7	CY, CZ, ES, HR, IT, RO,	LT, MD	BE, CH, FI, FR, UK
Thoracic spine	AP	7	3,5-7	2	CZ, HR, MD, SK	-	FR, LT, UK
	LAT	20	10-20	2	CZ, HR, MD, SK	-	FR, LT, UK
Abdomen	AP or PA	10	4,5-10	2,2	CZ, ES, IT, SK	-	BE, FI, FR, LT, UK
Lumbar spine	AP	10	5-10	2	CY, CZ, ES, FR, HR, IT, LT, MD, RO, SK	-	BE, BG, CH, DK, FI, IE, UK
	LAT	30	10-30	3	CY, CZ, ES, HR, IT, MD, SK	-	BE, BG, CH, FI, FR, LT, UK
	LSJ	40	26-40	1,5	CY, CZ, ES, IT, MD, RO	-	UK
Pelvis	AP	10	3,5-10	2,9	CY, CZ, ES, IT, MD, RO, SK	-	BE, BG, CH, FI, FR, LT, UK
Mammography	CC, MLO or LAT	10	7-12	1,7	CY, DK, ES, FI, IT, LU, RO	BG	EL, FR
	One projection	3	1,3-4; (CZ: 1,3-7,3)	3,1	HR, MD, NO, SK	IE, SE, UK	AT, CZ, DE, FR, LT, NL

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 MGD seems to be used in the majority of cases. For mammography, 68 % of European countries have given DRLs and 61 % of EU and EFTA countries.

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	CH, DE, LU	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	160	120-1000	8,3	DE, IE, LU	AT, BE, BG, CZ, FR, PL	CH, SI, UK
	LAT	600	250-1000	4	CH, LU	AT, CZ, FR, PL	BE, DE, SI
Thoracic spine	AP	1300	970-2200	2,3	DE, LU, SI	FR, PL	IE
	LAT	1700	1200-3200	2,7	DE, LU	FR, IE, NO, PL	SI
Abdomen	AP or PA	3000	2000-8000	4	AT, FI, DE, LU, NL, UK	BE, CZ, FR, NO, PL	IE, SI
Lumbar spine	AP	2300	1500-10000	6,7	DE	BE, BG,CH, CZ, FR, LU, PL	IE, SI, UK
	LAT	4200	2750-8000	2,9	DE, CH	BE, FR, PL	AT, IE, SI, UK
	LSJ	3000	2400-3000	1,3	SI, UK	-	IE
Pelvis	AP	3000	1500-7000	4,7	AT, DE, FI, UK	BE, BG, CZ, FR, LU, PL, SE	CH, DK, IE, NO, SI

The most common DRLs using ESD were the same as in EU guideline RP 109 (Table 2.5), but the variation is quite high. For thorax PA, for example, it is four-fold in range 0,15-0,6 mGy. Most of the countries with lower DRL than the most common value had carried out their own survey and about two- thirds of countries with the most common value or higher had adopted a recommended value from RP 109 or from International BSS 115. 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. European recommendations of DRLs could also be updated.

Table 2.5. DRLs in EU guideline RP 109.

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

DRLs for adult x-ray procedures are given for 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 DRLs such as published guidance, reports or results of national surveys. The concept of DRLs as described in EU RP 109 was adopted with the exception that DRLs were given in one country as guiding values. Only a few countries reported that they had regular surveys to update the DRLs.

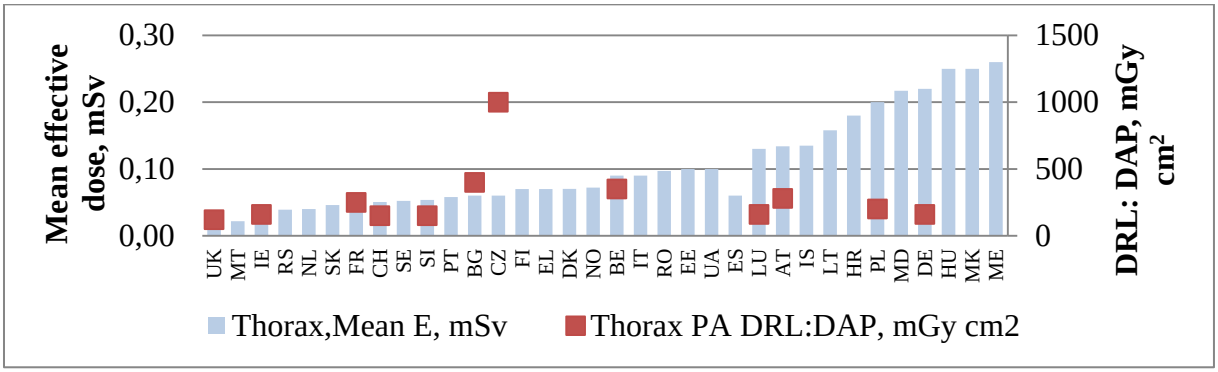

Figure 2.3. Comparison of DRL values with the mean effective doses for thorax PA plain radiography.

In Fig. 2.3. for 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 the 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. Additionally, if the mean effective dose in a procedure is approximately similar to the mean effective dose in other countries but the DRL is much higher or lower than DRLs in other countries, this might lead to subsequent re-evaluation of the DRL value.

The range of the DRLs is usually high: the variation is typically 2-4-fold but at maximum even 8-fold. Figures 2.4. to 2.9 illustrate the variation in the DRL values for a few selected cases.

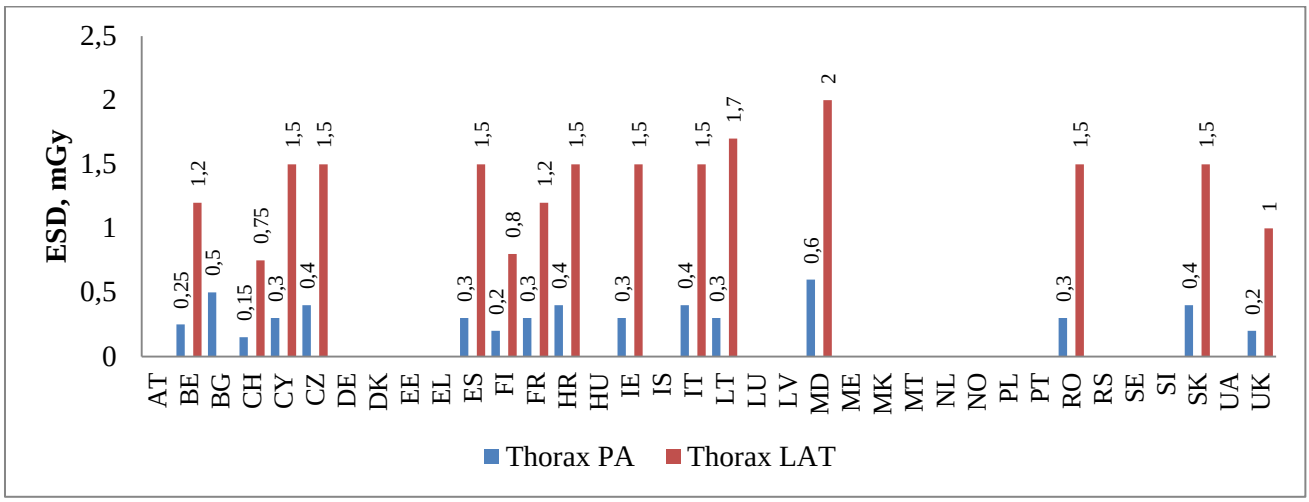

Figure 2.4. Comparison of DRLs for thorax plain radiography in terms of ESD (mGy).

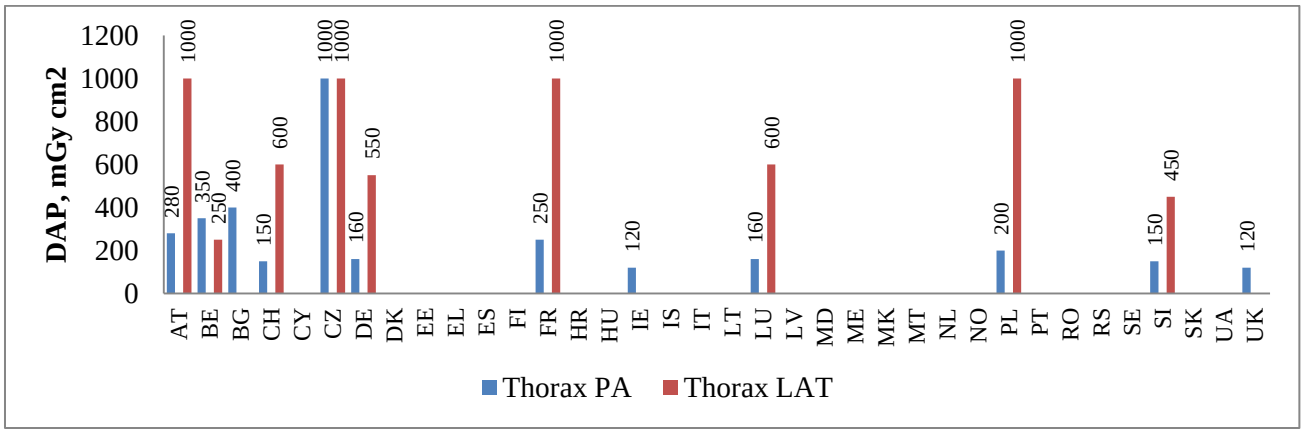

Figure 2.5. Comparison of DRLs for thorax plain radiography in terms of DAP (mGy cm2).

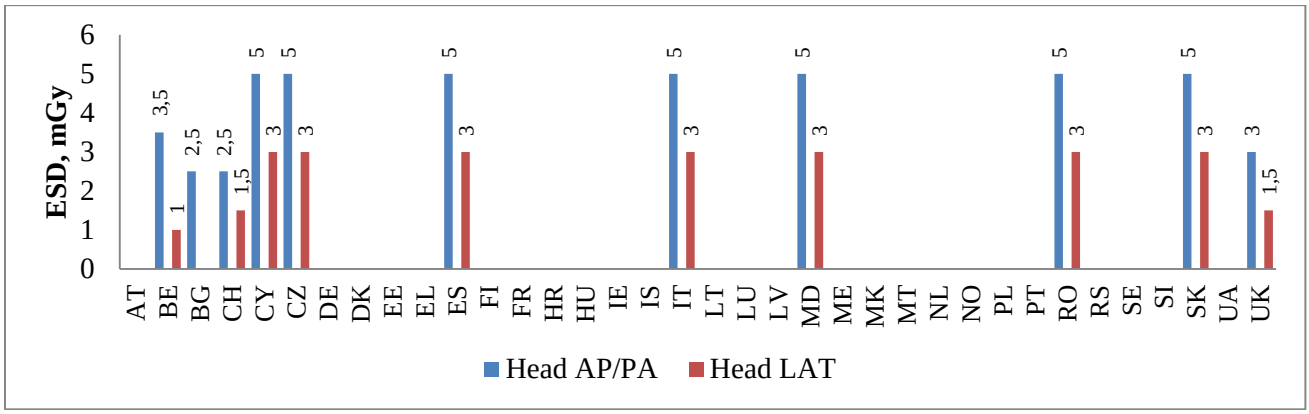

Figure 2.6. Comparison of DRLs for head plain radiography in terms of ESD (mGy).

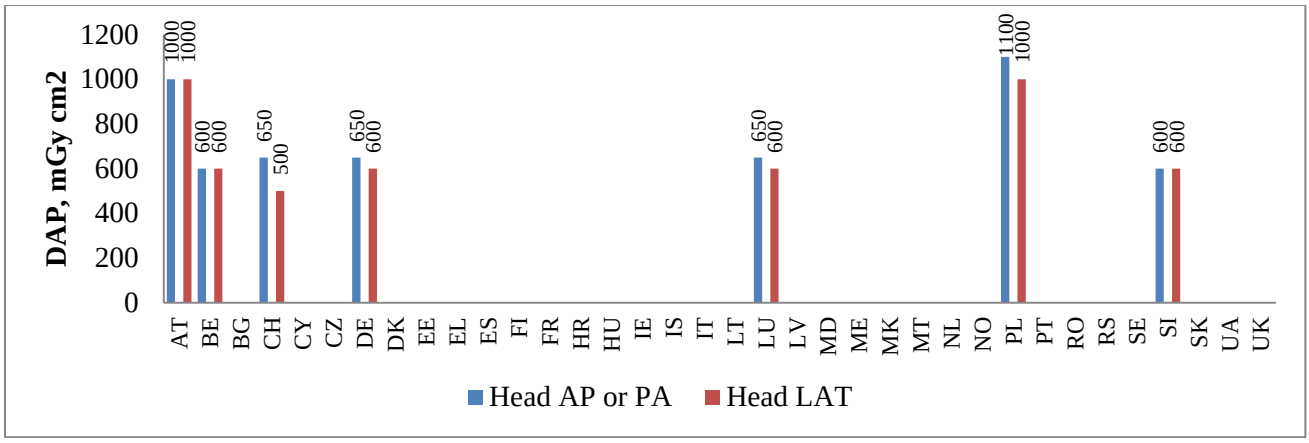

Figure 2.7. Comparison of DRLs for head plain radiography in terms of DAP (mGy cm2).

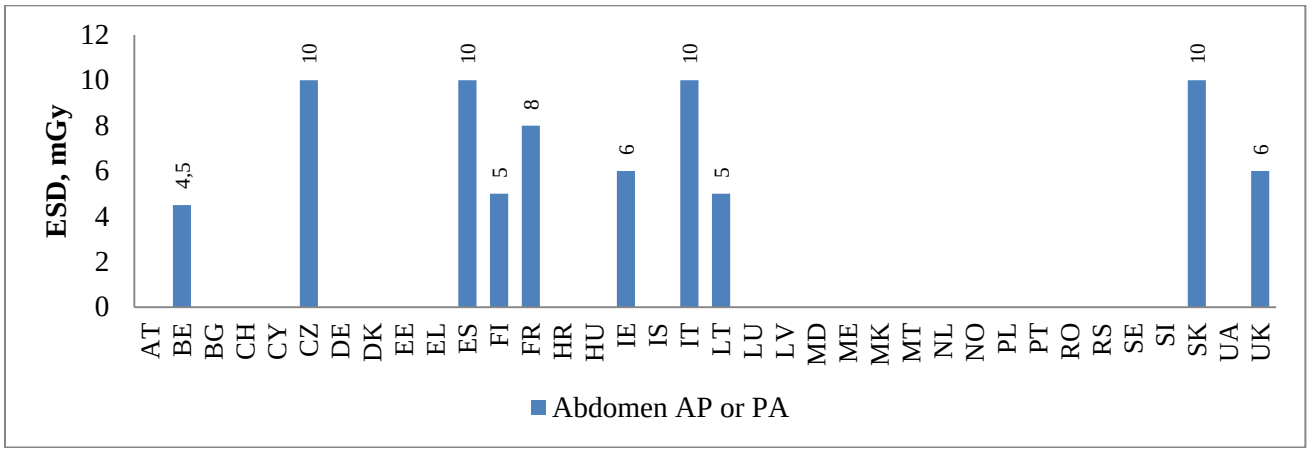

Figure 2.8. Comparison of DRLs for abdomen plain radiography in terms of ESD (mGy).

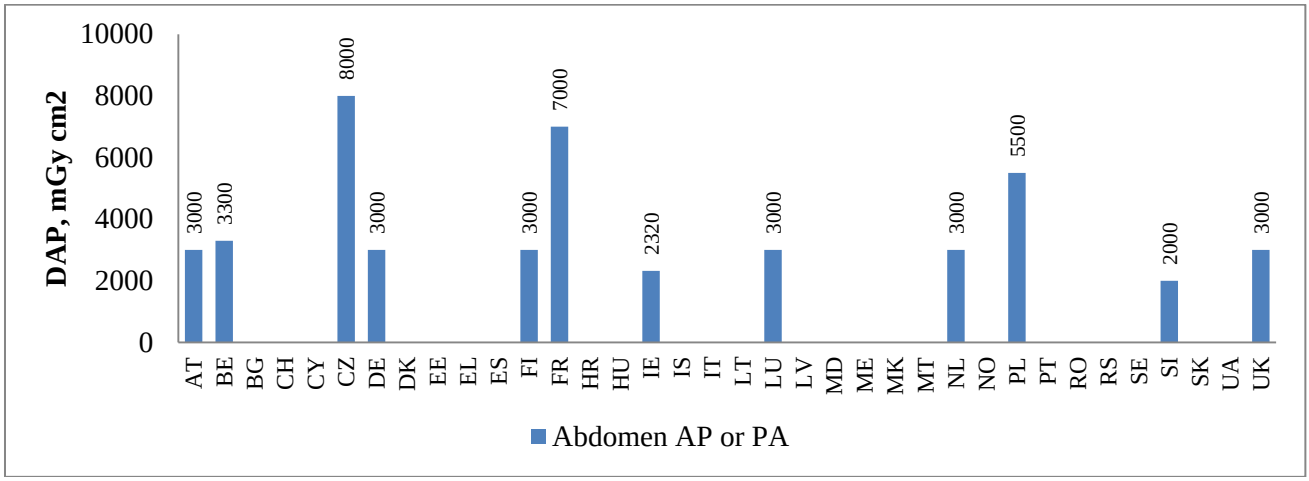

Figure 2.9. Comparison of DRLs for abdomen plain radiography in terms of DAP (mGy cm2).

All national DRLs for plain radiography procedures that were reported in the DDM2 survey are presented in the Annex 1 in Tables 1a-1e.

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 with this DRL are given; in case of competing options or no similar values, the lowest option is recorded. Furthermore, 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 value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
Barium meal	18	13-25	1,9	BG, LT	CY, CZ	UK
Small intestine	44	44-65	1,5	DE, LU	AT, UK	
Barium enema	40	30-60	1,9	BG, NO	CY, CZ, SE	DE, DK, LT, UK
Colon	37	23-50	2,2	LU	FI	IE
ERCP	30	30-45	1,5	CH	AT	
IVU	20	15-40	3,3	DK, FI, SE	CY, CZ	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	45-64	1,4	BG	LU	-

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

Examination or Anatomical region	Most common value	Range	Max/min	Countries with the most common DRL	Countries with higher DRL	Countries with lower DRL
Fluoroscopy time, min						
Barium meal	2,3	2,3-14,1	6,1	UK	BG	-
Barium enema	2,7	2,7/10,7-14,2	5,3	UK	BG	-
Coronary angiography (CA)	5,6	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 for many other fluoroscopy examinations but they typically exist only in only one country. All national DRLs for fluoroscopy procedures that were reported in the DDM2 survey are presented in the Annex 1 in Tables 2a-2h.

Table 2.8. Most common DRLs in terms of DAP [Gy cm2] 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 typically high: the variation is typically 2-6-fold. Figures 2.10 to 2.13 illustrate the variation in the DRL values for a few selected cases. The 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 the number of DRLs.

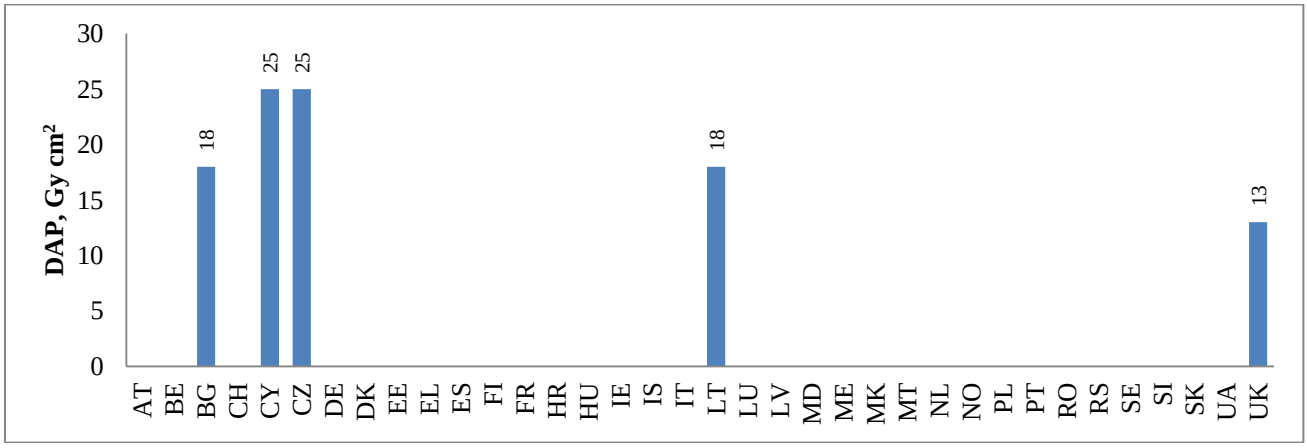

Figure 2.10. Comparison of DRLs for barium meal in terms of DAP (Gy·cm2).

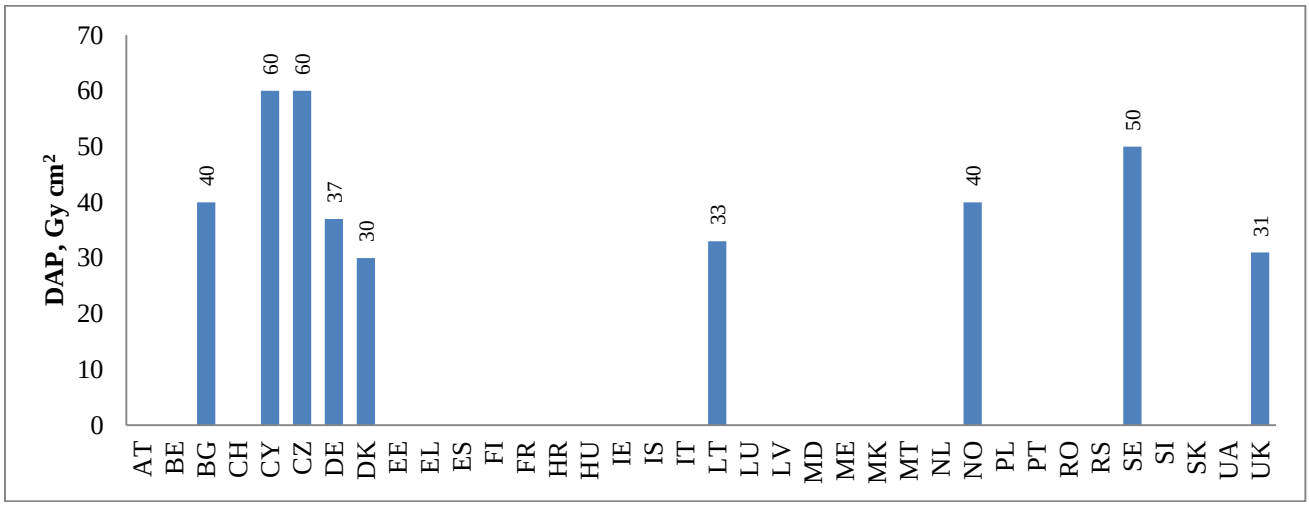

Figure 2.11. Comparison of DRLs for barium enema in terms of DAP (Gy·cm2).

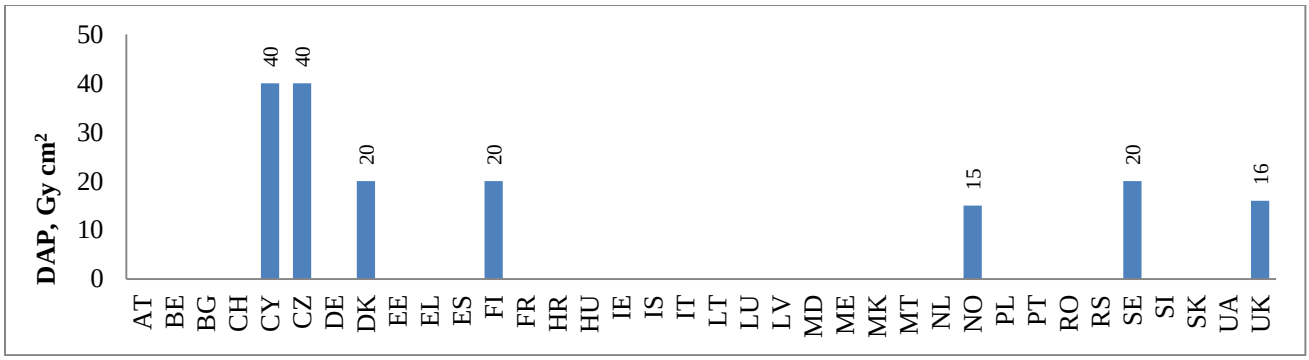

Figure 2.12. Comparison of DRLs for IVU in terms of DAP (Gy·cm2).

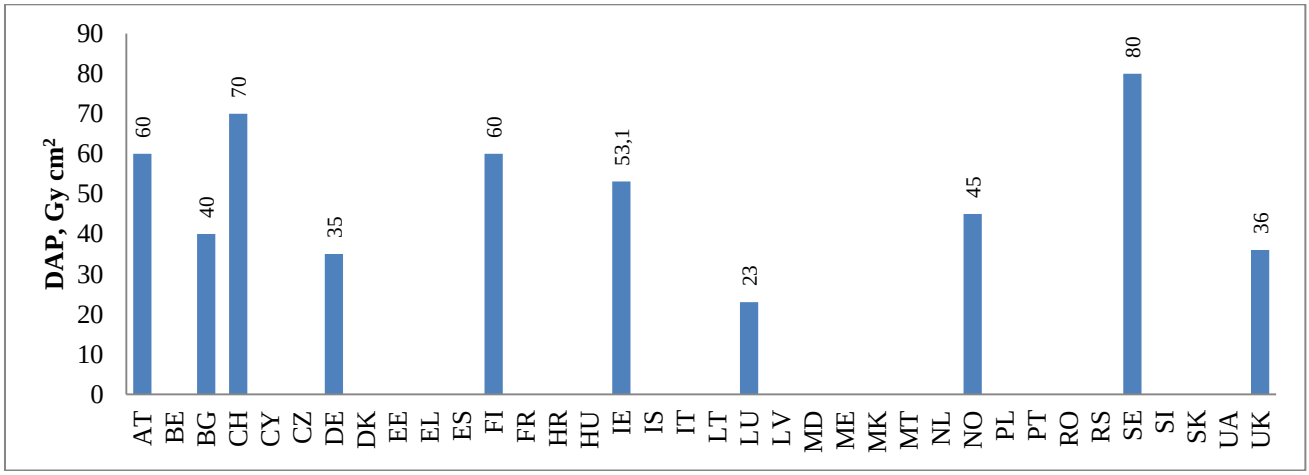

Figure 2.13. Comparison of DRLs for Coronary angiography (CA) in terms of DAP (Gy·cm2).

2.2.3 Interventional radiology

PTCA is the only interventional procedure where several (six) 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 for some other interventional procedures. All national DRLs for interventional procedures that were reported in the DDM2 survey are presented in the Annex 1 in Tables 3a-3c.

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	CH, FI	AT	DE, IE, LU

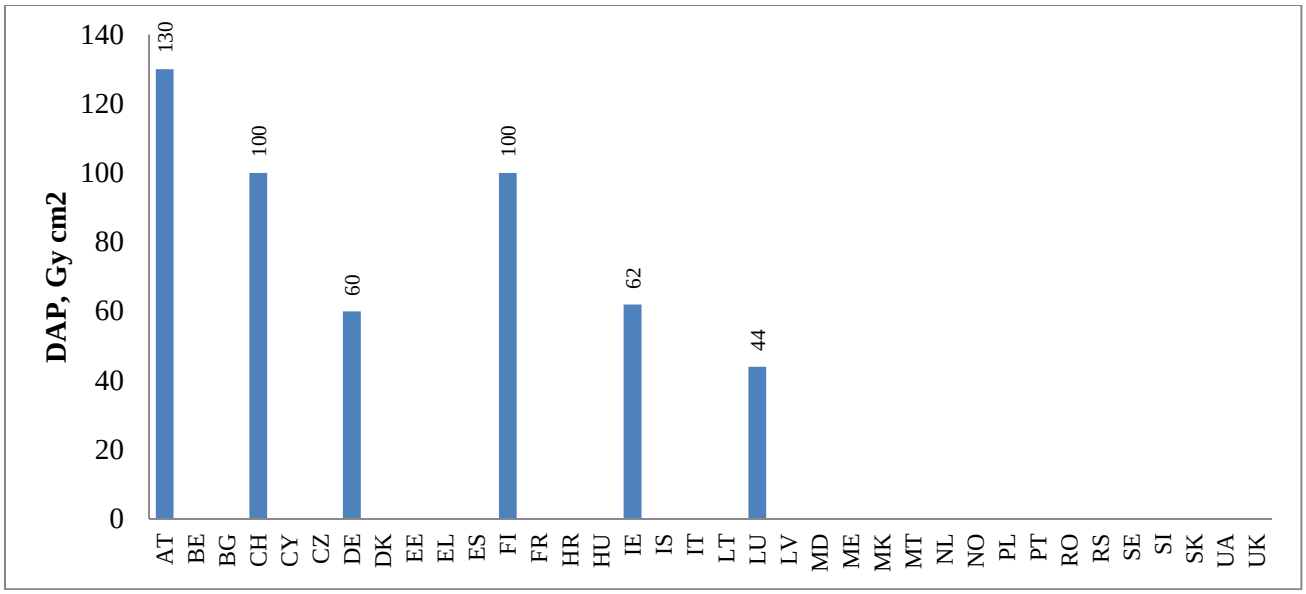

Figure 2.14. Comparison of DRLs for PTCA in terms of DAP (Gy·cm2).

2.2.4 Computed tomography

DRLs have been given in terms of either DLP (Dose Length Product) or CTDIvol (pitch corrected CT dose index) as summarized in Tables 2.10 and 2.11. The most common value of the DRL has been recorded when there has been more than one similar value, and the countries having this DRL have been identified. Furthermore, the countries with 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, CH, FI, LU, NO	AT, BE, DK, FR, IT, PL, SE, SI	DE, IE, LT, UK
Cervical spine	-	400-600	1,5	CH, IE, LU, NO	-	-
Neck	500	440-500	1,1	DK, CH	-	LU
Chest normal	400	270-700	2,6	BE, CH, DE, NO	AT, BG, DK, FI, FR, IE, IT, LT, PL, SE,	LU
Chest HRCT	-	80 -300	3,8	DK, IE, PL, UK	-	-
Upper abdomen	-	400-740	1,9	AT, CH, DE	-	-
Abdomen	800	460-1200	2,6	DK, IT, LU, NO	AT, BE, DE, LT	BG, CH, FI, IE, PL, SI, UK
Pelvis	550	450-650	1,4	BG, LT	AT, DK, IT, PL	CH, DE
Lumbar spine	500	300-870	2,9	FI, DE, LU, NO	BE, FR, SE, CH	LT

Table 2.11. DRLs given in terms of CTDIvol, 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	BG, CZ, IT	CH, FI, FR, NO, SE, SI	HR, MD, UK
Chest normal	10	10-30	3	CH, UK	BG, FI, FR, IT, NO, SE, SI	-
Abdomen	25	13-35	2,7	HR, MD, SE	BG, CZ, IT	CH, FI, NO, SI, UK
Lumbar spine	35	30-55	1,8	CZ, HR, MD	FI, FR, SE	CH, NO

In addition to the DRLs given in Tables 2.10 and 2.11, DRLs have been given for some other CT procedures in some countries. All national DRLs for CT procedures that were reported in the DDM2 survey are presented in the Annex 1 in Tables 4a-4d.

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

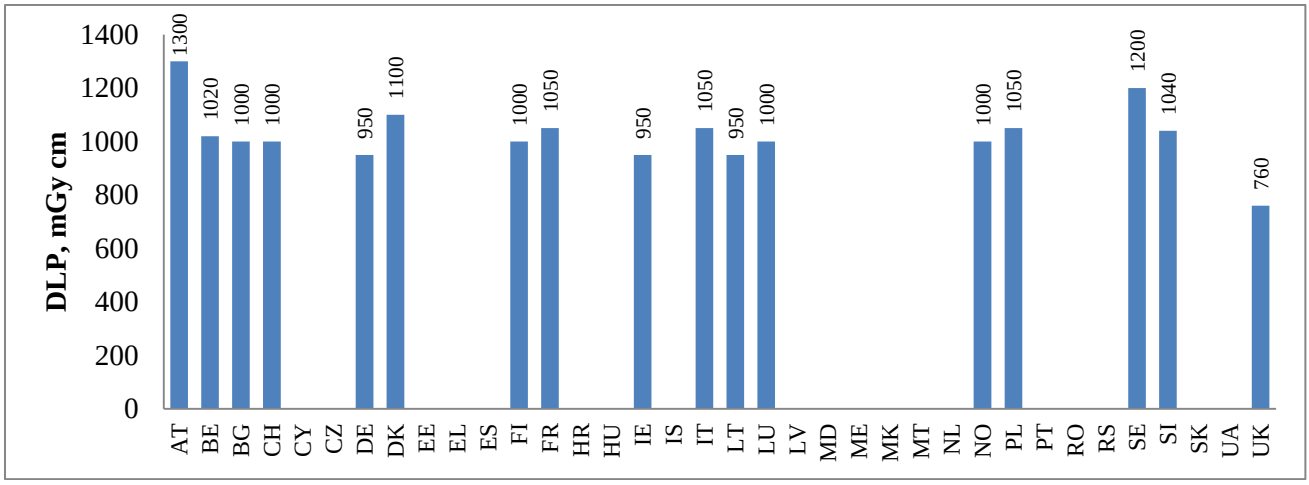

Figure 2.15. Comparison of DRLs for CT head in terms of DLP, mGy·cm.

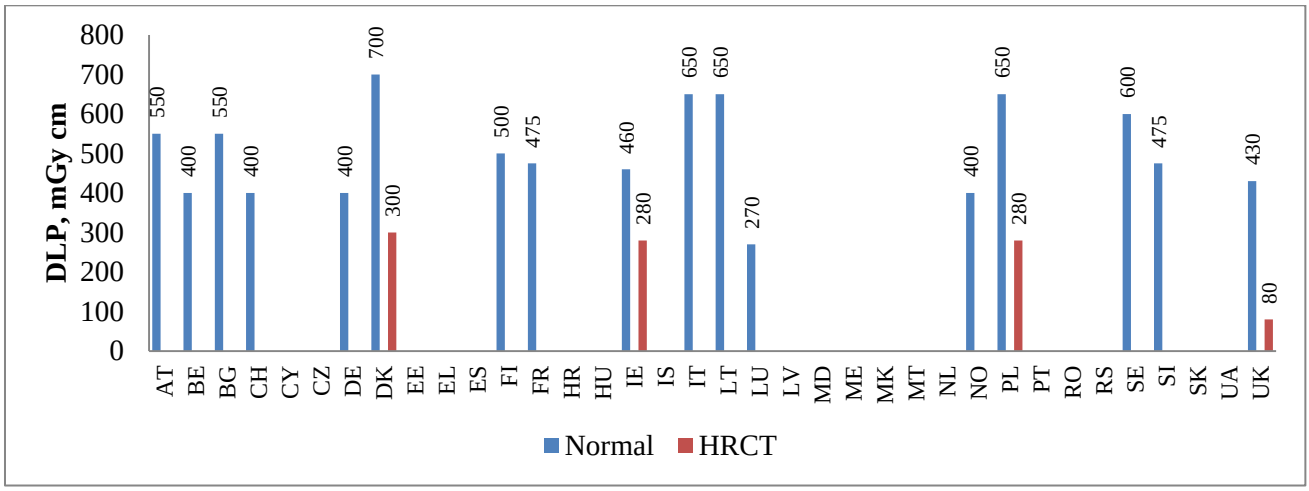

Figure 2.16. Comparison of DRLs for CT chest in terms of DLP, mGy·cm.

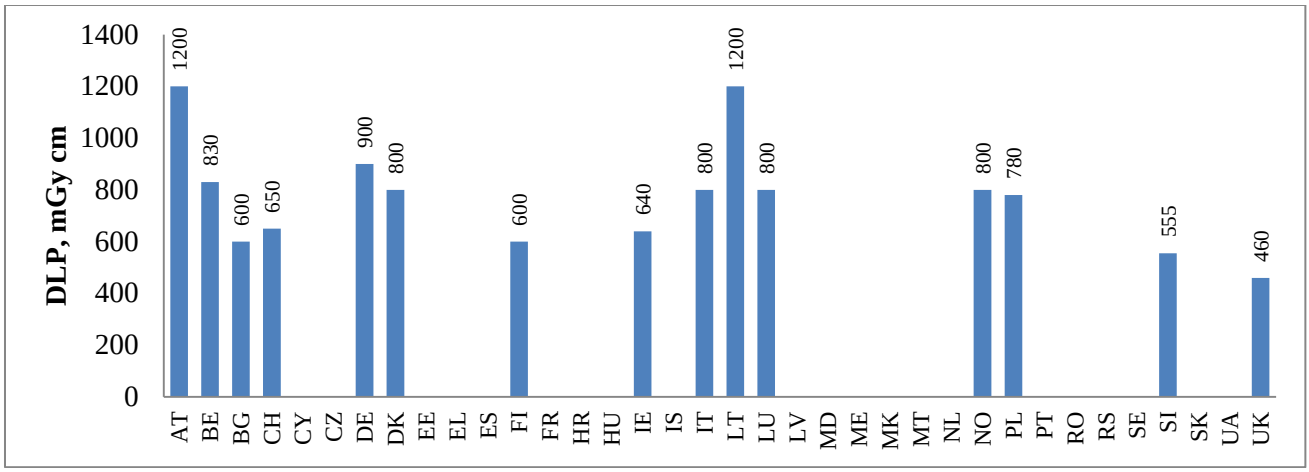

Figure 2.17. Comparison of DRLs for CT abdomen in terms of DLP, mGy·cm.

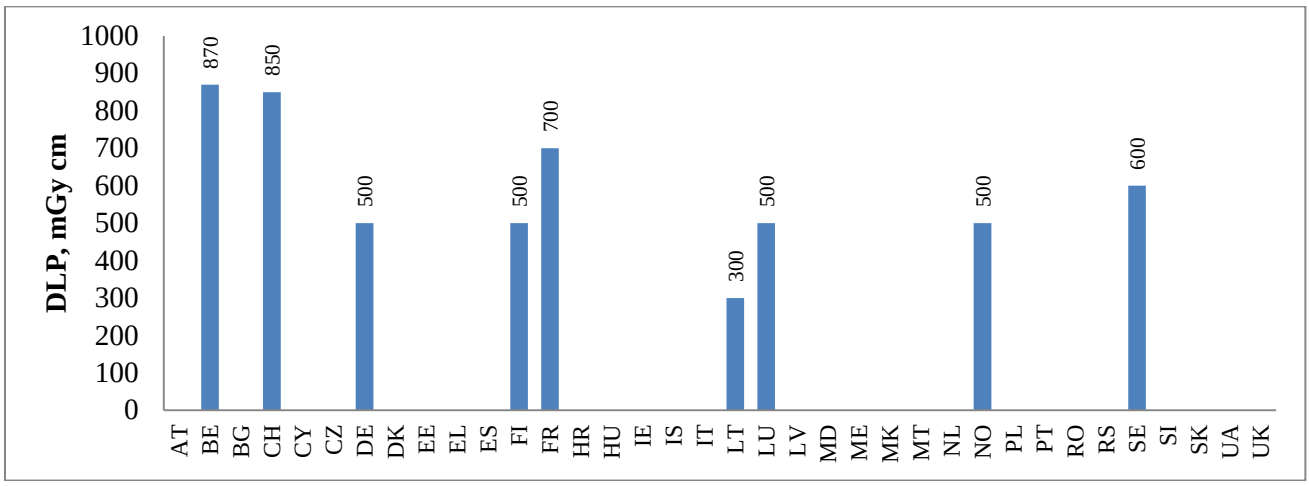

Figure 2.18. Comparison of DRLs for CT lumbar spine in terms of DLP, mGy·cm.

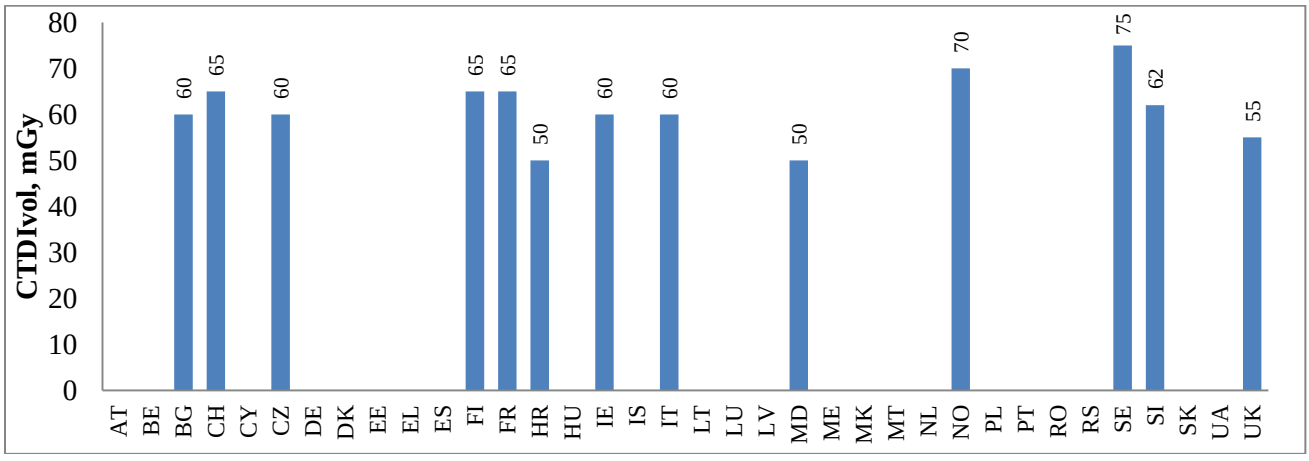

Figure 2.19. Comparison of DRLs for CT head in terms of CTDIvol, mGy.

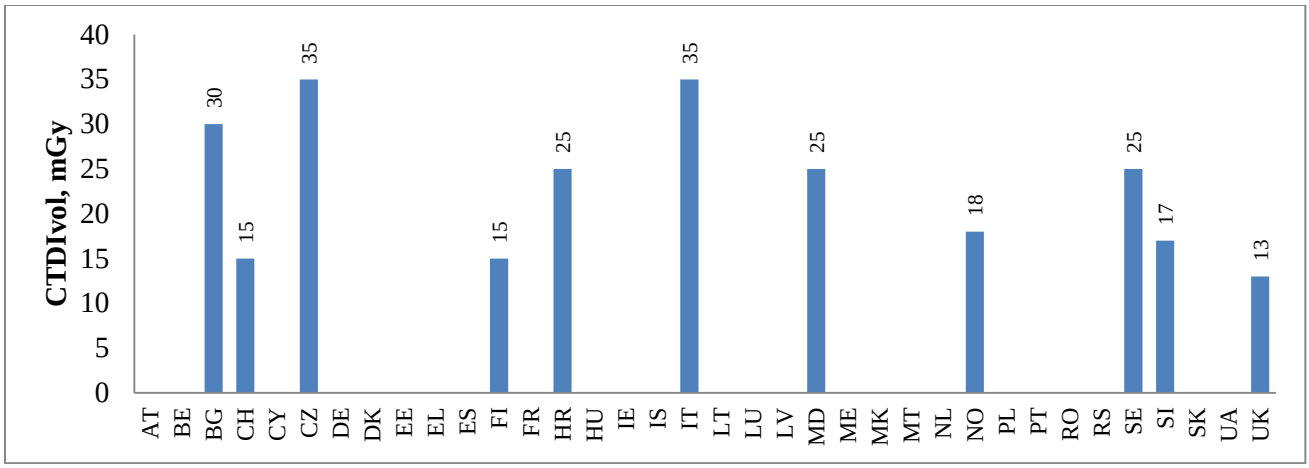

Figure 2.20. Comparison of DRLs for CT abdomen in terms of CTDIvol, mGy.

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 examples of DRLs given in RP 109. Most often in case of countries' own studies, DRLs are even lower. All national DRLs for paediatric x-ray procedures that were reported in the DDM2 survey are presented in Annex 1 in Tables 5a-5e.

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	1,5	1,37-1,5	1,1	CY, IT, LU, PL, RO	-	IE
	LAT	5 years	1	0,82-1	1,2	CY, IT, LU, PL, RO	-	IE
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	0,053-0,1	1,9	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	0,752-1	3,0	CY, IT, LU, PL, RO	-	IE
Pelvis	AP	Infants	0,2	0,2	1,0	CY, IT, LU, PL, RO	-	-
	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	-	200-250	1,3	AT, DE	-	-
	AP/PA	5 years	-	300-350	1,2	AT, DE	-	-
	LAT	1 year	200	200	1,0	AT, DE	-	-
		5 years	250	250	1,0	AT, DE	-	-
Thorax	AP or PA	Newborn	-	5-17	3,4	AT, DE, FR, NL	-	-
	AP or PA	5 years	50	37-50	1,0	DE, FR	-	AT
	LAT	5 years	-	40-60	1,5	DE, FR	-	-
	LAT	10 years	-	60-80	1,3	DE, FR	-	-
Abdomen	AP	1 year	-	90-200	2,2	AT, DE, NL	-	-
	AP	5 years	250	200-300	1,5	DE, NL	FR	AT
	AP	10 years	-	350-700	2,0	AT, DE, FR	-	-
Pelvis		5 years	-	150-200	1,3	DE, FR	-	-
		10 years	-	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	1,5	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	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	0,2-1	5,0	DK, FI, IE	UK	AT, DE, NL
	5 years	0,9	0,3-1,2	3,3	DK, FI	AT, IE, UK	DE, NL
	10 years	2,1	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	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	-	270-340	1,3	AT, CH, IE, UK	-	-
	1 year	-	270-470	1,7	AT, CH, FR, IE, UK	-	-
	5 years	600	470-600	1,3	AT, FR	IE	CH, UK
	10 years	-	620-900	1,5	AT, CH, FR, IE, UK	-	-
	15 years	900	850-920	1,1	AT, FR	CH	IE
CT chest	0 years	-	12-200	16,7	AT, CH, UK	-	-
	1 year	-	28-200	7,1	AT, CH, FR, UK	-	-
	5 years	-	55-230	4,2	AT, CH, UK	-	-
	10 years	-	105-370	3,5	AT, CH, FR, UK	-	-
	15 years	-	200-205	1,0	AT, CH	-	-
CT abdomen	0 years	-	27-130	4,8	AT, CH	-	-
	1 year	-	70-160	2,3	CH, FR, IE	-	-
	5 years	-	125-230	1,8	CH, IE	-	-
	10 years	-	240-400	1,7	CH, FR, IE	-	-
	15 years	-	400-500	1,3	CH, IE	-	-

Table 2.17 DRLs for paediatric CT examinations in terms of CTDIvol, mGy.

Anatomical region	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	-	20-27	1,4	CH, NL	-	-
	1 year	-	25-33	1,3	CH, NL	-	-
	5 years	-	35-40	1,1	CH, NL	-	-
	10 years	-	50	-	NL	-	-

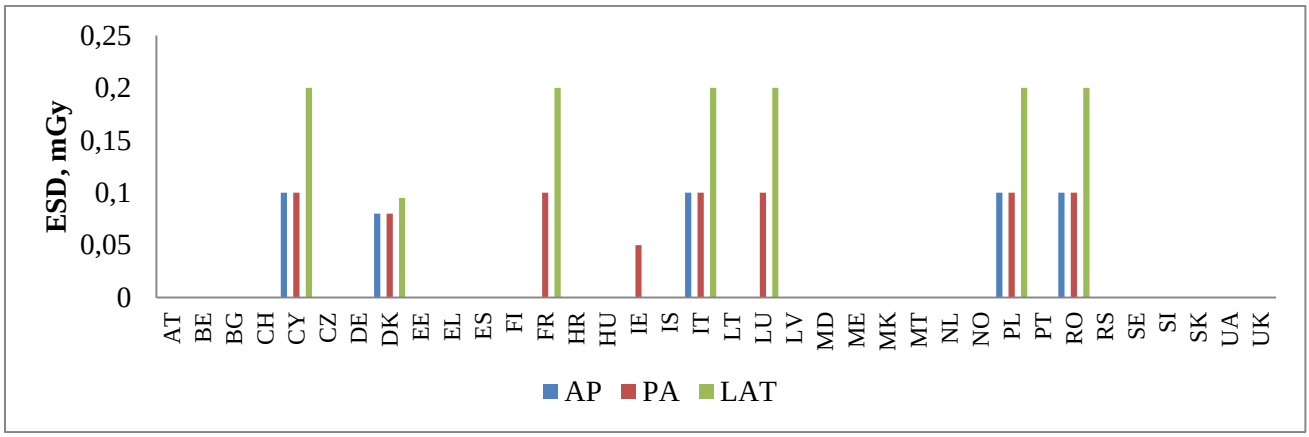

Figure 2.21. Comparison of DRLs for paediatric thorax plain radiography for a 5 year-old child in terms of ESD, mGy.

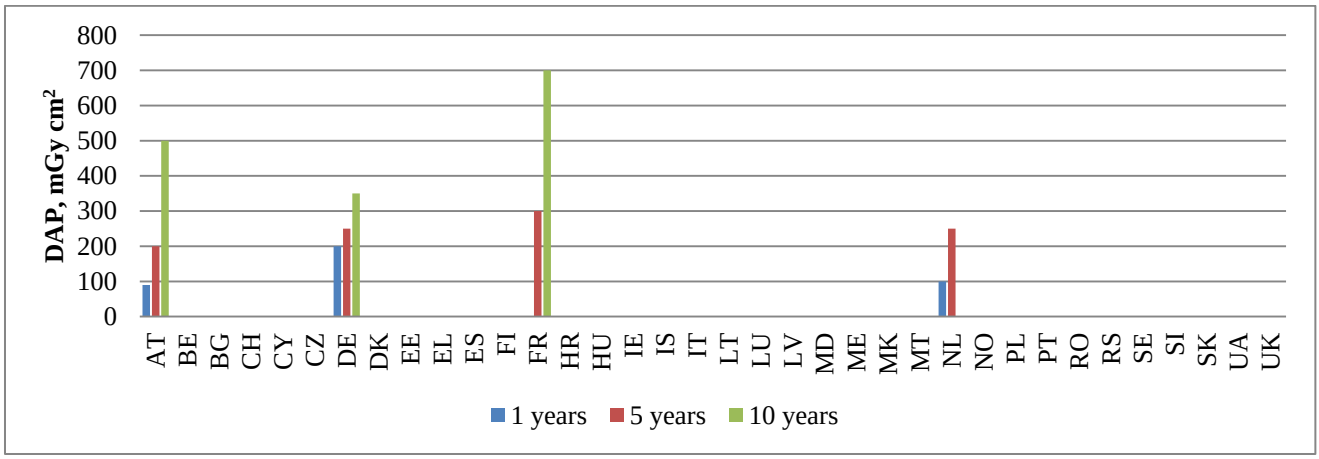

Figure 2.22. Comparison of DRLs for paediatric abdomen plain radiography, AP projection, for 1-10 year-old children in terms of DAP, mGy cm2.

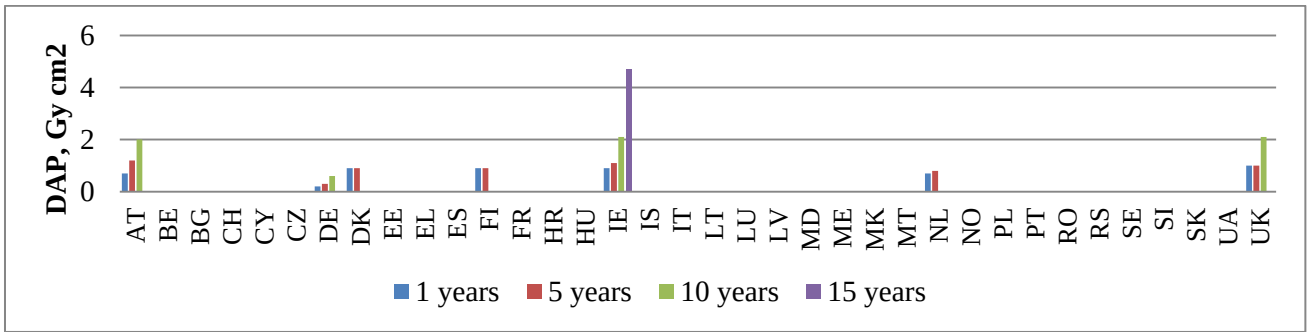

Figure 2.23. Comparison of DRLs for paediatric Micturating Cystourethrography (MCU), for 0-10 year-old children in terms of DAP, Gy·cm2.

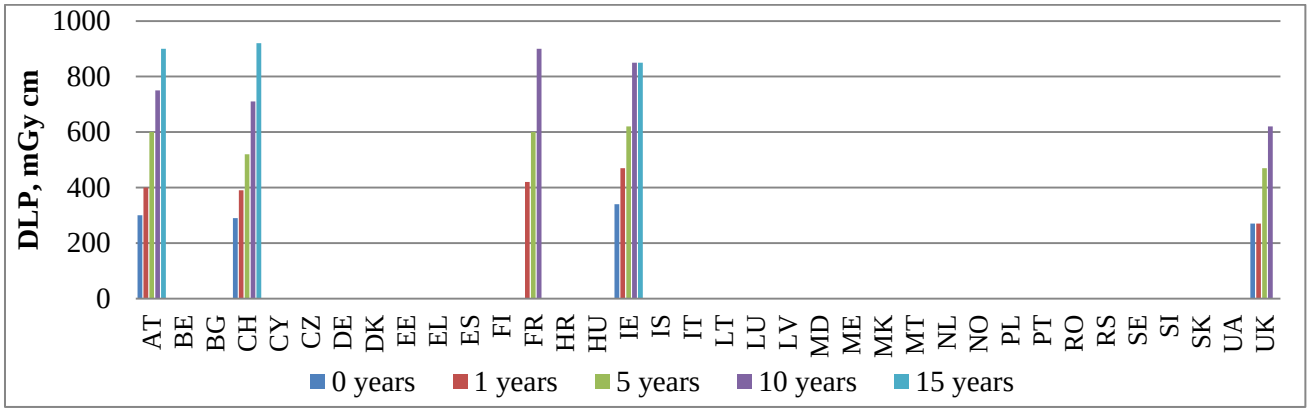

Figure 2.24. Comparison of DRLs for paediatric brain CT, for 1-15 year-old children in terms of DLP, mGy·cm.

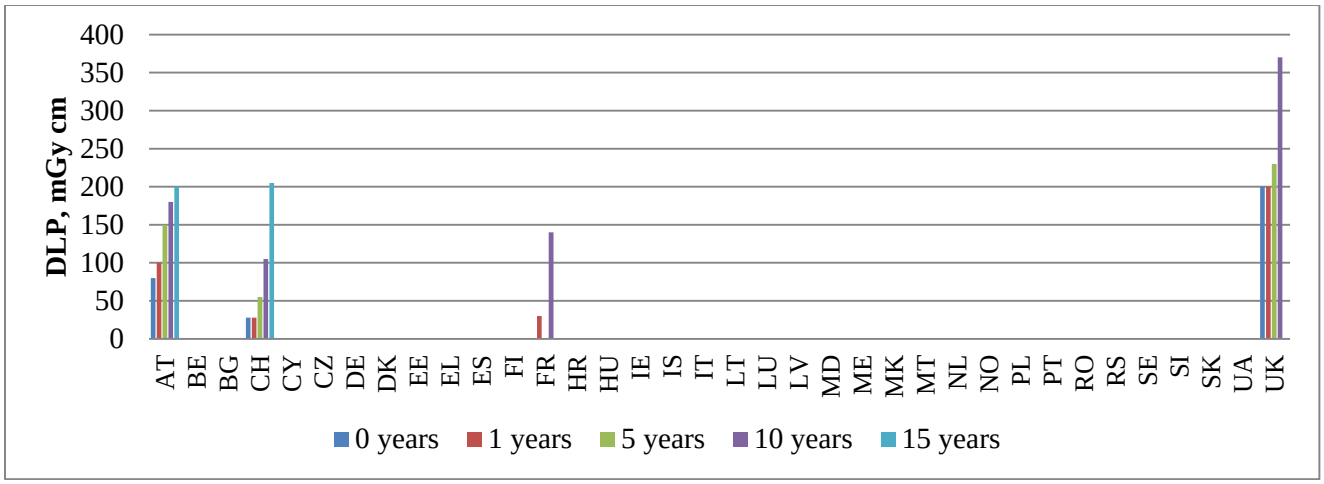

Figure 2.25. Comparison of DRLs for paediatric chest CT, for 0-15 year-old children in terms of DLP, mGy·cm.

3 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, 33 % have no DRLs and 3 % have not replied (Fig 3.1). The corresponding figures for EU and EFTA countries together are 71 %, 26 % and 3 % respectively. From the NM DRLs, 65 % are based on countries' own national dose surveys (Fig. 3.1), while the rest are based on published values; see more details in Table 3.1.

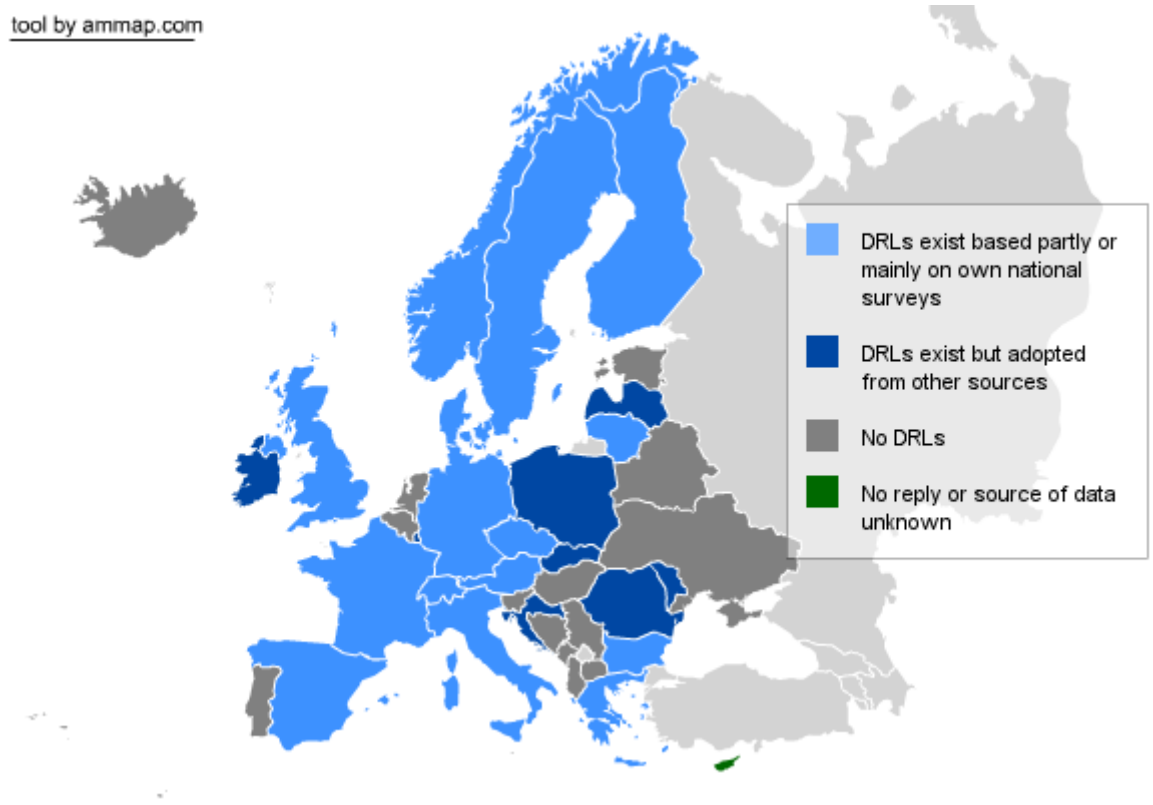

Figure 3.1. Diagnostic reference levels for NM examinations.

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 national DRLs for NM procedures that were reported in the DDM2 survey are presented in the Annex 1 in Tables 6a-6k.

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 five 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 with this DRL or a lower value have been

shown as well as those countries with a higher value. If it was not possible to record a common value, the countries giving the DRL have been shown.

In NM, the administered activities are highly dependent on the procedures used. Especially in heart studies there are one-day and two-day protocols for stress and rest imaging and also variation between these procedures. It is therefore difficult to compare administered activities without knowing precisely the protocol used. Countries have given a DRL in some cases for 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 this can already be seen in the DRLs for ten countries in EU RP 109. However, for the most common procedures that have only minor variation like, for example, bone imaging with Tc-99m phosphonates, a European recommendation for DRLs could be drawn up on the basis of this study.

DRLs in NM are based on administered activities used for 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 national surveys. The concept of DRLs as described in EU RP 109 is not based on the 75th percentile but on the administered activity necessary for a good image during a standard procedure.

In nuclear medicine, the effective dose is directly proportional to the administered activity. Therefore it is highly important to give guidance for a dosage and the following effective dose, especially concerning paediatric patients. The European Association of Nuclear Medicine (EANM) has published recommendations and most recently, the Paediatric Dosage Card 2008 prepared by the Paediatric and Dosimetry Committees of the EANM (Piepsz 1990, Jacobs et al 2005, Lassmann et al 2007, Lassmann et al 2008). There is a minimum activity for each radiopharmaceutical and a baseline activity that is multiplied with a factor given in tables according to the patient's weight. The guideline is considered good practice. The guideline is an update of what was used in RP 109.

There is a European project PEDDOSE funded by the European Commission under the FP 7 (www.peddose.net) and started in April 2010. In 2011, the PEDDOSE surveyed the use of radiopharmaceuticals. The recommended age-dependent doses will be compiled and evaluated in terms of their underlying data and the models used to derive them. PEDDOSE will provide general recommendations for minimum and maximum recommended activities with particular emphasis on paediatric nuclear medicine as the group of children and adolescents. The DDM2 tried to avoid overlap with the PEDDOSE.

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	No DRLs
Bulgaria	Own national surveys
Croatia	Published values
Cyprus	Unknown
Czech Republic	Own national surveys
Denmark	Own national surveys
Estonia	No DRLs
Finland	Own national surveys
France	Own national surveys
Germany	Own national surveys
Greece	Own national surveys
Hungary	No DRLs
Iceland	No DRLs
Ireland	Published values
Italy	Own national surveys
Latvia	Published values
Lithuania	Unknown
Luxembourg	Published values
Frmr. Yug, Rep. Of Macedonia	No DRLs
Malta	No DRLs
Moldova	Published values
Montenegro	No DRLs
Netherlands	No DRLs
Norway	Own national surveys
Poland	Published values
Portugal	No DRLs
Romania	Unknown
Serbia	No DRLs
Slovakia	Unknown
Slovenia	No DRLs
Spain	Own national surveys
Sweden	Own national surveys
Switzerland	Own national surveys
Ukraine	No DRLs
United Kingdom	Own national surveys

Table 3.2a. 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, IE, LT, LV, MD, SE, UK	BG, CZ, DE, EL, ES, FI, FR, IT, LU, NO, PL, RO	-	500-1110	2,2	no SPECT or no details
Myocardial Perfusion	Tl-201 chloride	110	AT, CZ, DE, EL, FR, IT, UK	ES, LU	-	75-150	2,0	1rst injection or SPECT or no details
Myocardial Perfusion	Tc-99m tetrofosmin	1200	CH, DE, ES, FI, FR, IE, LT, LV, NO, SE, UK	IT, LU	-	300-1500	5,0	same day or no details
Myocardial Perfusion	Tc-99m MIBI	1200	AT, BG, CH, DE, ES, IE, LT, RO, SE, UK	FR, IT, LU	_	300-1480	4,9	same day or no details
Tumour imaging (PET)	F-18 FDG	-	-	-	AT, DE, FI, FR, IE, SE, UK	200-400	2,0	2D: 350-400
Thyroid metastases (after ablation, uptake 0%)	I-131 iodide	400	BG, EL, FI, IE, IT, LT, LV, PL, UK	-	-	90-400	4,4	-
Thyroid imaging	Tc-99m pertechnetate	80	CH, DE, FR, LU, PL, RO, UK	AT, BG, CZ, EL,ES, IE, IT, LT, LV, MD, NO, SE	-	75-222	3,0	-
Thyroid imaging	I-123 iodide	20	AT, CH, FR, IS, IT, LV, PL, RO, SK, UK	ES, LU	-	10-37	3,7	-
MUGA, cardiac bloodpool, cardiac blood flow	Tc-99m erythrocytes	750	-	-	AT, BG, DE, EL,FI, FR, IT, LV, RO, UK	600-1000	1,7	pyrophos.& HAS as erythrocytes

Table 3.2b. 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
Lung perfusion	Tc-99m MAA	150	AT, BG, DE, FI, IE, LT, LU, MD, SE, UK	CH, EL, ES, FR, IT, LV, NO	-	100-296	3,0	200(SPECT; HR, MD, RO)
Renal imaging	Tc-99m DMSA	-	-	-	AT, BG, CH, CZ, DE, EL, FI, IT, LT, LV, UK	70-183	2,6	
Renal imaging	Tc-99m MAG3	100	CH, DE, IE, LT, LV, NO, UK	AT, BG, ES, FI, HR, IT, LU, SE	-	100-370	3,7	
Renal imaging	Tc-99m DTPA	-	-	-	AT, BG, CH, DE, EL, ES, FI, FR, HR, IE, IT, LT, LU, LV, MD, NO, SE, UK	150-540	3,6	
Parathyroid imaging	Tc-99m MIBI	-	-	-	BG, CH, FI, IT, LT, MD, PL, UK	400-900	2,3	
Cerebral blood flow	Tc-99m Exametazime(HMPAO, Ceretec)	500	FR, HR, LT, MD, UK	DE, ES, FI, IE, IT, LU, NO, PL, RO, SE	-	500-1110	2,2	
Infection/Inflammation imaging	Ga-67 citrate	-	-	-	AT, EL, ES, IT, LT, LU, UK	110-370	3,4	

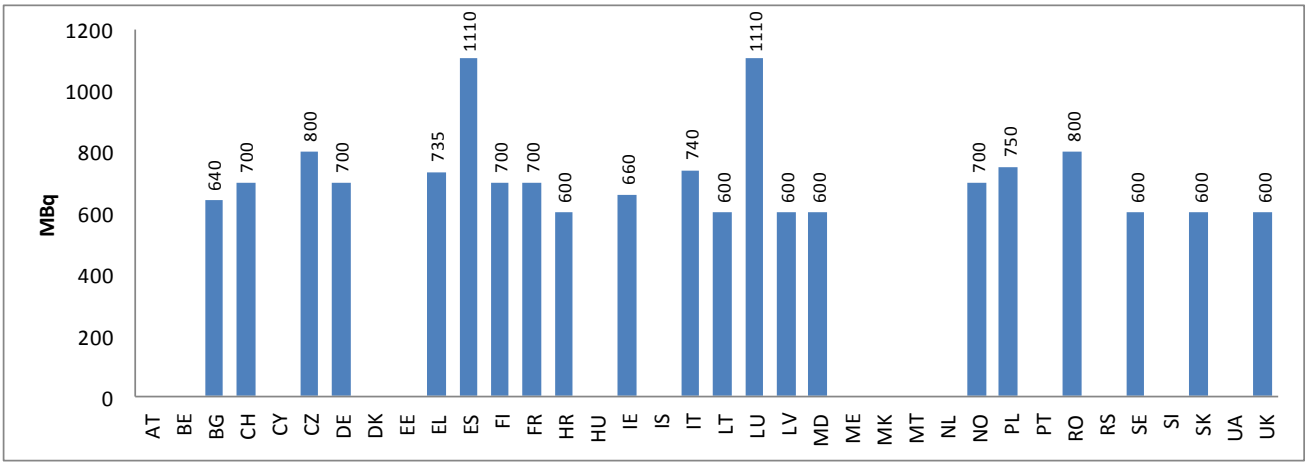

Figure 3.2. Comparison of DRLs for bone imaging, Tc-99m phosphates and phosphonates.

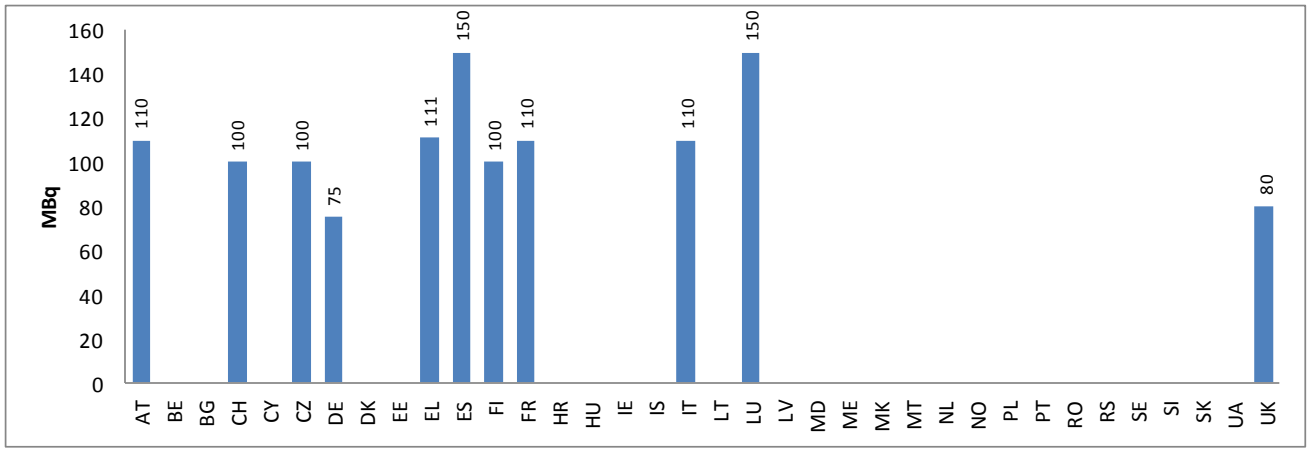

Figure 3.3. Comparison of DRLs for myocardial perfusion, Tl-201 chloride.

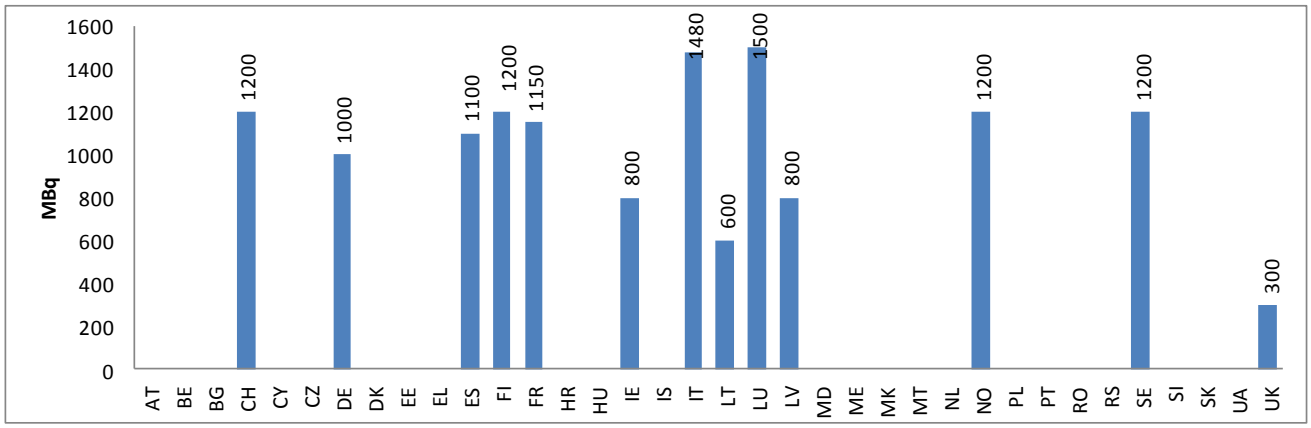

Figure 3.4. Comparison of DRLs for myocardial perfusion, Tc-99m tetrofosmin.

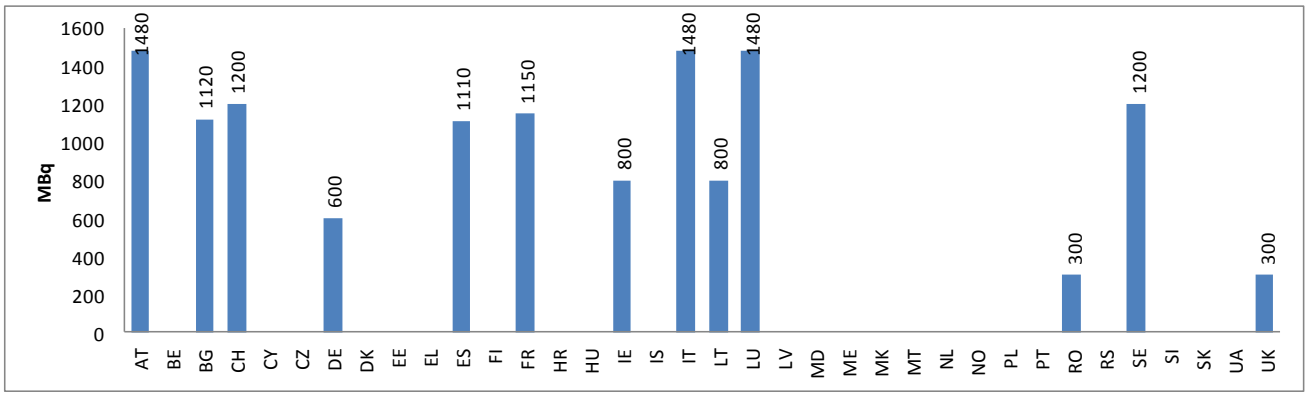

Figure 3.5. Comparison of DRLs for myocardial perfusion, Tc-99m MIBI.

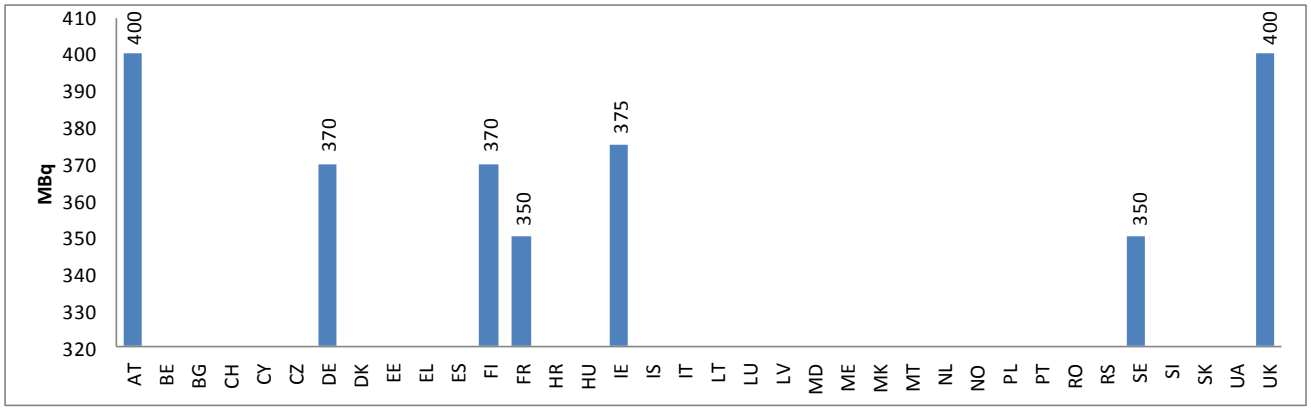

Figure 3.6. Comparison of DRLs for tumor imaging (PET), F-18 FDG.

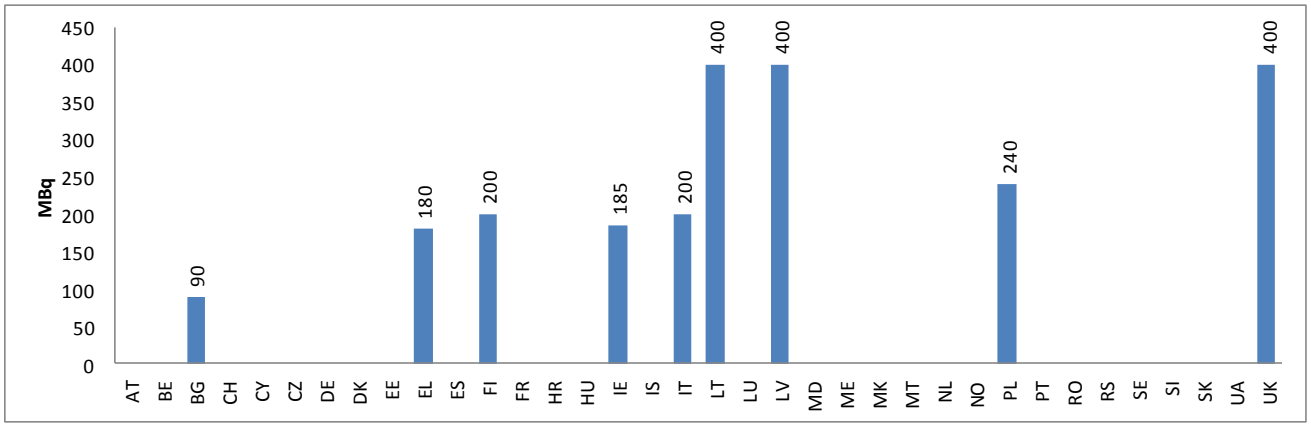

Figure 3.7. Comparison of DRLs for thyroid metastases (after ablation, uptake 0%), I-131 iodide.

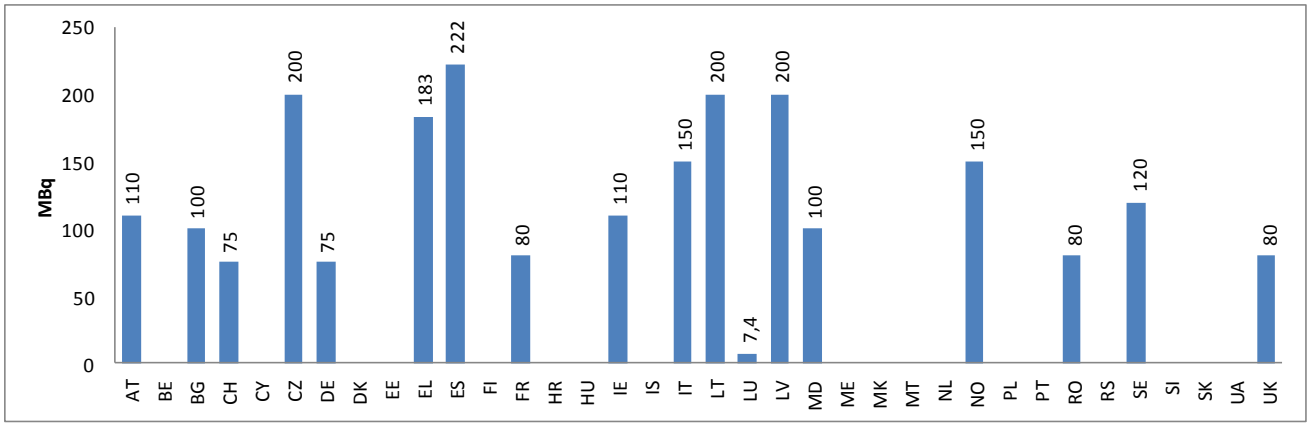

Figure 3.8. Comparison of DRLs for thyroid imaging Tc-99m pertechnetate.

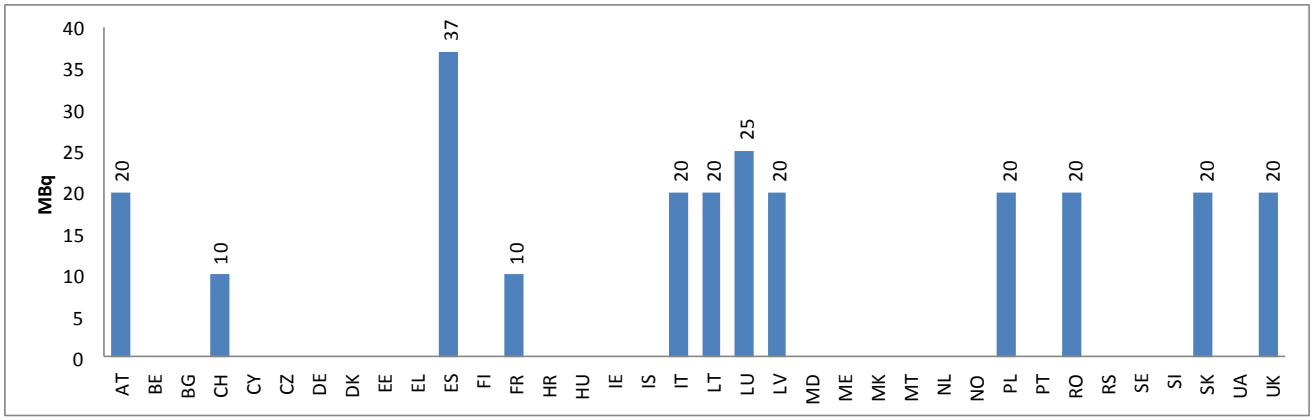

Figure 3.9. Comparison of DRLs for thyroid imaging, I-123 iodide.

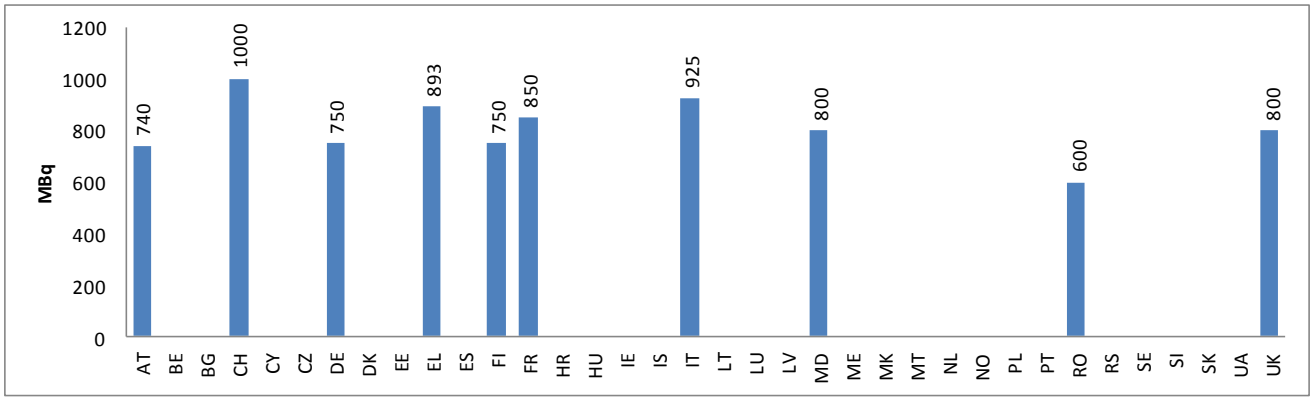

Figure 3.10. Comparison of DRLs for MUGA, cardiac blood pool, cardiac blood flow, Tc-99m erythrocytes.

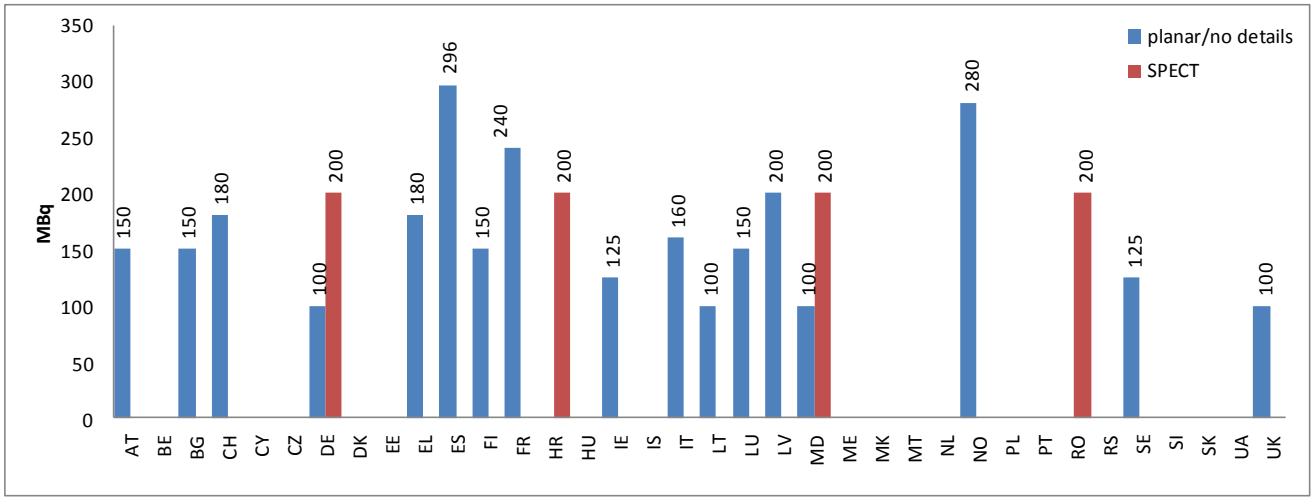

Figure 3.11. Comparison of DRLs for lung perfusion, Tc-99m MAA.

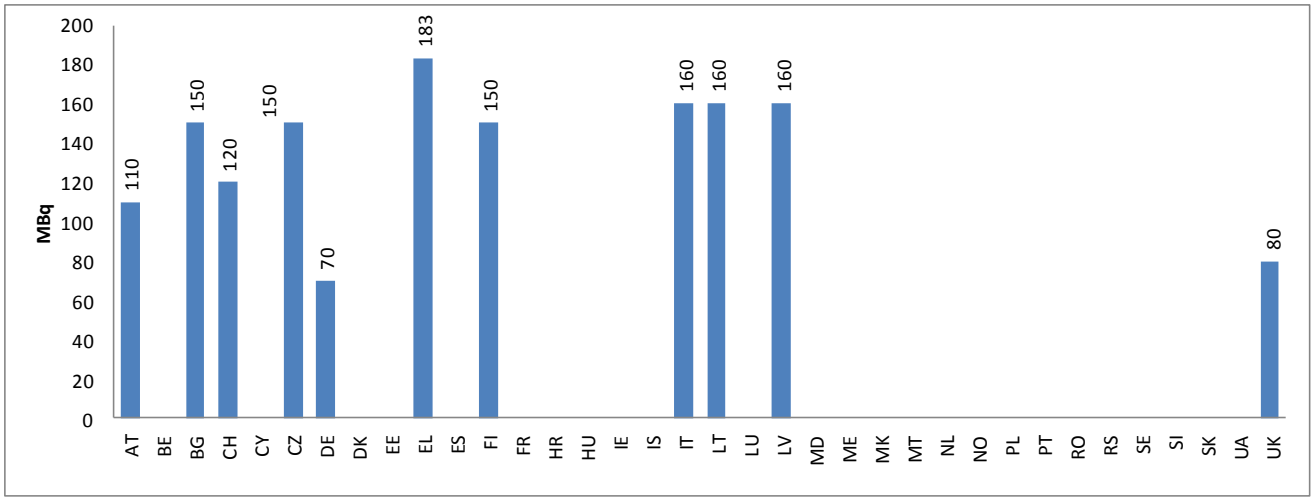

Figure 3.12. Comparison of DRLs for renal imaging, Tc-99m DMSA.

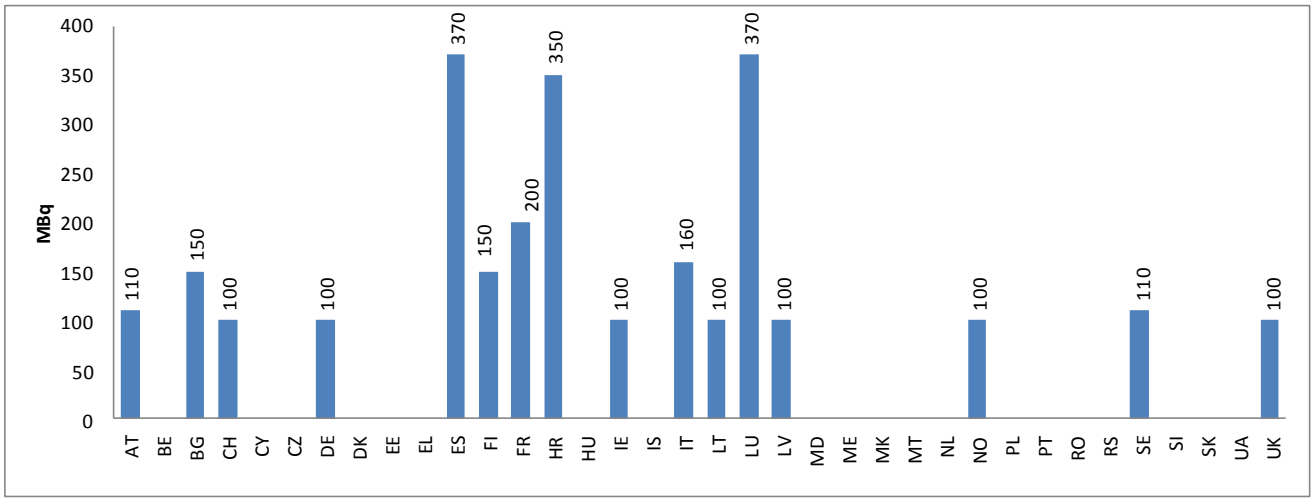

Figure 3.13. Comparison of DRLs for renal imaging, Tc-99m MAG3.

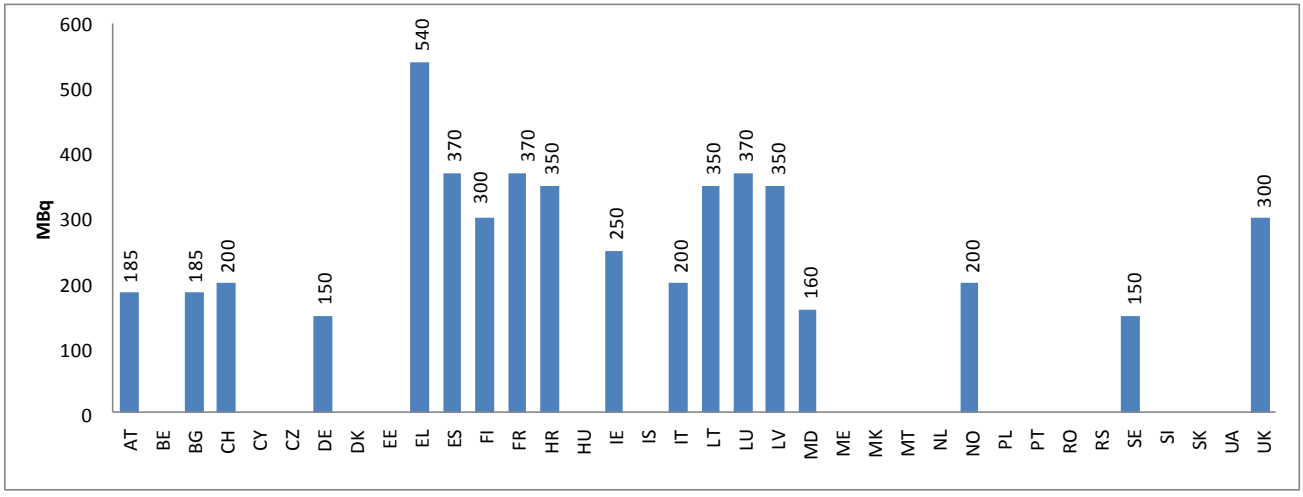

Figure 3.14. Comparison of DRLs for renal imaging, Tc-99m DTPA.

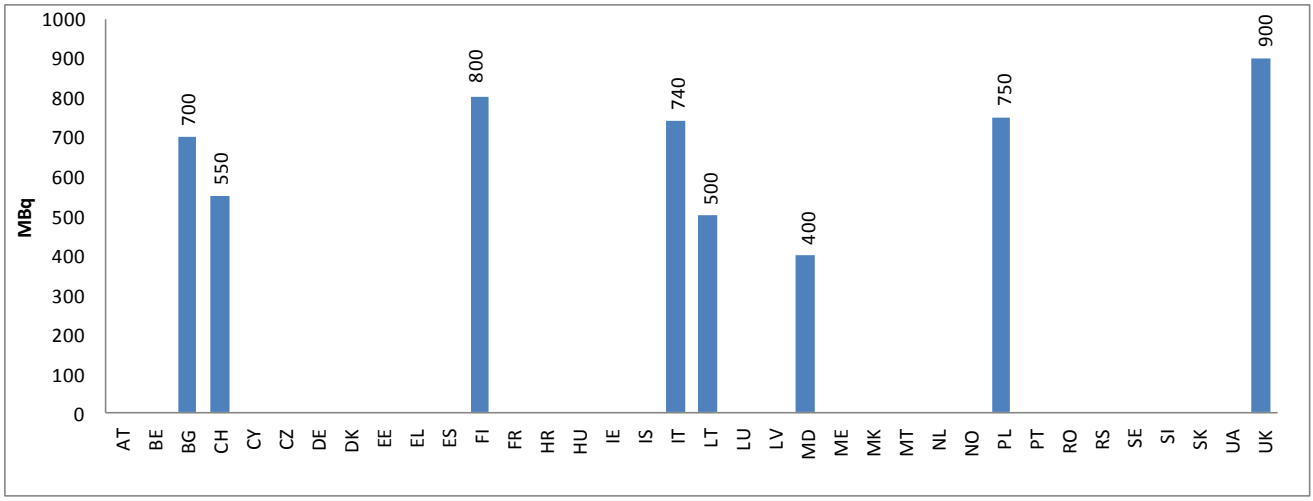

Figure 3.15. Comparison of DRLs for prathyroid imaging, Tc-99m MIBI.

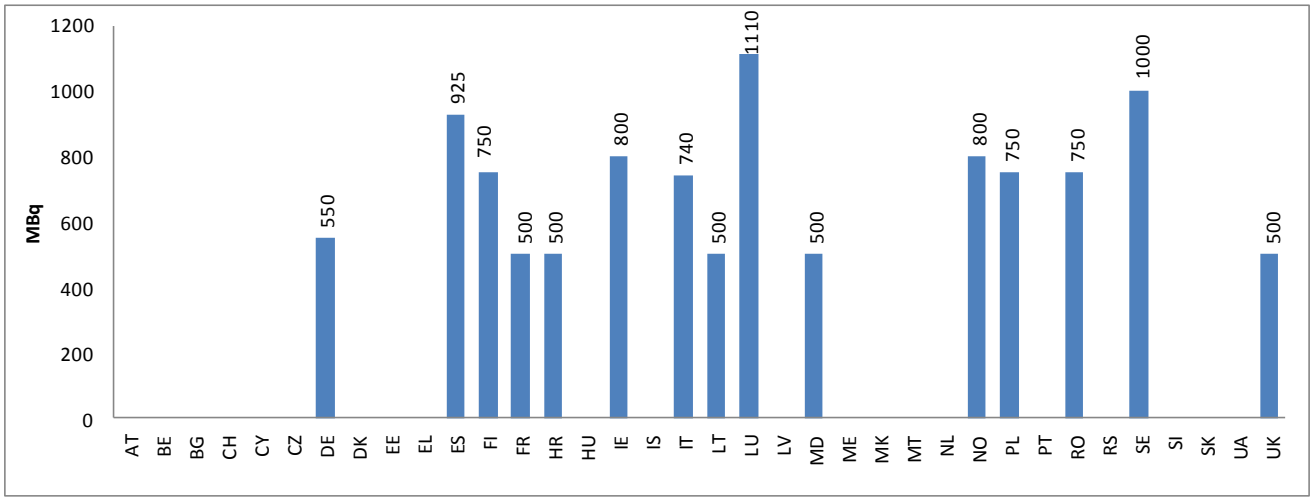

Figure 3.16. Comparison of DRLs for cerebral blood flow, Tc-99m Exametazime (HMPAO, Ceretec).

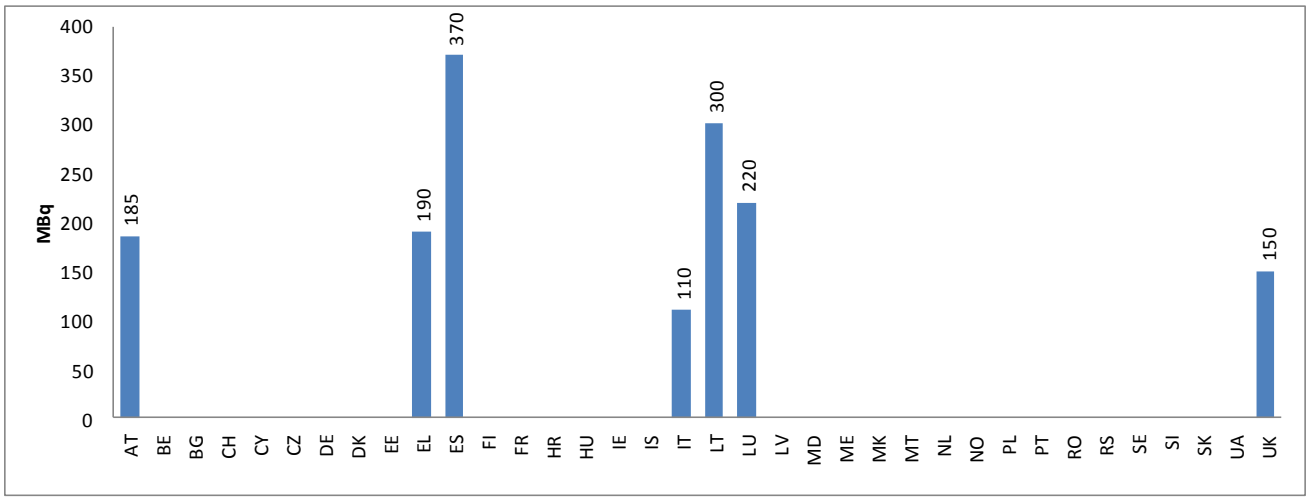

Figure 3.17. Comparison of DRLs for Infection/Inflammation imaging, Ga-67 citrate.

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5 EDITORIAL NOTE

This European Commission Report on European Population doses from Medical Exposure has been prepared in the context of EC project “Study on European Population Doses from Medical Exposure (Dose Datamed 2)”, financed by the EC (Contract ENER/D4/181-2010).

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6 ANNEX 1: NNATIONAL DRLS REPORTED TO DDM2

The national DRLs reported in the DDM2 survey are presented in tables as follows:

Tables 1a-1e: DRLs for plain radiography procedures

Tables 2a-2c: DRLs for fluoroscopy procedures

Tables 3a-3c: DRLs for interventional procedures

Tables 4a-4c: DRLs for CT procedures

Tables 5a-5e: DRLs for paediatric x-ray procedures

Tables 6a-6k: DRLs for NM procedures

Table 1a.. DRLs for plain radiography procedures: skull, head, and dental radiograpy.

Country	Procedure & quantity						
	Skull, AP/PA and lateral projections	Head AP/PA	Head, cranium AP/PA	Head, skull LAT	Head, skull, cranium LAT	Dental radiography, intra-oral bitewing film	Dental panoramic scan
	ESAK or ESD, mGy	ESAK or ESD, mGy	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2
AT			1000		1000		
BE	4,5 (skull total)	3,5 (AP)	1500 (several proj) 600 (AP)	1	600		
BG		2,5					
CH		2,5	650 (AP)	1,5	500		
CY	5			3			
CZ	5 (PA)			3		upper molar adult, 5 film 1 digi	
DE			650		600		
ES		5		3			
FI						5	120
FR							200
IE						4	
IT		5		3			
LU			650 (PA)		600		
MD		5 (PA)		3		7 (periapical) 5 (AP)	
PL			1100		1000		
RO		5 (PA)		3			
SI			600		600	0,6 (digi) (1,5 analog)	
SK		5 (PA)		3		5 (1 teeth RVG digi)	
UK		3 (AP/ PA)		1,5			

Table 1b. DRLs for plain radiography procedures: chest, thorax and cervical spine.

Country	Procedure & quantity						
	Chest, thorax	Thorax PA	Thorax PA	Thorax LAT	Thorax LAT	Cervical spine, AP	Cervical spine, LAT
	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2	DAP, mGy*cm2	DAP, mGy*cm2
AT			280		1000		
BE	1100	0,25	350	1,2	250		
BG		0,5	400				
CH		0,15	150	0,15	600		
CY		0,3		1,5			
CZ		0,4	1000 (PA or LAT)	1,5	1000 (PA or LAT)		
DE			160		550		
DK	500						
ES		0,3		1,5			
FI	400 (PA+LAT)	0,2		0,8			
FR		0,3	250	1,2	1000	750	750
HR		0,4		1,5			
IE			160 180(AP)			220	240
IT		0,4		1,5			
LT	2000	0,3		1,7			
LU			160		600		
MD		0,6		2			
NL	120						
NO	500					800 (four projections)	
PL			200		1000		
RO		0,3		1,5			
SE	600						
SI			150		450	300	300
SK		0,4		1,5			
UK		0,2	120	1			

Table 1c. DRLs for plain radiography procedures: thoracic spine and abdomen.

Country	Procedure & quantity					
	Thoracic spine AP	Thoracic spine LAT	Thoracic spine, AP	Thoracic spine, LAT	Abdomen, common technique, AP or PA	Abdomen, common technique, AP or PA
	ESAK or ESD, mGy	ESAK or ESD, mGy	DAP, mGy*cm2	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2
AT						3000
BE					4,5 (AP)	3300
CZ	7	20			10	8000
DE			1300	1700		3000 (proj not specified)
ES					10	
FI					5 (AP or PA)	3000 (AP or PA)
FR	5	7	1750	2750	8	7000
HR	7	20				
IE			970	2030		2320
IT					10	
LT	6	10			5 (AP)	
LU			1300	1700		3000
MD	7	20				
NL						3000
NO				3000 (front and lat)		5500 (3 images)
PL			2200	3200		5500
SI			1300	1200		2000 (AP/PA)
SK	7	20			10 (AP)	
UA						
UK	3,5	10			6 (AP)	3000

Table 1d. DRLs for plain radiography procedures: lumbar spine.

Country	Procedure & quantity						
	Lumbar spine, AP	Lumbar spine, AP	Lumbar spine, LAT	Lumbar spine, LAT	Lumbar spine, LSJ	Lumbar spine, LSJ	Lumbar spine common technique
	ESAK or ESD, mGy	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2	DAP, mGy*cm2
AT				4000			2000; 550
BE	6,5	2800	16	5000			21000 (2-9 radiographs)
BG	9	3000 4000 (AP)	12				
CH	7	2350 (or PA)	10	4150			
CY	10		30		40		
CZ	10	10000	30		40		
DE		2300		4200			
DK	7						7000 (2-3 projections)
ES	10		30		40		
FI	5		15				6000 (AP+LAT)
FR	10	4500	25	8000			
HR	10		30				
IE		1620		2680		2400	6550 (full spine T+L) 8380 (full spine C+T+L)
IT	10		30		40		
LT	10		20				
LU		2600					3500
MD	10		30		40		
NO							8000 (incl.LSJ)
PL		3200		8000			
RO	10				40		
SE							10000
SI		1500		2750		3000	
SK	10		30				
UK	6	1600	14	3000	26	3000	

Table 1e. DRLs for plain radiography procedures: pelvis, hip joint, hip and mammography.

Country	Procedure & quantity						
	Pelvis (AP)	Pelvis (AP)	Hip joint (AP)	Hip	Hip	Mammography, CC, MLO or LAT	Mammography
	ESAK or ESD, mGy	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2	ESAK or ESD, mGy	ESAK or ESD, mGy	MGD (AGD), mGy
AT		3000					2,5 (45 mm PMMA) 3 (50 mm PMMA)
BE	4,5	4500 (pelvis & hip)					
BG	4	4000 (AP)				12 (per proj.)	
CH		2500 (AP)					
CY	10					10	
CZ	10	5000 (AP)	10				1,3 for 3 cm PMMA, CC 2 for 4 cm PMMA CC 2,5 for 4,5 cm PMMA CC 3,3 for 5 cm PMMA CC 5 for 6 cm PMMA CC 7,3 for 7 cm PMMA CC
DE		3000 (AP)					2,5
DK		2500				10 (MLO or CC)	
EL						7	
ES	10					10	
FI	5	3000 (AP)				10 (CC or MLO or LAT)	
FR	9	7000		3000 (AP or LAT)	9	8	1,8
HR							3 (one projection)
IE		2640		1530(single AP) 1890 (double)			4,7 5,75 (screening)
IS							
IT	10					10 (CC)	
LT	5				5 (AP)		2,4
LU		3100				10 (MLO,CC or profile)	
MD	10		10				1 (CC without grid) 3 (CC with grid))
NL							1,5
NO		1500		1500			3
PL		5000					
RO	10					10 10 (LAT)	
SE		4000 (pelvis hip)					4 2,5 (screening)
SI		2600 (AP)					
SK	10						3
UK	4	3000 (AP)					3,5

Table 2a. DRLs for fluoroscopy procedures: barium swallow, oesophagus, barium meal, barium follow through and small intestine.

Country	Procedure & quantity							
	Bariun swallow	Bariun swallow	Fluoroscopy: oesophagus	Barium meal	Barium meal	Barium follow through	Barium follow through	Small intestine
	DAP, Gy*cm2	Fluoroscopy time, min	DAP, Gy*cm2	DAP, Gy*cm2	Fluoroscopy time, min	DAP, Gy*cm2	Fluoroscopy time, min	DAP, Gy*cm2
AT			13					65
BG				18	14,1			
CY				25				
CZ				25				
DE								44
IE			12,9			6,96		12,9 stomach & small intestine)
LT				18				
LU								44
UK	11	2,3		13	2,3	14	2,2	50

Table 2b. DRLs for fluoroscopy procedures: barium enema, colon, sialography and T-tube cholangiography.

Country	Procedure & quantity						
	Barium enema	Barium enema	Colon radiography/ fluoroscopy (double contrast)	Sialography	Sialography	T-tube cholangiography	T-tube cholangiography
	DAP, Gy*cm2	Fluoroscopy time, min	DAP, Gy*cm2	DAP, Gy*cm2	Fluoroscopy time, min	DAP, Gy*cm2	Fluoroscopy time, min
BG	40	14,2					
CY	60						
CZ	60						
DE	37						
DK	30						
FI			50				
IE			22,7				
LT	33						
LU			37 (with contrast media)				
NO	40						
SE	50						
UK	31	2,7 10,7 (small bowel enema)		1,6	1,6	10	2

Table 2c. DRLs for fluoroscopy procedures: ERCP, irrigoscopy, IVU and retrograde pyelography.

Country	Procedure & quantity					
	Fluoroscopy: ERCP	Fluoroscopy: irrigoscopy	IVU One image	IVU	Retrograde pyelography	Retrograde pyelography
	DAP, Gy*cm2	DAP, Gy*cm2	ESAK or ESD, mGy	DAP, Gy*cm2	DAP, Gy*cm2	Fluoroscopy time, min
AT	45	46				
BG			6 (urography, AP)			
CH	30					
CY				40		
CZ			10 (AP)	40		
DK				20		
FI			5 (urography)	20 (urography)		
IT			10			
LU			10			
MD			10 (AP)			
NO				15 (urography)		
RO			10 (urinary tract)			
SE				20		
UK				16	13	3

Table 2d. DRLs for fluoroscopy procedures: nephrostography, micturating cystourethrography and hysterosalpingography.

Country	Procedure & quantity					
	Nephrosto graphy	Nephrosto graphy	Micturating cystourethro graphy	Micturating cystourethro graphy	Hysterosalpingography	Hystero salpingography
	DAP, Gy*cm2	Fluoroscopy time, min	DAP, Gy*cm2	Fluroscopy time, min	DAP, Gy*cm2	Fluoroscopy time, min
CH	50 (nephrostomy)					
UK	13	4,6	17	2,7	4	1

Table 2e. DRLs for fluoroscopy procedures: venography, cerebral angiography, angiography of carotid arteries, phlebography and coronary angiography.

Country	Procedure & quantity						
	Venography (leg)	Venography (leg)	Cerebral Angiography	Angiography carotid artery, 4 vessels	Phlebography	Coronary angiography (CA)	Coronary angiography (CA)
	DAP, Gy*cm2	Fluoroscopy time, min	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	Fluroscopy time, min
AT					5,5	60	
BG						40	
CH			150	100		70	
DE					5	35	
FI						60	8
IE						53,1	
LU					5,0 (lower limb)	23	
NO						45	
SE						80	
UK	5	2,3				36	5,6

Table 2f. DRLs for fluoroscopy procedures: angiography of pulmonary artery, arteriography of aortic iliac vessels, abdominal angiography, mesenteric angiography, renal angiography and pelvic arteriography.

Country	Procedure & quantity					
	Angiography pulmonary artery	Arteriography aortic iliac vessels	Abdominal angiography (selective)	Angiography mesenteric	Angiography renal	Arteriography pelvic
	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2
CH	150	300	300	300	300	300

Table 2g. DRLs for fluoroscopy procedures: pelvi-leg angiography, lower limb arteriography, arteriography, upper limb angiography and femoral angiography.

Country	Procedure & quantity					
	Pelvi-leg-angiography	Lower limb arteriography (LLA)	Arteriography	Angiography upper limb	Femoral angiography	Femoral angiography
	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	Fluoroscopy time, min
AT	66					
BG		45				
CH				150		
DE			64			
LU		64				
UK					33	5

Table 2h. DRLs for fluoroscopy procedures: arthrography, theathre screening and orthopaedics.

Country	Procedure & quantity		
	Arthrography	Theathre screening (excl orthopaedics)	Orthopaedics
	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2
IE	0,83	3,12	0,78
UK			5

Table 3a. DRLs for interventional procedures: cerebral embolisation, PTCA, PCI+CA, PTA and embolisation of bronchial arteries.

Country	Procedure & quantity					
	Cerebral embolisation	PTCA	PTCA	PCI+CA	PTA	Embolisation bronchial arteries
	DAP, Gy*cm2	DAP, Gy*cm2	Fluoroscopy time, min	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2
AT		130 (with stent)				
BG				140		
CH	350	100			350 (cerebral PTA, lower limbs PTA) 200 (renal PTA, iliacal PTA)	150
DE		60			50	
FI		100	20			
IE		62				
LU		44			50	

Table 3b. DRLs for interventional procedures: bile duct drainage/dilatation, TIPS, hepatic embolisaton, vertebroplasty, embolisation of pelvic arteries, upper limbs embolisation and all iv lines e.g. Hickman.

Country	Procedure & quantity						
	Bile duct drainage/dilatation	TIPS (liver)	Hepatic emoblisation	Vertebroplasty	Embolisation pelvic arteries	Upper limbs embolisation	All IV lines, Hickman line
	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2
CH	250	350	300	15	300	150	
IE		144,4					2,76

Table 3c. DRLs for interventional procedures: cerebral procedures, all thoracic procedures, all abdominal procedures, all pelvic procedures, cardiac studies and pacemaker insertion.

Country	Procedure & quantity						
	Cerebral procedures	All thoracic procedures	All abdominal procedures	All pelvic procedures	All peripheral procedures	Cardiac studies	Pacemaker insertion
	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2
IE	56	7,8	51,6	79	29,1	53,1	2,76

Table 4a. DRLs for CT procedures: brain, head, cranium, face, sinuses, cervical spine and neck.

Country	Procedure & quantity							
	CT Brain, Head, Cranium	CT Head	CT Face and sinuses	CT Sinus	CT Cervical spine	CT Cervical spine	CT neck	CT Neck
	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	$CTDI_{vol}$ mGy
AT	1300							
BE	1020		150 (sinus)					
BG	1000	60						
CH	1000 1000(vascular)	65	350 (sinus)	25	600	30	500	20
CZ		60						
DE	950		250 (facial bones,tumor diagnosis) 100 (facial bones, sinisitis)					
DK	1100		400				500	
FI	1000	90 (skull) 65 (brain)						
FR	1050	65						
HR		50						
IE	950				470			
IT	1050	60						
LT	950							
LU	1000		75 (sinus, facial bones)		440		440	
MD		50						
NO	1000	70	140 (sinuses)	15	400	20		20
PL	1050		360					
SE	1200	75						
SI	1040 (per phase)	62 (per phase)						
UK	760 (routine head)	55 (cerebrum) 65 (posterior fossa)						

Table 4b. DRLs for CT procedures: chest, heart, upper abdomen and abdomen.

Country	Procedure & quantity							
	CT chest	CT chest	CT chest, HRCT	CT chest, HRCT	CT Heart (cardio vascular)	CT upper abdomen	CT abdomen	CT abdomen
	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	DLP mGy*cm	DLP mGy*cm	$CTDI_{vol}$ mGy
AT	550					740	1200	
BE	400						830	
BG	550	25					600	30
CH	400 450 (vasc.) 600 (chest, upper abd)	10			1000 (cardio vascular) 150 (Ca-scoring)	600 (chest, upper abd) 400 (upper abd) 500 (vascular)	650 (abd/pelvis) 650 (abd/pelvis vascular)	15
CZ								35
DE	400					450	900	
DK	700		300				800	
FI	500	30					600	15
FR	475	15						
HR								25
IE	460		280				640 (abd/pelvis) 850 (thx/abd/ pelvis)	
IT	650	30					800	35
LT	650						1200	
LU	270						800	
MD								25
NO	400	15					800	18
PL	650		280				780	
SE	600	20						25
SI	475	15					555	17
UK	430	10	80	3			460 510 (abdomen and pelvis)	13 (abd.& abd. and pelvis; abscess)

Table 4c. DRLs for CT procedures: colon, liver, spleen, pelvis and lumbar spine.

Country	Procedure & quantity								
	CT colon	CT colon	CT liver and spleene	CT liver	CT pelvis	CT Pelvis	CT osseus pelvis	CT spine, lumbar spine	CT spine, lumbar spine
	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	DLP mGy*cm	$CTDI_{vol}$ mGy
AT					650				
BE								870	
BG					550	30			
CH					650 (abd/ pelvis) 650 (abd/pelvis vascular) 500 (pelvis) 500 (pelvis vascular)	20		850	30
CZ									35
DE					450			250 (lumbar spine; per scan disc axial) 500 (lumbar spine; per scan vertebrae)	
DK				900		600 500 (osseous)			
FI								500	50 (lumbo sacral spine)
FR								700	45
HR									35
IT					600	35			
LT					550			300	
LU								500 (lumbosacral spine)	
MD									35
NO	700	12						500	30 (lumbal columna)
PL			900		570		520		
SE								600 (ls spine)	55
UK				11					

Table 4d. DRLs for CT procedures: thorax/abdomen/pelvis, petrous bone, urography, shoulder, lower limbs and vertebral trauma.

Country	Procedure & quantity						
	CT thorax/abdomen/pelvis	CT petrous bone	CT urography	CT urography	CT shoulder	CT lower limbs	CT vertebral trauma
	DLP mGy*cm	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	DLP mGy*cm	DLP mGy*cm	DLP mGy*cm
CH	100 (trauma)	250			500	1000	
NO			16 7 (low dose)	1500 300 (low dose)			
PL							460
UK	760 (lymphoma)						

Table 5a. DRLs for paediatric x-ray procedures: head, skull and sinuses.

Country	Procedure & quantity					
	Head AP/PA	Head AP/PA	Head, skull LAT	Head, skull LAT	Sinuses, PA tilted	Sinuses, PA tilted
	ESAK or ESD, mGy	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2	DAP, mGy*cm2	ESAK or ESD, mGy
AT		150 (0 months) 250 (12 months) 350 (60 months) 450 (120 months) 500 (180 months)		100 (0 months) 200 (12 months) 250 (60 months) 300 (120 months) 350 (180 months)		
CY	1,5 (5 y)		1			
DE		200 (10±2 months) 300 (5±2 y)		200 (10±2 months) 250 (5±2y)		
FI					250 (7-15 y)	2 (7-15 y)
IE	1,37 (5y)		0,82 (5y)			
IT	1,5 (5 y)		1			
LU	1,5 (5 y)		1 (5 y)			
PL	1,5		1			
RO	1,5 (5 y)		1,0 (5 y)			

Table 5b. DRLs for paediatric x-ray thorax procedures.

Country	Procedure & quantity					
	Thorax AP	Thorax PA	Chest, thorax	Thorax PA	Thorax LAT	Thorax LAT
	ESAK or ESD, mGy	ESAK or ESD, mGy	DAP, mGy*cm2	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2
AT				17 (0 mo) 23 (12 mo) 26 (60 mo) 37 (120 mo) 73 (180 mo)		
CY	0,1 (5 y), 0,08 (newborn)	0,1 (5 y)			0,2 (5 y)	
DE			3 (AP, 1000 g) 5 (AP; 3000 g) 15 (AP; 10±2 mo) 50 (21 kg 5 y) 25 (AP; 5±2 y) 35 (AP, 10±2 y)			40 (5±2 y) 60 (10 ±2 y)
DK	0,80 (5 y; exp scaling with equiv.diam. for other ages)	0,80 (5 y; exp scaling with equiv.diam. for other ages)			0,95 (5 y; exp scaling with equiv.diam. for other ages)	
FR		0,1 (5 years)	10 (3,5 kg-new born) 50 (20 kg - 5 y) 70 (30 kg- 10 y)		0,2 (5y)	60 (20 kg- 5 y) 80 (30 kg-10 y)
IE		0,057 (1y) 0,053 (5y) 0,066 (10 y) 0,088 (15 y)				
IT	0,08 (neonatal)	0,1 (AP/PA 5 y)			0,2 (5 y)	
LU	0,08 (newborn)	0,1 (5 y)			0,2 (5 y)	
NL			15 (4 kg - 0 y), 20 (11 kg, 1 y)			
PL	0,08 (newborn) 0,1 (5 y)	0,1 (5 y)			0,2 (5 y)	
RO	0,08 (newborn) 0,1 (5 y)	0,1 (5 y)			0,2 (5 y)	

Table 5c. DRLs for paediatric x-ray procedures: abdomen, pelvis MCU, barium meal and barium swallow.

Country	Procedure & quantity						
	Abdomen, common technique	Abdomen, common technique, AP	Pelvis AP	Pelvis AP	Micturating Cystourethrography (MCU)	Barium meal	Barium swallow
	ESAK or ESD, mGy	DAP, mGy*cm2	ESAK or ESD, mGy	DAP, mGy*cm2	DAP, Gy*cm2	DAP, Gy*cm2	DAP, Gy*cm2
AT		60 (0 months) 90 (12 months) 200 (60 months) 500 (120 months) 700 (180 months)			0,5 (0 months) 0,7 (12 months) 1,2 (60 months) 2,0 (120 months)		
CY	1 (5 y)		0,2 (neonatal) 0,9 (5y)				
DE		200 (AP/PA; 10±2 mo) 250 (5 ± 2y) 350 (10±2y)		150 (5±2y) 250 (10±2y)	0,1 (3000 g) 0,2 (10±2 mo) 0,3 (5±2 y) 600 (10±2 y)		
DK	0,075 (< 1 y)		0,375 (5 years)		0,3 (< 1 y) 0,9 (1-5 y)		
FI					0,3 (0-1 y) 0,9 (1-5 y)		
FR		300 (20 kg, 5 y) 700 (30 kg, 10 y)		200 (20kg/5y) 400(30kg/10y)			
IE	0,330 (1 y) 0,752 (5y)		0,265 (1y) 0,475 (5y) 0,807 (10 y) 0,892 (15 y)		0,4 (0 y) 0,9 (1 y) 1,1(5y) 2,1 (10 y) 4,7(15y)	0,7 (0 y) 2 (1-5 y) 4,5 (10 y) 4,6 (15y)	0,8 (0 y) 1,6 (1y) 1,32(5y) 2,7 (10 y) 4,6(15y)
IT	1 (5 y)		0,2 (neonatal) 0,9 (5y)				
LU	1 (5 y)		0,9 (5 y) 0,2 (infants)				
NL		15 (4 kg - 1 y) 100 (11 kg - 1 y) 250 (21 kg - 5y)			0,3 (4 kg, 0y) 0,7 (11 kg, 1y) 0,8 (21 kg, 5y)		
PL	1 (5 y)		0,9 (5 y) 0,2 (infants)				
RO	1 (5 y)		0,9 (5 y) 0,2 (infants)				
UK					0,4 (0 y) 1,0 (1-5 y) 2,1 (10 y)	0,7 (0 y) 2 (1-5 y) 4,5 (10 y)	0,8 (0 y) 1,5 (1-5y) 2,7 (10 y)

Table 5d. DRLs for paediatric CT procedures: brain, head, face and sinuses, facial bones and cerebrum.

Country	Procedure & quantity				
	CT Brain, cranial, skull	CT Head,	CT Face and sinuses, nasal cavity	CT Facial bones	CT Cerebrum
	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	DLP mGy*cm	$CTDI_{vol}$ mGy
AT	300 (0 months) 400 (12 months) 600 (60 months) 750 (120 months) 900 (180 months)				
CH	290 (newborn) 390 (0-1 y) 520 (1-5 y) 710 (6-10 y) 920 (11-15 y)	27 (newborn) 33 (0-1 y) 40 (1-5 y)	70 (newborn) 95 (0-1 y) 125 (1-5 y) 180 (6-10 y) 230 (11-15y)		
FR	420 (10 kg, 1 y) 600 (5y) 900 (30 kg, 10y)			200 (10 kg, 1y) 300 (30 kg, 10y)	
HR					
HU					
IE	340 (Newborn) 470(1-4y) 620 (5-9y) 850 (10-15y)				
NL		20 (4 kg, 0 y) 25 (11kg, 1 y) 35 (21 kg, 5 y) 50 (36 kg, 10y)			
UK	270 (0-1y) 470 (5y) 620 (10y)				30 (0-1y) 45 (5y) 50 (10y)

Table 5e. DRLs for paediatric CT procedures: brain, head, face and sinuses, facial bones and cerebrum.

Country	Procedure & quantity					
	CT chest	CT chest	CT chest HRCT)	CT chest	CT abdomen	CT petrous bone
	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	$CTDI_{vol}$ mGy	DLP mGy*cm	DLP mGy*cm
AT	80 (0 months) 100 (12 months) 150 (60 months) 180 (120 months) 200 (180 months)					
CH	12 (newborn) 28 (0-1y) 55 (1-5y) 105 (6-10y) 205 (11-15)				27 (newborn) 70 (0-1y) 125 (1-5y) 240 (6-10y) 500 (11-15y)	
FR	30 (10 kg, 1y) 140 (30 kg, 10y)				80 (10 kg, 1y) 245 (30 kg, 10y)	160 (10 kg, 1y) 340 (30kg, 10y)
HR						
HU						
IE					130 (Newborn) 160(1-4y) 230 (5-9y) 400 (10-15y) abdoben/pelvis	
UK	200 (0-1y) 230 (5y) 370 (10y)	13 (5y) 20 (10y)				

Table 6a. DRLs for nuclear medicine procedures: bone imaging, myocardial perfusion, heart-SPECT and myocardial imaging.

Country	Procedure & radiopharmaceutical						
	Bone imaging	Myocardial Perfusion	Myocardial Perfusion	Myocardial Perfusion	Myocardial Perfusion	Heart - SPECT	Myocardial imaging
	Tc-99m- phosphates and phosphonates	Tl-201 chloride	Tc-99m-tetrofosmin	Tc-99m-MIBI	Tc-99m teboroxime	Tc-99m	Tc-99m
AT		110		740 (2 day), 1200 (1 day)			
BG	640 (planar), 740 (SPECT)			1100 (rest and stress), 560 (rest or stress)			
CH	700	100	1200 (Mioview)	1200			
CZ	800	110 SPECT					
DE	500 (benign), 700 (malignant)	75	1000	600			
EL	735	111					
ES	1110	150	750 / max 1110 in 2 days	750 / max 1110 in 2 days			
FI	700	100 (SPECT)	1000 (SPECT, 1 day), 1200 (2 days)				
FR	700	110 (first injection, SPECT), 40 (second injection)	1 day: 300 (first injection, SPECT), 800 (second injection); 2 days 850	1 day: 300 (first injection, SPECT), 800 (second injection); 2 days 850			
HR	600					800	
IE	660		800	800			800
IS							
IT	740	110	370+1100 (rest+exercise: 1 day) 740+740 (rest+exercise: 2 days)	370+1100 (rest+exercise: 1 day) 740+740 (rest+exercise: 2 days)			
LT	600, 800 (with CT)		600	800			
LU	1110	150	1500	1480	1850		
LV	600. 800 (SPECT)		800				
MD	600 800 (SPECT)						600
NO	700		1200				
PL	750						
RO	800 (SPECT)			300			
SE	600		1200 (rest and stress scan on same day) 600 (rest and stress scan on seperate days)	1200 (rest and stress scan on same day) 600 (rest and stress scan on seperate days)			
SK	600, 800 (part of skeleton)						
UK	600	80	300	300			

Table 6b. DRLs for nuclear medicine procedures: tumor imaging, thyroid imaging and cardiac blood pool and blood flow.

Country	Procedure & radiopharmaceutical							
	Tumor imaging (PET)	Brain imaging (PET)	Thyroid metastases (after ablation, uptake 0%)	Thyroid	Thyroid imaging (no blocking)	Thyroid	Thyroid imaging	MUGA, cardiac blood pool, cardiac blood flow
	18F-FDG	18F-FDG	I-131-iodide	I-131-sodium-iodide	Tc-99m pertechnetate	Tc-99m-MIBI (Cardiolite)	I-123-iodide	Tc-99m-erythrocytes
AT	400			370	110		20	740
BG			90		100			
CH				3 (per oral)	75	170	10	1000
CZ					200			
DE	370 (2D mode), 200 (3D mode)				75			750
EL			180	3,5 (uptake measurement), 19 (uptake scan)	183			893
ES				1,5	222		37	
FI	370		200					750 (Cardiac Blood Pool)
FR	350				80		10	850
HU								
IE	375	290	185	2	110			
IT			200		150		20	925
LT			400		200		20 (uptake 35 %)	
LU				370	7,4		25	
LV			400		200		20	
MD					100			800
NO					150			
PL			240	4	80		20	
RO				0,2	80		20	600
SE	350			0,4 (uptake measurement)	120			
SK				400 (SPECT)			20	
UK	400		400		80		20	800

Table 6c. DRLs for nuclear medicine procedures: dopamine transporter imaging, lung perfusion, neuroendocrine tumors/somatostatin receptors and renal imaging.

Country	Procedure & radiopharmaceutical							
	Dopamine transporter imaging (parkisonism)	Lung perfusion	Lung perfusion	Lung imaging with CT	Neuroendocrine tumors/somatostatin receptors scan	Renal imaging	Renal imaging	Renal imaging
	I-123-Ioflupane (DaTScan)	Tc-99m-micro spheres	Tc-99m-MAA	Tc-99m-MAA	In-111 pentetreotide	Tc-99m DMSA	Tc-99m MAG3	Tc-99m DTPA
AT			150			110	110	185
BG	185		150			150	150	185
CH			180			120	100	200
CZ						150		
DE			100 (planar), 200 (SPECT)			70	100	150
EL			180		125	183		540
ES			296				370	370
FI			150			150	150	300
FR			240				200	370
HR			200 SPECT				350	350
IE	185		125		200		100	250
IT			160		185	160	160	200
LT			100	200		160	100	350
LU			150				370	370
LV			200			160	100	350
MD			100 (200 SPECT)					160
NO			280				100	200
PL		100						
RO			200 SPECT					
SE			125				110	150
SK								
UA								
UK			100			80	100	300

Table 6d. DRLs for nuclear medicine procedures: parathyreoid imaging cerebral blood flow, brain scintigraphy, infection/inflammation.

Country	Procedure & radiopharmaceutical							
	Parathyroid imaging	Parathyroid	Parathyroid	Cerebral blood flow	Brain Scintigraphy, Brain imaging, static	Cerebral blood flow	Infection/ inflammation imaging	Infection / inflammation imaging
	Tc-99m-MIBI	Tc-99m – pertechnetate	I-123-iodide	Tc-99m Exametazime (HMPAO, Ceretec)	Tc-99m	Tc-99m ECD Neurolite	Ga-67 citrate	Tc-99m labbelled leucocytes
AT					740 (HMPAO, DTPA,pertechnetate)		185	
BG	700							
CH	550		20 (per oral)					
CZ		200			600			600
DE				550				
EL							190	
ES				925			370	
FI	800			750				300
FR				500 (SPECT)		800		
HR				500	800 (SPECT)			
IE				800	800	800		
IT	740			740			110	
LT	500	80		500		500	300 (Infection, inflammation)	400
LU				1110		1110	220 (infection, inflammation)	370
LV					500, 800 SPECT			
MD	400			500	500, 800 (SPECT)			
NO				800				
PL	750			750		750		
RO				750		500		
SE				1000				
SK					800 (SPECT)			
UK	900			500			150	

Table 6e. DRLs for nuclear medicine procedures: lung ventilation, brain cerebral blood flow, brain benzodiazepine receptors, brain dopamine receptors and brain.

Country	Procedure & radiopharmaceutical						
	Lung ventilation	Brain - Cerebral blood flow	Brain - Benzodiazepine receptors	Brain - Dopamine receptors	Dopamine receptors SPECT	Dopamine receptors SPECT	Brain
	Tc-99m aerosol (Technegas)	I-123-iofetamine (IMP)	I-123-IBZM	I-123-iomazenil	I-125-β-CIT	I-125-FP-CIT (DatScan)	I-123 Benzamid, β-CIT
CH	300 (inhalation); 1000 (DTPA, inhalation)						
DE	1000						
FI	40				185	185	
IE	620 aerosol 120 Technegas						
LU	40 (DTPA)						
PL	200 (DTPA)						
RO			185	185			
RS		185					
UK	80 (DTPA), 40 (technegas?)						

Table 6f. DRLs for nuclear medicine procedures: bone marrow scintigraphy, bone marrow, lung ventilation, lymph node imaging and breast imaging.

Country	Procedures & radiopharmaceuticals						
	Bone marrow scintigraphy	Bone marrow	Lung ventilation	Lung ventilation	Lung ventilation	Lymp node imaging, Lymphatic system	Breast imaging
	Tc-99m DPD, MDP, HDP	Tc-99m-colloid	Xe-113 gas	Xe-127 gas	Krypton gas	Tc-99m	Tc-99m-MIBI
AT	740						
BG						74 (colloid)	740
CH			400				
CY							
CZ	550					150	
LU			750 (Xe-133)		400 (lung ventilation)		
LV						80	
MD	400						
PL		400	400	200			
RO		400					
UK					6000		

Table 6g. DRLs for nuclear medicine procedures: cardiac blood flow, first pass blood flow and heart and blood vessels.

Country	Procedures & radiopharmaceuticals						
	Cardiac Blood Flow (CBF)	Cardiac Blood Flow (CBF)	First pass blood flow	First pass blood flow	Heart and blood vessels Function/ CAD	Heart and blood vessels Phleboscint.	Heart and blood vessels Deep vein thromb
	Tc-99m-ECD, erythrocytes and human albumin	Tc-99m-HMPAO	Tc-99m-TcO4	Tc-99m-DTPA	Tc-99m-pentetate	Tc-99m-MAA	I-125-fibrinogen
FR	850						
NO	850	800					
PL			400	800			
PO							
RO					800	80	4
UK	800 (cardiac blood pool)						

Table 6h. DRLs for nuclear medicine procedures: vessel angiography, blood pool imaging, liver scintigraphy, spleen imaging, liver and spleen, blood and immune system, hepatobiliary imaging and functional biliary system imaging.

Country	Procedures & radiopharmaceuticals							
	Vessel angiography	Blood pool imaging	Liver scintigraphy, Liver imaging	Spleen imaging, planar	Liver and spleen	Blood and immune system - Spleen	Hepatobiliary imaging planar	Functional biliary system imaging
	Tc-99m	Tc-99m	Tc-99m-colloid	Tc-99m	Tc-99m	Tc-99m -RBC	Tc-99m	Tc-99m
AT			200 (marked tracers)					
CZ	800	80		100			150	
EL			179					
ES			259				370	
HR			200 (SPECT)					
IT			110					
LV			200					150
MD			200 (99mTC)	16	80			150
PL		800		100	100			200
RO						100		

Table 6i. DRLs for nuclear medicine procedures: kidney, urinary bladder, testes scintigraphy, tumor scintigraphy and neuroendocrine tumors.

Country	Procedures & radiopharmaceuticals						
	Kidney	Kidney	Urinary bladder direct cystography	Testes scintigraphy	Tumor scintigraphy	Neuroendocrine tumors	Neuroendocrine tumors
	I-123 Hippuran	Cr-51 EDTA	Tc-99m	Tc-99m	Tc-99m	I-123-MIBG	I-131-MIBG
CH	40	4					
CZ			50	600	800		
ES	3,7	5,5					
IE						385	
LT						400	20

Table 6j. DRLs for nuclear medicine procedures: inflammation, infection, tumors and adrenal gland.

Country	Procedures & radiopharmaceuticals						
	Inflammation	Inflammation	Infection/ inflamentation	Infection, inflammation, tumors	Infection, inflammation, tumours	Adrenal gland	Adrenal gland
	Tc-99m HIG, MAK, granulocytes, Isonitrile	Tc-99m nanokolloid	In-111-leukocytes	Exametazime	Pentetreotide	I-123 MIBG	I-131 Norcholesterol
AT	740	500				200	40
ES			20				
LU			18,5				
UK				200	110		

Table 6k. DRLs for nuclear medicine procedures: search for digestive hemorrhage, salivary gland, ventriculogammagrafia, leucosytes and cisternography.

Country	Procedures & radiopharmaceuticals				
	Search for digestive hemorrhage	Salivary gland	Ventriculogammagrafia	Leucosytes	Cisternography
	Tc-99m Erythrocytes	Tc-99m-pertechnetate	Tc-99m-hematíes/albumina	Tc-99m-HMPAO	In-111-DTPA
BG		100			
CZ		100 (GIT salivary glands)			
ES			925	370	
LU	1100				
LV		40			
PL					40

7 ANNEX 2: LIST OF CONTACT PERSONS

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