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Estimation of entrance surface dose for radiography examinations in Arrazi Hospital from Mohammed VI University Hospital Center of Marrakech (Morocco)

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Abstract – Diagnostic Reference Levels (DRLs) are an important tool for radiography and radiological science practice optimization. Assessment of entrance surface doses for patients in digital radiography examinations should be made as a means for the optimization of the radiation protection of the patients. This study aims to determine the typical DRLs (TDRL) values based on entrance surface dose (ESD) for routine radiography in Arrazi Hospital at the Mohammed VI University Hospital Centre (ARH Med VI UHC) in Marrakech, Morocco. A total of 1170 radiography examinations (RE) were included. They underwent 13 separate projections in the adult radiology department of the Marrakech-Safi region teaching hospital. The X-ray tube's dose area product (DAP) was used to figure out the patient's entrance surface dose for the cervical spine anterior-posterior (AP), cervical spine lateral (LAT), lumbar spine AP/LAT, abdomen AP, pelvis AP, shoulder AP, knee AP/ LAT, skull AP/ LAT, and the chest PA. The TDRL values of ESD for cervical spine AP/LAT, lumbar spine AP/LAT, abdomen AP, pelvis AP, shoulder AP, knee AP/LAT, skull AP/LAT, and chest AP were 1.52 mGy/1.46 mGy, 3.34 mGy/4.76 mGy, 1.56 mGy, 1.98 mGy, 1.25 mGy, 0.58 mGy/0.58 mGy, 2.2 mGy/2.1 mGy, and 0.22 mGy, respectively. We compared our TDRL values with those of other countries. Although the estimated TDRLs are encouraging, significant efforts are needed to reduce them, particularly for shoulder, knee, and skull X-rays.

Keywords: Conventional radiology / dose / radiation protection / DAP / ESD / DRL / TDRL

1 Introduction

According to research conducted by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2000), approximately 4 to 5 billion X-ray examinations are performed worldwide each year. No other imaging technique is utilized on such a large scale. These exams can provide radiologists with efficient diagnostic capabilities for various diseases and at a lower cost. Although the radiation doses from these examinations are generally low and late effects are expected to be minimal, it's important to ensure that the exposures are justified and optimized in relation to their benefits and risks.

The radiation dose received by a patient during an X-ray examination depends on several factors, including tube current, beam voltage, exposure time, the type of X-ray generator used, and the image receptors. Additionally, the patient dose is significantly affected by technician-specific variables and the procedures employed in radiography. Surveys conducted at national and international levels indicate that the patient dose can vary greatly between different patients and X-ray facilities for the same type of X-ray projection. Therefore, it is crucial to assess the patient dose in any diagnostic X-ray facility (Ciraj *et al.*, 2005; Hart *et al.*, 2009; Roch P. *et al.*, 2013).

To minimize the risks associated with radiation exposure, it is essential to reduce the dose received by patients. This can be achieved through various measures, including quality control of facilities and radiological procedures, as well as the establishment of diagnostic reference levels. The concept of DRLs was introduced by the International Commission on Radiological Protection (ICRP) and the European Commission (EC) (ICRP, 1996; EC, 1999). DRLs were created to promote the optimization of radiation exposure for patients.

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Table 1. Number of radiography projections, minimum, maximum, mean values of tube potential (kV), tube current (mAs), and exposure time (ms) of technical parameters for studied radiographic examinations.

Radiography Projection	Number of radiographies	kV	mAs	Exposure time (ms)
		Min-Max-Mean	Min-Max-Mean	Min-Max-Mean
Cervical spine (AP)	**52**	**55-70-64**	**3-12-9**	**7-38-25**
Cervical spine (LAT)	**51**	**57-77-68**	**1-50-13**	**2-126-31**
Lumbar spine (AP)	**52**	**57-77-70**	**10-33-22**	**13-39-24**
Lumbar spine (LAT)	**53**	**60-90-76**	**5-80-28**	**6-208-37**
Abdomen (AP)	**160**	**57-85-75**	**4-113-26**	**4-116-29**
Pelvic (AP)	**85**	**50-85-72**	**3-40-18**	**3-43-20**
Shoulder (AP)	**50**	**50-77-68**	**1-85-17**	**1-70-21**
Knee (AP)	**115**	**44-85-61**	**1-8-5**	**4-56-30**
Knee (LAT)	**115**	**48-85-64**	**1-6-5**	**1-10-9**
Skull (AP)	**50**	**60-77-73**	**8-16-15**	**9-19-16**
Skull (LAT)	**51**	**48-80-73**	**3-22-14**	**9-27-17**
Chest (PA)	**336**	**70-125-94**	**1-13-3**	**2-17-7**

Many organizations, including the ICRP (2017), IAEA (2007), and EC (2014), as well as several countries such as Germany (2010), Lithuania (Ziliukas *et al.*, 2010), the UK (Hart *et al.*, 2012), Greece (Metaxas *et al.*, (2019)), France (IRSN 2020), Iran (Mohsenzadeh *et al.*, 2020), and Saudi Arabia (Alrehily, 2022), have been involved in establishing DRLs for diagnostic imaging. In recent years, the concept of DRLs has gained significant interest and importance in Morocco. As a result, several studies have been conducted to determine the DRLs in computed tomography (CT) and in both conventional and interventional radiology (Benmessaoud *et al.*, 2021; El Mansouri *et al.*, 2022; Talbi *et al.*, 2022; Benamar *et al.*, 2023; Khajmi *et al.*, 2023).

The Marrakech-Safi region has a large number of radiology departments. These facilities are equipped to perform a range of imaging procedures and to provide essential medical imaging services to the local population; however, no dosimetric investigation has been carried out to analyze the X-ray doses administered in the region's radiology departments.

This research was performed to evaluate the exposure parameters selected for radiographic examinations of adult patients and to estimate the entrance surface dose delivered to patients undergoing common diagnostic radiographic projections in the conventional radiology department of the Arrazi Hospital at the Med VI UHC in Marrakech, Morocco. Additionally, we aim to propose typical DRLs values for general radiography examinations. The outcomes of this study will contribute to the limited information currently available on radiation doses to adult patients from medical radiography in Morocco. The results will help clinicians understand the importance of using DRLs as a valuable tool for managing radiation doses in diagnostic radiology and will serve as a basis for further research.

2 Materials and methods

2.1 Patient exams and dosimetric calculations

This study was conducted prospectively. Picture Archiving and Communication Systems (PACS) were utilized to collect, store, and categorize data for each examination on a computer using a Microsoft Excel spreadsheet. The study included 1170 radiography exams of adult patients (over 18 yr of age), with radiographs sampled between March and July 2022. In this paper, we focused on patients with an average weight of 70 kg to evaluate the typical dose administered to an average patient. This audit of entrance surface dose estimation excluded patients who weighed less than 60 kg or more than 80 kg. Table 1 shows the number of conventional radiology examinations carried out and the exposure factors involved.

The conventional emergency radiology department at the ARH of Med VI UHC is equipped with a Philips digital tube diagnostic system, which has been in operation since 2016. It uses a flat sensor as an X-ray detector and regular maintenance is carried out to ensure optimal performance and the production of high-quality images, enabling accurate diagnosis and improved patient care. Dose assessment was performed on patients undergoing the eight most common diagnostic radiographs, which include twelve individual projections. These projections cover the following areas: cervical spine (AP/LAT), lumbar spine (AP/LAT), abdomen (AP), pelvis (AP), shoulder (AP), knee (AP/LAT), skull (AP/LAT) and chest (AP). Each radiograph was performed in the same radiology department.

2.2 Dose calculations

The dosimetry of the patients was carried out according to the projection using both the Dose Area Product (DAP) and the Entrance Surface Dose (ESD). The DAP is calculated by multiplying the radiation dose in air by the area of the X-ray field and is measured in mGy.cm^2. This value is computed automatically for each exposure. DAP is used to assess the radiation doses administered to patients. These measurements are routinely displayed on the X-ray console for each examination. The following formula was used to estimate the ESD (Leclet, 2016):

$$\mathrm{ESD} = \mathrm{BSF}.\frac{\mathrm{DAP}}{\mathrm{IF}}.$$

IF is the irradiation field in cm^2, and BSF is the backscattered factor. As per the study of Leclet in 2016 (Leclet, 2016), BSF is equivalent to 1.35 for voltages ranging from 60 to 80 kV and 1.5 for voltages over 80 kV.

2.3 Statistical assessment

The data was organized for analysis using Microsoft Excel 2019. Typical DRL values were computed as median distributions for each radiographic examination, in line with the International Commission on Radiological Protection Publication 135 (ICRP, 2017). Descriptive statistics, including the mean, median, 50th percentile, and 75th percentile values of the dosimetric variable of ESD, were utilized to evaluate the information. Additionally, the minimum, maximum, and average values of voltage (kV) and intensity (mAs) were calculated. We conducted a thorough analysis by comparing the TDRLs values with DRLs from significant studies carried out around the world: in France in 2013 (Roch *et al.*, 2013), throughout the European Union in 2014 (EC, 2014), in the United Kingdom in 2016 (UK, 2016), in Nigeria in 2017 (Joseph *et al.*, 2017), in Iran in 2020 (Hoseini *et al.*, 2020), and in Ghana in 2023 (Gyan *et al.*, 2023). This comprehensive comparison highlights the relevance of our findings within the context of international standards and practices.

3 Results and discussion

In this study, we examined all the radiographs performed in the radiology department of the Arrazi hospital over a five-month period during the year 2022, in order to determine the TDRL values, in line with the description of the different DRL categories in ICRP135 (ICRP, 2017).

The total number of adult patients included in this research is 1170. 62% (n = 756) were men, and 38% (n = 414) were women. Figure 1 shows that the most common radiographs are chest, knee and abdominal radiographs with a percentage of 30%, 19% and 10% respectively. Radiographs of the pelvis, lumbar spine, cervical spine and skull did not exceed 7%. For each of the eight radiographs, the average tube potential (kVp), tube current (mAs) and exposure time (ms) were obtained and are presented in Table 1. The minimum and maximum age criteria for all examinations were 19 and 84 yr, respectively. For the kV, the range is 44 kV to 125 kV; for the mAs, the range is 1 mA to 113 mAs; and for exposure time in milliseconds, the range is 1 ms to 208 ms. The large ranges of kV, mAs and ms were caused by the significant variations in patient size, weight, height and radiographic techniques used by radiology technicians. The documented technical radiographic parameters show that there are variations in technical factors when compared to the recommendations of the European Commission Quality Criteria (EC, 1996). Table 3 summarizes the calculated mean and the 50th and 75th percentiles of the entrance surface dose in mGy for each projection and examination considered.

For all examinations and projections, the estimated mean ESD ranged from a minimum of 0.24 mGy to a maximum of 4.59 mGy. Whereas the established typical DRL values for the entrance surface doses of all radiography projections were 1.52 mGy, 1.46 mGy, 3.34 mGy, 4.76 mGy, 1.56 mGy, 1.98 mGy, 1.25 mGy, 0.58 mGy, 0.58 mGy, 2.2 mGy, 2.1 mGy, and 0.22 mGy, for cervical spine AP, cervical spine LAT, lumbar spine AP, lumbar spine LAT, abdominal X-ray AP, pelvis X-ray AP, shoulder AP, knee AP, knee LAT, skull AP, skull LAT, and chest PA, respectively.

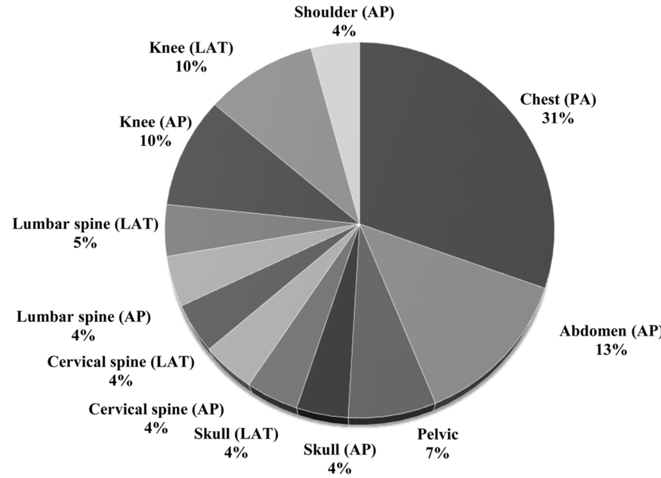

Fig. 1. Frequency distribution of radiographs studied.

The typical DRL of ESD of 4.76 mGy for lumbar spine LAT radiography is higher than the other values. This is due to higher exposure parameters (*i.e.*, kVp and mAs) than for the other examinations. The field size is another factor influencing the diagnostic reference level, which is larger for the abdomen than for the other radiographs. The chest X-ray AP projection had the lowest TDRL of ESD at 0.22 mGy, indicating lower exposure compared to the other radiographs.

In this study, the TDRL of the cervical spine AP and LAT (1.52 mGy/1.46 mGy), the knee AP and LAT (0.58 mGy/0.58 mGy), and the skull AP and LAT (2.2 mGy/2.1 mGy) are approximately identical; the discrepancy does not exceed 4%. This indicates that the radiology technicians at Arrazi hospital do not change the acquisition parameters between AP and LAT projections for these examinations. However, because the patient width is greater in the LAT position than in the AP position, the TDRL of 4.76 mGy of the LAT lumbar spine is 142% higher than in the AP lumbar spine of (3.34 mGy). In comparison of the median value of ESD for the abdominal X-ray (1.56 mGy) AP projection and the pelvic X-ray (1.98 mGy) AP projection, the TDRL value of the pelvic X-ray AP projection is 26% higher. For the shoulder X-ray AP projection, Table 2 shows that the TDRL (1.25 mGy) is 82% higher than that for the chest X-ray AP projection (0.22 mGy). The use of a high mAs (1–85 mAs) and kilovolt (50–77 kV) in this radiography could be behind the high dose delivered to the patients.

The high dose values observed in certain examinations in our survey may be due to inadequate training of imaging staff or to variations in technical parameters, clinical complexity of patients, and untimely quality control programs. The above finding is not unique to this study, this is confirmed by a study in Ghana (Ofori, 2013) and Nigeria (Joseph *et al.*, 2017), but is common in other developing countries (Johnson *et al.*, 2000; Wall *et al.*, 2001; Kings *et al.*, 2002).

The quantity of DRLs is contingent on numerous factors that influence patient exposure. The kVp has an effect on both the quantity and quality of the radiation beam, and for all radiography devices, the output increases with increasing kVp,

Table 2. The calculated entrance surface dose (ESD) for all projections and examinations.

Radiography Projection	ESD (mGy)			
	Mean	Median	50th percentiles	75th percentiles
Cervical spine (AP)	**1.35**	**1.52**	**1.04**	**2.1**
Cervical spine (LAT)	**1.69**	**1.46**	**0.83**	**1.8**
Lumbar spine (AP)	**3.09**	**3.34**	**3.15**	**3.7**
Lumbar spine (LAT)	**4.59**	**4.76**	**3.68**	**5.9**
Abdomen (AP)	**1.44**	**1.56**	**1.25**	**1.9**
Pelvic (AP)	**1.68**	**1.98**	**1.74**	**2.35**
Shoulder (AP)	**1.2**	**1.25**	**1.01**	**1.5**
Knee (AP)	**0.53**	**0.58**	**0.47**	**0.7**
Knee (LAT)	**0.57**	**0.58**	**0.5**	**0.65**
Skull (AP)	**1.77**	**2.2**	**1.29**	**2.9**
Skull (LAT)	**1.96**	**2.1**	**1.57**	**2.7**
Chest (PA)	**0.24**	**0.22**	**0.15**	**0.25**

Table 3. Comparison of the TDRL result of each examination with the relevant ESD (mGy) literature.

Examinations Projection	This study	French 2013	EC 2014	UK 2016	Nigeria 2017	Iran 2020	Ghana 2023
Cervical spine (AP)	1.52	4	4	–	0.62	1.6	0.3
Cervical spine (LAT)	**1.46**	**4**	**7**	**-**	**0.79**	**1.7**	**0.3**
Lumbar spine (AP)	**3.34**	**10**	**5**	**5.7**	**1.22**	**5.3**	**1.6**
Lumbar spine (LAT)	**4.76**	**25**	**8**	**10**	**1.59**	**11.8**	**3.1**
Abdomen (AP)	**1.56**	**8**	**3**	**4**	**1.01**	**4.3**	**1.3**
Pelvic (AP)	**1.98**	**9**	**4**	**4**	**0.82**	**3.2**	**0.9**
Shoulder (AP)	**1.25**	**-**	**0.7**	**0.5**	**0.71**	**-**	**-**
Knee (AP)	**0.58**	**-**	**0.4**	**0.3**	**0.5**	**-**	**-**
Knee (LAT)	**0.58**	**-**	**0.7**	**0.3**	**0.91**	**-**	**-**
Skull (AP)	**2.2**	**3**	**0.7**	**1.8**	**1.02**	**2.2**	**0.7**
Skull (LAT)	**2.1**	**5**	**1**	**1.1**	**1.01**	**2.4**	**0.6**
Chest (PA)	**0.22**	**0.3**	**0.3**	**0.15**	**0.59**	**1.4**	**0.3**

resulting in a higher dose to the patients. The exposure is directly proportional to the mAs parameter, and the scattered radiation will increase with a larger field and impose more surface doses. The focal spot-to-surface distance (FSD) factor could also affect radiation exposure to patients. The operator's selection of settings, as outlined above, is a pivotal factor in determining the absorbed dose. The expertise and dedication of the operator in utilizing appropriate settings can significantly influence the outcome. Reducing patient dose while maintaining image quality is achievable through routine staff training.

4 International comparison of DRLs

Table 3 shows the comparison of established typical diagnostic reference level values for radiographic examination with data from France in 2013 (Roch *et al.*, 2013), the European Commission in 2014 (EC, 2014), the United Kingdom in 2016 (UK, 2016), Nigeria in 2017 (Joseph *et al.*, 2017), Iran in 2020 (Hoseini *et al.*, 2020), and Ghana in 2023 (Gyan *et al.*, 2023).

The typical DRL value for the AP/LAT cervical spine of (1.52 mGy/1.46 mGy) was found to be higher than the values recorded in Nigeria of (0.62 mGy/0.79 mGy) and Ghana of (0.3 mGy/0.3 mGy) but lower than those of Iran of (1.6 mGy/1.7 mGy), France of (4 mGy/4 mGy), and EC of (4 mGy/7 mGy).

The median value of ESD for the AP/LAT lumbar spine of (3.34 mGy/4.76 mGy) in this analysis was lower than that seen in France of (10 mGy/25 mGy), in EC of (5 mGy/8 mGy), in the UK of (5.7 mGy/10 mGy), and in Iran of (5.3 mGy/11.8 mGy). However, it exceeds the registered DRL in Nigeria (1.22 mGy/1.59 mGy) and Ghana (1.6 mGy/3.1 mGy). This discrepancy can be attributed to the radiography techniques employed.

The established typical DRL values for abdominal and pelvic X-ray AP projection of 1.56 mGy–1.98 mGy were observed to be considerably lower than the values recorded values in France of 8 mGy–9 mGy, EC of 3 mGy–4 mGy, UK of 4 mGy–4 mGy, and Iran of 4.3 mGy–3.2 mGy, but higher when compared to Nigeria of 1.01 mGy–0.82 mGy and Ghana of 1.3 mGy–0.92 mGy. This could generally be linked to the technology used.

The typical value of the entrance surface dose presented here for the shoulder AP projection of 1.25 mGy is well above the statistics of other studies. This demonstrates that higher exposure parameters are used for this radiography because of the greater thickness in this part of the body. The TDRL value of this work based on ESD for knee AP projection is 0.58 mGy. This is higher than the DRL values for the EC (0.4 mGy), the UK (0.3 mGy), and Nigeria (0.5 mGy). Whereas, expect DRL in the UK during 2016 for knee LAT projection; the median value of ESD is lower. Regarding skull AP/LAT, the DRL values of 2.2 mGy/2.1 mGy were higher than those published in the other countries, with the exception of France's 2013 estimate of 3 mGy/5 mGy and Iran's 2022 value of 2.2 mGy/2.4 mGy. For chest X-ray PA projection, the TDRL in this study was found to be 0.22 mGy higher than that seen in the UK (0.15 mGy) but less than those registered in France (0.3 mGy), EC (0.3 mGy), Nigeria (0.59 mGy), Iran (1.4 mGy), and Ghana (0.3 mGy).

Table 3 shows that there are differences between our study's TDRLs and those of official organizations (EC, 2014) and the other reporting nations. The variations in dosage between the research centers are consistent with the results of Shrimpton *et al*. (1986), who revealed that disparities between the centers might reach up to 10 to 40 in the UK and 8 to 20 in Norway. The radiography technology system may be responsible for these variances. Different DRLs in such an inter-survey comparison will result from a range of causes, including statistical variances, measuring techniques, clinical approaches, and equipment. For example, the French (Roch *et al.*, 2013) and UK (UK, 2016) surveys during 2013 and 2016 selected patient dosage data from a large number of institutions of different sizes. Besides, a very large number of hospital radiological examination doses were also reviewed. In Nigeria (Joseph *et al.*, 2017), the study was conducted in two university teaching hospitals, and 750 patients were assessed. While all 1170 radiographs in our investigation were conducted in a single digital radiography room with one X-ray machine.

5 Conclusion

This project developed typical DRLs values in terms of ESD for eight radiographic examinations at the Mohammed VI University Hospital Centre at the Arrazi Hospital in Marrakech, Morocco. An evaluation of local practices, taking into account operational procedures or equipment performance. The findings demonstrated that, with the exception of the TDRLs of the shoulder, knee, and skull radiographs, which were greater than those published elsewhere, most of the DRLs were lower than the suggested international DRLs.

In order to minimize the risk of stochastic effects associated with radiography, the X-ray department of the Arrazi Hospital requires a process of homogenization of radiation exposure to patients undergoing radiographic examinations, regular quality control of equipment, and a dose optimization strategy.

To establish a baseline, the information collected in this study can be compared to future dose assessments. Authorities at the national and professional levels might also find this dose survey helpful to develop the national DRLs for conventional radiography in Morocco.

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Conflicts of interest

There is no conflict of interest for this paper.

Data availability statement

The entire study results are available from H. KHAJMI, the corresponding author.

Author contribution statement

Each author contributed to the study's design and implementation, analysis of the results, and writing of the report.

Ethics approval

Ethical approval was not required.

Informed consent

This study did not require informed consent.

References

Alrehily F. 2022. Diagnostic reference levels of radiographic and ct examinations in Saudi Arabia: A systematic review. *Radiat Prot Dosim* 198 (19): 1451–1461. https://doi.org/10.1093/rpd/ncac183.

Benamar M, *et al.* 2023. Patient dose assessment in computed tomography in a Moroccan imaging department. *Radioprotection* 58 (1): 49–53. https://doi.org/10.1051/radiopro/2022039.

Benmessaoud M, *et al.* 2021. Derivation of local diagnostic reference levels for common adult computed tomography examinations in Moroccan hospital. *Radiat Prot Dosim* 194 (4): 208–213. https://doi.org/10.1093/rpd/ncab095.

Ciraj O, *et al.* 2005. A survey of patient doses from conventional diagnostic radiology examinations: first results from Serbia and Montenegro. *Phys Med* 21 (4): 159–163.

EC European Commission. 2014. Radiation Protection No. 180. https://ec.europa.eu/energy/sites/ener/files/documents/RP180%20part2.pdf.

EUR96 European Guidelines on Quality Criteria for Diagnostic Radiographic Images, European Commission, EUR 16260 EN, June 1996.

El Mansouri M, *et al.* 2022. Establishing local diagnostic reference levels for adult computed tomography in Morocco. *Radioprotection* 57 (1): 61–66. https://doi.org/10.1051/radiopro/2021035.

European Commission. 1999. Radiation protection report 109. Guidance on diagnostic reference levels (DRLs) for medical exposures. European Commission, UK.

European Commission (EC): Diagnostic Reference Levels in Thirty-six European Countries Part 2/2. Radiation protection No.180. Luxembourg: Publications Office of the European Union, 2014.

France IRSN PRP-HOM. 2020. Analyse des données relatives à la mise à jour des niveaux de référence diagnostiques en radiologie et en médecine nucléaire. Bilan 2016–2018. Rapport parut en 2020.

Gyan E, *et al.* 2023. Proposed institutional diagnostic reference levels in computed and direct digital radiography examinations in two teaching hospitals. *J Radiat Prot Res*. https://doi.org/10.14407/jrpr.2021.00367.

Hart D, *et al.* 2009. National reference doses for common radiographic, fluoroscopic and dental X-ray examinations in the UK. NRPB-R200. *Br J Radiol* 82 (973): 1–12. https://doi.org/10.1259/bjr/12568539.

Hart D, *et al.* 2012. Doses to patients from radiographic and fluoroscopic X-ray imaging procedures in the UK – 2010 review. HPA-CRCE-034.

Hoseini Motlagh Z, *et al.* 2020. Determination of diagnostic reference level in routine examinations of digital radiography in Mazandaran province. *Radiat Prot Dosim* 190 (1): 31–37. https://doi.org/10.1093/rpd/ncaa074.

ICRP. 1996. *Publication 73, annals of the ICRP 26, recommendations of the international commission on radiological protection*. Oxford: Pergamon Press.

International Commission on Radiological Protection (ICRP). 2017. Diagnostic reference levels in medical imaging. ICRP Publication 135. *Ann. ICRP* 46 (1): 1–144.

International Atomic Energy Agency. Dosimetry in diagnostic cradiology: an international code of practice. Technical Reports Series No. 457 (Vienna: IAEA) (2007).

Johnson, *et al.* 2000. Reference dose levels is for patients undergoing common diagnostic X-rays examination in Irish Hospitals. *British J Radiol* 73: 396–402. https://doi.org/10.1259/bjr.73.868. 10844865.

Joseph DZ *et al.*, 2017. Establishment of Local Diagnostic Reference Levels (DRLs) for Radiography Examinations in North Eastern Nigeria. *Sci World J* 12 (4).

Khajmi H, *et al.* 2023. Evaluation of X-ray doses in pediatrics multislice computed tomography. *Radioprotection*. https://doi.org/10.1051/radiopro/2023029.

King S, et al. 2002. Optimizing medical radiation exposures for uroradiological procedures, with special emphasis on paediatric imaging. *BJU Int* 89 (6). https://doi.10.1046/j.1464-410X.2002.02660.x.

Leclet H. 2016. La métrologie des niveaux de dose dans les pratiques radiodiagnostiques. http://www.bivi.metrologie.afnor.org

MedizinischeStrahlenschutzverordnung, Verordnung der Bundesministerinfür Gesundheit und Frauen überMaßnahmenzum Schutz von PersonenvorSchädendurchAnwendungionisierenderStrahlungimBereich der Medizin, BGBl. II Nr. 197/2010, (2010). Germany.

Metaxas VI, *et al.* 2019. Patient doses in common diagnostic X-ray examinations. *Radiat Prot Dosim* 184 (1): 12–27. https://doi.org/10.1093/rpd/ncy169.

Mohsenzadeh B, *et al.* 2020. Assessment of patient dose in routine digital radiography in Iran. *Int J Radiat Res* 18 (3): 449–460. https://doi.org/10.18869/acadpub.ijrr.18.3.449.

Ofori EK. 2013. Radiology & imaging. *Radiology* 2013. https://doi.org/10.4172/2167-7964.S1.002.

Roch P, *et al.* 2013. French diagnostic reference levels in diagnostic radiology, computed tomography and nuclear medicine: 2004-2008 review. *Radiat Prot Dosimetry* 154: 52–75. https://doi.org/10.1093/rpd/ncs152.

Shrimpton PC, *et al.* 1986. National survey of doses to patients undergoing a selection of routine X-ray examination in english hospitals. *NRBP- R 200: Chilton, UK*.

Talbi M, *et al.* 2022. Local Diagnostic Reference Levels (LDRLs) for routine X-ray examinations in Morocco. *Radioprotection* 57 (2): 149–155. https://doi.org/10.1051/radiopro/2022008.

UK. 2016. https://www.gov.uk/government/publications/diagnostic-radiology-national-diagnostic-reference-levels-ndrls/ndrl. Accessed 2-9-2024.

United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and effects of ionizing radiation: report to the General Assembly, annex D, medical radiation exposures. New York, NY: United Nations, 2000.

Wall BF. 2001. Diagnostic reference levels – the way forward. *British J Radiol* 74 (885): 785–788. https://doi.org/10.1259/bjr.74.885.740785.

Ziliukas JL, *et al.* 2010. Management of patient doses and diagnostic reference levels in X-ray radiography in Lithuania. *Radiat Prot Dosim* 139 (1-3): 313–316. https://doi.org/10.1093/rpd/ncq102.

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