ISSN: 2634-9221
European Journal of Applied Sciences; Vol. 14 No. 01 (2026) (10-23)
https://doi.org/10.14738/aivp.1401.19783

Dosimetry Evaluation of Conventional Radiology Examinations in Adults in Benin

O. H. Fachinan[1,2] *, G. D. Houndetoungan[1,3], H. H. E. Houmbade[4], T. A. Zohizalan[5], A. Avocefohoun[4], E. H. L. Bathily[6], K. M. Savi De Tove[7], K. M. Amoussou-Guenou[3]

1. Centre de Recherche en Sciences Morphologiques et Fonctionnelles Humaines (CRS-MORFOH), École Doctorale de Sciences de la Santé (EDSS), Université d'Abomey-Calavi, République du Bénin
2. Institut de Formation en Soins Infirmiers et Obstétricaux, Université de Parakou, République du Bénin
3. Unité d'Enseignement et de Recherche de Biophysique et Médecine Nucléaire, Faculté des Sciences de Santé, Université d'Abomey-Calavi, République du Bénin
4. École Polytechnique d'Abomey-Calavi (EPAC), Université d'Abomey-Calavi, République du Bénin
5. Department of oncology and X-ray Radiology named after V.P. Kharchenko, Medical Institute, RUDN University, Russia
6. Service de Médecine nucléaire, Hôpital Général Idrissa Pouye de Dakar, République du Sénégal
7. Faculté de Médecine, Université de Parakou, République du Bénin

Abstract: Introduction and objective: Exposure to ionizing radiation raises concerns regarding radiation protection. The objective of this study was to evaluate the entry dose of X-rays during conventional radiography examinations in adult patients in Benin. Methods: This was a cross-sectional study conducted over an eleven-month period, from January to November 2025. The study was carried out in 34 healthcare facilities distributed across the national territory and equipped with functional conventional radiography units. Diagnostic Reference Levels (DRLs) were defined as the 75th percentile of entry dose (ED) and Dose–Area Product (DAP) values for each type of examination. Results: Pulmonary diseases were the most frequently investigated conditions among adult patients, with 966 patients examined, representing 27.52% of all examination indications. Posteroanterior chest radiography accounted for 34.8% of the examinations performed. The national 75th centile values (DRLs) of the entry dose (mGy) by examination type were 0.70, 17.28, 2.35, and 3.63 for chest, lumbar spine, cervical spine, and skull radiography, respectively. The national 75th centile values (DRLs) of dose–area product (mGy·cm^2) by examination type were 1,120, 25,592, 938, and 1,438 for chest, lumbar spine, cervical spine, and skull radiography, respectively. Conclusion: The doses delivered to patients during conventional radiography examinations in Benin were significantly higher than international standards. Therefore, it is necessary to implement a process of procedural harmonization and dose optimization based on the established diagnostic reference levels.

Keywords: conventional radiography, dosimetry evaluation, diagnostic reference levels, Benin.

INTRODUCTION

Conventional radiography remains one of the most widely used imaging modalities worldwide, particularly in low- and middle-income countries where access to advanced

imaging techniques such as computed tomography and magnetic resonance imaging is limited. It plays a crucial role in routine medical diagnosis by providing rapid and cost-effective visualization of anatomical structures. However, conventional radiography involves exposure to ionizing radiation, which raises important concerns regarding radiation protection, as cumulative low-dose exposure may lead to potential stochastic biological effects in adult populations undergoing repeated examinations [1].

The Entrance Surface Dose (ESD) is a key dosimetry quantity used to assess patient exposure in diagnostic radiology. It represents the absorbed dose at the point where the X-ray beam enters the patient's skin and is widely recognized as an essential indicator for evaluating and optimizing radiographic practices. ESD assessment contributes significantly to patient dose monitoring and forms the basis for establishing Diagnostic Reference Levels (DRLs), which are internationally recommended tools for dose optimization and quality assurance in medical imaging [2,3].

Numerous studies worldwide have evaluated ESD values for common radiographic examinations in adult patients, providing reference data for comparison and optimization. Studies conducted in North Africa and sub-Saharan Africa have reported substantial variations in entrance surface doses depending on examination type, radiographic technique, and equipment performance, highlighting the need for local and national dose assessments [4,5]. These investigations emphasize the importance of continuous monitoring of patient doses to harmonize radiological practices and ensure compliance with radiation protection principles.

In Benin, despite the widespread use of conventional radiography in healthcare facilities, published data on patient radiation doses, particularly entrance surface doses in adult populations, remain scarce. The absence of national diagnostic reference levels limits the ability to assess dose optimization and patient safety in routine radiographic practice. Therefore, evaluating ESD values in conventional radiography is essential to establish baseline dosimetric data and to support the development of local or national DRLs.

The aim of this study is to evaluate the entrance surface dose of X-rays during conventional radiographic examinations in adult patients in Benin and to compare the obtained values with international diagnostic reference levels. The findings are expected to contribute to the optimization of radiographic practices and the strengthening of radiation protection for patients in medical imaging departments across the country.

METHODOLOGY

This was a descriptive cross-sectional study with both retrospective and prospective data collection, conducted over an eleven (11) month period from January to November 2025. The study was carried out in the radiology departments of healthcare facilities in Benin, including public institutions (university teaching hospitals, regional hospitals, district hospitals) as well as private healthcare facilities equipped with functional conventional radiography units.

The study population consisted of conventional radiography equipment and patients examined in radiology units. An exhaustive sampling approach was adopted, including all patients aged over 15 years who underwent conventional radiography examinations in medical imaging departments, as well as all functional radiography units with a dosimetric

accuracy of less than 10%. The variables studied included patients' socio-clinical data, acquisition parameters, and dosimetric data for each examination, namely entry dose (ED) and dose–area product (DAP). These two dosimetric quantities were calculated using the acquisition parameters (kV, mAs, focus-to-patient distance, and irradiation field area) according to the following formulas:

$$ED = 0.15 \times ([U/100]^2 \times Q \times [100/FPD]^2)$$

- **ED** = X-ray entrance dose, expressed in mGy
- **U** = tube voltage, expressed in kV
- **Q** = X-ray tube charge, expressed in mAs
- **FPD** = focus-to-patient distance, expressed in cm

$$DAP = ED \times S / BSF$$

- **DAP** = dose–area product, expressed in mGy·cm^2
- **ED** = X-ray entrance dose, expressed in mGy
- **BSF** = backscatter factor (1.35 for tube voltages between 60–80 kV; 1.5 for tube voltages ≥120 kV)
- **S =** irradiation field area

Data were collected using Google Forms and subsequently exported to SPSS version 2020 for statistical analysis. Analyses were performed by examination type, defined according to the anatomical region or organ examined, and by healthcare facility. Acquisition parameters and dosimetric data were considered only for commonly performed examinations. These examinations were identified in accordance with the criteria specified in the *Safety Standards Guide* (SSG-46) published by the International Atomic Energy Agency (IAEA) [6], which requires a minimum of 20 examinations per radiological examination type within each healthcare facility. For comparative purposes, only examinations that met these criteria in at least two centers were included [7,8]. These included skull (anteroposterior view), chest (posteroanterior view), cervical spine (anteroposterior and lateral views), and lumbar spine (anteroposterior and lateral views) radiographic examinations. The 75th percentiles of entrance dose (ED) and dose–area product (DAP) were calculated for each examination type, both at the facility level and at the national level. The calculated 75th percentiles of ED and DAP, representing the national diagnostic reference levels (DRLs), were subsequently compared with DRLs reported in the literature.

The research project was submitted for approval to the Local Ethics Committee for Biomedical Research of the University of Parakou (CLERB-UP) and received ethical approval under reference number 694/2024/CLERB-UP/P/SP/R/SA.

RESULTS

A total of 34 conventional radiology units were included based on the study criteria. To ensure confidentiality, these units were labelled from C1 to C36. Each unit was equipped with a radiology device.

Characteristics of Conventional Radiology Devices

The conventional radiology devices used for examinations in the included healthcare facilities were manufactured between 1993 and 2023 and installed in these facilities between 1994 and 2023, mostly as new equipment. The devices varied in brand and type. They consisted of analog devices (14 units), indirect digital devices (14 units), and direct digital devices (4 units). Preventive maintenance was not systematically performed in almost all conventional radiology devices (24 out of 34 units). Calibration was carried out at the start of each device's commissioning. Subsequent calibration was performed in case of malfunction for twelve devices and annually for eight devices.

Demographic Characteristics of Patients Undergoing Conventional Radiology Examinations

A total of 3,513 adult patients who underwent conventional radiology examinations were included in this study, originating from the 34 surveyed radiology units. The mean age was 44.91 ± 15.62 years, ranging from 16 to 90 years. The age group of 35 to 55 years was the most represented, accounting for 45.49% of the adult patients. In this series, 1,586 patients (45.15%) were male, corresponding to a sex ratio of 0.82.

Clinical and contextual characteristics of conventional radiology examinations

Types of pathologies investigated:

Lung disease was the most frequently investigated type of pathology in adult patients, with 966 patients seen, representing 27.52% of the reasons for examination. Figure 1 illustrates the distribution of patients according to the pathology groups that prompted conventional radiology examinations in adult patients.

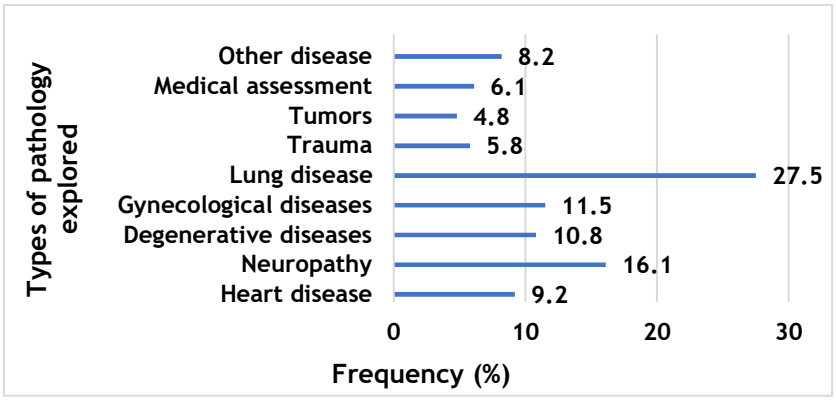

Figure 1: Distribution of adult patients received according to the pathology groups that motivated the performance of conventional radiology examinations in health facilities in Benin

Types of Conventional Radiology Examinations Commonly Performed:

In adults, frontal chest radiography accounted for 34.8% of examinations performed.

Table 1 lists the types of examinations commonly performed by radiology unit.

Table 1: Distribution of Examination Types Commonly Performed in Adult Patients by Radiology Unit

Radiology Unit	Skull X-ray	HSG	Chest X-ray	Cervical spine	Lumbar spine	Total
C1	-	-	61	-	-	61
C2	-	38	57	-	-	95
C3a	72	38	136	44	147	437
C3b	-	-	-	-	70	70
C4	38	-	57	46	43	184
C5	40	-	54	36	43	173
C6	33	35	42	39	39	188
C7	54	37	75	45	43	254
C8	37	41	43	36	41	198
C9	-	-	-	37	-	37
C10	35	37	43	33	37	185
C11	-	-	-	-	-	-
C12	37	33	87	36	-	193
C13	38	36	37	39	35	185
C15	-	-	70	-	-	70
C16	-	-	51	-	-	51
C18	-	-	40	-	-	40
C19	-	-	42	-	-	42
C20	-	-	39	-	-	39
C22	-	-	34	-	-	34
C23	-	-	37	-	-	37
C24	-	-	38	33	-	71
C25	-	35	38	-	43	116
C26	-	-	35	-	-	35
C27	35	-	40	-	-	75
C28	-	-	44	-	-	44
C29	34	32	37	39	-	142
C31	32	-	37	34	-	103
C32	37	-	37	-	-	74
C33	40	35	41	-	-	116

C34	-	-	47	-	-	47
C35	37	-	39	-	-	76
C36	-	-	41	-	-	41
Total	634	403	1438	497	541	3513

Dosimetry Data for Conventional Radiology Examinations

The dosimetry parameters studied were the X-ray entry dose (ED) and the dose-area product (DAP). Dosimetry data for conventional radiology examinations in adult patients were determined by commonly performed examination type and by CT scanner unit (more than 20 examinations per examination type and per CT scanner unit in at least two units).

Dosimetry Data for Chest X-rays (PA)

Thirty (30) standard radiology units met the number and frequency criteria for dosimetry calculations of chest X-rays.

Table 2 presents the dosimetry statistics for chest X-rays by radiology unit.

Table 2: Description of ED and DAP for Chest X-rays by Radiology unit

Radiology Unit	ED (mGy)				DAP (mGy.cm^2)			
	Average	25ème Centile	50ème Centile	75ème Centile	Average	25ème Centile	50ème Centile	75ème Centile
C3a	0,69	0,56	0,70	0,70	1371	1120	1400	1400
C1	0,69	0,56	0,70	0,73	1382	1120	1400	1460
C10	0,33	0,23	0,32	0,32	489	336	478	478
C12a	0,58	0,27	0,56	0,70	912	312	1120	1400
C12b	0,58	0,43	0,56	0,70	979	505	765.5	1400
C13	0,45	0,36	0,43	0,50	529	421	505	585
C15	0,69	0,46	0,63	0,71	1126	686	1120	1400
C16	0,65	0,51	0,70	0,70	1259	1020	1122	1400
C18	0,48	0,36	0,43	0,56	722	417	505	1095
C19	0,40	0 ,36	0,41	0,45	481	417	482	523
C2	0,70	0,56	0,70	0,92	1404	1120	1400	1840
C20	0,45	0,36	0,46	0,51	671	425	686	757
C22	0,35	0,19	0,24	0,27	275	231	286	312
C23	0,43	0,37	0,46	0,49	590	433	686	686
C24	0,41	0,24	0,37	0,46	458	286	425	686

C25	0,51	0,46	0,46	0,56	828	569	686	918
C26	0,43	0,32	0,46	0,50	571	425	585	686
C27	0,44	0,36	0,43	0,50	595	417	505	6112
C28	0,44	0,36	0,43	0,55	634	417	505	654
C29	0,37	0,28	0,32	0,46	542	420	478	686
C31	0,47	0,32	0,56	0,56	691	478	830	830
C32	0,44	0,32	0,56	0,56	647	478	830	830
C33	0,34	0,26	0,32	0,46	500	384	478	686
C34	0,37	0,29	0,32	0,46	541	433	478	686
C35	0,37	0,29	0,32	0,46	551	425	478	686
C4	0,38	0,20	0,24	0,27	276	239	286	312
C5	0,45	0,46	0,46	0,47	836	686	686	704
C6	0,40	0,36	0,39	0,43	464	417	459	505
C7	0,73	0,70	0,75	0,75	1227	1112	1112	1120
C8	0,73	0,56	0,83	0,83	1196	1120	1235	1235
National	0,52	0,32	0,46	0,70	1438	442	686	1120

Dosimetry Data for Lumbar Spine X-rays (AP and Lateral)

Fourteen (14) standard radiology units met the number and frequency criteria for dosimetry calculations of lumbar spine X-rays.

Table 3 presents the dosimetry statistics for lumbar spine X-rays by radiology unit.

Table 3: Description of Dosimetry Data for Lumbar Spine X-rays by Radiology unit

Radiology Unit	ED (mGy)				DAP (mGy.cm^2)			
	Average	25ème Centile	50ème Centile	75ème Centile	Average	25ème Centile	50ème Centile	75ème Centile
C3a	18,14	17,28	18,36	19,50	24738	22491	25704	27300
C3b	18,04	17,28	18,36	19,50	26722	22491	25704	27300
C4	5,25	3,84	5,41	5,81	5253	3840	5418	5808
C5	4,05	3,84	3,84	4,33	3604	3414	3414	3854
C6	5,40	4,56	5,31	5,76	5396	4563	5315	5760
C7	4,78	4,86	5,41	5,41	4250	4320	4814	4814
C8	4,03	3,84	4,25	4,80	2384	3414	2400	4267
C10	5,84	5,84	5,84	5,84	5840	5840	5840	5840
C13	6,66	6,00	6,00	7,50	3449	3108	3108	3885

C25	2,75	2,43	2,88	2,88	2448	2160	2560	2560
C12a	5,36	4,51	5,20	5,66	5780	4411	5013	5530
C12b	5,05	3,23	4,25	4,66	5053	3401	2400	4200
C35	3,94	3,74	5,29	5,68	3532	3640	5118	5508
C9	4,69	4,66	5,23	5,42	4191	4120	4614	4784
National	10,12	4.41	5.84	17.28	12608	3610	5840	25592

Dosimetry Data for Cervical Spine X-rays (AP and lateral views)

Thirteen (13) conventional radiology units met the number and frequency criteria for dosimetry calculations of cervical spine X-rays.

Table 4 presents the dosimetry statistics for cervical spine X-rays by radiology unit.

Table 4: Description of Dosimetry Data for Cervical Spine X-rays by Radiology unit

Radiology Unit	ED (mGy)				DAP (mGy.cm^2)			
	Average	25ème Centile	50ème Centile	75ème Centile	Average	25ème Centile	50ème Centile	75ème Centile
C3a	3,27	2,94	2,94	3,96	4839	4354	4354	5872
C4	1,35	1,18	1,47	1,47	499	435	544	544
C5	1,67	1,47	1,47	1,84	617	544	544	680
C6	2,09	1,47	2,35	2,56	774	544	870	948
C7	2,53	2,53	2,53	2,53	938	936	936	936
C8	1,48	1,18	1,18	1,69	2196	1742	1742	2499
C9	1,10	0,76	0,76	1,58	408	281	281	582
C10	2,11	1,47	2,35	2,57	780	544	870	952
C12	1,92	1,47	1,58	2,35	711	544	582	870
C13	1,92	1,47	1,58	2,35	709	544	582	870
C24	1,02	0,76	0,76	1,42	377	281	281	525
C29	1,70	1,58	1,69	1,84	629	582	624	680
C31	0,51	0,34	0,45	0,81	190	125	168	300
National	1,78	1,18	1,58	2,35	1100	469	582	938

Dosimetry Data for Skull X-rays

Sixteen (16) conventional radiology units met the number and frequency criteria for dosimetry calculations of skull X-rays.

Table 5 presents the dosimetry statistics for skull X-rays by radiology unit.

Table 5: Description of Dosimetry Data for Skull X-rays by Radiology unit

Radiology Unit	ED (mGy)				DAP (mGy.cm^2)			
	Average	25ème Centile	50ème Centile	75ème Centile	25ème Centile	25ème Centile	75ème Centile	75ème Centile
C3a	4,15	3,63	3,63	5,19	6148	5378	5378	7689
C4	4,04	1,81	2,90	6,83	1494	671	1074	2526
C5	2,64	2,17	2,93	2,93	976	802	1083	1083
C6	2,98	2,09	2,94	3,89	1101	774	1083	1083
C7	2,92	2,17	2,93	3,89	1082	802	1083	1438
C8	2,87	2,17	2,93	3,89	1061	802	1083	1438
C10	1,95	1,67	1,89	1,89	721	616	701	701
C12	2,90	2,17	2,93	3,89	1074	802	1083	1438
C13	4,23	2,02	2,17	6,83	1565	7.46	802	2526
C25	4,16	3,63	3,63	5,19	6170	5378	5378	7689
C27	2,80	2,17	2,93	2,93	1058	802	1083	1083
C29	1,45	1,27	1,41	1,72	539	468	521	638
C31	1,20	0,59	0,76	2,02	446	218	280	746
C32	2,97	2,17	2,93	3,89	1099	802	1083	1438
C33	2,55	2,02	2,93	2,93	945	746	1083	1083
C35	2,81	2,17	2,93	2,93	1041	802	1083	1083
National	3,01	2,02	2,93	3,63	1892	746	1083	1438

Dosimetry Data for Hysterosalpingographies (HSG)

Eleven (11) conventional radiology units met the criteria for number and frequency of hysterosalpingography dosimetry calculations. Table 6 presents the dosimetry statistics for hysterosalpingographies by radiology unit.

Table 6: Description of Dosimetry Data for Hysterosalpingographies by Radiology unit

Radiology Unit	ED (mGy)				DAP (mGy.cm^2)			
	Average	25ème Centile	50ème Centile	75ème Centile	Average	25ème Centile	50ème Centile	75ème Centile
C3a	5,85	4,63	6,05	6,05	8658	6858	8960	8960
C6	3,59	3,25	3,37	4,33	5316	4815	4929	6420
C7	3,80	3,36	3,84	4,33	5634	4976	5687	6420
C8	2,98	2,57	2,95	3,37	4412	3810	4373	4999
C10	3,92	2,57	4,22	4,37	5800	3810	6247	6475

C12	4,63	3,25	3,84	4,33	6863	4815	5687	6420
C13	3,46	2,95	3,37	4,21	5121	4373	4987	6236
C2	3,55	3,17	3,37	4,22	5264	4700	4999	6247
C29	3,60	3,25	3,84	4,33	5328	4815	5687	6420
C33	3,84	3,36	3,84	4,33	5688	4976	5687	6420
C36	4,58	4,22	4,33	4,63	6789	6247	6420	6858
National	3,98	3,36	3,84	4,33	5900	4976	5687	6420

National dosimetry data by examination type in adults

The median and 25th and 75th national percentile values for ED and DAP of examination types are presented in Table 7.

Table 7: Median, 25th, and 75th (representing the NRD) national percentile values for ED and DAP of examination types

X-rays exams	ED (mGy) national				DAP (mGy.cm^2) national			
	Average	25ème Centile	50ème Centile	75ème Centile (NRD)	Average	25ème Centile	50ème Centile	75ème Centile (NRD)
Chest X-rays	0,52	0,32	0,46	0,70	1438	442	686	1120
Lumbar Spine X-rays	10,12	4,41	5,84	17,28	12608	3610	5840	25592
Cervical Spine X-rays	1,78	1,18	1,58	2,35	1100	469	582	938
Skull X-rays	3,01	2,02	2,93	3,63	1892	746	1083	1438
HSG	3,98	3,36	3,84	4,33	5900	4976	5687	6420

The 75th percentile represents the NRD

DISCUSSION

Demographic Characteristics of Patients Undergoing Conventional Radiology Examinations

The 35–55 age group (45.49%) is largely represented. This observation is consistent with international data indicating that chest and spinal radiographs are frequently requested in this age group due to common respiratory and musculoskeletal conditions [9].

The female predominance (54.85%) contrasts slightly with some African studies where men are generally more represented [10, 11]. However, our result may be explained

by local variations in healthcare utilization, as well as the inclusion of typically female examinations (HSG) in our data.

Pathologies Examined

Lung disease is the leading indication in adults (27.52%) and significantly so in children (90.8%). This observation is consistent with national and regional epidemiology, where lower respiratory tract infections are among the main causes of consultation and hospitalization [12]. This high proportion explains the predominance of chest radiography, which corresponds to international trends: chest radiography is the most frequently performed diagnostic examination worldwide, representing 25 to 40% of all radiographs [13].

Types of examinations commonly performed

Chest radiography (34.8%) is the most frequently performed, followed by spinal radiographs. These trends are typical in African radiology departments, where simple and readily available examinations are used for the diagnosis of common pathologies [10, 11].

Dosimetry analysis of adult examinations

Chest X-rays:

The values obtained (75th percentiles) were 0.70 mGy and 1120 mGy·cm² for De and PDS, respectively. These are higher than many international NRDs. In Europe (EC 2018) [114], the United Kingdom [117], France [77], and Nigeria [118], the NRD PDS are 200–300, 150–200, 250, and 300–500 mgy·cm², respectively. The PDS of 1120 mGy·cm² observed in Benin is therefore approximately 3 to 5 times higher than European references and about twice as high as in well-optimized African radiology unit [14]. The likely causes are: the lack of systematic harmonization of protocols, the frequent use of high kV, inadequate focal-film distances, and the low rate of equipment replacement.

Lumbar spine X-rays:

The obtained NRD (PDS = 25,592 mGy·cm²) is significantly higher than European NRDs (8,000–10,000 mGy·cm²) [15, 16]. However, our value is close to the levels reported in some Nigerian and Kenyan studies [14, 17].

Cervical spine and skull X-rays

The doses obtained are generally in ranges similar to those observed in several African countries [106, 118], but remain higher than European NRDs [15]. Poor collimation and variable focal spot-to-film distances are often implicated [18].

Hysterosalpingography (HSG)

The NRD for HSG (PDS ≈ 6,420 mGy·cm²) is consistent with some African studies but higher than European recommendations (3,500–4,200 mGy·cm²) [10]. The difference can be

explained by the higher number of incidences and the absence of the use of tight diaphragms.

CONCLUSION

Dosimetry evaluation of the most frequently performed conventional radiology examinations in healthcare facilities in Benin reveals exposure levels that are often higher than the expected reference values, indicating marked heterogeneity in practices across radiology unit. This situation can be attributed in particular to the lack of standardized protocols, insufficient continuing education of medical imaging professionals, and inadequate use of technical acquisition parameters. Consequently, the implementation of coordinated measures appears necessary, including capacity building of personnel, modernization of equipment, and the development of a regulatory framework aimed at supervising and harmonizing radiological practices.

Acknowledgements

The authors thank the administrative authorities of the healthcare facilities that authorized this research within their computed tomography units. They also express their gratitude to the healthcare personnel of these facilities who facilitated data collection.

Funding:

The authors received no financial support for the research, authorship, and/or publication of this article.

Conflicts of Interest:

The authors declare that there are no conflicts of interest related to this research and this article.

Data Availability Statement:

The data are available in Excel and Google Forms databases through a link that can be shared upon reasonable request.

Authors' Contributions:

FACHINAN OH: conceptualization, methodology, data collection and analysis, interpretation of results, writing, and revision; HOUNDETOUNGAN GD: interpretation of results and revision; AVOCEFOHOUN A: methodology, revision, and supervision; ZOHIZALAN TA: data analysis and revision; BATHILY EHL: methodology, revision, and supervision; SAVI de TOVE KM: methodology, revision, and supervision; AMOUSSOU-GUENOU KM: methodology, interpretation of results, revision, and supervision.

Ethical Approval:

The research project was submitted to the Local Committee for Biomedical Research Ethics of the University of Parakou (CLERB-UP) and received ethical approval under reference No. 694/2024/CLERB-UP/P/SP/R/SA.

Informed Consent Statement:

Free and informed consent was obtained from the patients and, where applicable, from their parents prior to inclusion in the study. Data anonymity was ensured.

All collected data were analyzed and presented anonymously.

REFERENCES

1) United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and effects of ionizing radiation. UNSCEAR 2008 Report. New York : United Nations ; 2010.
2) International Commission on Radiological Protection. Radiological protection in medicine. ICRP Publication 105. Ann ICRP. 2007 ; 37(6).
3) International Atomic Energy Agency. Diagnostic reference levels in medical imaging. IAEA Safety Reports Series No. 96. Vienna : IAEA ; 2018.
4) El Fahssi M, Semghouli S, Amaoui B, Jroundi L, Çaoui M. Assessment of entrance skin dose for adult patients undergoing diagnostic X-ray examinations in the Souss-Massa region of Morocco. Radioprotection. 2023 ; 58(2) :107–112.
5) Njoya Sylvain LAAH, Mouliom Tapouh JR, Samba O, Bintou Soumo H, Moifo B. Comparative evaluation of entrance surface doses for chest and lumbar spine radiography in three radiology departments in Yaoundé, Cameroon. J Afr Med Imaging. 2024 ;12(3) :110.
6) IAEA (2017) Radioprotection et sûreté radiologique dans les applications médicales des rayonnements ionisants : Guide de sûreté particulier, Bruxelles.
7) ICRP Publication 105. Radiological Protection in Medicine, *Ann ICRP* 2007; 37(6) :1-63.
8) IRSN. Analyse des données relatives à la mise à jour des niveaux de références diagnostiques en radiologie et en médecine nucléaire : Bilan 2019-2021. Fontenay-aux-Roses 2023 : IRSN.
9) International Commission on Radiological Protection (ICRP). Publication 135 : Diagnostic Reference Levels. 2017.
10) Muhogora WE et al. Estimation of patient doses from radiographic X-ray examinations in Tanzania. Radiat Prot Dosimetry. 2015.
11) Bamidele L et al. Diagnostic reference levels for common radiographic examinations in Nigeria. J Radiol Prot. 2018.
12) World Heath Organization (WHO). Global Health Observatory Data Repository. 2022.
13) European Commission. Radiation Protection No. 180 : Medical radiation exposure of the European population. Luxembourg : Publications Office of the European Union ; 2014.
14) Mettler FA, Huda W, Yoshizumi TT, Mahesh M. Effective doses in radiology and diagnostic nuclear medicine. Radiology. 2008; 248(1): 254-63.

15) European Commission. Radiation Protection No. 228 : European Diagnostic Reference Levels (DRLs). Luxembourg : Publications Office of the European Union ; 2018.

16) Shrimpton PC, Hillier MC, Lewis MA, Dunn M, Hart D. Doses from computed tomography (CT) examinations in the UK-2003 review (Report NRPB-W67). Chilton (UK) : National Radiological Protection Board; 2005.

17) Korir GK, Wambani JS, Korir IK, Tries MA, Boen PK. Establishing diagnostic reference levels for adult general radiography in Kenya. *Radiat Prot Dosimetry*. 2019 ;187(1) :545-552.

18) International Atomic Energy Agency. Positioning and Collimation in Radiography. Vienna : International Atomic Energy Agency ; 2019.