

Research Article

Open Access

Assessment of Radiation Protection Practices in Diagnostic Radiology Départements in Yaoundé, Cameroon: Compliance with National and International Standards

Kuete Darielle Francine¹, Sonwa Leslie Duchelle⁴ and Kuiate David^{2,3,5 *}

¹Higher School of Health Sciences La Rosière (ESSSARO), University of Douala, Cameroon

²Department of Radiology and Medical Imaging, «Les Promotion de la Bonne Santé Medical» Center

³Faculty of Medicine and Biomedical Sciences (FMSB) of Yaoundé I

⁴Pan-African Institute of Paramedical Training (IPAF-PM) of Yaoundé

⁵Faculty of Health and Medical Sciences, kesmonds international University, Ngaoundéré, Cameroun

ABSTRACT

Background: Exposure to ionizing radiation (IR) in medical settings is a major public health concern. In Cameroon, radiation protection is regulated by the Radiological Safety and Nuclear Security Authority (ASRAN), but its effectiveness in diagnostic radiology departments remains poorly documented.

Objective: To assess the level of compliance of radiation protection practices in diagnostic radiology services in Yaoundé with national and international standards.

Methods: A descriptive cross-sectional survey was conducted over 3 months (February–April 2024) in 18 public and private facilities in Yaoundé, using a standardized data collection form covering architecture, dosimetry, personal protective equipment, and regulatory control.

Results: Room dimensions were non-compliant in 57% of cases. Lead aprons were present in 100% of services, but lead glasses in only 11.11%. Individual dosimetry was insufficient in 50% of facilities and regularly read in 55.56%. Only 44.44% had undergone regular ASRAN inspections, and 100% of nuclear departments lacked any radioactive waste management system.

Conclusion: Radiation protection practices in Yaoundé show significant gaps compared to IAEA and WHO standards. Urgent corrective measures are required.

*Corresponding author

Kuiate David, Department of Radiology and Medical Imaging, «Les Promotion de la Bonne Santé Medical» Center, Faculty of Medicine and Biomedical Sciences (FMSB) of Yaoundé I, Faculty of Health and Medical Sciences, kesmonds international University, Ngaoundéré, Cameroun.

Received: September 04, 2026; **Accepted:** September 11, 2026; **Published:** September 18, 2026

Keywords: Radiation Protection, Ionizing Radiation, Regulatory Compliance

Introduction

Ionizing radiation (IR) plays a predominant role in modern medicine, particularly through diagnostic imaging techniques such as conventional radiography, computed tomography (CT), and interventional radiology. Their increasing use in health facilities, including in resource-limited countries, is accompanied by a rise in occupational and population exposure to IR (IAEA, 1997). IR is classified as a definite carcinogen for humans (Group 1) by the International Agency for Research on Cancer (IARC). They can induce deterministic and stochastic effects including

genetic mutations, leukemias, solid cancers, and radiation-induced cataracts (INRS, 2022; UNSCEAR, 1994). It is in this context that radiation protection—the set of rules and measures aimed at limiting the harmful effects of IR—becomes an absolute necessity in any health system (French Republic, 2002).

In Cameroon, radiation protection is legally governed by Law No. 95/08 of January 30, 1995. The National Radiation Protection Agency (ANRP), which became the Radiological Safety and Nuclear Security Authority (ASRAN), is responsible for enforcing these provisions (MINRESI, 2023). Despite this regulatory framework, the uncontrolled proliferation of diagnostic radiology departments in major Cameroonian cities, notably Yaoundé, raises

concerns regarding the effectiveness of radiation protection measures.

A previous study conducted in 2016 by Chimène Pulchérie Guiegui et al. documented deficiencies in radiation protection in public hospitals in Yaoundé. Since then, the private sector has undergone remarkable expansion, making it imperative to update the status report to include these new facilities (Chimène Pulchérie Guiegui et al., 2016).

This study aims to assess the level of compliance of radiation protection practices in diagnostic radiology departments in Yaoundé, whether public or private, with national standards and the standards of the IAEA and the World Health Organization (WHO). It specifically seeks to: (1) inventory and characterize services using IR; (2) assess architectural compliance; and (3) analyze staff protection, particularly via dosimetry and the use of personal protective equipment (PPE).

Materials and Methods

This was a descriptive cross-sectional study conducted in 18 active departments (diagnostic radiology and nuclear treatment) in Yaoundé, the political capital of Cameroon. The study was carried out over a period of three (3) months, from February to April 2024, in public and private health facilities across all districts of the city.

Data were collected using a standardized technical form, developed in reference to IAEA, ICRP standards, and Cameroonian legislation. The form covered the following dimensions: (i) the type and location of the service; (ii) available imaging modalities; (iii) architectural characteristics (surface area, wall protection, doors, and screens); (iv) the status of dosimetric monitoring; (v) the availability of PPE; (vi) regulatory control by ASRAN; and (vii) the radioactive waste management system.

Data were entered and analyzed using Microsoft Excel 2019, and quantitative architectural data were presented as means ± standard deviations with extreme values. A comparative analysis was performed with results from similar studies conducted in other sub-Saharan African countries.

Ethical Considerations

The study was conducted in compliance with the ethical principles of human health research. An authorization request was submitted to the Regional Committee for Ethics in Human Health Research of the Center (CRERSH-C). An informed consent form was obtained from the heads of each facility. Anonymity and confidentiality of data were guaranteed throughout the study.

Results

Geographic Distribution and Characterization of Services

A total of 18 services using sources of ionizing radiation were inventoried and investigated in the city of Yaoundé. These facilities were distributed across all districts of the city.

Table 1: Geographic Distribution of Diagnostic Radiology Services Surveyed in Yaounde

District	Number of department	Proportion (%)
Yaoundé III (Efoulan)	6	33%
Yaoundé VI (Kondengui)	4	22%
Yaoundé I (Nlongkak)	3	17%
Yaoundé V and VII (Essos/Biyem-Assi)	2 each	11% each
Yaoundé II (Tsinga)	1	6%
TOTAL	18	100%

According to the table above, 33% of services were located in the Yaoundé III (Efoulan) district, 22% in Yaoundé VI (Kondengui), 17% in Yaoundé I (Nlongkak), 11% in Yaoundé V and VII (Essos/Biyem-Assi) each, and 6% in Yaoundé II (Tsinga).

Table 2: Distribution of Service Types and Imaging Modalities Recorded

Type / Modality	Proportion (%)
Diagnostic radiology services	90%
— Conventional radiography	43%
— Computed Tomography (CT/Scanner)	24%
— Dental panoramic	14%
— Mammography	12%
— Image intensifier (Fluoroscopy)	5%
— Bone densitometry	2%
Interventional services	5%
Storage/waste treatment unit	5%

The table above shows that 90% were diagnostic radiology units, 5% interventional radiology services, and 5% radioactive waste storage and treatment units. The predominant modality was conventional radiography (43%), followed by computed tomography (24%).

Architectural Compliance of Diagnostic Radiology Rooms

Table 3: Architectural Compliance of Surveyed Diagnostic Radiology Rooms

Architectural parameter	Conform / Present (%)	Non-conform / Absent (%)
Adequate room dimensions	43%	57%
Adequate wall protection	88.89%	11.11%
Adequately protected doors	77.78%	22.22%
Adequate protective screen	83.33%	16.67%
Mean surface area (public) $\pm$ SD (m ²)	27.55 $\pm$ 6.83	Standard: 20 m ²
Mean surface area (private) $\pm$ SD (m ²)	23.87 $\pm$ 11.93	Extremes: 6.3–54

The architectural evaluation revealed that only 43% of rooms presented dimensions compliant with regulatory standards. The average surface areas were 27.55 $\pm$ 6.83 m² for public facilities (range: 16–39 m²) and 23.87 $\pm$ 11.93 m² for private facilities (range: 6.3–54 m²). Lead protection of walls, doors, and screens was generally satisfactory.

Dosimetric Monitoring

Table 4: Status of Dosimetric Monitoring in Surveyed Services

Dosimetric parameter	Performed / Present (%)	Not performed / Absent (%)
Sufficient individual dosimeters	50%	50%
Presence of control dosimeter	50%	50%
Regular reading of dosimeters	55.56%	44.44%

The assessment of dosimetric monitoring, based on the availability of individual and control dosimeters as well as the regularity of their reading, reveals a concerning situation where only 50% of services had a sufficient number of individual dosimeters, and regular reading was only ensured in 55.56% of cases.

Personal Protective Equipment (PPE) and technical measures

Table 5: Availability of Personal Protective Equipment and Technical Prevention Measures

Personal Protective Equipment (PPE)	Present (%)	Absent (%)
Lead apron	100%	0%
Thyroid collar	33.33%	66.67%
Gonad shield	38.89%	61.11%
Lead glasses	11.11%	88.89%
Signage system	50%	50%
Radiological emergency plan	38.89%	61.11%
Regulatory zoning (areas A/B)	55.56%	44.44%
Radiation Protection Officer (RPO)	66.67%	33.33%

It appears that the lead apron was present in all investigated services (100%), whereas lead glasses (11.11%), thyroid collars (33.33%), and gonad shields (38.89%) were less common. Technical prevention measures were present in 50% for the signage system, 38.89% for the radiological emergency plan, 55.56% for regulatory zoning, and 66.67% for the presence of a Radiation Protection Officer.

Regulatory Control and Radioactive Waste Management

Table 6: Regulatory Control Parameters and Radioactive Waste Management

Regulatory control parameter	Performed / Present (%)	Not performed / Absent (%)
Regular ASRAN inspection	44.44%	55.56%
Regular internal quality control	55.56%	44.44%
Regular internal equipment maintenance	77.78%	22.22%
Availability of inspection reports	44.44%	55.56%
Personal irradiation control equipment	0%	100%
Service opening authorization	88.89%	11.11%
Radioactive waste management system	0%	100%

Regulatory inspection by ASRAN was only regularly performed in 44.44% of services. Even more concerning, 100% of services lacked any personal irradiation control equipment, and for nuclear services, none had a radioactive waste management system.

International Comparative Analysis

Table 7: Comparison of Radiation Protection Indicators Between Different African Studies

Indicator	Yaoundé 2025 (present study)	SAVI-TOVE (Benin, 2020)	YEKPE (S. Benin, 2019)	Khaled (Algeria, 2019)
Adequate room dimensions	43%	78.3%	80%	N.A.
Lead apron present	100%	Partial	N.A.	N.A.
RPO designated	66.67%	N.A.	N.A.	44%
Sufficient individual dosimetry	50%	Low	Low	N.A.
Regular regulatory controls	44.44%	N.A.	N.A.	Low
Radioactive waste management	0%	N.A.	N.A.	N.A.

N.A : Not available in the cited study

The table above presents a comparative summary of the main radiation protection indicators between our study and similar work conducted in other African countries.

This comparative analysis reveals that the radiation protection deficits observed in Yaoundé are part of a sub-regional context characterized by transversal structural insufficiencies. However, the situation in Cameroon presents specific particularities, notably the total absence of radioactive waste management and insufficient regulatory supervision, which justify targeted and urgent interventions.

Discussion

Distribution and Characterization of Services

Our study identified 18 services using IR sources across all districts of Yaoundé, witnessing a significant expansion of this health sector since the reference study by Guiegui et al. in 2016. The predominance of conventional radiography (43%) and CT (24%) is consistent with the epidemiological profiles and diagnostic needs observed in the sub-region. This result is comparable to data reported by YEKPE AHOUANSON et al. in Benin in 2019, where 86.54% of recorded equipment were conventional radiography devices (African Journal of Medical Imaging, 2020). The predominance of conventional radiography reflects a socio-economic reality common to sub-Saharan health systems, characterized by budgetary constraints limiting access to advanced imaging technologies.

The presence of a radioactive source storage unit managed by ASRAN (Yaoundé III), created in 2019 with IAEA support, represents a notable advance in radiological risk management at the national level. Before 2019, decommissioned sources were stored in precarious conditions, exposing surrounding communities to uncontrolled risks (Miklos Gaspar, IAEA, 2022). It is noted that approximately 200 radioactive sources are currently in service in Cameroon, of which about fifty have been withdrawn but still contain non-negligible quantities of radioactive material.

Architectural Compliance: A Persistent Structural Deficit

The dimensional non-compliance observed in 57% of rooms constitutes one of the most concerning results of this study. Standard NF C15-160 (revised in March 2021) and IAEA recommendations set minimum surface areas for radiology rooms to ensure sufficient attenuation of scattered radiation and to protect personnel not directly assigned to work under radiation (DATR). A radiography room with a surface area of 6.3 m², the minimum value found in our sample, presents risks of irradiation by scattered radiation significantly higher than recommended standards (Pierre FRAMONT-TERRASSE, 2012).

These results are significantly lower than those reported by SAVI de TOVE et al. in Benin (2020), where 78.3% of rooms presented adequate surface areas, and by KOUASSI et al. (2005), where 80% of rooms respected minimum standards. This divergence likely reflects a difference in the rigor of controls at the opening of facilities, as well as health urban planning deficits specific to Yaoundé.

Conversely, the lead protection of walls (88.89%), doors (77.78%), and screens (83.33%) appears relatively satisfactory. This dissociation between the passive protection of premises and dimensional compliance suggests that while investors invest in protective materials during construction, compliance with surface area standards is often sacrificed to land and economic constraints.

Dosimetric Monitoring: A Chronic Insufficiency

The insufficient availability of individual dosimeters in 50% of services constitutes a direct violation of ICRP and IAEA recommendations, which require individual dosimetric monitoring for any worker occupationally exposed to IR (IAEA, 1997; ICRP). The irregular reading of dosimeters in nearly 45% of structures deprives the occupational physician of essential data for the early detection of radiation-induced effects and the organization of appropriate care.

These results concur with those of other African studies. Houndetoungan (2015) in Benin, Mbo Amvene et al. (2017) in the Far North of Cameroon, and SAVI de TOVE-Mensa et al. (2020) reported similar dosimetric insufficiencies. At the international level, Niklason et al. (1993) reported that 43% of fluoroscopy operators never wore their dosimeters, while the RIMED study (2008) documented a non-wear rate that could reach 50% in certain French establishments. A cohort of interventional cardiologists in 2006 showed that 30% did not submit their dosimeters for processing, a proportion reduced to 10% in 2013 but with only 40% of regular wearers (Quinn C. Meisinger et al., 2016). The persistence of this phenomenon in such different contexts testifies to structural and behavioral challenges transcending national borders.

Personal Protective Equipment: Between Progress and Critical Gaps

The universal presence of lead aprons (100%) represents real progress compared to previous studies conducted in the sub-region, notably that of Mbo Amvene et al. (2017) which documented

a near-total absence of PPE in structures in the Far North of Cameroon. Nevertheless, the extremely low availability of lead glasses (11.11%) is particularly worrying in light of recent epidemiological data on radiation-induced cataracts.

Several studies have demonstrated an increased incidence of cataracts by a factor of 2 to 3 among interventional radiologists and cardiologists (B. Le Guen, R. Masse, 2007). A cohort study of 42,545 medical electroradiology operators (MERM) over 7 years showed a significantly higher risk of cataracts among workers exposed to nuclear medicine procedures (Marie-Odile Bernier et al., 2017). These data led the ICRP to lower the dose limit for the lens of the eye to 20 mSv/year starting in July 2023. The absence of ocular protection in nearly 89% of Yaoundé services exposes staff to an uncontrolled occupational risk.

The absence of thyroid collars (66.67%) and gonad shields (61.11%) is also concerning. This equipment is particularly critical for the protection of radiosensitive organs, notably in pediatric procedures and women of childbearing age. Comparison with the study by SAVI de TOVE et al. (2020) on 23 Beninese facilities reveals a similar deficit in specific PPE across the sub-region, suggesting a structural supply problem rather than an individual one.

The presence of an RPO in 66.67% of services is an encouraging result, superior to the 44% reported by Khaled et al. in Algeria (2019) and data from Mbo Amvene in Cameroon (2017) where no RPO had been identified. However, international regulations stipulate that any establishment using IR must have a duly trained RPO, making this still insufficient rate a priority for improvement.

Regulatory Control Failures

The insufficient regularity of ASRAN controls (only 44.44% of services) and the absence of inspection reports in more than 55% of cases reveal a still limited capacity for regulatory supervision. The fact that 11.11% of services operate without formal opening authorization indicates the presence of facilities operating in regulatory illegality, exposing patients and staff to uncontrolled risks.

ASRAN, created in 2002 and constantly restructuring since 2010, faces challenges related to its institutional youth, the multiplicity of sites to control, and resistance from certain actors in the private medical sector. The speed of expansion of the private imaging sector currently exceeds the agency's regulatory capacity, a phenomenon documented in several sub-Saharan African countries (SAVI de TOVE et al., 2020).

The total absence (0%) of a radioactive waste management system in all nuclear services constitutes a major environmental and health threat. Unlike France, where the regulatory framework (Public Health Code, articles R1333-1 to R1333-27) imposes strict procedures for the treatment and elimination of radioactive waste, Cameroon does not yet have private infrastructure specialized in this field. The entire responsibility for management currently rests on the ASRAN storage unit in Yaoundé III, whose capacity remains limited [1-39].

Conclusion

This descriptive cross-sectional study conducted in 18 diagnostic radiology services in Yaoundé highlighted significant gaps in the implementation of radiation protection practices compared to IAEA, ICRP, and WHO standards. While the universal presence of lead aprons and the designation of an RPO in the majority

of services constitute notable advances, major deficits persist, notably: the dimensional non-compliance of certain rooms, the insufficiency of individual dosimeters in half of the services, the near-absence of lead glasses, the total absence of radioactive waste management, and the deficient regulatory supervision by ASRAN.

Study Limitations

This study presents several limitations. First, the non-probabilistic convenience sampling method limits the generalizability of results to all services in Yaoundé. Second, the absence of direct dosimetric measurements (physical measurement of ambient doses) does not allow for precise quantification of exposure risk. Third, the short duration of the study (3 months) may not reflect all seasonal or circumstantial practices. Finally, social desirability bias, inherent in declarative surveys, may have led some heads of facilities to overestimate their radiation protection practices.

Conflict of Interest

The authors declare no conflicts of interest in connection with this article.

Funding

This study received no external funding.

References

1. Bernier MO, Journy N, Villoing D (2017) Cataract risk in a cohort of US radiologic technologists performing nuclear medicine procedures. *Radiology* 281: 584–593.
2. Guiegui CP (2016) Observance des mesures de radioprotection en milieu hospitalier public à Yaoundé en 2016. *Health Sciences and Diseases* 20.
3. Housni A, Es-Samssar O, Saoud B (2023) Radiation protection in the operating room: Need for training, qualification and accompaniment for the professionals. *Volume* 58: 37–42.
4. Journal Africain d'Imagerie Médicale (JAIM) (2020) Études sur la radioprotection en Afrique subsaharienne. *Journal Africain d'Imagerie Médicale (JAIM)* 12: 213–219.
5. Khaled A, Ghomari O, Kandouci AB (2019) La radioprotection dans les établissements de soins utilisant les rayons X : évaluation et constats dans la ville de Sidi Bel-Abbès. *Journal Algérien de Médecine* 15–48.
6. Meisinger QC, Stahl CM, Andre MP (2016) Radiation protection for the fluoroscopy operator and staff. *Vascular and Interventional Radiology Review*.
7. Framont-Terrasse P (2012) Norme NF C 15-160 de mars 2011. In: *Changement et Nouveauté*.
8. Roguin A, Goldstein J, Bar O, Goldstein JA (2013) Brain and neck tumors among physicians performing interventional procedures. *American Journal of Cardiology* 111: 1368–1372.
9. Rose A, De Rae WI, Sweetlove MA (2022) Radiation induced cataracts in interventional occupationally exposed to ionising radiation. *PubMed*.
10. Röntgen WC (1896) Ueber eine neue Art von Strahlen. *Sitzungsberichte der Physikalisch-Medicinischen Gesellschaft zu Würzburg*.
11. Roué T, Crescini D, Baysson H (2015) Étude du risque de cancer radio-induit chez les professionnels de santé: mise en place de la cohorte ORICAMs. Elsevier Masson SAS.
12. Savi de Tove KM (2020) Radioprotection en imagerie médicale dans les hôpitaux du nord Bénin. *Journal Africain d'Imagerie Médicale (JAIM)* 12.
13. Debré P (2015) Avec les rayons X et la radiologie, Röntgen bouscule le monde. *L'Humanité*.
14. Agence Internationale de l'Énergie Atomique (AIEA) (1997) Normes fondamentales internationales de protection contre

- les rayonnements ionisants et de sûreté des sources de rayonnements. Vienne: AIEA 332.
15. Clerc H (1991) Effets biologiques des rayonnements ionisants et normes de radioprotection. Bruyères-le-Châtel Commission de l'Énergie Atomique 44.
 16. Bard DD, Lévesque B, Pirard P (2003) Rayonnements ionisants. In: Environnement et santé publique. Chap 17: 463-477.
 17. Le Guen B, Masse R (2007) Effets des faibles doses des rayonnements ionisants. EMC – Toxicologie - Pathologie professionnelle. Paris Elsevier Masson SAS.
 18. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (1994) Sources and effects of ionizing radiation. New York Nations Unies.
 19. Agence Fédérale de Contrôle Nucléaire (AFCN) (2020) Applications médicales des rayonnements ionisants. Bruxelles AFCN.
 20. Autorité de Sûreté Nucléaire (ASN) (2013) Fiche d'information du public n° 2 : Les principes de la radioprotection. Paris ASN.
 21. Autorité de Sûreté Nucléaire (ASN) (2020) Rapport de l'ASN sur l'état de la sûreté nucléaire et de la radioprotection en France en 2020. Chap 1: 102–109.
 22. Autorité de Sûreté Nucléaire (ASN) (2021) Principales dispositions réglementaires de radioprotection : Application en radiologie médicale et dentaire. Paris ASN.
 23. Beninson D, Boice JD, Cox R, et al. (2000) Pregnancy and medical radiation. *Annals of the ICRP* 30(1).
 24. Centre National de la Recherche Scientifique (CNRS) (s.d.) La dosimétrie passive et active (opérationnelle). Fiche 11. Les Cahiers de préventions. Guide risques radioactifs et radioprotection: 104–106.
 25. Institut de Radioprotection et de Sûreté Nucléaire (IRSN) (2019) Assurer la surveillance de l'exposition externe des travailleurs. Paris: IRSN.
 26. Institut de Radioprotection et de Sûreté Nucléaire (IRSN) (2021) Bilan 2020 des expositions professionnelles aux rayonnements ionisants en France. Paris: IRSN.
 27. Institut de Veille Sanitaire (2008) Étude RIMED : Rayonnements Ionisants en Milieu Médical. Étude de faisabilité – Rapport final. Paris: InVS 23.
 28. Institut National de Recherche et de Sécurité (INRS) (2006) ED 958 : Les rayonnements ionisants. Prévention et maîtrise des risques. Paris: INRS.
 29. MINRESI (Ministère de la Recherche Scientifique et de l'Innovation du Cameroun) (2023) Rapports de l'ASRAN. Yaoundé: MINRESI.
 30. Code de la santé publique (2001) Décret n° 2001-1154 du 5 décembre 2001 relatif à l'obligation de maintenance et au contrôle de qualité des dispositifs médicaux.
 31. Code du travail (2018) Sous-section 1 : Valeurs limites d'exposition (Articles R4451-6 à R4451-9).
 32. Legifrance (2006) Arrêté du 22 septembre 2006 relatif aux informations dosimétriques devant figurer dans un compte rendu d'acte utilisant les rayonnements ionisants.
 33. République du Cameroun (1995) Loi n° 95/08 du 30 janvier 1995 portant sur la radioprotection. Yaoundé.
 34. République Française (2002) Définition de la radioprotection. Décret de loi 2002-255. Paris.
 35. Agence Fédérale de Contrôle Nucléaire (AFCN) (2023) Risques liés à l'exposition aux rayonnements ionisants. Available at: <https://afcn.fgov.be/fr>
 36. Gaspar M (2022, July 1) Entreposage, transport et événements sportifs sécurisés : améliorer la sécurité nucléaire au Cameroun. Agence Internationale de l'Énergie Atomique. Available at: <https://www.iaea.org>
 37. Institut de Radioprotection et de Sûreté Nucléaire (IRSN) (2012) Différents rayonnements ionisants : alpha, bêta, gamma. Available at: <https://www.irsn.fr>
 38. Institut National de Recherche et de Sécurité (INRS) (2022) Effets sur la santé des rayonnements ionisants. Rubrique Risques. Paris: INRS.
 39. Société Française d'Énergie Nucléaire (2019) La radioactivité.