IMPLEMENTATION OF RADIATION PROTECTION MEASURES FOR WORKERS IN MEDICAL ENVIRONMENTS IN TOGO

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https://www.doi.org/10.59277/RJB.2026.1.01

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Abstract. The purpose of this study is to assess the practical implementation of radiation protection measures for workers in medical settings in Togo. This work is a descriptive cross-sectional study conducted from July 1 to December 31, 2020, in services utilizing ionizing radiation in both public and private health facilities in Togo. A total of 77 services (all radiology) using ionizing radiation were identified, with 127 devices (55 % conventional radiography) and 137 staff members (43.1 % technicians). Among the services, 21.5 % had rooms with a surface area of less than 20 m², and 76.6 % of the rooms had solid brick walls. Service doors were made of wood in 32.5 % of the cases and aluminum in 19.5 % of the cases. Fewer than half (42.8 %) of these doors were lead-lined. Controlled zones were defined in 64.5 % of the cases, and 61.2 % of the services reported public zones. More than half of the services had warning pictograms (59.7 %) and light signage at room entrances (54.5 %), 11.7 % displayed regulations in controlled areas. Staff categorization was performed in 68.8 % of the cases, and 39 % of the services had staff dosimeters. Only 19.5 % of services conducted medical surveillance for their staff. The implementation level of radiation protection measures for workers exposed to ionizing radiation in medical environments is relatively unsatisfactory. Efforts must be made to ensure safer medical use of ionizing radiation in Togo.

Key words: Ionizing radiation, radiation protection, health personnel, Radiology Department, Togo.

INTRODUCTION

The radiation protection of workers in the medical environment is a major concern for their health and safety [5]. Indeed, ionizing radiation is used in medicine for diagnostic purposes (radiodiagnosis and nuclear medicine) and therapeutic

Received: October 2025;
in final form December 2025.

purposes (radiotherapy) [4, 7]. In developing countries such as Togo, the medical use of ionizing radiation is represented mainly by radiodiagnosis [8, 15, 19]. The benefits linked to the medical use of this ionizing radiation must not make us forget the potential risks of harmful effects that can result from its uncontrolled use. These risks, which are expressed by deterministic and stochastic radio-induced lesions, require protective measures not only for workers and patients but also for the public [6, 21]. All the measures taken to ensure the protection of humans and their environment against the harmful effects of ionizing radiation define radiation protection. The implementation of radiation protection measures for workers requires compliance with standards for the layout of radiological installations and the medical management of personnel working in departments using ionizing radiation in accordance with the directives and standards established by regulatory institutions for various applications of ionizing radiation [10, 11].

In sub-Saharan Africa, regulatory authorities are often absent or poorly functional, which explains the reason for the scarcity of periodic inspections on the implementation of radiation protection measures for workers in both medical and industrial structures using ionizing radiation in several countries, particularly French-speaking countries such as Togo [1]. It provides a national overview of the implementation of radiation protection measures in radiology departments in Togo, in a context where the radiation protection authority is not yet operational.

MATERIALS AND METHODS

The study was conducted in healthcare facilities across the six health regions of Togo, namely: Grand Lomé, the Maritime Region, the Plateaux Region, the Central Region, the Kara Region, and the Savanes Region. Togo is a West African country located on the Gulf of Guinea. It covers an area of 56,600 km² and had an estimated population of about 8 million in 2022. All medical centers with a radiology department were included in the study [9]. Centers using X-ray generators or radioactive sources for non-medical purposes were not include.

This was a descriptive study carried out from July 1 to December 31, 2020. The parameters studied included the general characteristics of radiology departments, compliance with radiological facility layout standards, and medical human resource management in these departments.

The radiation protection measures investigated during this study included:

- Collective measures related to the layout of radiological facilities, such as room size (to assess whether it was cramped), wall shielding, proper zoning, signage, warning symbols, and floor markings.
- Individual measures related to the dosimetric monitoring of workers, classification of workers, medical surveillance of workers, and the availability of personal protective equipment.

The collected data were processed and analyzed using SPSS and Microsoft Excel 2013. The results were presented as absolute and relative frequencies in tables and figures.

RESULTS

The results of the study are presented in the following order: general characteristics of the services, equipment, and workers; development of radiological facilities; and finally, the protection and monitoring of medical personnel exposed to ionizing radiation.

GENERAL CHARACTERISTICS OF SERVICES, EQUIPMENT AND WORKERS

Seventy-seven (77) services using ionizing radiation (all radiodiagnostic services) were identified throughout the national territory and were distributed in the health structures as follows: Three University Teaching Hospitals (CHU), representing 3.9 %; six Regional Hospitals (CHR), 7.8 %; fourteen Prefectural Hospitals (CHP), 18.1 %; eleven private practices, 14.3 %; five Medical and Social Centers (CMS), 6.5 %; thirty-one clinics, 40.3 %; and seven general hospitals, 9.1 %. There were no nuclear medicine or functional radiotherapy services provided during the study period.

Nearly one-third of radiodiagnostic services were created after 2010, and more than three-fifths (3/5) were created in the Lomé-Commune health region (Table 1).

Table 1

Distribution of radiology services by region and year of creation

Region	Before 1980		1981 –1990		1991 –2000		2001 –2010		After 2010		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Savanes	0	0	0	0	0	0	3	17.6	1	4	4	5.2
Kara	1	14.3	0	0	1	6.3	1	5.9	1	4	4	5.2
Centrale	1	14.3	2	28.6	2	12.4	2	11.8	0	0	7	9.1
Plateaux	1	14.3	3	14.3	1	6.3	6	35.3	0	0	11	14.3
Maritime	0	0	0	0	0	0	3	17.6	1	4	4	5.2
Lomé	4	57.1	7	57.1	12	75	2	11.8	22	88	47	61.0
Total	**7**	**9.1**	**12**	**15.6**	**16**	**20.1**	**17**	**22.1**	**25**	**32.4**	**77**	**100**

A total of 127 devices emitting ionizing radiation were identified during our study. All of these devices were X-ray generators. There was no equipment equipped

with a radioactive source for medical use. The conventional radiology devices represented more than half of the X-ray generators identified (Fig. 1).

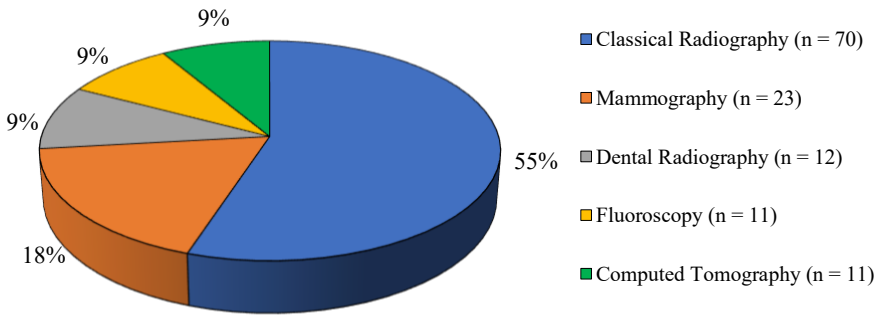

Fig. 1. Distribution of X-ray generator types.

There were 137 workers in the radiodiagnostic services, of which the manipulators were the most represented (Table 2).

Table 2

Distribution of health structure personnel according to their qualifications by health region

Region	Radiologist		Manipulators		Secretaries		Assistant handlers		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Savanes	1	4.5	1	1.7	1	3	3	13.1	6	4.4
Kara	4	18.2	2	3.4	2	6.1	2	8.7	10	7.3
Centrale	2	9.1	2	3.4	2	6.1	1	4.3	7	5.1
Plateaux	0	0	1	1.7	0	0	3	13.1	4	2.9
Maritime	1	4.5	4	6.7	0	0	1	4.3	6	4.4
Lomé	14	63.7	49	83.1	28	84.8	13	56.5	104	75.9
Total	**22**	**16.0**	**59**	**43.1**	**33**	**24.1**	**33**	**16.8**	**137**	**100**

DEVELOPMENT OF RADIOLOGICAL FACILITIES

Approximately 1/5 of the rooms in private radiology departments had areas of less than 20 m^2 (Table 3).

Table 3

Distribution of room areas according to health facility

	Area ≤10 m²		Area 10–20 m²		Area 20–30 m²		Area 30–40 m²		Area ≥40 m²	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Public (*n* = 28)	**1**	**3.6**	**5**	**17.9**	**5**	**17.9**	**8**	**28.5**	**9**	**32.1**
University Hospital (*n* = 3)	0	0	0	0	0	0	1	33.3	2	66.7
CHR (*n* = 6)	0	0	1	16.7	1	16.7	3	50	1	16.7
CHP (*n* = 14)	0	0	3	21.4	2	14.2	4	28.6	5	35.7
CMS (*n* = 5)	1	20	1	20	2	40	0	0	1	20
Private (*n* = 49)	**3**	**6.1**	**10**	**20.4**	**18**	**36.8**	**8**	**16.3**	**10**	**20.4**
Clinics (*n* = 31)	1	3.2	3	10	14	4.2	5	16.2	8	25.8
Hospitals (*n* = 7)	0	0	4	57.1	1	14.3	0	0	2	28.6
Offices (*n* = 11)	2	18.2	3	37.5	3	25	3	27.3	0	0
Total (*n* = 77)	**4**	**5.2**	**15**	**19.4**	**23**	**29.9**	**16**	**20.8**	**19**	**24.7**

The vast majority of services were built in solid bricks, including all those in the CHR and 2/3 in the CHU (Table 4).

Table 4

Distribution of room walls according to health structure

	Solid bricks		Hollow bricks	
	n	%	*n*	%
Public (*n* = 28)	**23**	**82.1**	**5**	**17.9**
University Hospital (*n* = 3)	2	66.7	1	33.3
CHR (*n* = 6)	6	100	0	0
CHP (*n*=14)	12	86	2	14.2
CMS (*n* = 5)	3	60	2	40
Private (*n* = 49)	**36**	**73.5**	**13**	**26.5**
Clinics (*n* = 31)	22	71	9	29
Hospitals (*n* = 7)	6	86	1	14.3
Offices (*n* = 11)	8	73	3	27.3
Total (*n* = 77)	**59**	**76.6**	**18**	**23.4**

Just over half (52 %) of the doors were made of wood and aluminum (Table 5).

Table 5

Distribution of the nature of doors according to health structure

	Wooden doors		Aluminum doors		Doors in lead	
	n	%	*n*	%	*n*	%
Public (*n* = 58)	**19**	**32.8**	**9**	**15.5**	**30**	**51.7**
University Hospital (*n* = 23)	1	4.3	2	8.7	20	87
CHR (*n* = 16)	5	31.3	1	6.3	10	62.5
CHP (*n* = 14)	10	71.4	4	28.6	0	0
CMS (*n* = 5)	3	60	2	40	0	0
Private (*n* = 65)	**21**	**32.3**	**15**	**23.1**	**29**	**44.6**
Clinics (*n* = 40)	10	25	10	25	20	50
Hospitals (*n* = 9)	3	33.3	2	22.2	4	44.4
Offices (*n* = 16)	8	50	3	18.8	5	31.3
Total (*n* = 123)	**40**	**32.5**	**24**	**19.5**	**59**	**48**

The delimitation of zones was not effective in any department, and only the radiology departments of university hospitals delimited the controlled, regulated and public zones (Table 6).

Table 6

Distribution of zone delimitation according to health structure

	Controlled area		Monitored area		Public area	
	n	%	*n*	%	*n*	%
Public (*n* = 28)	**24**	**85.7**	**9**	**32.1**	**22**	**78.6**
University Hospital (*n* = 3)	3	100	3	100	3	100
CHR (*n* = 6)	6	100	1	16.7	6	100
CHP (*n* = 14)	11	78.6	2	14.3	10	71.4
CMS (*n* = 5)	4	80	3	60	3	60
Private (*n* = 49)	**21**	**42.9**	**15**	**30.6**	**32**	**40.5**
Clinics (*n* = 31)	14	52.4	10	19	21	80.1
Hospitals (*n* = 7)	4	66.7	3	50	6	100
Offices (*n* = 11)	3	37.5	2	25	5	62.5
Total (*n* = 77)	**45**	**58.4**	**24**	**31.2**	**54**	**70.1**

Pictograms and signs were present in approximately half of the services, and floor markings and internal regulations were rarely effective (Table 7).

Table 7

Distribution of the different signs and internal regulations according to health structure

	Pictogram		Light signaling		Marking		Internal regulations	
	n	%	*n*	%	*n*	%	*n*	%
Public (*n* = 28)	**27**	**96.4**	**18**	**64.3**	**0**	**0**	**3**	**10.7**
University Hospital (*n* = 3)	3	100	3	100	0	0	1	33.3
CHR (*n* = 6)	5	83.3	5	83.3	0	0	2	33.3
CHP (*n* = 14)	7	50	10	71.4	0	0	0	0
CMS (*n* = 5)	2	40	0	0	0	0	0	0
Private (n = 49)	**29**	**59.2**	**25**	**51**	**8**	**16.3**	**6**	**12.2**
Clinics (*n* = 31)	23	74.2	19	61.3	8	26	5	16.1
Hospitals (*n* = 7)	3	50	3	50	0	0	1	16.7
Offices (n = 11)	3	27.3	2	18.2	0	0	0	0
Total (*n* = 77)	**46**	**59.7**	**42**	**54.5**	**8**	**10.4**	**9**	**11.7**

MANAGEMENT OF MEDICAL PERSONNEL EXPOSED TO IONIZING RADIATION

Only 30 departments, or 39 %, had a dosimeter, the vast majority of which were in private facilities, where only the active dosimeter was also recorded (Table 8).

Table 8

Distribution of the dosimeters according to health structure

	Passive dosimeter		Active dosimeter	
	n	%	*n*	%
Public (*n* = 28)	**3**	**10.7**	**0**	**0**
University Hospital (*n* = 3)	3	100	0	0
CHR (*n* = 6)	0	0	0	0
CHP (*n* = 14)	0	0	0	0
CMS (*n* = 5)	0	0	0	0
Private (*n* = 49)	**26**	**53.1**	**1**	**2**
Clinics (*n* = 31)	25	81	1	4.8
Hospitals (*n* = 7)	0	0	0	0
Offices (*n* = 11)	1	12.5	0	0
Total (*n* = 77)	**29**	**37.7**	**1**	**1.3**

Passive dosimeter readings were carried out monthly in 3 departments (3.9 %), quarterly in 12 departments (15.6 %), and half-yearly in 8 departments (10.4 %).

Leaded aprons were the most available protective equipment, followed by gonad protectors (Table 9).

Table 9

Distribution of health structures according to the radiation protection equipment they had available

	Private		Audience		Total	
	n	%	*n*	%	*n*	%
Leaded apron	45	67.2	22	32.8	67	100
Gonad protector	17	61	11	39.3	28	100
Protector of thyroid	10	71.4	4	29	14	100
Leaded glasses	5	83.3	1	17	6	100
Leaded screen	4	100	0	0	4	100

Fifty-three (53) diagnostic radiology services (68.8 %) provided their staff with a categorization. This categorization was effective in 37 private structures (69.8 %) and in 16 public structures (30.2 %).

With respect to radiation protection specialists, the country has only one biophysicist in a university hospital and only one competent person in radiation protection in a private structure.

Fifteen (15), or 19.5 % of the services, including 13 (86.7 %) private services, provided medical monitoring of their staff.

DISCUSSION

In Togo, in the absence of a nuclear medicine and radiotherapy department, occupational exposure to ionizing radiation in the medical environment is linked mainly to radiodiagnosis. The number of radiology departments has increased considerably, from 44 in 2014 to 77 in 2020 [1]. The sources of exposure to ionizing radiation in the medical environment in Togo are similar to those reported in some French-speaking sub-Saharan African countries, such as Benin, which also does not have a scintigraphy imaging department [2]. Owing to the support of the International Atomic Energy Agency (IAEA), other countries in the region, such as Senegal, Burkina Faso and Niger, have succeeded in establishing nuclear medicine departments. Our study revealed that conventional radiology is the most widespread source of ionizing radiation in Togo. A similar trend has been observed in other countries, such as Benin, where conventional radiology accounted for 85 % of diagnostic radiology devices in 2019 [13]. Radiology technicians play a vital role in the smooth operation of radiology departments, representing approximately 40 % of

the staff in our study, a proportion identical to that reported in the aforementioned Beninese study [13]. These professionals are key players in the daily management of radiology departments and in preventing the risk of exposure to ionizing radiation.

The layout of radiological facilities must comply with essential standards to ensure the protection of workers [6]. These standards include the sizing of rooms, electrical safety and radiological safety. With respect to sizing, a minimum surface area of 20 m² is recommended for scanner rooms and for public conventional radiology rooms, and a minimum surface area of 12 m² is recommended for private conventional radiology practices outside health establishments [13]. Unfortunately, our study revealed that 6.1 % of private practices in Togo have a surface area of less than 10 m². Similarly, 16.7 % of the radiology rooms in the CHR and 21.4 % of those in the CHP had surface areas of less than 20 m². These results are similar to those reported in Benin, where 20 % of radiography rooms had areas of less than 20 m² in 2020 [18, 22]. Tapsoba *et al.* reported in Ouagadougou, Burkina Faso, in 2010 that 40.6 % of medical imaging services were cramped [20].

Room that is too cramped hinders the effective application of radiation protection measures and complicates maintenance operations. The radiological safety of workers requires that the walls of the premises be constructed with the required thicknesses to ensure the protection of workers and the public while keeping exposure levels as low as reasonably achievable, with reference to the dose limits of 20 mSv and 1 mSv, respectively. This also depends on the delimitation of controlled and monitored areas in relation to contiguous areas [6, 10].

The wall thickness is usually expressed in mm Pb equivalent. For example, 1 mm of lead is equivalent to 6 mm of iron, 70 mm of concrete, 20 mm of baryta concrete, 30 mm of baryta plaster, 100 mm of solid bricks, 200 mm of hollow concrete blocks, or 300 mm of hollow bricks [17]. Therefore, walls built with solid bricks or hollow bricks of low thickness do not comply with the planning standards and cannot guarantee adequate protection of workers and the public. In addition to the walls, doors and windows are protected, especially if the electrical voltage of the installation exceeds 50 kV. Unfortunately, more than half of the doors examined in our study were not sealed.

The delimitation of zones is essential for the radiation protection of workers. In France, the regulations stipulate, in articles R. 4451-18 to 4451-28 of the French Labor Code, the need to delimit supervised, controlled, specifically regulated or prohibited work zones. The decree of May 15, 2006, known as the "zoning decree", sets the conditions for delimitation and signage of these zones according to exposure to ionizing radiation, as well as the hygiene, safety and maintenance rules associated with them [17]. The objective of these regulations is to adequately inform the worker about his or her workstation and to prevent any accidental intrusion. The risk assessment must consider the reality of the radiological activity and must not be underestimated or overestimated under any circumstances. Employers of services

whose areas are not demarcated (more than a third of services) must therefore take measures to ensure that the monitored and controlled areas are always correctly defined. Similar observations were made in Cameroon by Mbo in 2017 and Noessi in 2018 [14, 16]. In principle, the delimitation must be continuous, visible and permanent. A sign specific to the area concerned must be displayed at all accesses to the premises and inside the areas, while sources of ionizing radiation must be indicated.

Our study revealed that pictograms and light signals were effective in only half of the services and that floor markings were rare. This situation is worrying, and efforts must be made to ensure that each access is indicated by a pictogram compliant with the NFM60-101 standard, which defines the characteristics of pictograms, often called "trefoils" [13, 17]. The sources of ionizing radiation must be clearly identified, and double light signaling should be mandatory.

The management (protection and monitoring) of workers in radiology departments is not satisfactory. Indeed, more than two-thirds of the departments did not have a dosimeter for their medical staff, who, moreover, were not categorized in one-third of the departments and did not benefit from medical monitoring in 80.5 % of the cases. This deficient management was also reported in Nepal by Adhikari *et al.*, where 60 % of workers had no dosimetric monitoring [3]. Studies conducted in Benin in 2019 also revealed a lack of dosimetric monitoring of staff in radiodiagnostic departments [18, 22]. In principle, all workers exposed to ionizing radiation should benefit from dosimetric monitoring. Depending on their activity and level of exposure, a passive dosimeter or an active dosimeter may be used. The accumulation of doses received helps occupational physicians anticipate the occurrence of radiation-induced pathologies. Even low-dose exposure can cause adverse health effects in workers [12, 21].

The shortcomings noted in the implementation of radiation protection measures are partly due to the shortage of radiation protection officers in radiology departments in Togo. Indeed, the radiation protection officers play a key role in helping employers and other staff effectively implement radiation protection rules [22]. Measures must therefore be taken to designate and train competent persons to ensure better compliance with radiation protection measures for workers exposed to ionizing radiation in medical settings in Togo. In addition, the absence of an operational regulatory authority capable not only of authorizing but also of inspecting radiology departments in Togo contributes to the noncompliance of radiological installations with the required standards and to the insufficient management (protection and monitoring) of workers exposed to ionizing radiation. Efforts must be made by political and health authorities to operationalize the regulatory authority currently being set up to ensure rigorous implementation of radiation protection measures in the country.

CONCLUSION

The level of implementation of radiation protection measures for workers in medical settings in Togo is relatively unsatisfactory. This requires significant improvement, both in terms of facility design and personnel management. It is imperative to intensify efforts at two levels: first, employers must ensure compliance with the guidelines of international radiation protection organizations; second, the government must work toward operationalizing the regulatory authority. This is crucial to ensure the radiological safety of not only workers but also of patients and the entire population.

Competing interests: The authors declare that they have no competing interests.

Authors' contributions: K.A. put the idea and the design of the study. K.A., G.D.H., Y.A.A. had contributed to data collection and to the conception and design of the manuscript. A.B., K.P.G, A.B.K had contributed to the conception and design of the manuscript. All authors have been involved in drafting and revising the manuscript. All authors read and approved the final manuscript.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements. The authors gratefully acknowledge the heads of healthcare institutions in Togo with radiology departments for their authorization and support during data collection.

*Declaration of generative AI and AI-assisted technologies in the writing process***:** During the preparation of this work, the author did not use generative AI or AI-assisted technologies.

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