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Knowledge and practices in radiation protection of workers under ionizing radiation in hospitals in Dakar

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ABSTRACT

Background: Radiation protection is part of a global approach to managing the risks of exposure to ionizing radiation (IR). The objective of this study is to assess the knowledge of workers in an environment at risk of irradiation and to describe the radiation protection measures implemented in services using IR.

Materials and method: We conducted a cross-sectional study for 3 months from November 22, 2022 to February 22, 2023. It took place in the radiology, nuclear medicine, radiotherapy, and orthopedic surgery departments of hospitals in Dakar. Our study population was all workers exposed to IR and on the job at the time of the survey. The study instrument was an anonymous self-administered questionnaire whose variables concerned socio-professional data, collective and individual radiation protection measures, and patient radiation protection. Data analysis was obtained using EPI Info version 7 software.

Results: Out of 160 questionnaires distributed, we collected 97, representing a participation rate of 60.63%. The average age was 36.20 years $\pm$ 8.66 (extremes of 23 and 62 years) and the sex ratio was 1.38 in favor of men. The average duration of daily exposure was 6 hours (39.19%) and 81.58% concerned imaging services. The main sources of irradiation were conventional radiography (69.07%) followed by computer tomography scanning (55.67%). In our cohort, 50.52% had knowledge of the regulatory texts on radiation protection and 60.82% were aware of the existence of dosimetric monitoring where they work. The most used personal protective equipment is the lead apron (51.55%), the dosimeter (47.42%), and the thyroid cover (13.40%). Workers respected the regulatory distance from the source in 69.79% but 84.54% were not able to describe the action to be taken in the event of an incident or accident.

Conclusion: Workers' knowledge of radiation protection was unsatisfactory and the right attitudes in this area were not always adopted. Strengthening the radiation protection module in the training of this type of personnel is a necessity. The authorities must strengthen radiation protection equipment and ensure compliance with appropriate measures.

Keywords: Irradiation, physical risks, occupational cancer.

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Introduction

Exposure to ionizing radiation (IR) is a worrying reality for a large professional population because it affects more than 24 million workers worldwide [1].

According to the 2014 Council of the European Union, radiation protection of people subject to public or occupational exposure must be optimized as low as reasonably achievable, namely the ALARA principle (as low as reasonably achievable) which takes into account the current state of technical knowledge [2]. The use of IR for medical purposes is an essential practice that contributes significantly to diagnostics,

treatments, and medical research. The scale of this medical exposure due to technological advances highlights the need for increased vigilance in terms of protection at the global level. To this end, international radiation protection organizations collaborate closely to guarantee the implementation of adequate safety measures and formulate recommendations for controlled use of IR [3]. The International Atomic Energy Agency advocates the assessment and appropriate confirmation of the knowledge, training, skills, and competencies of workers directly assigned to work under IR on the fundamental principles of radiation

protection and safety to ensure the ability of workers to safely perform specified tasks in medical applications [4].

However, the knowledge of exposed workers of radiation protection in medical environments in French-speaking sub-Saharan African countries is generally considered low with insufficient supervision of radiation protection [5,6].

In light of these findings, we initiated a study to evaluate the knowledge, attitudes, and practices of workers operating in an environment at risk of irradiation.

Methods

This is a descriptive cross-sectional study, carried out in the radiology, nuclear medicine, radiotherapy, and orthopedic surgery departments of Dakar hospitals over a period of 3 months.

Our study concerns all workers exposed to IR.

The questionnaire is tested and validated with the staff of the biophysics laboratory. The form anonymous was sent by Google form to all agents exposed to IR in Dakar hospitals.

The variables were grouped into four categories:

- Socio-professional data: age, gender, department, position held; the type of radiological activities (conventional radiology, mammography, tomography, scintigraphy, irraherapy, radiotherapy, radio immunological assay, in the operating room, other to be specified); the average duration of daily exposure; and the number of years of practice;
- knowledge of collective radiation protection measures, namely regulatory texts, the existence of a radiation protection entity within the establishment, the classification of work areas and workers, the thresholds of irradiation sources, the dosimetric monitoring of exposed personnel and medical surveillance, the action to be taken in the event of an incident or accident;
- The application of individual radiation protection measures, in particular the wearing of personal protective equipment, the regulatory reduction of exposure time and distance from the radiation source;
- Knowledge of the risks related to irradiation, more specifically the risks of radiation-induced cancer and the pathologies that can survive.
- Ethical considerations were respected with anonymity and consent to share the results. The data were entered and analyzed by the EPI info version 7 software. During the descriptive analysis, the qualitative variables were described by frequency tables, bar charts, histograms, and disks. The quantitative variables were described by their

position parameters (mean, median, and mode) and dispersion (standard deviation, extremes). For statistical analysis, the Chi square test and Fisher's exact test made it possible to verify the existence of a link between two variables and considered statistically significant if p -value is less than 0.05.

Results

The cohort is made up of 97 workers. The majority of the study population was male (56).

The sex ratio was equal to 1.38. The average age was 36.20 ± 8.66 ; with extremes of 23 and 62 years.

Distribution of staff according to position

Regarding the occupation, there were 47 radiologists, 36 technicians, 5 nuclear physicians, 5 orthopedic surgeons, and 4 radiotherapists (Table 1).

Radiation activity

The main radiological activity carried out was conventional radiography at 69.07% ($n = 67$) Figure 1.

Exposure duration

The average daily exposure duration was higher among technicians, i.e., 45.83% ($n = 11$) for an exposure of 8 hours and 84.62% for an exposure greater than 8 hours (Figure 2).

Knowledge of radiation protection

Among the people questioned about the texts governing the radiation protection of workers, 50.52% ($n=49$) were aware of them.

Figure 3 shows the distribution by profession.

The existence of a structure dedicated to radiation protection within the hospital was known by 47.92% ($n = 47$). The criteria for demarcating work zones were known by 46.39% ($n = 45$). The classification of workers exposed to IR was known by 18.75% ($n = 19$). The existence of dosimetric monitoring of exposed hospital staff was known by 60.82% ($n = 59$) and 90.22% ($n = 83$) did not know that there is specific medical monitoring for exposed workers. To IR in the department by a dedicated occupational physician. In our study population, 83.70% ($n = 77$) were aware of the

Table 1. Distribution of staff according to position occupied.

Occupation	Frequency	Percentage
Radiologists	47	48.45%
Radiotherapists	4	4.12%
Nuclear physicians	5	5.15%
Orthopedic surgeon	5	5.15%
Technicians	36	37.11%
Total	97	100%

We found that 39.99% ($n = 32$) of this series had work experience of 2–5 years as personnel exposed to IR.

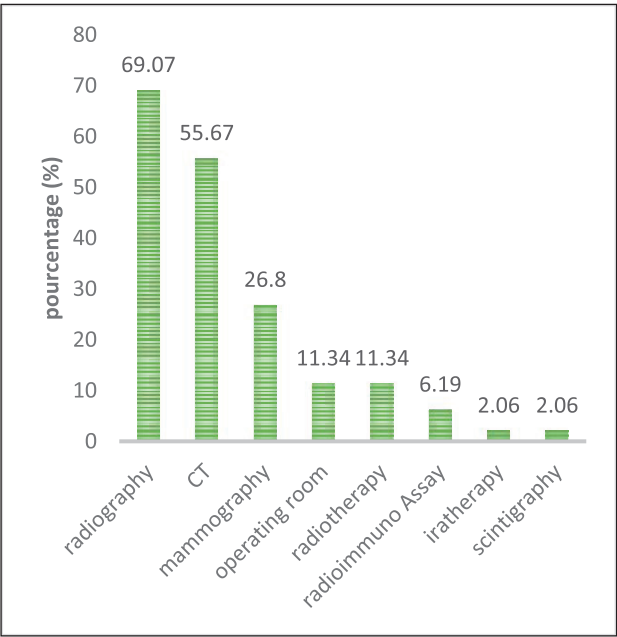


Figure 1. Distribution of exposed workers according to the main radiological activities carried out in a hospital environment.

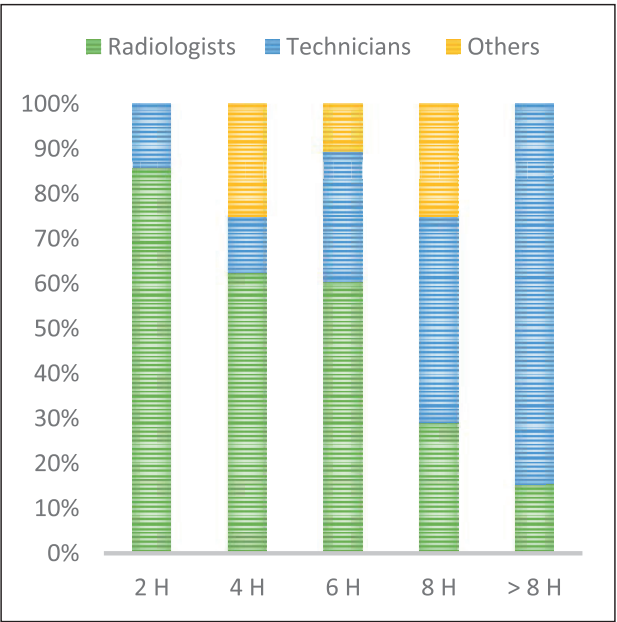


Figure 2. Distribution of average daily exposure duration by type of practitioner.

risks of radiation-induced pathology. The description of what to do in the event of an incident or accident linked to IR was satisfactory for 02.06% ($n = 2$).

Radiation protection measure

The wearing of PPE was respected at 73.96% ($n = 71$) and the list below summarizes the main PPE used in the hospitals studied (Table 2).

Respecting the planned distance between the radiation source and the practitioner was applied by 69.79% of workers ($n = 67$) at varying distances from one person to another. In the workforce studied,

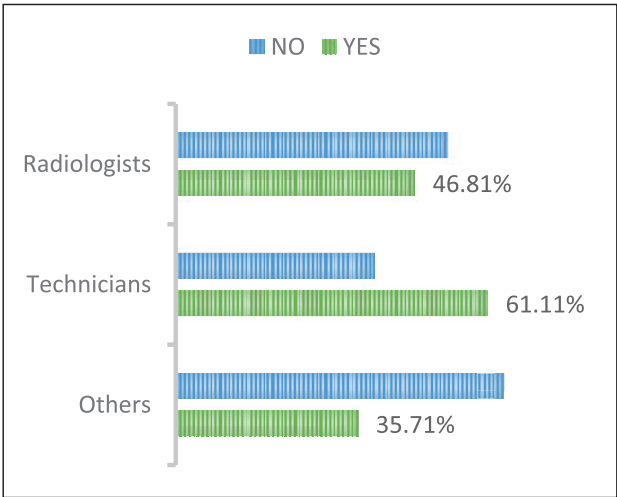


Figure 3. Knowledge of radiation protection regulatory texts depending on the qualification of personnel exposed to IR.

Table 2. List of the most used personal protective equipment.

PPE	Effective	Proportion (%)
Leaded apron	50	51.55
Dosimeter	46	47.42
Thyroid cover	13	13.4
Lead gloves	12	12.37
Portable screen	2	2.06
Leaded glasses	1	1.03

Table 3. Distancing from the source of IR applied by workers.

Distance (m)	Frequency	Percentage
1 m	2	6.98%
2 m	6	13.95%
3 m	20	46.51%
>4 m	14	32.56%

66.67% ($n = 64$) did not reduce the regulated exposure time aimed at optimizing individual protection.

The observed distances from the source are described in the Table 3.

Discussion

Our survey among healthcare personnel exposed to IR was carried out using a questionnaire that does not take into account medical specificities. Besides this, self-administration can also generate bias, whether in the quality of responses and the participation rate or the number of participants in the study.

In our study, unsealed irradiation sources were the most used, including conventional radiography and computer tomography with 69.07% and 55.67%, respectively. The average duration of exposure varies between 6 hours and 8 hours per day, this result is close to that reported by Kane [7], namely 7–8 hours.

Only half of our respondents, i.e., 50.52%, knew the regulatory texts regarding radiation protection. A similar study reported a higher percentage of 93.41% for an overall knowledge score classified as “Poor” with a better score for doctors [5].

This difference in level of knowledge according to professional qualification was also observed in Yaoundé and Tunis [6,8]. However, it is the absence of qualified radiation protection trainers that is a problem in Senegal as in many countries [9,10].

We recorded 53.61% of workers who were unaware of the existence of a radiation protection entity. Either the latter is absent, or she does not effectively fulfill her role with the workers.

This observation is not specific to Senegal but has been observed in the Central African Republic and Cameroon [9,10]. We noted that some workers do not know which category they belong to. In comparison with a study carried out in a medical environment in Togo in which the categorization of staff was done in 58.10% of cases [11].

The description of the action to be taken in the event of an incident or accident was good that for 02.06% of the staff, we can deduce that their attitude remains to be desired. However, this low rate can be explained by the lack of correct initial training of practitioners during their studies. A study conducted in 2014, aimed at evaluating the impact of radiation protection training during the course, showed that the best attitudes were noted among residents who followed a radiation protection training module [12,13].

Not all staff benefit from regular dosimetric monitoring which, moreover, is a regulatory requirement for the employer even though the Senegalese Labor Code recommends it in its article 170 relating to hygiene and safety [14]. Thanks to this dosimetric monitoring the Jalli study [15] showed cases of exceeding the annual regulatory limit among workers in hospitals.

Elsewhere, staff do not benefit from medical surveillance specific to exposure to IR by a dedicated occupational physician as required by the Senegalese labor code in article 176 relating to hygiene and safety [14]. Eighty-four percent of workers surveyed know the effects of IR on health. This is a prevalence higher than that of Marzouk in Tunisia in 2016 which was 76% [8].

The irregular use of personal protective equipment results from the lack of equipment available in health structures. This is not surprising in the Senegalese context where the Diouf study and that of Kane and Ndong had highlighted the same deficit [7,16,17]. Moreover, our results are similar to those of Guiegui who noted that personal protective equipment (thyroid covers, gonads, and leaded glasses)

were generally absent apart from the leaded apron present in certain departments [18]. In practice, moving away from the radiation source contributes to the absorption of radiation according to the law of the inverse square of the distance. This distancing is well respected by practitioners, i.e., 69.79% of workers. However, the variation in the number of meters is subject to the construction of the premises and the types of examinations.

Our study found that 66.67% of the surveys did not minimize the duration of exposure to RI or the time spent in the monitored areas. While the reduction of time aims to optimize individual protection: it is a fundamental principle.

Only 33.33% alternate their workstation and benefit from one day's leave per week.

Conclusion

Knowledge of radiation protection among workers exposed in medical settings in Senegal is insufficient. In view of numerous shortcomings and inappropriate individual behaviors, it appears that major efforts, particularly educational ones, are necessary in the hospital environment in Dakar. Training, information exchange, and continuous health monitoring are also important factors. For an effective occupational radiation protection regime, responsibilities must be clearly assigned at all levels. Finally, an evaluative study of the ambient dosimetry of the nuclear medicine services of Dakar should be considered, because the monitoring of the health of workers assigned to work under radiation should be based on the general principles of occupational health.

List of abbreviations

ALARA	As low as reasonably achievable
CT	Computer tomography
IR	Ionizing radiation
m	Meter
PPE	Personal protective equipment

Conflict of interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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Consent to participate

Written consent was obtained from all the participants.

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REFERENCES

1. Organisation internationale du travail: 3e Conférence internationale sur la radioprotection professionnelle. Available from: https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_854879/lang--fr/index.htm
2. Conseil de l'Union européenne. Directive 2013/59/Euratom du Conseil du 5 décembre 2013 fixant les normes de base relatives à la protection contre les dangers résultant de l'exposition aux rayonnements ionisants. Journal officiel de l'Union européenne. 2014 ;13:128.
3. Recommandations 2007 de la CIPR: Publication 103. Éd. Tec & doc, 2009.
4. AIEA: Radioprotection et sûreté radiologique dans les applications médicales des rayonnements ionisants. Normes de sûreté N°SSG-46. 2022.
5. Akanni D, Savi de Tove KM, Damien BG, Kiki SM, Adjadohoun SB, Yekpe-Ahouansou P, et al. Connaissances en radioprotection des travailleurs exposés aux rayonnements ionisants en milieu médical en Afrique francophone sub-saharienne. Radioprotection. 2021;56(1):43–8.
6. Ongolo-zogo P, Nguehouo MB, Yomi J, Nko'o Amven S. Connaissances en matière de radioprotection: enquête auprès des personnels des services hospitaliers de radiodiagnostic, radiothérapie et médecine nucléaire à Yaoundé Cameroun. Radioprotection. 2013;48(1):39–49.
7. Kane AF. Etat des lieux de la radioprotection à Dakar: étude préliminaire dans 15 structures sanitaires(thèse). Dakar, Senegal: UCAD; 2013.
8. Marzouk M, Kamoun H. Connaissances des travailleurs en radioprotection: Enquête au CHU Mongi Slim à La Marsa (Tunisie). Radioprotection. 2016;51(2):123–8.
9. Kouandongui F, Bangue S, Bidan Tapiade E, Ouimon M, Mobima T. Connaissances en matière de radioprotection des manipulateurs de radiologie de Bangui et de Bimbo (Centrafrique). Radioprotection. 2019;54(1):41–5.
10. Mbo Amvene J, Amougou M, Djonyang B, Mballa Amougou JC, Ngaroua D, Nko'o Amvene S. Observance des règles de radioprotection dans les services d'imagerie de l'Extrême-Nord du Cameroun. Health Sci Dis, 2017;18(2):83–7.
11. Adambounou K, Adigo A., Y. A.J. Evaluation de la mise en œuvre des mesures de radioprotection des travailleurs exposés aux rayonnements ionisants en milieu médical au Togo. Journal de la Recherche Scientifique de l'Université de Lomé. 2017;19:489–97.
12. Adambounou K, N'timon B, Kouame-Koutouan A, Sedo K, Adigo AM, Kluyibo K, et al. Assessment of technical conditions and radiation protection measures during pediatric chest radiography examinations realized in Togo. Radioprotection. 2021;56(4):287–93. <https://doi.org/10.1051/radiopro/2021026>
13. Ramanathan S, Ryan J. Radiation awareness among radiology residents, technologists, fellows and staff: where do we stand? Insights Imaging. 2015;6(2):133–9.
14. République du Sénégal. Loi n°97-17 portant code du travail de la république du Sénégal. Journal officiel de la république n°97-17 Sénégal; déc 01, 1997
15. Jalli T. Surveillance dosimétrique des travailleurs sous rayonnements à l'hôpital général de Grand Yoff. [thèse]: UCAD; 2010.
16. Diouf F. Evaluation des mesures de radioprotection en milieu hospitalier de niveau III au Sénégal. [memoire]: UCAD; 2014.
17. Ndong B, Dia SA, Djigo MS, Fachinan H, Bathily EHL, Diop O, et al. Inventory of radiation protection in hospitals of level III in Senegal. Open J Biophysics. 2021;11:397–406. <https://doi.org/10.4236/ojbiphy.2021.114016>
18. Guigui CP, Owona J, Aka INA, Tchouasseu N'gassam L, N'guessan Affoue LM, Chantal Kra AA, et al. Observance des Mesures de Radioprotection en Milieu Hospitalier Public à Yaoundé en 2016. Health Sci Dis. 2019;20(1):91–4.