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Radioprotection and Medical Monitoring in Health Facilities in Douala, Cameroon

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Abstract

Introduction: The use of radioactive radiations in healthcare facilities must comply with radioprotection safety rules in order to avoid threatening the health of workers and patients. This study aimed to assess the working conditions, the protective measures and the medical monitoring of workers directly involved in X-ray work at hospitals in Douala, Cameroon. **Materials and Methods:** A descriptive cross-sectional study was carried out during the 1st quarter of 2018, across various state and private health facilities of the city of Douala. Sampling was non-random, based on convenience and all the willing participants that fulfilled the inclusion criteria were enrolled. Quantitative analyses were conducted using EPI INFO 7.0 software and the results were presented in both univariate and bivariate forms. **Results:** The sample consisted of 56 men and 31 women with a mean age of 34.75 ± 8.77 years. X-ray technicians were over-represented (41.38%). Day/night shift work was the main work pattern (68.96%). The distribution of work zones A&B was known by 87.5% of the participants. Hazard warning signs were effective in work zones A and B (75.86%), and the walls of the premises were also reinforced in these work zones (88.51%), but the use of radiation dosimeters was rare (9.20%). Radiation aprons (94.30%) and hand-held dosimeters (63.20%) were the most commonly used personal protective equipment. The majority of the participants did not benefit from medical follow-up by an occupational health specialist (62.1%). **Conclusion:** The implementation of radiation protection measures remains a significant concern in Douala based health facilities, and requires stricter administrative controls and sanctions to prevent serious health consequences for exposed staff.

Keywords

Ionizing Radiation, Hospital, Radiation Protection, Medical Monitoring, Douala

1. Introduction

The use of x-rays (XR) is of long standing in the health sector, dating back to the late 19th century [1] [2]. They are used for two purposes: to help diagnose internal lesions in the body and for therapeutic purposes as part of cancer treatment. The use of radiotherapy is widely practiced in hospitals throughout the world, with almost 200,000 prescriptions given annually to cancer patients in France [3]. According to available data, the use of radiotherapy is not optimal in most European countries, nor in the world as a whole [4] [5].

Though they help to improve patient prognoses, their use is not without risk for patients, technicians and the environment due to the deep penetration of radiation into body tissues and materials [6]. The impact of accidental exposure to X-rays varies depending on the degree and frequency of exposure to radiation, the dose of radiation absorbed and the sensitivity of the irradiated living environment. These can range from immediate deterministic health effects, with a threshold of 0.1 Gray (Gy), to more delayed stochastic effects [7] [8]. Deterministic effects include disorders such as: blood count, tiredness, haematopoietic disorders, gastrointestinal disorders, immediate diarrhea followed by death within 1 - 2 weeks, and central nervous system damage followed by death within 1 - 2 hours [9]. Further down the line, stochastic effects such as cancers, genetic abnormalities and leukemia may be observed, whose probability of occurrence is independent of the radiation threshold [7] [10]. In the case of an industrially-produced nuclear disaster, major human and environmental consequences may be observed in neighboring populations, as seen in the case of Chernobyl and Hiroshima [11] [12].

The exposure of health workers to X-rays is occupation in origin, occurring during their activities in the hospital [13]. Peak exposure typically happens during the performance of radiodiagnosis operations [14] and interventional radiology activities [15]. According to a 2010 report by the International Labour Office (ILO), 7.44 million workers were occupationally exposed at an average annual rate of 0.5 mSv/year during the medical use of X-rays [14]. In order to mitigate the dangers of X-rays for health workers, general and specific preventive measures as well as radioprotection protocols have been implemented in several countries with the aim of preventing any deterioration in the health of users [13]-[17]. Scientific data on the prevention and monitoring of workers assigned to work with ionizing radiation are scarce in our context, hence the interest of this study whose goal is to improve the medical and safety conditions of hospital workers, and specifically those directly appointed to work under radioactive x-rays in public hospitals within the city Douala, the Cameroon's main economic city.

2. Material and Methods

2.1. Type, Location and Duration of Study

A descriptive cross-sectional study was conducted during the 1st quarter of 2018, in the radiology departments of both state and private health facilities in the city of Douala.

2.2. Study Population and Sampling

The study population consisted of permanent health workers employed at the study settings and exposed to X-Rays during their routine activities in the radiology departments. Participants were recruited non randomly, by convenience. Trainees, medical and health sciences students, absent or on paid leave staff and patients were not included. The sample size was determined at the end of the collection process.

2.3. Data Collection, Analysis

We collected data after obtaining research authorizations from the Regional Public Health Delegate for the Littoral region as well as from the Directors of the health facilities. We used a questionnaire to collect variables related to specific objectives and included socio-professional data (age, sex, health facility, occupation, seniority), the working conditions (work organisation, work zones, lead apron, frequency of exposure), the preventive measures (radioprotection officer, safety equipment's) and medical monitoring (frequency). The data was recorded using EPI INFO 7.0 software, processed and presented in descriptive form according to the type of variable and the specific objectives of the study. Meaningful associations were sought out between the variables of interest using Chi-squared and Fisher tests with an error threshold of 5% and significance level of $p < 5\%$.

2.4. Ethical Considerations

The study was conducted in strict compliance with the fundamental ethical principles for human health research in Cameroon. Ethical clearance N˚ 1214 CEI UDo/01/2018/T was granted by the Institutional Ethics Committee of the University of Douala. The rights, dignity and privacy of each participant were respected. A great care was taken to protect the confidentiality of participants' individual data.

3. Results

The sample was made up of participants working in 10 health facilities, mainly in the public sector.

3.1. Socio-Professional Characteristics of Participants.

The sample consisted of 87 volunteers, including 56 men (64.4%) and 31 women (35.6%), giving a sex ratio of 1.80 men/1 woman. The mean age was 34.75 ± 8.77 years (24 years - 63 years). The modal age group consisted of participants aged

under 30 years (45.98%). The overwhelming majority of participants (93.1%) worked in public health facilities. They included 36 radiology technicians (41.38%), 18 nurses (20.69%) and 9 doctors (10.34%). Their average professional seniority was 6 years (1 - 29 years) which was higher in the public sector [M = 6 ± 6.2 years; (1 - 29 years)] than in the private sector [M = 4 ± 1 year; (2 - 5 years)]. Socio-professional characteristics are shown in Table 1.

Table 1. Sociodemographic characteristics of participants.

Variables		(n)	(%)
Sex	Féminin	31	35.63
	Masculin	56	64.37
Age	≤30 ans	40	45.98
	31 - 40 ans	28	32.18
	41 - 50 ans	13	14.94
	> 50 ans	6	6.90
Health facility	Private	6	6.90
	Public	81	93.10
Occupational category	Radiology technician	36	41.38
	Other	18	20.69
	Nurse	18	20.69
	Medical Doctor	9	10.34
	Administrative staff	3	3.45
	Cleaner	3	3.45
Category of the health facility	1st category	45	51.72
	2nd category	15	17.24
	4th category	17	19.54
	Other	10	11.49

3.2. General Working Conditions

- *Work pattern*

The alternating day/night work schedule is the main form of organization used by the majority of participants (68.96%).

- *Layout of work areas*

The separation of the workplace areas into zones A (exposure level greater than 6 mSv) and B (exposure level less than 6 mSv) was known by almost all the participants.

- *Knowledge of the emergency procedure*

The emergency plan was displayed and known by the majority of participants (80.46%).

3.3. Preventive and Radioprotection Measures

The level of compliance versus radioprotection measures was low (21.8%) or medium (46%). Usage patterns were as follows.

- *Compliance with radiation protection standards*

The participants confirmed the setting up of protection measures such as: the strengthening of leaded walls in zones A and B (88.51%), the location of administrative premises outside work zones A and B (80.46%), the effectiveness of hazard signs in work areas (75.86%), and the presence of ambient dosimeters (9.20%). The participants refused to disclose the monitoring results for confidentiality issues. Hence, we cannot assume the safety of these workplaces for the patients and health workers.

- *Radiation protection officer*

The presence of a radiation protection officer in the work area was confirmed by seventy-three participants (83.91%).

- *The radioprotection apron*

The anti-radiation protective apron was used by almost all the sample (94.25%). Usage patterns were illustrated in Figure 1 as follows: systematic (36.78%), occasional (52.87%) or rare (10.34%). Of the 5 participants (5.75%) who did not have one, all worked in public health facilities.

- *Hand-held dosimeter use*

A total of fifty-five participants (63.20%) used a passive portable dosimeter in the course of their activities. Those from public hospitals used them continuously (92.73%) and 68.96% reported monthly readings.

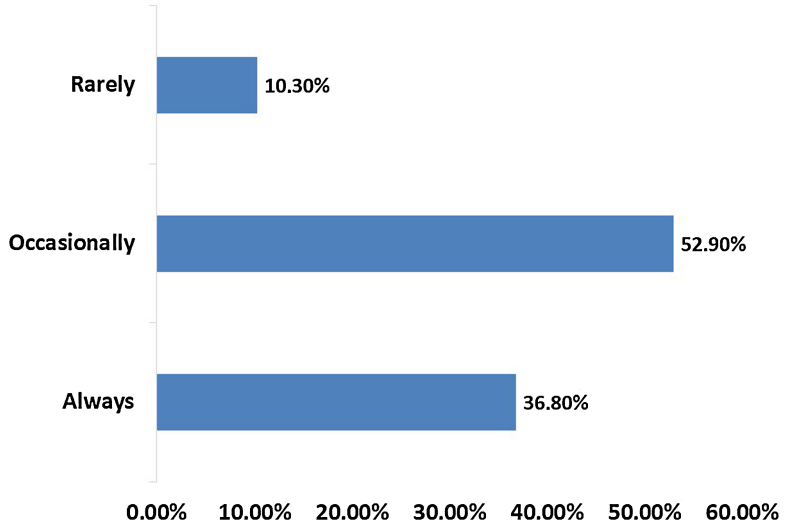

Figure 1. The use of the radioprotective apron.

3.4. Medical Monitoring

The majority of participants (62.1%) did not receive medical follow-up from an occupational physician. Only 10 (11.49%) of the beneficiaries had an individual medical monitoring card. The benefits received are illustrated in Table 2.

Table 2. Type of occupational health services.

Occupationnal health services	(n)	(%)
Pre-employment medical check	18	20.69
Periodic medical check	15	17.24
Medical check on request	12	13.79
Health and safety training	9	10.34
Job related medical examinations	6	6.89

4. Discussion

4.1. Limitations

The Covid-19 health crisis has had a serious negative impact on global economy and national health systems, including the priorities in research. With the return of normalcy, it was noted that the issues identified in our research in 2018 remained relevant and deserved to be shared with the scientific community for academic purpose and public health improvements. The main limits of the study consisted on the refusal of some managers and staff to participate in the study, nor to disclose their level of exposure for confidentiality issues.

4.2. Comparative Results

- Socioprofessional characteristics

There was an over-representation of men in our sample (64.37%) as well as in the sample of Ongolo-Zogo *et al.* in Yaounde (64%) [18]. Meanwhile women were over-represented in the Jaouad sample in Morocco (54.3%) [19]. Results showed that the participants were young, with an average age of 34.75 ± 8.77 years. This average age which was lower than that of their colleagues in the public hospitals of 1^{sr} and 2nd category in Yaounde (38.8 ± 7.7 years) [18]. Our study revealed an over-representation of participants under 30 years of age (45.98%), in contrast to the findings of Mbo Amvene *et al.* in which participants in their thirties were overrepresented (62.9%) [20]. The younger the modal age group, the more relevant the study is to reproductive health. Failure to comply with preventive and radiation protection measures could lead to accidental exposure of workers and endanger their reproductive health through irradiation of the germ cells of the effector organs [6] [21]. With respect to the occupation, radiology technicians were over-represented in our study (41.4%) compared with that of Mbo Amvene *et al.* (25%) [20]. On the other hand, the under-representation of physicians (10.3%) in the sample could be explained by the low rate of radiologists at national level [22] and the reluctance of medical staff to participate in health research in Cameroon [23]. The professional experience of the participants was low (6 years), comparable to that of participants not stackable in the study by Ongolo-Zogo *et al.* in Yaounde, which was lower than 5 years (63.9%) [18].

- Working conditions

The only recommended option for workers directly exposed to ionizing

radiation is to practice active primary prevention. Optimal working conditions must be provided and work activities must be organized according to controlled work zones (zone A & zone B). In accordance with radioprotection rules, these work zones must be known to all workers in the department and clearly marked with conventional safety pictograms. Almost all the participants (87.5%) were aware of the distribution of these zones, and 68.8% had taken part in defining them. In hospitals in the Far North region of Cameroon, the boundaries between A&B work zones were not delineated in the radiology departments [20], creating a real safety risk for healthcare workers and users of these facilities. Furthermore, this failure also constitutes a professional offense for employers, who must inform and protect users against this physical risk in accordance with Order No.039/MPTS on general health and safety measures in the workplace [24]. This risk of accidental overexposure could occur at any moment, but more specifically during night shifts, performed in small teams by some participants. Indeed, night work lengthens response time and increases the risk of error by omission among care workers [25]. For this category of workers (68.96%), vigilance should be stepped up during night shift to avoid work-related accidents, which are more frequent during this period [26], and whose consequences for their health and that of users are well known. The regulations on radioprotection recommend that the emergency procedure in the event of overexposure to X-rays should be displayed and users made aware of it. The emergency procedure in the event of accidental overexposure to X-rays appears on the notice board, but is known by only 70 participants (80.46%), hence the need to increase awareness and organize refresher courses to optimize knowledge of the emergency procedure in accordance with the ILO's recommendations concerning the promotion of the right to safety and health of workers exposed to radiation [14].

- Prevention and protection measures

On the whole, the level of compliance with radiation protection measures was low (21.8%) or average (46.0%), reflecting non-compliance with decree 039/1983 on health and safety rules in the occupational environment [24]. This hazardous situation could be explained by many contributing factors such as the lack of investment regarding general safety/radioprotection, the unavailability of safety equipment's and safety devices, the ignorance or refusal to comply with work procedures, and the lack of safety training.

-Collective measures

There is a wide range of preventive and protective measures in test hospitals. One of the main measures is to indicate the hazards to which staff and users are exposed. This preventive measure, which is a legal requirement, was effective in public hospitals in Yaounde (73.1%) [18], but was absent from radio diagnostic departments in health facilities in the Far North of Cameroon [20].

In Cameroun and other countries around the world, radioprotection is a legal requirement. In 2013, Ongolo-Zogo *et al.* estimated that the status of radioprotection was worrying in several African countries due to the weakness of

radioprotection laws, regulations and bodies [18]. Even though, the situation has improved with the adoption of legal texts in several sub-Saharan African countries [27]-[30], the average level of knowledge of radioprotection remains low for 93.41% of TADR workers in this region [31]. As the ongoing economic crisis continues to impact the national health system, a great attention should be given to the quality of services in other to prevent the adverse consequences of X-Ray exposure. Considering the dangers and consequences of such situations, state or private legal advisors should develop efficient safety policies, safe operating procedures and safety trainings to cover these issues. In the other hand, government inspectors must also reinforce the frequency of controls and implement the necessary sanctions against the non-compliant managers and health facilities as per the law. These sanctions include fines, suspension of managers, as of temporary or permanent closure of the non-compliant health facilities.

It is essential to implement radiation protection measures to ensure a safer use of ionizing radiation [13] and to prevent any damage to the health of users and staff working in the vicinity of ionizing radiation sources. Some of these measures are under the responsibility of radiologists [32] and the occupational physician who is the main actor in radioprotection, due to his multiple roles such as clinician, advisor, consultant, auditor, expert and manager [33]. Hence, compliance with collective radioprotection standards was reflected in the effective separation of high-risk activity areas from administrative premises in accordance with national legislation [34], which has been confirmed by 4 out of 5 participants (80.46%), and the reinforcement of walls with lead in zones A and B (88.51%). The use of lead sheeting in the construction of walls is a legal requirement at both national [35] and international [14] level to protect staff and users from ionizing radiation.

The appointment of a radioprotection officer (RPO) is recommended to promote radiation protection measures and apply the ALARA concept to work activities [17] [36]. The RPO is an expert trained in radioprotection, and specific training has been compulsory in France since 2009 [13]. In Cameroon, the presence of RPO's was confirmed by 73 participants (83.91%) in our study and refuted by 60.2% of participants (60.2%) in the study by Ongolo-Zogo *et al.* in Yaounde [18], but no RPOs were available in health facilities in the Far North of Cameroon according to Mbo Amvene *et al.* [20]. Elsewhere, the presence of RPO's varied from country to country. There were 01 RPO in 1/6 facilities surveyed in Abidjan in 2005 [27], 01 RPO in the 17 radiology departments in operation in Ouagadougou in Burkina-Faso [28] and 154 RPO's among the 181 health facilities set up in Ile de France in 2002 (85.08%) [37]. At Marrakech in Morocco, 82% of staff claimed that there were means of signposting and delimiting work areas and the role of the RPO was performed by the director of the institution, the CNRP or the occupational physician (54%) [19]. Environmental monitoring using fixed dosimeters varied according to the type of health facility. Compared with other health facilities, environmental monitoring was more widespread in public health facilities.

The authorities responsible for monitoring radiation protection carry out regular checks.

-Individual measures

Effective now, all users of ionizing radiation for diagnostic or therapeutic purposes must be able to demonstrate proof of having received a safety training in radioprotection and should be able to introduce practice dose estimation for each examination carried out [13]. The availability of a radioprotection apron was almost systematic in our study (94.3%), as in Abidjan (97.5%) [27] and Ouagadougou [28]. Apron use was nearly universal; almost systematic in Marrakech [19] and Ouagadougou [28], average in our study (52.9%) and irregular in Ibn Sina (33.33%) [38]. This result indicates non-compliance with personal protective measures, which endanger their health through "voluntary" and unconscious exposure to X-rays. Personal exposure of workers was monitored using a hand-held dosimeter, which was worn almost constantly (92.73%) by 55 participants (63.2%). In Abidjan, these dosimeters were worn by the majority of workers in the study (52.5%) [27], while in Ile de France, the regularity with which portable dosimeters were used ranged from 90% to 50% depending on the hospital [37]. In Morocco, the portable dosimeter was being worn by 65.7% of staff in Marrakech [19] and 42.42% in Ibn Sina [38]. In contrast, personal dosimetry was non-existent in radiology departments in the Far North of Cameroon [20].

- Medical monitoring

The medical surveillance of workers exposed to X-rays is the responsibility of the occupational physician [39]. The frequency of monitoring is defined in the laws of each country, and combines both clinical and para-clinical components depending on the characteristics of the workstation and the worker's level of exposure [36]. Moreover, more than 3 out of 5 participants (62.1%) did not benefit from medical monitoring by an occupational physician, which raises a problem of compliance with the legal duty of employers to ensure medical monitoring of the workers for whom they are responsible. According to the Cameroon Labour Code and Executive order 039/MTPS/IMT laying down general health and safety measures in the workplace, employers are obliged to provide medical follow-up for workers exposed to known risks [24]. Ongolo-Zogo also reported a low rate of periodic medical check-ups in Yaounde (4.2%) [18], whereas the annual follow-up rate for category A workers was higher in France (54%), according to INRS [37]. Concerning the preemployment medical check, we noted similar low trends in our study (17.24%), as in Abidjan (22.1%) [27], in Ouagadougou (5.9%) [28] and in Cotonou (5.71%) [40]. The results of table II confirm the poor quality of medical monitoring of workers exposed to X-rays in Yaounde in 2016 [41], with possible adverse effects on the transmission of individual data needed to draw up curricula laboris. On the other hand, the low number of holders of individual monitoring cards (11.50%) and the unavailability of monitoring results suggest that future difficulties will be encountered when it comes to establishing causal links between work and pathologies that workers previously exposed to X-rays

may present in the future.

5. Conclusion

In Douala, staff exposed to ionizing radiation were radiology technicians in their thirties and were all male. They worked primarily in controlled Zone A in premises where compliance with radiation protection measures was poor (46.0%). Collective preventive and radioprotection measures were as follows: reinforcement of walls in Zones A and B (88.51%), the presence of a senior radiation protection officer (83.91%), outsourcing of administrative premises outside work Zones A and B (80.46%), effective signposting of hazards in work premises (75.86%), and a low presence of ambient dosimeters (9.20%). The use of radioprotection aprons was frequent in state hospitals, but irregular, and portable dosimeters were used permanently (92.73%) by 62.1% of participants. Medical monitoring was inadequate for the majority of participants (62.1%) and was of poor quality. The radiation protection situation remains worrying in state and private health facilities in Douala, and appropriate solutions must be found quickly to prevent serious health consequences for exposed staff.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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