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Radiation Exposure of Personnel Categories at the Center of Oncology and Hematology at Mohammed VI Hospital in Marrakech

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Authors' contributions

This work was carried out in collaboration among all authors. Authors BA and SS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AEK, OKH and AC managed the analyses of the study. Author MA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Objective: This study aims to estimate the annual doses for personnel categories following their exposure to ionizing radiation during their occupation in the external radiotherapy department of the Center of Oncology and Hematology (COH) at Mohammed VI Hospital in Marrakech.
Materials and Methods: Operational dosimeters PACK MGP DMC 3000 were used to measure the dose rates around the machines operating with ionizing radiation. In order to assess the reliability of the measurements made by these dosimeters, they were checked against measurements made at the same position by the Inspector detector. The annual effective dose was calculated by multiplying the average dose rate measured during a procedure by the overall treatment time throughout a year.

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Results: Regarding the reliability check of the measuring instrument, the recorded error is between 2 and 10% with an average of 7%. For personnel category A, the measured dose rate ranges from 0.066 to 0.083 µSv/h, with an average value of 0.075 µSv/h. For category B, it varies between 0.066 and 0.083 µSv, with an average value of 0.092 µSv/h. It is 0.074 µSv/h for category C. The annual dose for category A ranges from 0.089 to 0.113 mSv/year, with an average value of 0.101 mSv/year. For category B, it varies between 0.089 and 0.113 mSv/year, with an average value of 0.100 mSv/year. It is 0.100mSv/year for category C.
Conclusion: The annual effective doses to personnel categories, assessed by this study, are very low compared to the regulatory standards set by the International Commission on Radiological Protection (ICRP). As a result, workers benefit from good radiation protection conditions within the Center of Oncology and Hematology at Mohammed VI Hospital in Marrakech.

Keywords: Medical exposure; annual dose; personnel categories; radiotherapy.

1. INTRODUCTION

Ionizing radiation has many useful uses in many fields. In medicine, X-rays are used to diagnose internal diseases and injuries. Nuclear medicine specialists use radioactive products as tracers to form detailed images of internal structures and to study metabolism. There are radiopharmaceuticals available to treat diseases such as hyperthyroidism and cancer. Radiation therapists use gamma rays, electron beams, neutrons and other types of radiation to treat cancerous tumors. The medical use of radiation represents 98% of the dose of artificial origin received by the population from all artificial sources and 20% of the total exposure of the population. Every year, more than 3.6 billion diagnostic radiology examinations are performed worldwide, 37 million nuclear medicine procedures are performed and 7.5 million radiotherapy treatments are performed [1]. Health professionals are often exposed to low doses of ionizing radiation. The radiation absorbed by the body causes cellular changes that can increase the risk of cancer and hereditary effects [2]. More specifically, there is two categories of adverse health effects of radiation exposure. Deterministic, short-term effects directly related to cellular damage for which a threshold of onset has been defined [3]. Stochastic, random effects, which are long-term probabilistic consequences, in an individual or in his offspring, of the transformation of a cell [4]. It is therefore important for workers to limit their exposure to radiation in the workplace. The effective dose is used to measure ionizing radiation in terms of its impact on human health. The Sievert (Sv) is the effective dose unit that takes into account the type of radiation and the sensitivity of tissues and organs. In 1987, the International Labor Organization identified two worker categories: Those who are engaged in radiation work and others not engaged in radiation work, but who might be exposed to radiation because of their work [5]. The second category is treated as members of the public in term of restricting their exposure to radiation. The effective dose limit for public exposure is 1 mSv/year. The occupational physician classifies exposed workers into a category A (likely to receive a dose of between 6 and 20 mSv per year) or B (likely to receive a dose of between 1 and 6 mSv per year) [6]. Category A or B workers benefit from enhanced preventive measures: Enhanced medical surveillance, individual dosimetric surveillance, mandatory radiation risk training, post-occupational surveillance for category A workers. Any pregnant woman should be removed from category A or B position during pregnancy, hence the need to report its pregnancy as soon as possible. Based on the ICRP and the IAEA publication, the effective dose limit for occupational exposure is 20 mSv/yr, averaged over five consecutive years (100 mSv in 5 years) yet not more than 50 mSv in any single year [7]. The annual equivalent doses to the lens of the eye, to the skin and to the hands and feet are 20, 500 and 500 mSv, respectively. In Morocco, The medical uses of ionizing radiations continue to increase. To date, there are 800 installations with 1100 X-ray devices for conventional and interventional radiology. Nearly 2,000 installations with 3,000 X-ray machines are designed for dental radiology. For radiotherapy and brachytherapy, there are 24 facilities with 35 accelerators, 1 Gamma-knife and 12 sources of High dose-rate (HDR) brachytherapy. In addition, 22 facilities, including 11 radioiodine therapy facilities, are equipped for nuclear medicine practices [8]. For all this, rigorous monitoring of the occupational medical radiation exposure within health facilities seems very necessary. The scarce studies, at the national level, on

exposure to ionizing radiation of various categories of personnel working in medical facilities was the reason for undertaking this study [9-14]. The objective of this study is to estimate the annual dose to personnel categories in the Center of Oncology and Hematology (COH) at Mohammed VI Hospital in Marrakech.

2. MATERIALS AND METHODS

This quantitative descriptive study aims to evaluate the dose received by practitioners in the radiotherapy department.

2.1 Materials

Eight operational dosimeters PACK MGP DMC 3000, an Inspector detector and a MKS-05 TERRA Survey meter were used to compile and carry out dose rate and annual dose rate measurements during this study:

- A dosimeter PACK MGP DMC 3000 records the dose to workers using an integrated sensor. It can measure X-rays and gamma rays and can also be used in nuclear medicine.
- An Inspector detector uses a Geiger-Muller tube to detect radiation. It is ideal for detecting low radiation levels and measuring alpha, beta, gamma and x-rays. Every time a radiation passes through the halogen in the tube, an electrical pulse is generated and recorded as a count. A measurement is more precisely expressed as an average over time, and this average is more accurate over an extended period.

2.2 Annual Dose Exposure

The annual dose D_r to personnel in the radiotherapy department of COH at Mohammed VI Hospital in Marrakech is a function of the average dose rate D_m measured during a procedure and the overall treatment time T:

$$D_r = D_m \times T$$

The average number of patients N_d treated per day is 35 and 700 per month. If integrated throughout the year, this number could reach 8400 patients treated. Practically, the average treatment time (t_t) per patient in the radiotherapy unit is 10 minutes. The overall treatment time (T_t) is then estimated at 1400 hours per year ($T_t = t_t \times N_d$).

2.3 Data Analysis

Microsoft Office Excel 2013 software is used to perform the dose rate data analysis and annual dose calculations.

3. RESULTS

Dose rate measurements around the treatment rooms and the surrounding areas are carried out in the COH at Mohammed VI Hospital in Marrakech. The purpose is to assess the annual exposure to ionizing radiation of personnel categories.

Before taking dose rate measurements and in order to assess the reliability of the measurements to be made by a dosimeter PACK MGP DMC 3000, we checked these measurements against those made at the same positions by the Inspector detector.

Dose rates measurements were taken simultaneously at the same location by the two measuring devices. The recorded error is between 2 and 10% with an average of 7% (Table 1). This is due to the uncertainties related to the different circumstances and features of the measuring devices. This comparison ensures that measurements with operational dosimeters are reliable.

Table 1. Dose rates simultaneously taken at the same location by two different measuring devices

Measuring device / Measurement point	PACK MGP DMC 3000 dosimeter D_1 (µSv/h)	Inspector D_2 (µSv/h)	Difference (D_2 -D_1) (µSv/h)	Error (%) P%=($\frac{D_2 - D_1}{D_1}$) ×100
Accelerator 1 control panel	1	1.08	0.08	8.00
Dosimetry room	1	1.09	0.10	10.00
Dosimetric scanner control Desk	1	1.02	0.02	2.00

The dose rate measured for personnel in category A ranges from 0.066 to 0.083 μSv/h, with an average value of 0.075 μSv/h. For personnel in category B, it varies between 0.066 and 0.083 μSv/h, with an average value of 0.092 μSv/h. It is 0.074 μSv/h for personnel in category C (Table 2).

The estimated annual dose for the personnel in category A ranges from 0.089 to 0.113 mSv/year, with an average value of 0.101mSv/year. For personnel in category B, it varies between 0.089 and 0.113mSv/year, with an average value of 0.100mSv/year. It is 0.100mSv/year for personnel in category C (Table 3).

4. DISCUSSION

Daily dose rates measurements were carried out at different sites and areas in the external radiotherapy department of the COH in Marrakech (Table 1). The values obtained were then used to estimate the annual doses to different personnel categories.

The average annual dose likely to be received by the three personnel categories in the external radiotherapy department of the COH in Marrakech is about 0.1mSv/year (Table 2). The shielding in the surrounding areas is well designed and as a result, the exposure is very low in all the measured areas.

Fig. 1 shows a comparison between the annual dose estimated to personnel category A in the external radiotherapy department of the COH in Marrakech and doses in international surveys [15,16] as well as the regulatory standard.

The estimated annual dose to personnel category A in the external radiotherapy department of the COH in Marrakech is well below the UNSCEAR values for the annual average effective doses for the period of 2000-2002 in Japan and Canada, which are 1.33 and 1.16 mSv/year, respectively [15]. It is also below 0.64 mSv/year assessed by the European study on occupational radiation exposure for European countries [16]. It is no more than the values evaluated in Southern Nigeria for radiology departments' staff [17] and at the external radiotherapy department of the Regional Center for Oncology in Agadir, Morocco [10], which are 0.32 and 0.19 mSv/year, respectively. In addition, it makes only 0.5% of the annual dose limit for personnel category A, which is 20 mSv/year [6].

Table 2. Average dose rates for the three personnel categories of the COH in Marrakech

Categories	Site	Average dose rate in (μSv/h)
Category A	Accelerator 1 control panel	0.066
	Accelerator 2 control panel	0.083
	Dosimetry room	0.083
	Dosimetric scanner control desk	0.066
Category B	Rest room	0.066
	Medical consultation room	0.072
	Meeting room	0.083
	Operating room	0.083
	Secretariat	0.066
Category C	Waiting area	0.074

Table 3. The estimated annual doses for the three personnel categories of the COH in Marrakech

Categories	Site	Annual dose in (mSv/year)
Category A	Accelerator 1 control panel	0.089
	Accelerator 2 control panel	0.113
	Dosimetry room	0.113
	Dosimetric scanner control desk	0.089
Category B	Rest room	0.089
	Medical consultation room	0.097
	Meeting room	0.133
	Operating room	0.113
	Secretariat	0.089
Category C	Waiting area	0.100

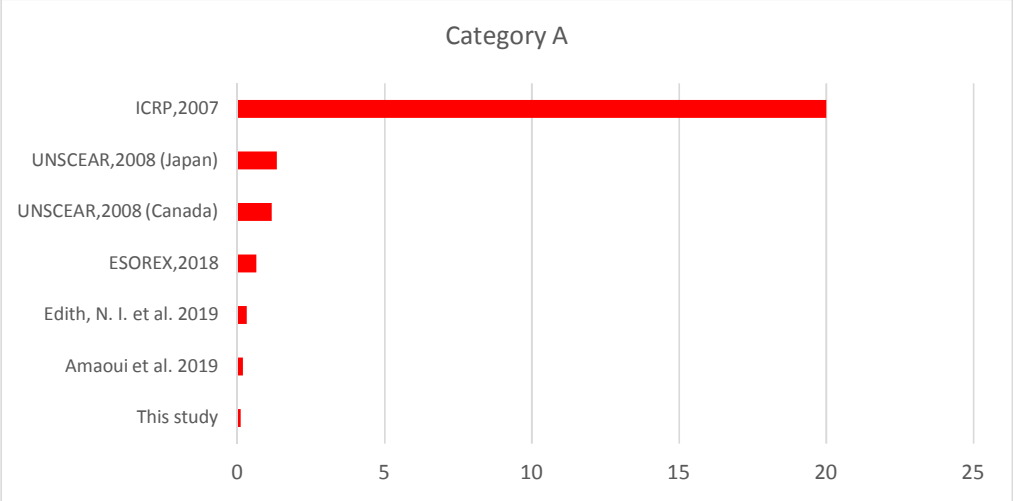

Fig. 1. Average annual effective dose (mSv) to personnel in category A compared to international surveys and the regulatory standard

Fig. 2 shows a comparison between the annual dose estimated to personnel category B in the external radiotherapy department of the COH in Marrakech and doses in international surveys [15,16] as well as the regulatory standard.

The estimated annual dose to personnel in category B in the external radiotherapy department of the COH in Marrakech is comparable to the UNSCEAR values for the annual average effective doses for the period of 2000-2002 in Japan and Canada, which are 0.34 and 0.09 mSv/year, respectively [15]. It is lower than 0.13 mSv/year presented by the European study on occupational radiation exposure for European countries [16]. It is almost in the same range with the results presented in Southern Nigeria [17] and Agadir in Morocco [10], which are 0.03 and 0.14 mSv/year, respectively.Furthermore, this value is less than 2 % annual dose limit (6 mSv/yr) for category B workers [6].

Fig. 3 shows a comparison between the annual doses estimated to individuals of personnel in category C in the COH in Marrakech around the external radiotherapy department and doses assessed in similar previous studies on national level [9,10] as well as the regulatory standard.

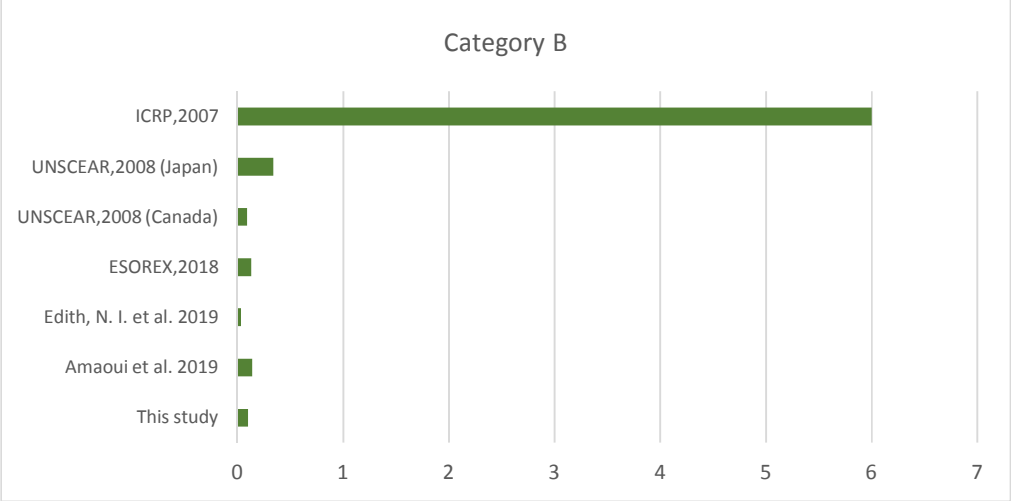

Fig. 2. Average annual effective dose (mSv) to personnel in category B compared to international surveys and the regulatory standard

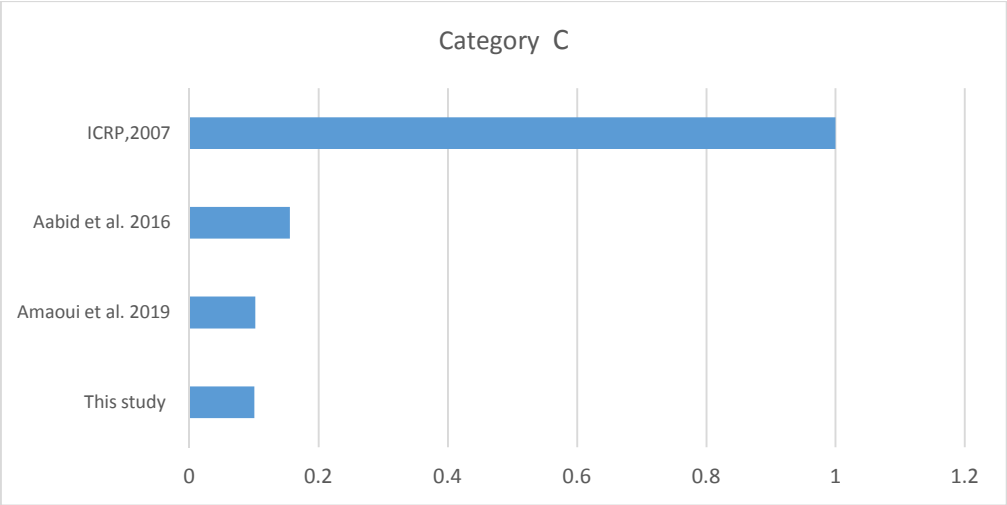

Fig. 3. Average annual effective dose (mSv) to personnel in category C compared to previous studies and the regulatory standard

The annual dose likely to be received by personnel in category C is 0.100 mSv/year in COH of Marrakech. For the Regional Center of Oncology (RCO) in Agadir, it was 0.102 mSv/year [10]. In the National Center for Rehabilitation and Neuroscience (NCRNS) of Rabat, it was 0.155 mSv/year [9]. The annual exposure to individual personnel in category C is almost the same in the three different studies, with a slight increase for the study in the NCRNS. This dose value represents 10% of the dose limit for category C individuals or the public exposure, which is 1 mSv/year.

5. CONCLUSION

New medical techniques using ionizing radiation are continually developing to deal with different kinds of cancer and other complicated diseases. Stringent monitoring of medical radiation exposure in health care facilities seems very necessary. During this study, dose rate measurements were performed in the external radiotherapy department of the Center of Oncology and Hematology at Mohammed VI Hospital in Marrakech. The measured dose rates are then used to estimate the annual doses to different personnel categories in the external radiotherapy department and its surrounding areas. The annual effective dose likely to be received by the three personnel categories is in order of 0.1 mSv/year. This value is very low compared to previous studies, international surveys and the regulatory standards for the occupational exposure implemented by the International Commission on Radiological Protection (ICRP). As a whole, personnel categories at the Center of Oncology and Hematology at Mohammed VI Hospital in Marrakech are far from being exposed to significant levels of medical radiations. However, an awareness strategy based on periodic and continuous training sessions in radiation protection must be implemented in the healthcare facilities in order to improve practitioners' knowledge and prevent any possible over exposure.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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