First assessment of individual monitoring of medical workers occupationally exposed to ionizing radiation in Burkina Faso

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Abstract. This paper reports the results of monitoring of medical workers occupationally exposed to ionizing radiation as a consequence of exposure to X-rays, from 2007 to 2010, in Burkina Faso. The radiation exposure monitoring was made with thermoluminescent dosimeters (TLD-100) type 0110 and the reader used was Harshaw 4500. The medical establishments subscribers were provided with personal dosimeters (measuring Hp(10) and Hp(0.07)) and dosimeters for background and workplace exposure (H*10) measurement. The dosimeters have been worn for periods of 2 months each. The number of establishments subscribed and workers monitored has gradually increased from 4 radiology establishments with 13 workers monitored at September 2007 to 23 subscribers with 121 workers monitored at the end of April 2010. 13 establishments were still working without monitoring. From September 2007 to April 2010, no individual annual dose limit has really been reached. 88.16% of the 2 months dose values of personal dosimeters were below 0.1mSv, the detection limit and 96.61% of Hp(10) bimonthly values were below 3.33mSv. The workplace exposure monitoring values were often low (varying from 0.00mSv to 40.45mSv). 87.08% of the values of H*(10) were below 3.33mSv, the upper limit of Hp(10) for a period of 2 months. Low values of individual dose have also been recorded despite of high values of workplace monitoring. This allowed to state that the workers monitored were not exposed to a major risk.
Nevertheless, 13 TLD have been lost and 3 damaged by subscribers (out of 1504 TLD provided). 26 times (out of 240), background measurement and workplace exposure monitoring dosimeters have been placed at the improper location. Therefore, sensitization of the establishments using ionizing radiation should be reinforced and the national regulations should impose radiation monitoring.

KEYWORDS: Radiation protection, ionizing radiation, TLD, monitoring, Burkina Faso.

1. Introduction

The ionizing radiation, in Burkina Faso, is used primarily in the medical field, particularly for radiodiagnosis. Exposure is thus due to X-rays.

In 2006, the Radiation protection department of the National Public Health Laboratory (LNSP) has conducted an inventory of ionizing radiation emission sources in all the health regions across the country [1]. 36 radiology establishments employing 157 workers exposed have been identified, mainly electroradiology technicians. Assessments of work conditions of these workers have been made which helped to accept that the radiation risk is real and is not under control. The Radiation protection department of LNSP then has developed its monitoring programme with the aim of preventing the risk of overexposure and complying with radiation protection requirements. Measurement of workers and workplace exposure has been a great part of this programme.

"The primary justification for measurement must be found in the way in which it helps to achieve and demonstrate adequate protection, including implementation of optimization of protection." [2]

The main objective of this study was to assess the workers' protection level and the respect of good practices by workers occupationally exposed to ionizing radiation in medical imaging in Burkina Faso.

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2. Methodology

2.1 Equipment used

The radiation exposure measurement was made with thermoluminescent dosimeters (TLD), TLD-100 with LiF:Mg,Ti material. The cards type was 001A1A00-00151500-A (i.e. 0110), silver and the holders type, 8814 black/white. The cards reader used was the Harshaw TLD reader model 4500. Nitrogen supply was provided by nitrogen generator Nitrox UHPN 2501 and for local calibration purpose, Thermo irradiator model 2210 with $^{90}Sr/^{90}Y$ source was used.

2.2 Subscription

The sensitization of workers and their employers has occurred through meetings and other communication channels (phone, letters, etc.) for the subscription to monitoring. Some documents explaining monitoring procedures and the subscription forms have been provided to employers.

The subscription was made through forms filled by subscribers and sent back to LNSP for treatment prior to monitoring. Every employer has therefore his database created and updated at LNSP.

The workers who were employed in more than one establishment have been monitored as different persons for these establishments.

2.3 Monitoring method

2.3.1 The laboratory of dosimetry

The method used in the dosimetry laboratory was the one described by the provider of the equipment.
Dosimeters have been annealed, calibration cards generated, reader (Time Temperature Profile) and cards calibrated.
Calibration with assistance of SSDL has been conducted three times, twice in 2007 with IAEA's SSDL and Tunis SSDL, once with Algiers SSDL in 2009. Three blind tests have been performed respectively once with Tunis SSDL (2007) and twice with Algiers SSDL (2008 and 2009). The results were considered satisfactory.

The medical establishments subscribed have been provided with personal dosimeters and other dosimeters for background and workplace exposure (H*(10)) measurement.

The results were interpreted and sent anonymously to employers and the decoding made by the designated person of the radiology department.

2.3.2 The workplace

According to the IAEA Safety Guide No. RS-G-1.3 [3], "exchange frequencies can range from daily, in special operations, to every six months, if the exposure is expected to be very low, but exchange periods of one to three months are typical". So during the national meeting of restitution of our investigation results mentioned above [1], we decided, by mutual agreement, to adopt a period of two months.

The dosimeters were worn on the front of the torso, between the shoulders and the waist, for individual monitoring purpose. The quantities measured were therefore Hp(10) and Hp(0.07). In this paper, emphasis is laid on Hp(10) due to its low limit and the lack of activities using beta particles or involving specially high exposure of skin and extremities in Burkina Faso.
"Measurement of Hp(10) is often sufficient to assess a worker's exposure. However, if the radiation field contains significant amounts of weakly penetrating radiation (such as beta particles, or photons of low energy below 15keV), Hp(0.07) may be comparable with or significantly larger than, Hp(10); for those fields, the dosimeter should be capable of measuring the dose equivalent at a depth of 0.07mm.

In radiation fields where only photon radiation is important, it is usually sufficient to measure only Hp(10)". [3]

The ambient dose measurement has been made with background measurement dosimeter hung in the office of the radiology department's head and workplace exposure measurement dosimeter hung permanently at the shielded screen on the apparatus side. Aim was to provide an upper limit of the equivalent dose received by workers. In that case, it was assumed that a person would be located for the entire working time in that part of the workplace.

3. Results

3.1 Number of establishments and workers monitored

The monitoring started in September 2007 with four (04) radiology establishments subscribed and 13 workers monitored. The number of establishments subscribed and workers monitored gradually increased and, at the end of April 2010, we had 23 subscribers (within which 11 are located in Ouagadougou the capital and 12 in other locations across the country) with 121 workers monitored. Distribution of workers monitored by gender and profession is given in Fig. 1. Up to 13 establishments (36.11%) were still working without monitoring. Subscription fluctuations are reported by Fig. 2.

Figure 1: Repartition of workers by gender and profession

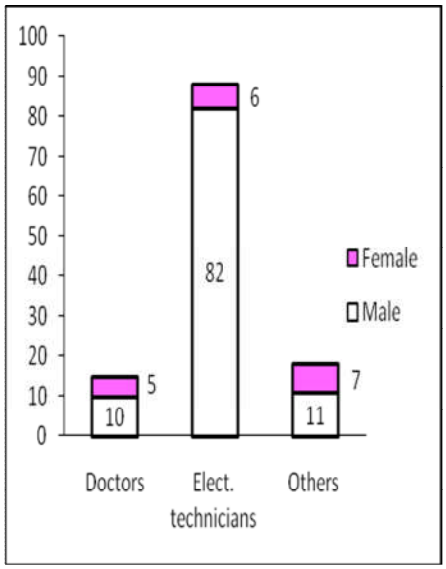
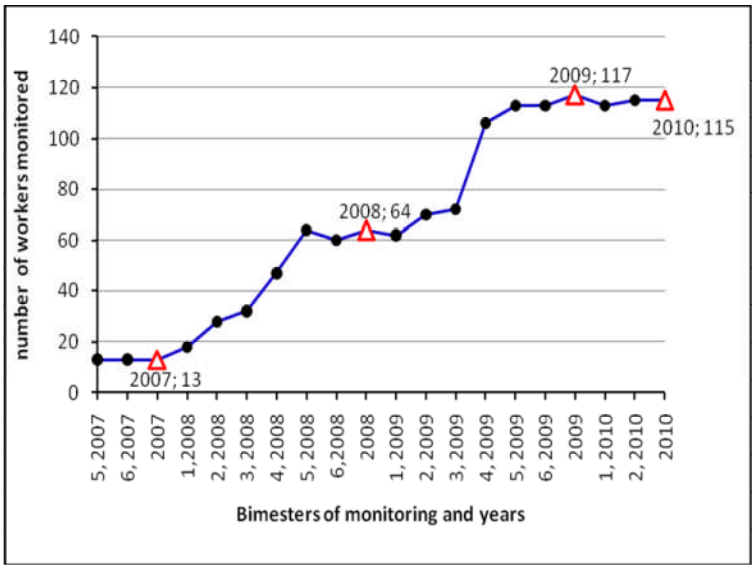


Figure2: Evolution of number of workers monitored every 2 months (●) and synthesis per year(Δ).



3.2. Compliance with dose limits

From September 2007 to April 2010, no individual annual dose limit, according to the IAEA BSS 115 [4], has absolutely been reached. Nevertheless, the dose limits in accordance with the length of each monitoring period were sometimes exceeded. A dose value of 42.84mSv has even been recorded during a two months period (Table 1).

Table 1: Number of Hp(10) annual values per year and per class.

Classes of Hp(10) (mSv) for 1 year	Years				Total	%
	2007	2008	2009	2010		
0	8	45	77	87	217	70.23
0.1 - 1	4	16	32	25	77	24.92
1.1 - 2	1	2	3		6	1.94
2.1 - 3			1		1	0.32
3.1 - 4				2	2	0.65
4.1 - 5			1		1	0.32
5.1 - 6			1		1	0.32
6.1 - 7		1			1	0.32
7.1 - 8				1	1	0.32
…					0	0.00
11.1 - 12			1		1	0.32
…					0	0.00
>20			1 (42.84)		1	0.32
Total	13	64	117	115	309	100.00

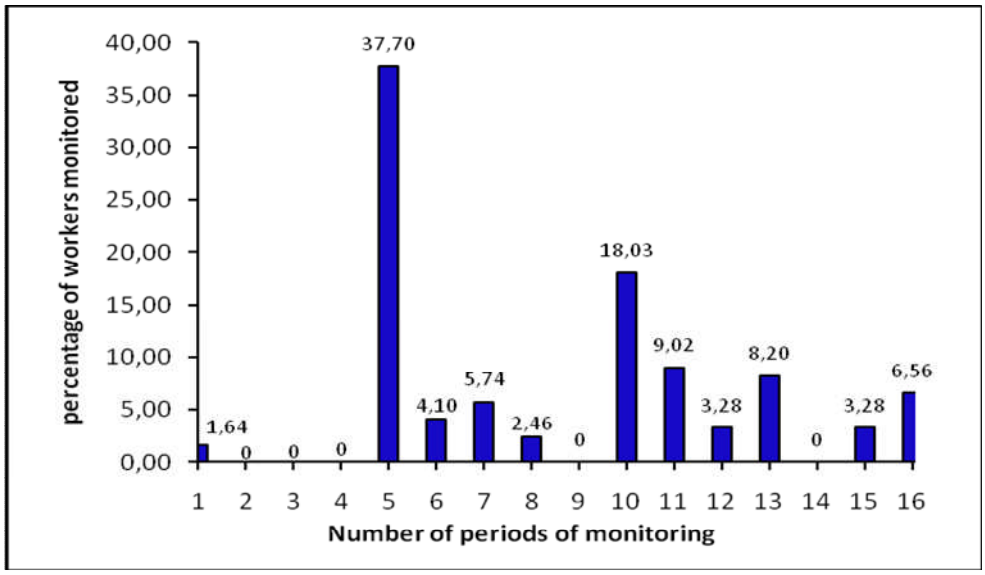
It should be noted that during the whole monitoring period 88.16% of the 2 months dose values of personal dosimeters were below 0.1mSv, the dosimeter's detection limit (value reported was then 0) (Table 2). 99.61% of the bimonthly Hp(10) values were also below the limit of 3.33mSv. This allows to state that the workers were not exposed to a major risk.

Table 2: Number of Hp(10) bimonthly values per year and per class.

Classes of Hp(10) (mSv) for 2 months	Years				Total	%
	2007	2008	2009	2010		
0	20	217	480	199	916	88.16
0.1 - 1	6	30	44	26	106	10.20
1.1 - 2		1	4	2	7	0.67
2.1 - 3			5	1	6	0.58
3.1 – 3.33					0	0.00
3.33 - 4			1		1	0.10
4.1 - 5			1		1	0.10
5.1 - 6		1			1	0.10
6.1 - 7					0	0.00
7.1 - 8					0	0.00
8.1 – 8.33					0	0.00
> 8.33			1 (42.84)		1	0.10
Total	26	249	536	228	1039	100.00

However, the monitoring did not last a long period enough and 39.34% of the workers were not monitored more than 5 times (Fig. 3).

Figure 3: Monitoring frequency of workers.



The workplace exposure (H*(10)) measurement values were often low (varying from 0.00mSv to 40.45mSv). 87.08% of the values were below 3.33mSv, the upper limit of Hp(10) for a period of 2 months (Table 3). The H*(10) values greater than 3.33mSv were met 31 times (12.92%) but in only 5 establishments.

Low values of individual dose have also been noticed despite high values of workplace monitoring. As a matter of fact, all the values of personal dosimeters worn when H*(10) values were above 8.33mSv ranged below 3.33mSv.

Table 3: Number of H*(10) values ranged per bimester and per class.

Classes of H*(10) (mSv)	Years				Total	%
	2007	2008	2009	2010		
H*(10) < 3.33	8	58	102	41	209	87.08
3.33 < H*(10) < 8.33	0	8	12	5	25	10.42
H*(10) > 8.33	0	0	4	2	6	2.5
Total	8	66	118	48	240	100.00

3.3. Handling of dosimeters by workers

During the whole monitoring period, thirteen (13) TLD have been lost and 3 damaged by subscribers (out of 1504 TLD provided). 26 times (out of 240), background measurement and workplace exposure monitoring dosimeters have been placed at the improper location. Sometimes, dosimeters were sent back by the subscribers after the deadline set by the procedure.

4. Discussion

The increasing of the number of subscribers and workers monitored, from 2007 to 2010, shows the awareness of workers and their employers of ionizing radiation effects and the efficiency of sensitization.
Modifications of subscription encountered were due to the movement of some workers to another establishment already subscriber or not and subscription of new establishments.

Some reasons of the non subscription of some establishments (36.11%) might be the lack of the related national regulations and the deficit of information about radiation protection requirements. The

law dealing with radiation protection and nuclear safety has been passed in April 2005 ("loi n° 010-2005/AN du 26 avril 2005 portant sur la sûreté nucléaire et la protection contre les rayonnements ionisants") and the National authority of radiation protection and nuclear safety (ARSN) has just been created in July 2007. Monitoring should be imposed to any establishment using ionizing radiation and sensitization be reinforced.

The percentage of 88.16% of the 2 months dose values of personal dosimeters below 0.1mSv, the detection limit (Table 2), is comparable with the value of 87% recorded in France in 2005 with a total number of 273,886 workers [5]. However, this percentage is less than the one (more than 90% for a total number of 4,500 conventional radiology workers) noticed in Philippines from 2000 to 2005 [6] and 94.86% mentioned in the Swiss Federal Public Health Office annual report of 2005 [7]. 99.61% of the bimonthly Hp(10) values were below the limit of 3.33mSv. This allows to state that the workers monitored were not exposed to a major risk.

The single dose (42.84mSv), greater than the annual limit (20mSv) noticed in two months monitoring, was justified by the improper location of the said dosimeter. Indeed, it has been left in the irradiation room and during troubleshooting and tests of the radiology facilities.

The five (05) establishments where H*(10) values were greater than 3.33mSv usually receive large number of patients due to reasons such as the relatively low cost of the tests, the large number of examinations achievable there and the lack of same type of establishments in the region. The workplace exposure was relatively low so the risk of workers' overexposure was low.

Compliance with annual limits of dose suggests that the workers' exposure was low in Burkina Faso and allows making the following interpretations:

- Medical workers are exposed, in normal conditions, only to scattered radiation;
- Low H*(10) and Hp(10) values recorded might be explained by the shortness of working time per worker due to the low attendance of some establishments by the patients and/or the adequacy of the number of workers per radiology department;
- Low personal doses recorded even when H*(10) values were high, allow us to state that radiation protection instructions were respected by workers.

Nevertheless, we can consider that the frequency of loss and damage of dosimeters was relatively high. The main source of damage was the accidental soaking of dosimeters in contrast liquids used for specific examinations. Dosimeters have been lost either by carriers or workers themselves. Sensitization of the establishments concerned should still continue.

5. Conclusion

The assessment of individual monitoring of medical workers in Burkina Faso has revealed that the level of workers' exposure complied with dose limits. Satisfactory justifications have been given in the cases when bimonthly limit was exceeded.

The workplace monitoring has also shown that the risk of workers' overexposure is very low.

Despite of the shortness of the monitoring period, this study should help in taking actions for more compliance with radiation protection requirements.

Thirty-six percent (36.11%) of the medical establishments have not subscribed to monitoring and a great mishandling of dosimeters by workers has been noticed.

The sensitization of employers should be reinforced for the subscription of all the establishments using ionizing radiation. Workers should also be trained on radiation protection requirements in order to continue reducing individual doses, avoid misplacing of workplace monitoring dosimeters and loss or damage of dosimeters.

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