

# Research Article

Malays. j. med. biol. res.



## Occupational Exposure to Ionizing Radiation in Interventional Cardiology Practices in Bangladesh during 2010-2014

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### ABSTRACT

**Objective:** The objective of this study is to assess, analyze and discuss the occupational exposure to ionizing radiation in interventional cardiology practices in Bangladesh for the last 5-year periods.

**Method:** Each year, about 100 workers working in interventional cardiology departments of big hospitals in Dhaka City were monitored using Harshaw Thermoluminescent Dosimeters (TLDs) for quarterly basis. The effective dose of the occupational workers were measured using Two Harshaw TLD Readers (one is manual TLD reader, model-4500, and another is automatic TLD reader, model 6600 plus).

**Finding:** The average annual effective dose (about 80 % workers) in interventional cardiology practices were <2mSv in 2010-2014 and no monitored workers were found to have received an occupational exposure >50 mSv in a single year or >100 mSv in a 5 year period. The status and trends in occupational exposure demonstrate that radiation protection conditions at the majority of the workplace were adequate. Despite that, further optimization is necessary due to large variations observed in the maximum individual doses over the 5-year periods.

**Key words:** Interventional Cardiology, Ionizing Radiation, Occupational Health, TLD, Dose limit

12/31/2016

Source of Support: Nil, No Conflict of Interest: Declared

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### INTRODUCTION

Interventional cardiology is a branch of cardiology that deals with diagnosis and treatment of heart diseases using image-guided catheters. Most imaging equipment used for this purpose is X-ray fluoroscopy with a possibility of changing projections without patient moving (c-arm) and production of high-quality image series (cine mode). Occupational radiation doses in fluoroscopy-guided interventional procedures are highest among medical staff using X-rays, particularly cardiologists involved in interventional procedures (Vano et al., 1998), (Beganovic et al., 2010), (Basic B et al., 2010). The danger of radiation, such as radiation-induced cataracts in occupational workers (Vano E et al., 1998), (Ciraj-Bjelac O et al., 2010), (Jacob S et al., 2010), has led to a significant focus on radiation safety in the cardiac catheterization laboratory.

Any individual radiation monitoring program has at least two common aims. The first aim is to provide information on the adequacy of protection measures which is an input for operational decisions related to the optimization principle (ICRP, 2007), (IAEA GSR part-3, 2014). Secondly, the individual monitoring programs aim to demonstrate compliance with the relevant dose limits as required by the international recommendations and standards (ICRP,

2007), (IAEA GSR part-3, 2014). In this context, the annual effective dose to the occupationally exposed workers should not exceed 20 mSv averaged over a defined period of 5-year, with a provision that the individual dose does not exceed 50 mSv in any single year. Regular assessment of occupational radiation exposures and the analysis of related trends are vital to examine changes that have taken place over time due to regulatory operations or technological improvements. The objectives of this paper were to present the occupational radiation exposure in interventional cardiology practices in Bangladesh and to evaluate the related trends over a period of 2010-2014.

## MATERIALS AND METHODS

Monitoring of occupational workers by the Health Physics Division (HPD), Atomic Energy Centre, Dhaka (AECD) using Thermoluminescent Dosimeters (TLDs) begin immediately after a facility is licensed to operate. HPD, AECD is the only institute that provides dosimetry service for facilities that employ the use of ionizing radiation in Bangladesh. LiF:Mg,Ti (TLD-100) dosimeters have been in use throughout the period 2010-2014. In the same period, two Thermoluminescent Dosimetry systems have been employed to read Thermoluminescent Dosimeters (TLDs). They are Harshaw Manual TLD Reader, Model 4500 (from 2000 and still running) and Automatic TLD Reader, Model 6600 Plus (from June 2014) with a manual system of data transfer. Harshaw 6600 plus Automatic TLD Reader (Harshaw TLD Reader, Model 6600 plus manual, 2007), which is one of the most technically advanced dosimetry systems for whole body, extremity, neutron and environmental monitoring, is being used by the HPD, AECD. The system offers 'one dosimetry solution' by its ability to monitor whole body (beta, photon, and neutron), extremity and environmental exposure with a single dosimeter. It can take up to 200 dosimeters per cycle and also saves significant time by virtue of its automatic calibration capabilities. It has a flat panel display and touch-screen operation service, and it exceeds International Electrotechnical Commission (IEC), International Organization for Standardization (ISO) and American National Standards Institute Performance requirements. The Harshaw TLD Readers were connected to an external personal computer (PC) and are operated through installed menu-driven WinREMS software.

The Secondary Standard Dosimetry Laboratory (SSDL) has been available at Bangladesh Atomic Energy Commission (BAEC) since 1991, which is traceable to the Primary Standard Dosimetry Laboratory (PSDL) of National Physical Laboratory (NPL), UK. The performance of BAEC SSDL is maintained according to the requirements of the International Atomic Energy Agency (IAEA)/World Health Organization (WHO) network of SSDLs. Therefore, the evaluated doses are traceable to the international measurement system. As an input to support this traceability, the personal monitoring laboratory regularly participates in inter-laboratory dose comparisons as organized by IAEA. In the latest comparison, adequate performance was achieved according to the standards trumpet curve criteria (IAEA, RS-G-1.3, 1999), (ICRP 27 -1, 1997). For all individual doses, the background radiation dose is subtracted, and the minimum detectable level (MDL) is 0.05 mSv for three months for two TLD systems were taken as dose recording level. Those Occupational workers who received doses less than MDL was regarded as zero (0). Table I shows the number of monitored workers for the years 2010-2014.

Table I: Number of monitored workers in interventional cardiology practices for the years 2010-2014.

Type of worker/Year	2010	2011	2012	2013	2014
Physician	46	45	46	42	46
Non-physician	58	50	49	49	56
<b>Total</b>	<b>104</b>	<b>95</b>	<b>95</b>	<b>91</b>	<b>102</b>

### Data Analysis

In this study, four quantities as recommended elsewhere (UNSCEAR 2000) were used to analyze individual doses for the years 2010-2014. They include the annual collective effective dose, the average annual effective dose, the individual dose distribution ratio and the annual collective effective dose distribution ratio. In addition, the minimum and the maximum values of the annual individual effective doses were analyzed to complement the average annual effective doses.

Annual collective effective dose (S)

The annual collective effective dose (S) was obtained according to the following equation (UNSCEAR 2000):

$$S = \sum_{i=1}^N E_i \quad (1)$$

Where  $E_i$  is the annual effective dose received by the  $i^{\text{th}}$  worker and N is the total number of workers monitored. The parameter S gives an estimate of the impact of particular practice on the population in given time frame.

### Average annual effective dose

The average annual effective dose  $\bar{E}$  was obtained from the ratio  $S/N$ , where the meaning of symbols are the same as in equation (1).

The individual dose distribution ratio

The individual dose distribution ratio,  $NR_E$  was obtained according to the following equation (UNSCEAR 2000):

$$NR_E = \frac{N(>E)}{N} \quad (2)$$

Where  $N(>E)$  is the number of workers receiving annual dose exceeding  $E$  mSv. In this study,  $NR_E$  was analyzed for values of  $E$  of 15, 10, 5 and 1 mSv. The parameter  $NR_E$  provides an indication of the fraction of workers exposed to higher levels of individual doses.

The annual collective dose distribution ratio

The annual collective dose distribution ratio,  $SR_E$  was obtained according to the following equation (UNSCEAR 2000):

$$SR_E = \frac{S(>E)}{S} \quad (3)$$

Where  $S(>E)$  is the annual collective dose delivered at an annual dose exceeding  $E$  mSv. In this study,  $SR_E$  was analyzed for values of  $E$  of 15, 10, 5 and 1 mSv. The parameter  $SR_E$  provides an indication of the fraction of the collective dose received by workers exposed to higher levels of individual doses.

## RESULTS AND DISCUSSION

### *Annual collective dose and average effective dose*

Annual collective effective dose and average annual effective dose per exposed worker values are calculated separately for each of the year 2010-2014 periods, and the data have been presented in Fig. 1 and Fig.2 respectively. The maximum annual collective effective dose of 208 person.mSv for the 5-year study period was recorded in 2012 and the minimum of 108 person.mSv was recorded in 2010. It can be seen that there were no visible dose trends for interventional cardiology practices for the year 2010-2014 periods. The average annual effective dose of occupational workers in interventional cardiology practices are 1.04, 1.40, 2.18, 1.66 and 1.30 mSv for the year 2010, 2011, 2012, 2013 and 2014 respectively. Trends in the average annual effective doses were largely similar to the trends in the annual collective effective doses. From the data collected for the year 2010-2014, no occupational workers were found to have received an effective dose  $>50$  mSv in a single year or  $>100$  mSv in a consecutive 5-year period. Therefore, occupational exposure to ionizing radiation of all workers in interventional cardiology practices is lower than the prescribed dose limit by ICRP 2007 and IAEA GSR part-3, 2014. However, very few workers (2% in 2011, 1% in 2012 and 2% in 2013) individual effective doses are higher than average annual dose limit ( $20 \text{ mSv.y}^{-1}$ ) (ICRP, 2007), (IAEA GSR part-3, July 2014). Therefore, occupational workers in interventional cardiology practices should pay more attention to radiation protection procedures and guidelines to keep the doses below the annual average dose limit other than the maximum allowable dose limit in a year. The status and trends in occupational exposure demonstrate that radiation protection conditions at the majority of the workplace were adequate. Despite that, further optimization is necessary due to large variations observed in the maximum individual doses over the 5-year periods (Table II).

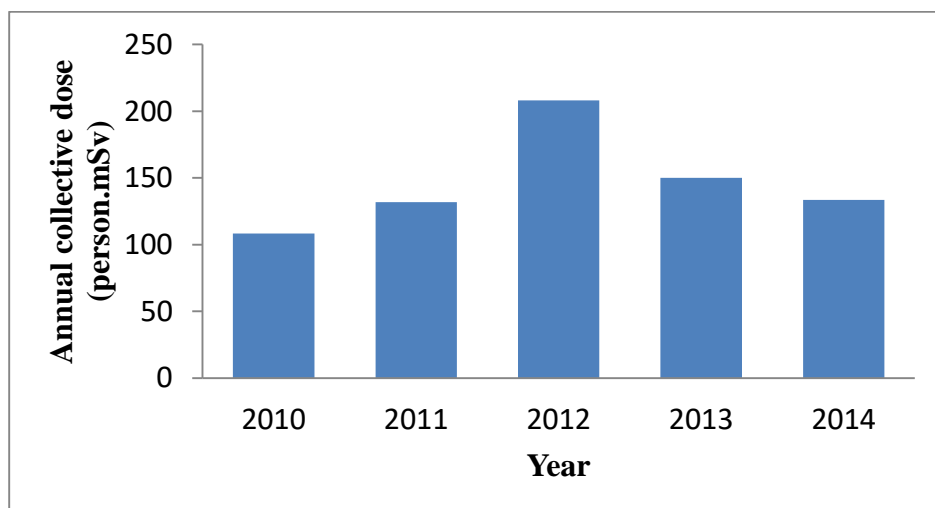


Fig. 1 Annual collective dose of occupational workers for 2010-2014 periods

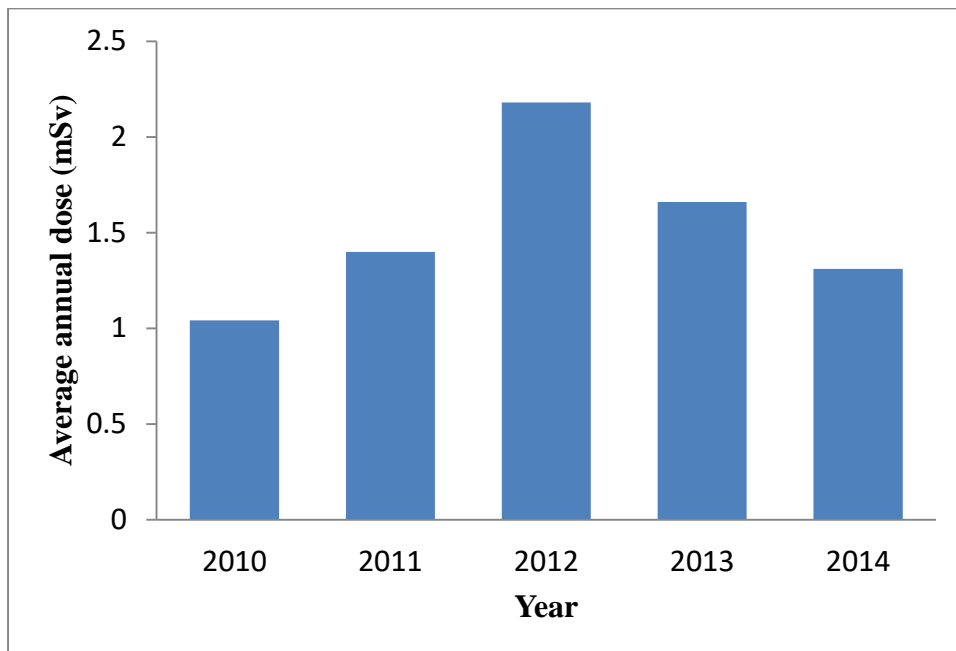


Fig. 2 Average annual dose of occupational workers for 2010-2014 periods

Table II: The maximum (max) and minimum (min) annual individual doses in mSv for the years 2010-2014.

Type of worker/year	2010		2011		2012		2013		2014	
	max	min	max	min	max	min	max	min	max	min
Physician	10.66	0	26.24	0	18.14	0	22.68	0	15.00	0
Non-physician	10.32	0	23.72	0	40.82	0	49.37	0	6.00	0

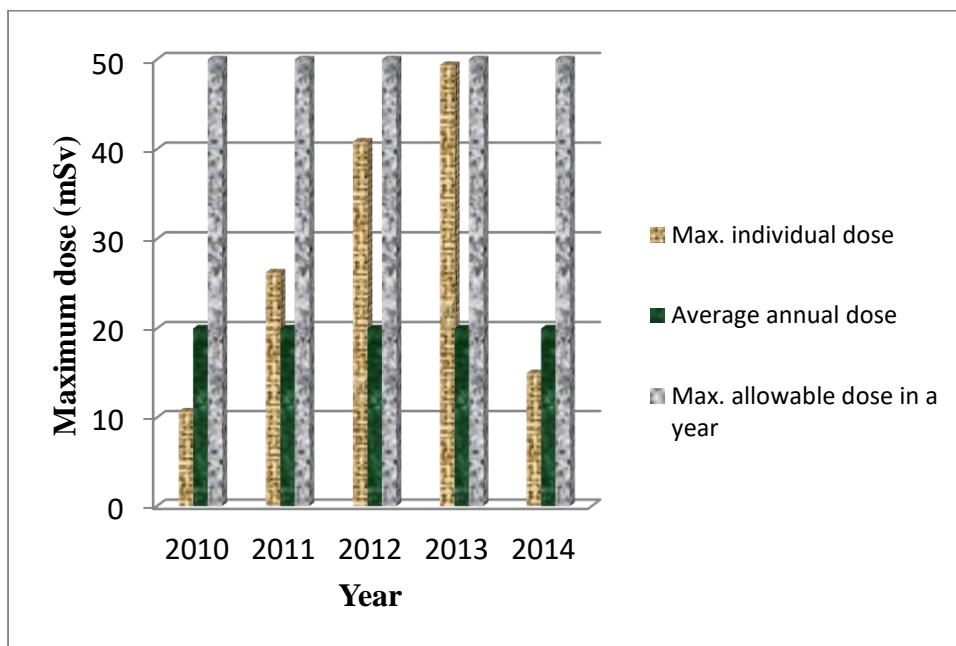


Fig. 3 The maximum individual dose received by occupational workers along with dose limit (ICRP, 2007, IAEA GSR part-3, 2014).

**Individual and collective dose distribution ratio**

The individual dose distribution ratios in the 5-year periods were presented in Table III. It is seen that very few individuals were exposed to doses exceeding 10 and 15 mSv. Furthermore, < 4 % of the monitored workers received doses above 10 mSv. Table IV presents the results of the collective dose distribution ratio in the 5-year periods.

Table III: The individual dose distribution ratio for 2010-2014 periods.

Annual individual dose exceeding (mSv)	Individual dose distribution ratio				
	2010	2011	2012	2013	2014
15	0.00	0.021	0.021	0.022	0.009
10	0.009	0.021	0.042	0.022	0.009
5	0.048	0.117	0.179	0.100	0.078
1	0.298	0.276	0.411	0.267	0.284

Table IV: Collective dose distribution ratio for 2010-2014 periods.

Annual individual dose exceeding (mSv)	Collective dose distribution ratio				
	2010	2011	2012	2013	2014
15	0.00	0.371	0.278	0.473	0.112
10	0.194	0.371	0.375	0.473	0.112
5	0.332	0.712	0.687	0.706	0.376
1	0.722	0.886	0.861	0.833	0.534

## CONCLUSION

Occupational exposure to ionization radiation in interventional cardiology practices in Bangladesh and dose trends for the years 2010-2014 are presented. For the 5-year periods, no occupational workers were found to have received an effective dose >50 mSv in a single year or >100 mSv in a consecutive 5-year periods. Therefore, occupational exposures to ionizing radiation of all workers in interventional cardiology practices are lower than the prescribed dose limit recommended by International Organizations. However, very few workers individual effective doses are higher than recommended average annual dose limit (20 mSv.y<sup>-1</sup>). Therefore, occupational workers in interventional cardiology practices should pay more attention to radiation protection procedures and guidelines to keep the doses below the annual average dose limit other than the maximum allowable dose limit in a year. The status and trends in occupational exposure demonstrate that radiation protection conditions at the majority of the workplace were adequate. Despite that, further optimization is necessary due to large variations observed in the maximum individual doses over the 5-year periods.

## ACKNOWLEDGEMENT

The authors wish to express their gratitude to their colleagues for their support. The International Atomic Energy Agency (IAEA) is thanked for providing TLD readers whose data were reported in this study.

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