

INTRODUCTION

Since the relationship between low-dose radiation exposure and cancer risk is unclear, the International Commission on Radiological Protection (ICRP) recommends the adoption of the linear, no-threshold model as a predictive risk model for radiation protection purposes [1]. The ICRP recommend that the occupational radiation dose limit should be expressed as an effective dose of 20 mSv per year, averaged over defined 5 year periods (100 mSv in 5 years), with the further provision that the effective dose does not exceed 50 mSv in any single year and the goal that exposure is kept as low as reasonably achievable (ALARA) [1]. Furthermore, the annual equivalent dose limit for the lens of the eye and the skin should not exceed 20 mSv and 500 mSv, respectively [1]. Medical radiation workers are subject to occupational exposures through various sources and differences in workload, work area and types of exposures can lead to variations in exposures between various occupational groups.

AIM

To investigate the occupational radiation exposure of different occupational groups within the Diagnostic Imaging, Radiotherapy, Catheterization Laboratory and Nuclear Medicine departments in two Hospitals from 2015 to 2019. The distribution of occupationally exposed workers by area of work is presented and the average annual and collective deep dose equivalent (Hp(10)), the dose equivalent to the lens of the eye (Hp(3)) and the shallow dose equivalent (Hp(0.07)) associated with various occupational groups is summarized.

METHODS

- **Study population:** occupational radiation exposure of 572 workers stratified into 22 broad occupational categories were evaluated. Of the total monitored workers, 140 were from a radiotherapy department, 287 from a diagnostic imaging department, 53 from a nuclear medicine department and 92 from a catheterization lab.
- **Monitoring occupational exposure:** The TLD badge monitoring programme has been used by all four departments for collecting staff occupational radiation exposure and the measured dosimetrist parameters include the deep dose equivalent (Hp(10)), the shallow dose equivalent (Hp(0.07)) and the dose equivalent to the lens of the eye (Hp(3)).
- **Data collection and analysis:** staff occupational doses were retrieved directly from the dosimetry provider’s online database.
- **Estimated dosimetric parameters:** Annual effective and equivalent doses, Collective effective and equivalent doses, Cumulative lifetime doses, Probability of exceeding a given lifetime dose range

RESULTS

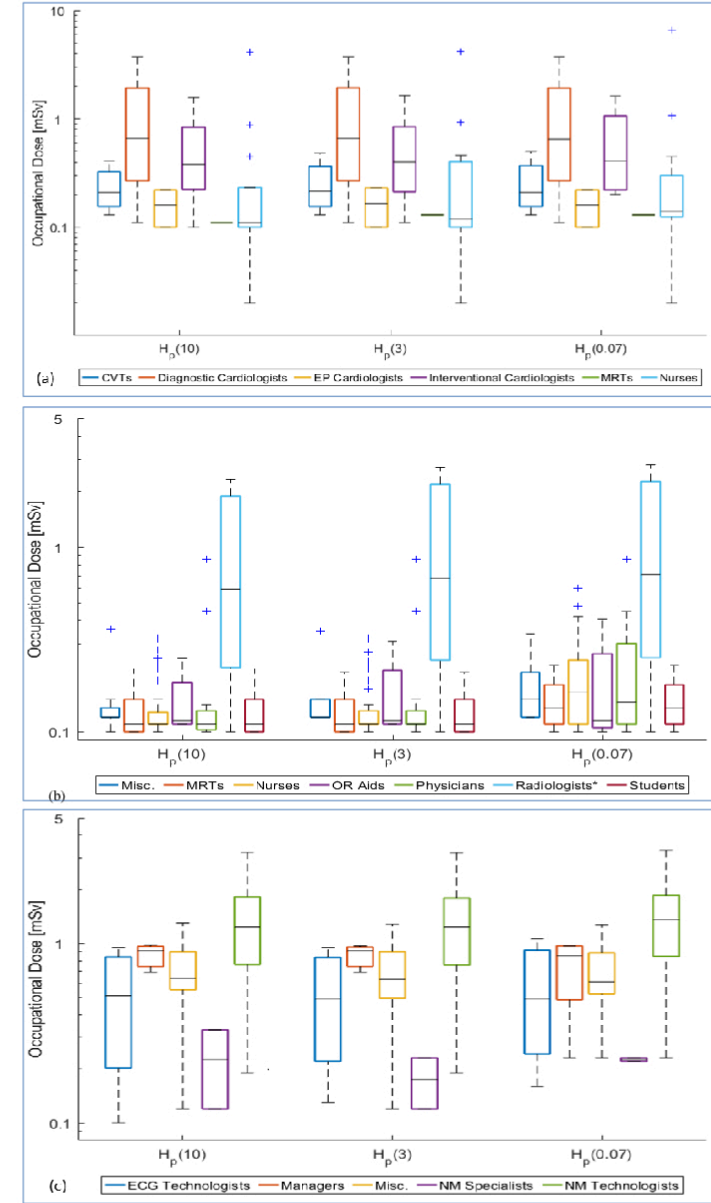


Figure 1. Semi-log box plots for individual annual $H_p(10)$, $H_p(3)$ and $H_p(0.07)$ doses (mSv) for TLDs worn on the torso in the (a) Catheterization Lab, (b) Diagnostic Imaging and (c) Nuclear Medicine departments. CVTs: Cardiovascular Technologists; EP: Electrophysiology; MRTs: Medical Radiation Technologists; ECG: Electrocardiogram; NM: Nuclear Medicine; OR: Operating Room., *Includes both diagnostic and interventional radiologists.

Table 1. The average non-zero $H_p(10)$, $H_p(3)$ and $H_p(0.07)$ doses (mSv) \pm SD (range) for staff occupational doses measured using TLDs worn on the torso and collar for the monitoring period 2015-2019 for the four departments. All doses below the detection limit of the dosimeter are reported as an asterisk (*).

Department	Occupational group	TLDs worn on the torso			TLDs worn on the collar		
		$H_p(10)$	$H_p(3)$	$H_p(0.07)$	$H_p(10)$	$H_p(3)$	$H_p(0.07)$
Catheterization Lab**	Diagnostic Cardiologists	1.2 \pm 1.3 (0.1 - 3.7)	1.2 \pm 1.3 (0.1 - 3.7)	1.2 \pm 1.3 (0.1 - 3.7)	3.6 \pm 3.7 (0.4 - 10.6)	3.6 \pm 3.6 (0.4 - 10.7)	3.8 \pm 3.6 (0.4 - 10.8)
	Interventional Cardiologists	0.6 \pm 0.5 (0.1 - 1.6)	0.6 \pm 0.5 (0.1 - 1.6)	0.6 \pm 0.5 (0.2 - 1.6)	8.1 \pm 4.3 (1.6 - 21.1)	8.3 \pm 4.4 (1.7 - 21.1)	8.5 \pm 4.3 (2.1 - 20.9)
Diagnostic Imaging**	Radiologists***	1.0 \pm 1.2 (0.1 - 2.3)	1.2 \pm 1.4 (0.1 - 2.7)	1.2 \pm 1.4 (0.1 - 2.8)	6.4 \pm 5.5 (0.1 - 14.2)	6.7 \pm 5.7 (0.1 - 14.9)	6.9 \pm 5.6 (0.1 - 14.8)
Nuclear Medicine	Nuclear Medicine Specialists	0.2 \pm 0.2 (0.1 - 0.3)	0.2 \pm 0.1 (0.1 - 0.2)	0.2 \pm 0.01 (0.2 - 0.2)	-	-	-
	Nuclear Medicine Technologists	1.4 \pm 0.7 (0.2 - 3.2)	1.4 \pm 0.7 (0.2 - 3.2)	1.4 \pm 0.7 (0.2 - 3.3)	-	-	-

Torso TLDs were worn under a lead apron and collar TLDs were placed over the lead apron., *Includes both diagnostic and interventional radiologists.

Table 2. The annual collective $H_p(10)$, $H_p(3)$ and $H_p(0.07)$ doses (man.mSv) by occupational groups for TLDs worn on the collar, above lead apron, in the Catheterization Lab and Diagnostic Imaging and TLDs worn on the torso in the Catheterization Lab, Diagnostic Imaging and Nuclear Medicine.

Department	Occupational group	TLDs worn on the collar														
		$H_p(10)$					$H_p(3)$					$H_p(0.07)$				
		2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
Catheterization Lab	Diagnostic Cardiologists	14.7	21.5	16.9	10.4	11.4	14.9	21.8	16.9	10.4	11.8	15.2	22.3	18.7	11.0	13.7
	Interventional Cardiologists	39.3	46.7	48.2	58.6	78.6	40.7	47.2	51.4	60.9	80.4	41.8	48.9	54.5	61.9	80.7
Diagnostic Imaging	Medical Radiation Technologists	118.9	143.7	66.9	44.6	74.1	121.5	149.2	69.3	45.9	75.3	122.8	157.3	76.3	48.3	75.3
	Nurses	92.1	175.1	65.3	34.0	32.3	89.9	239.2	65.7	31.3	33.1	87.8	160.4	49.9	31.4	36.7
Department	Occupational group	TLDs worn on the torso														
		$H_p(10)$					$H_p(3)$					$H_p(0.07)$				
		2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
Catheterization Lab**	Diagnostic Cardiologists	2.0	*	*	8.1	2.9	1.9	*	*	8.1	2.9	2.0	*	*	8.1	2.9
	Interventional Cardiologists	2.7	*	*	1.5	4.6	2.6	*	*	1.4	5.3	2.7	*	*	1.4	4.7
Diagnostic Imaging**	Medical Radiation Technologists	*	7.6	8.1	10.3	8.4	*	7.6	11.4	10.2	10.9	*	7.6	8.1	10.2	8.4
	Nurses	*	6.8	9.2	9.8	10.5	*	22.8	19.5	12.6	13.4	*	12.6	9.1	10.7	10.9
Nuclear Medicine	Nuclear Medicine Specialists	0.7	0.2	*	*	*	0.5	0.4	*	*	*	0.5	0.2	*	*	*
	Nuclear Medicine Technologists	25.1	25.8	25.9	25.7	21.3	25.5	28.5	27.4	27.7	21.1	24.8	25.6	25.8	25.6	20.9

**Torso TLDs were worn under a lead apron

CONCLUSIONS

- Relatively higher doses were observed in nuclear medicine technologists, diagnostic imaging radiologists and diagnostic and interventional cardiologists.
- All occupational groups within the radiotherapy department reported doses below the detection limit of the TLD.
- All occupational doses reported in this study are low and below the annual $H_p(10)$, $H_p(3)$ and $H_p(0.07)$ dose limits
- Since the relationship between exposure to low dose ionizing radiation and cancer risk is not yet fully determined, compliance of radiation safety protocols should be periodically assessed in any radiological department in order to keep radiation exposure to staff as low as reasonably achievable.

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REFERENCE

[1] ICRP 2007 The 2007 Recommendations of the International Commission on Radiological Protection ICRP Publication 103 *Ann. ICRP* **37** 2-4

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