The estimation of the occupational radiation dose for medical staff in Thailand by using retrospective annual dosimetry data

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► ***Short report***

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ABSTRACT

Background: A medical radiation staff is a person who provides medical services to use radiation for the diagnosis and treatment of diseases in humans. To ensure radiation safety, they have to work according to the ALARA principle and monitor radiation exposure within dose limit. ***Materials and Methods:*** The study was estimating the mean annual occupational radiation dose for medical staff in Thailand by using retrospective OSLDs data at the Bureau of Radiology and Medical Devices. ***Results:*** A total of 2040 medical institutes, consists of 18 430 OSLD badges for diagnostic radiology, 645 for radiotherapy, and 138 for nuclear medicine. The mean annual occupational radiation dose reports as Hp (10), Hp (0.07), and Hp (3). The analysis shows that the mean annual radiation dose in diagnostic radiology staff was 0.023 ± 0.065, 0.023 ± 0.062 and 0.023 ± 0.061 mSv respectively. The radiotherapy staff was 0.015 ± 0.023, 0.019 ± 0.035 and 0.018 ± 0.022 mSv and the nuclear medicine staff was 0.038 ± 0.029, 0.038±0.033 and 0.037 ± 0.028 mSv. The result reveals statistically non-significant differences in the mean effective doses between the medical staff who work with different field. ***Conclusion:*** The occupational radiation dose depends on several factors within the workplace, job description, annual workload, distribution of the workload among workers and radiation protection practices. An evaluation of how such factors affect occupational exposure is beyond the scope of this study. The mean annual occupational radiation dose of nuclear medicine staff was greater than the diagnostic radiology and radiotherapy staff respectively. However, all of the occupational radiation doses were within ICRP dose limit.

INTRODUCTION

Radiation is the energy emission or transmission in the form of waves or particles which can penetrate substances and human beings [1]. Radiation is divided into two groups: ionizing radiation and non-ionizing radiation according to its effects on the substance [2]. Ionizing radiation is very damaging to the vital processes of life, inducing DNA damage that underlies a variety of human diseases, including cancer [3]. Currently, the application of ionizing radiation in the field of medicine has been increasing continuously [4]. It is critical to apply protective and measures when dealing with ionization radiation for medical procedures. Otherwise, medical workers and patients could be exposed to a high amount of radiation, which will lead to dangerous health effects. An occupational radiation dose is a term that refers to the exposure of people at work to ionizing radiation from natural and man-made sources as a result of operations within a workplace [5]. It was recommended for workers exposed to medical radiation source follow and to apply all the requirements established by the International Commission on Radiological Protection (ICRP, 2007) [6]. The key tool in radiation protection practices is radiation monitoring to estimate the occupational radiation dose in order to assess radiation risks and create protective measures for occupational dose within the dose limit [7]. To monitor the radiation dose can be estimated by measuring the accumulative radiation exposure with a personal radiation dose monitoring device; such as a thermo luminescent dosimeter (TLD), optically stimulated luminescence dosimeter (OSLD), and others. According to the 2014 report by the IAEA on radiation protection and safety of radiation sources, the radiation dose is expressed in terms of effective dose; Hp (10) represents the deep dose (whole-body), equivalent dose; Hp (0.07) represents the shallow dose for extremities and Hp (3) represents eye lens dose, as stated by the ICRP report number 60 [5,8]. The dose limit for workers proposed by the ICRP was established as an annual effective dose [9]. An effective dose limit of 20 mSv each year has been set for persons employed in radiation work [10].

In Thailand, the OSLD is the most used devices to carry out measurement on personal dosimeters and the Bureau of Radiology and Medical Devices, Department of Medical Sciences is the prominent

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institute to provide OSLD reading services. Therefore, in this study, the researcher's retrospective collecting OSLD data according to investigate the annual occupational radiation dose history among the workers in Thailand hospitals. The study concentrated on three medical departments in Thailand hospital-diagnostic, radiotherapy and nuclear medicine-during the period from 1 January 2022 to 31 December 2022. The objective of this study was to track these departments' occupational dose history and to determine the highest exposure area to assess the dose limit for workers proposed by the ICRP. This study presents the results as a part of a nationwide survey data set and represents the annual radiation dose in medical staff in Thailand in order to justify, optimize, and dose limit in radiation protection in the field of medicine.

MATERIALS AND METHODS

In this study, whole-body OSLDs were assigned to all the workers with a bar-coded number that represented their identity and their period of use. These workers occupied the following departments: diagnostic radiology, radiotherapy, and nuclear medicine. The OSLDs consist of badges with holders containing a detector crystal of aluminum oxide (Al_2O_3) to provide measurements of Hp (10), Hp (0.07), and Hp (3). A retrospective study by collecting 19 213 OSLD badges from 1 January to 31 December 2022 was taken from the Bureau of Radiology and Medical Devices, Department of Medical Sciences. The OSLD consists of 18 430 badges for diagnostic radiology, 645 badges for radiotherapy, and 138 badges for nuclear medicine. A total of 2040 institutes including 1989 sites for diagnostic radiology, 40 sites for radiotherapy, and 11 sites for nuclear medicine. A model Landauer Automatic Reader 200A, made in France and Landauer OSLR250, made in United State was used as an OSLD Reader with a whole-body dose algorithm for the Landauer InLight Basic-OSLN Dosimeter software to evaluate the occupational radiation dose. The OSLDs readings were calibrated and quality control by irradiated with ^{137}Cs 5 - 5000 mSv and analyzed by using the IBM SPSS Statistics (SPSS) software, version 28.0.1.1. This study was approved by the Human Research Ethics Committee of Thammasat University (Science), Thailand, with the Declaration of Helsinki, the Belmont report, CIOMS guidelines and the International practice (ICH-GCP) COA No.003/2566.

RESULTS

OSLDs were used to monitor 2040 institute 19 213 medical workers in 2022. The number of workers in each department was listed in table 1. The analysis of the mean annual collective doses for all workers in 2022 reports as a Hp (10), Hp (0.07) and Hp (3). The mean annual radiation dose in diagnostic radiology staff was 0.023 ± 0.065, 0.023 ± 0.062 and 0.023 ± 0.061 mSv respectively. The radiotherapy staff was 0.015 ± 0.023, 0.019±0.035 and 0.018 ± 0.022 mSv and the nuclear medicine staff was 0.038 ± 0.029, 0.038 ± 0.033 and 0.037 ± 0.028 mSv respectively as shown in table 2. To assess the significance of these differences, the annual mean effective dose in all departments were statistically compared using a one - Way ANOVA. The test reveals statistically non-significant differences in the equivalence doses, extremities, and the eye lens all medical staff radiation dose in Thailand ($F = 0.115, 0.064, 0.055$), $p = 0.892, 0.938, 0.946$) as shown in table 3. Regardless of the differences in the data range, the table provides a rough assessment of the occupation radiation dose. The only limitation of this study is that it did not specify the effective dose for each occupation group (i.e., radiologists, technologists, nurses, or medical assistants). This is mainly due to the fact that database of the OSLDs does not include the occupational position for all medical workers. For future work, OSLDs will update its policy to include the occupational position of each worker in their database in Thailand.

Table 1. The number of radiation workers monitored as works in the medical department.

Number of	Diagnostic radiology	Radiotherapy	Nuclear medicine	Total
Institute	1989	40	11	2040
OSLD badges	18 430	645	138	19213
Male	6881	170	44	7095
Female	12371	477	94	12942

Table 2. The mean annual occupational dose for all the medical worker comparing with ICRP 103, 2007 dose limit [19].

The mean annual occupational dose (mSv)	Diagnostic radiology	Radiotherapy	Nuclear medicine	ICRP 103 dose limit (mSv)/year	
				Worker	Public
Effective dose	0.023±0.065	0.015±0.023	0.038±0.029	20	1
Equivalent dose					
Skin/extremities dose	0.023±0.062	0.019±0.035	0.038±0.033	500	50
Eye lens dose	0.023±0.061	0.018±0.022	0.037±0.028	20	15
Maximum radiation dose	26.67	4.30	1.40		
Minimum radiation dose	1*	1*	1*		

mSv; milli-Sievert, Hp (10); the equivalent dose, Hp (0.07); the extremities dose, Hp (3); the eye lens dose. 1* radiation dose less than 100 micro-Sievert for the period of OSLD used.

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Table 3. The annual mean effective dose in all medical staff worker were statistically compared using a one - Way ANOVA.

						95% Confidence Interval for Mean			
		N	Mean	Std.Deviation	Std.Error	Lower Bound	Upper Bound	Minimum	Maximum
Equivalent dose	Diagnosis	18430	0.0229	.11204	.00083	.0213	.0245	.00	6.43
	Therapeutic	645	0.0216	.06107	.00241	.0168	.0263	.00	.76
	Nuclear medicine	138	0.0264	.14401	.01221	.0023	.0506	.00	1.52
	Total	19213	0.0229	.11098	.00080	.0213	.0245	.00	6.43
Extremities	Diagnosis	18430	0.0231	.11871	.00087	.0214	.0249	.00	6.63
	Therapeutic	645	0.0221	.06568	.00259	.0170	.0272	.00	.78
	Nuclear medicine	138	0.0259	.14422	.01223	.0018	.0501	.00	1.53
	Total	19213	0.0231	.11753	.00085	.0215	.0248	.00	6.63
The eye lens	Diagnosis	18430	0.0232	.11610	.00086	.0216	.0249	.00	6.67
	Therapeutic	645	0.0225	.06528	.00258	.0174	.0275	.00	.79
	Nuclear medicine	138	0.0260	.14418	.01223	.0019	.0502	.00	1.52
	Total	19213	0.0232	.11499	.00083	.0216	.0249	.00	6.67

*N = number of OSLDs badge

DISCUSSION

In Thailand 2022, the comparison of mean annual occupational radiation dose values among the studied departments as shown in table 2. revealed that the highest values lie within the nuclear medicine workers, followed by the diagnostic radiology workers which is similar to the occupational dose reported in Saudi Arabia studies [5,7]. This usually happens when they use unsealed radioactive sources and during the radiopharmaceutical preparation. Moreover, they remain in very close proximity to the patients during radiopharmaceutical injections [12,13]. These factors account for the increase in the radiation dose among the nuclear medicine workers compared to the other medical workers in diagnostic radiology and radiotherapy [14].

However, the results showed that no single occupational dose exceeded the annual dose limit of 20 mSv in nuclear medicine but, in this study the mean annual radiation dose in diagnostic radiology reveal the maximum value is show in table 2 and table 3. Although, the mean annual radiation dose in nuclear medicine workers is higher than the others but the statistically analysis reveal nonsignificant differences in the equivalence doses, extremities, and the eye lens. Our study showed that the mean annual occupational radiation dose of medical workers was less than dose limit, which is similar to the occupational dose reported in studies from different parts of the world [15-18].

CONCLUSION

This study aimed to provide an indication of the effective dose and equivalent dose values for medical workers in Thailand. During the study period, all the workers received occupational doses below the annual effective dose limit, in compliance with the ALARA principle, the occupational doses were distributed with a low dose range in mind. Among the different medical departments, workers in the nuclear medicine exposed to the highest annual occupational radiation doses.

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