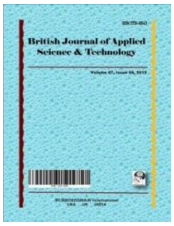

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Time Period in Which Radiation Workers Completed the 20 mSv Annual Limit

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Authors' contributions

This work was carried out in collaboration between both authors. Author SAM gave basic idea of study and designed it, searched the literature, managed the data properly, performed the statistical analysis and wrote the first draft of the manuscript. Author NAL managed the data analyses and reviewed the study critically form all aspects. Both authors read and approved the final manuscript.

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ABSTRACT

Background: Nuclear Institute of Medicine and Radiotherapy Jamshoro, an institute of Pakistan Atomic Energy Commission provides the facilities of diagnosis and treatment to cancer patients of encasement areas of Jamshoro/Hyderabad through its dedicated radiation workers wearing film badges as the personal monitoring devices to monitor their occupational doses. The main rationale of the current study was to analyze the occupational doses received by the radiation workers and to explore the achievement of annual limit as recommended by regularity bodies.
Materials and Methods: For the measurement of workers' personal occupational radiation doses, each worker handling radioactive sources has been issued with a film badge with unique number provided by Pakistan Institute of Nuclear Science and Technology Islamabad. The readings of developed films were kept as radiation workers' occupational dose history. Total 30 radiation workers, 8 (27%) of nuclear medicine section, 4 (13%) of Radiology, 3 (10%) each of Radio-

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Immune-Assay & Repair Maintenance sections respectively and 12 (40%) of Radiotherapy section were included in this study.
Results: Almost half of the workers received 10% of 20 mSv limit. The average occupational radiation doses for workers ranged from 1.11 mSv to 3.42 mSv. The time period in which radiation workers attained the 20 mSv limit ranged from 6 to 18 years.
Discussion: More than 50% of workers received the dose less than 2 mSv, 10% of the limit. The highest of radiation dose for worker of nuclear medicine section received 4.82 mSv (24% of limit). The workers deputed in hot lab of nuclear medicine section completed the limit in the shortest time period of 6 to 7 years whereas radiology section's workers achieved the limit in 9 to 10 years. The one of radiotherapy workers have achieved the same limit of 20 mSv in 12 years due to source stuck handling whereas most of the workers attained the limit in more than 15 years.
Conclusion: Our data is not comparable with any of the studies already completed on film badge dosimetry as the gathered data is exceptional in nature, so more studies must be conducted on subject topic for comparison.

Keywords: Occupational dose; film badge; regulatory agency; nuclear medicine; radiotherapy; unsealed source.

1. INTRODUCTION

The Nuclear Institute of Medicine and Radiotherapy (NIMRA) Jamshoro of Pakistan Atomic Energy Commission (PAEC) has a good reputation for providing diagnostic and therapeutic facilities to encasement areas of Jamshoro/Hyderabad using ionizing sources emitting beta, gamma and x-rays.

Low level radiation from the natural environment is present in soil, terrestrial etc. and the radiation emitting from manmade radioactive sources (beta, gamma ray emitting sources) and medical devices (x-rays generator etc) may expose the general population continuously [1-5]. Many of the scientists working on the discovery of radioactivity and its effects in the early days noticed severe radiation effects on their bodies [6].

The detection and measurement of radiation is an essential tool to take proper protection measurements, for which many types of the detectors and monitoring devices (area survey, personal monitoring etc) are being used since the discovery of radioactivity. For personal dose monitoring, film badges are used to measure radiation doses to the radiation workers [3]. The film badge unit has two components (i) plastic holder and (ii) film. The photographic film is placed in plastic holder. The plastic holder is fitted with a many filters of different types and thicknesses to distinguish between different types of radiations (beta, gamma, x-rays, etc.) [7-8]. On developing this film exposed during sources' handling, the blackness (named optical density) shows the dose received by specific radiation worker [9-10].

The main advantages and disadvantages of film badges are:

1.1 Advantages

i. Used for measuring doses to individuals.
ii. Give information about type and energy of the radiation received by the worker.
iii. Film can be kept as a permanent record of an individual's dose.
iv. Film can be reassessed at a later date if necessary.
v. Cheap as compared to other personal monitoring devices/gadgets.

1.2 Disadvantages

i. Sensitive to light and heat.
ii. Require dark room facilities for assessment of film.
iii. Manual handling during assessment of film.
iv. Film cannot be reused.
v. Limited supply.

Pakistan Nuclear Regulatory Authority (PNRA) has implemented an occupational dose limit (20 mSv) for radiation workers of Pakistan [11] adopted from standard and guidelines of International Atomic Energy Agency (IAEA) [12] and International Commission on Radiological Protection (ICRP) [13-15].

The aim of present study was to evaluate occupational doses of workers of the institute and the time period in which the radiation worker could attain the radiation occupational dose limit of 20 mSv as implemented/adopted by national and international regularity bodies [12-15].

2. MATERIALS AND METHODS

For the measurement of workers' personal occupational radiation doses, the film badge is one of the recommended devices [3,5,8,10,16]. In this context, each of the worker handling radioactive sources has been issued a distinct identifying number's film badge. Pakistan Institute of Nuclear Science and Technology (PINSTECH) Islamabad is the main provider of the film badge service in Pakistan on monthly basis [3,5,17] and the results kept as record of occupational doses of workers.

Amongst 30 occupationally exposed workers, 8 (27%) were in Nuclear Medicine section (5 Nuclear Physicians and 3 Technologists), 4 (13%) in Radiology (Technologists), 3 (10%) each in Radio-Immune-Assay (Technologists) & Repair Maintenance section (Technicians) respectively whereas 12 (40%) were in Radiotherapy section (4 radiation oncologists, 2 health physicists & 6 radiotherapy technologists). All the workers were instructed to wear the film badges during the occupational working hours between their chests and waists or either area (chest/waist). The occupational radiation doses of workers and the time period (in years) in which the workers attain the limit of 20 mSv have been shown in Table 1. The film badges' readings for radiation workers were kept as their occupational dose history [3,5,17,18].

This study was commenced to analyze the occupational doses received by the radiation workers of NIMRA Jamshoro Pakistan and to explore that the achievement of annual limit as recommended by regularity bodies [12-15].

3. RESULTS

The occupational radiation dose data of radiation workers has been shown in Table 1. Also the time period (in years) in which the workers attain the limit of 20 mSv is also included in this table. The graphical representation of minimum, maximum occupational radiation doses of workers has been shown in Fig. 1.

Range of maximum occupational doses received by radiation workers has been summarized in Table 2 and pictographic demonstration of percentage-wise contribution of radiation workers' occupational doses has been given in Fig. 2. Table 3 illustrated the time period in which each of workers achieved the limit of 20 mSv with proportionality with total workers and graphics of year-wise completion of 20 mSv limit by workers has been point out in Fig. 3.

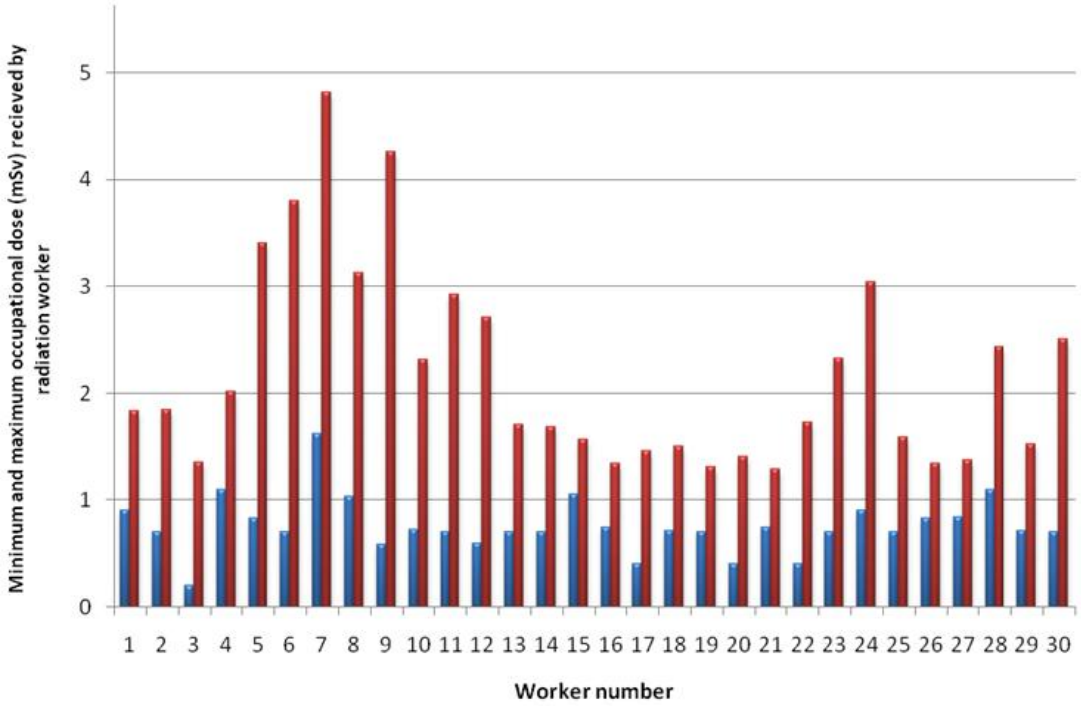

Fig. 1. The minimum, maximum occupational radiation doses of workers

Table 1. The occupational radiation doses of workers with minimum, maximum, average doses and the time period in which the workers attained the limit of 20 mSv

Section	Machine/Unit	Section-wise worker No.	Total worker No.	Gender	Annual radiation dose from total period		Time period in which limit completed (Years)	Average annual dose of total period (mSv)
					Minimum (mSv)	Maximum (mSv)		
Nuclear Medicine (NM)	Nuclear Physicians	1	1	F	0.91	1.83	16	1.28
		2	2	F	0.70	1.85	15	1.38
		3	3	M	0.20	1.35	17	1.20
		4	4	M	1.10	2.02	14	1.47
		5	5	M	0.83	3.40	15	1.40
	Hot Lab Technologists	6	6	M	0.70	3.80	6	3.42
		7	7	M	1.62	4.82	7	2.86
		8	8	M	1.03	3.13	12	1.71
Radiology	Mammography Technologist	1	9	F	0.58	4.26	9	2.30
	Simulator Technologist	2	10	M	0.72	2.32	15	1.37
	X-rays Machine Technologists	3	11	M	0.70	2.92	10	1.97
		4	12	M	0.59	2.71	12	1.65
Radio-Immune-Assay (RIA)	RIA Lab Technologists	1	13	F	0.70	1.71	16	1.24
		2	14	F	0.70	1.69	16	1.24
		3	15	M	1.05	1.57	16	1.26
Repair and Maintenance	Repair and Maintenance Technicians	1	16	M	0.74	1.34	18	1.12
		2	17	M	0.40	1.46	15	1.32
		3	18	M	0.71	1.50	16	1.28
Radiotherapy	Radiation Oncologists	1	19	M	0.70	1.31	17	1.15
		2	20	M	0.40	1.41	16	1.22
		3	21	M	0.74	1.29	18	1.11
		4	22	M	0.40	1.73	17	1.18
	Health Physicists	5	23	M	0.70	2.33	16	1.25
		6	24	M	0.91	3.04	13	1.60
	Teletherapy units (Radiotherapy Technologists)	7	25	F	0.70	1.59	17	1.19
		8	26	F	0.83	1.34	16	1.24
		9	27	F	0.84	1.37	16	1.26
		10	28	M	1.10	2.43	12	1.66
		11	29	M	0.71	1.53	17	1.18
		12	30	M	0.70	2.51	15	1.32

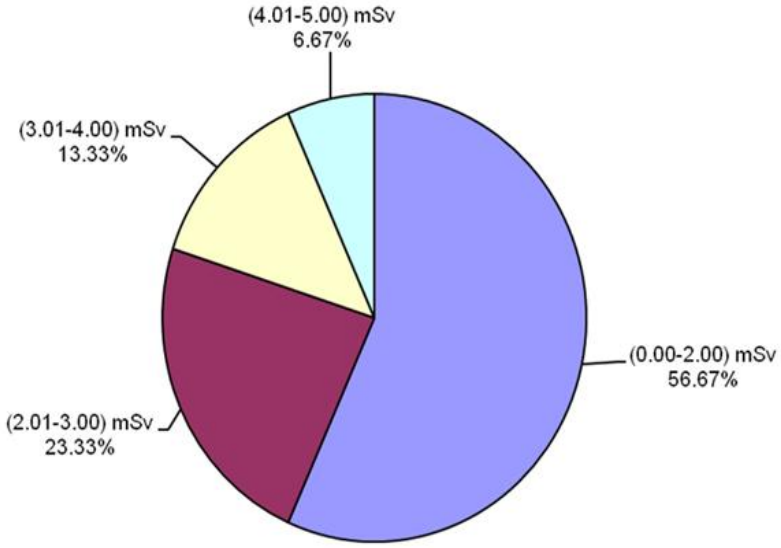

Fig. 2. Percentagewise contribution of radiation workers' occupational doses

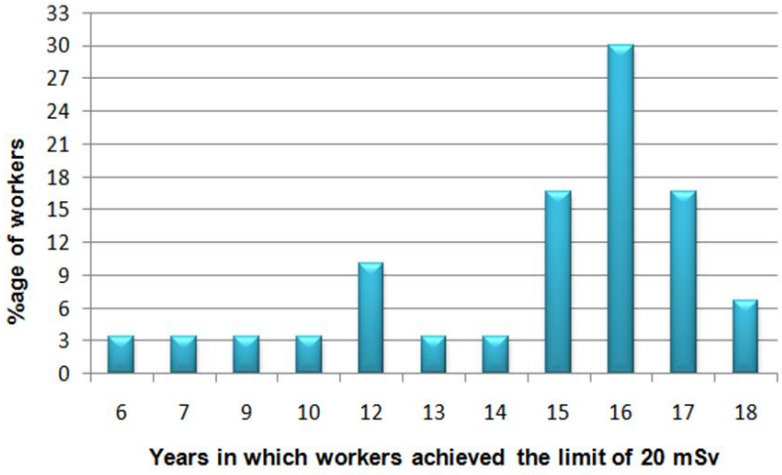

Fig. 3. Year wise completion of 20 mSv limit by workers

4. DISCUSSION

The non availability of data on subject topic makes our results incomparable [19]. Most of the workers (56.67%) received 10% of the limit of 20 mSv as recommended/suggested and implemented by the Nuclear Regulatory Authorities [12-15]. The highest of radiation dose for a worker is 4.82 mSv (24% of 20 mSv limit) which is one of the radiation workers deputed in hot lab of nuclear medicine section. The high dose in hot lab is due to usage of open/unsealed sources of Tc-99m and I-131 for diagnostic & therapeutic purposes and the injected subjects may be the source of increasing dose to worker.

The workers in hot lab attained the limit in the shortest time period of 6 and 7 years respectively whereas radiology section's workers achieved the limit in 9 and 10 years due to the nature of work and handling the unsealed sources. The Radiotherapy workers have achieved the same limit of 20 mSv in more than 15 years except one (12 years) who engaged to carry back the source in safe position on getting stuck in teletherapy along with one health physicist (13 years to attain 20 mSv).

Table 2. Dose range of maximum occupational doses received by radiation workers

Dose range (mSv)	No. of workers
0.00 to 2.00	17
2.01 to 3.00	7
3.01 to 4.00	4
4.01 to 5.00	2

Table 3. The time period in which each of workers achieved the limit of 20 mSv with percentages of total workers

Years	Worker(s)
6	1
7	1
9	1
10	1
12	3
13	1
14	1
15	5
16	9
17	5
18	2

5. CONCLUSION

The main intention of conducting this study was the evaluation of occupational doses of radiation personnel and comparison to permissible limit as recommended/adopted by the Nuclear Regulatory Authorities [12-15]. More than half of the workers received 10% of the limit of 20 mSv and attained the limit in more than 15 years. The highest occupational radiation dose of a worker was 4.82 mSv which is 24% of limit and attained the limit in the shortest time period of 6 years. Due to non availability of data about subject theme, our particulates will remain unmatched and it is suggested that more studies may be conducted for appropriate comparison on film badge dosimetry [19].

ETHICAL APPROVAL

It is confirmed that the authors have obtained all necessary ethical approval from relevant committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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