Romanian Reports in Physics, Vol. 67, No. 2, P. 431–438, 2015

ASSESSMENT OF OCCUPATIONAL EXPOSURE IN MEDICAL PRACTICE IN TEHRAN, IRAN

S. M. MOTEVALLI, A. M. BORHANAZAD

University of Mazandaran, Department of Physics, Faculty of Science, P. O. Box 47415-416, Babolsar, Iran, E-mail: motavali@umz.ac.ir

Received May 15, 2014

Abstract. The present study analyses the data for occupational exposure to radiation in medical centres in Tehran, Iran, from film badge dosimetry data. The radiation workers belonged to three categories: diagnostic radiology (DR), radiotherapy (RT) and nuclear medicine (NM). For each category, the average effective doses during the years 2009 to 2011 were evaluated. Results show that occupational risk depended on job category. The highest exposure was recorded for NM workers and the lowest for RT ones. The annual average effective doses were found to be well below the permissible annual limit of 20 mSv with no over-exposure detected.

Key words: occupational exposure, radiology, nuclear medicine, radiotherapy.

1. INTRODUCTION

Exposures to radiation to which the Standards apply include any occupational, medical or public exposure [1]. The term ‘occupational exposure’ has been used by the International Labour Office (ILO) to refer to the exposure of a worker during work hours [2]. The International Atomic Energy Agency (IAEA) provides a more limited definition of occupational exposure: ‘All exposures of workers incurred in the course of their work with the exception of exposures excluded from the Standards and exposures from practices or sources exempted by the Standards’ [3].

Occupational exposure to radiation can occur as a result of human activity. This includes work associated with the different stages of a nuclear fuel cycle, the use of radioactive sources and x-ray machines in medicine, scientific research, education, agriculture and activities that involve handling of materials containing enhanced concentrations of naturally occurring radionuclides. In order to control this exposure, it is necessary to be able to assess the magnitude of the associated doses [4].

When protection and safety are not adequately or properly implemented, the exposure of the workers to ionizing radiation at the workplace can create to them injuries or disease [2]. Hence, occupational exposure is subject to regulatory control with the requirements defined in Publication 103 of the International Commission on Radiological Protection [5]. Exposure is usually determined by individual monitoring, but sometimes by evaluation of the results of environmental monitoring. An important objective of such determination is to provide information on the adequacy of protective measures that are key input for operational decisions related to radioprotection optimization. In addition, they demonstrate compliance with relevant dose limits [6].

The aim of the study is to present the results of the assessment of the annual average occupational dose of radiation received by the medical staff in Tehran, Iran over 3 consecutive years from 2009 to 2011. Occupational exposure of workers employed in nuclear medicine (NM), radiotherapy (RT) and diagnostic radiology (DR) was measured and recorded by personnel dosimetry film badges. The results were analysed and compared.

The United Nations Scientific Committee on the Effects of Atomic Radiation reviews the distributions of individual annual effective doses and annual collective effective doses from occupational radiation exposure in various sectors of industry or from sources based on studies done in different countries [7–15]. It is of particular interest to examine changes that have taken place over time after the introduction of improved practices, new technology and revised regulations [6].

2. MATERIALS AND METHODS

The operational quantity recommended by the Basic Safety Standards of the IAEA for individual monitoring is the personal dose equivalent Hp(d) [1]. This quantity is the dose equivalent in soft tissue below a specified point on the body at an appropriate depth d. The personal dose equivalent at a depth of 10 mm (Hp(10)) is used to provide an estimate of the effective dose [18, 19].

Calibration of film dosimeters was performed under simplified conventions on an appropriate phantom [4, 20, 21] and the quantity Hp(10) was used to specify the effective dose at a point in a phantom representing the body. The film badge was placed on radiation workers under the lead apron at the upper left side of the thorax to measure the personal dose equivalent over a time period of 2 months. The film badges were dispatched using the postal service and all dose results were recorded and archived. For those Hp(10) doses with values greater than investigation levels designated by the regulatory authority, the licensee of related centre and radiation protection division of Atomic Energy Organization of Iran (AEOI) were informed in order to allow investigation of the causes and to confirm its validity. Unconfirmed results were deleted from the dose recording.

The film badge dosimetry service was provided by Parsian Radiation Dosimetry Services Company (PRDS) and was controlled by the Radiation Protection

Department of the AEOI according to the requirements of regulatory authority. The results of the PRDS met accuracy criteria and remained within the trumpet curves provided by IAEA for personal dosimetry [16].

Calibration of film dosimeters was done at the Secondary Standard Dosimetry Laboratory (SSDL) of the AEOI. Its measurements can be traced by the IAEA dosimetry laboratory in Austria.

The PRDS used Foma Personal Monitoring Film (Foma PMF) to record the doses. Foma PMF is a set of two films intended for personal dosimetry of gamma, x-radiation and electrons: Foma DF10, a high speed film double-coated on a blue polyethylene terephthalate base and Foma DF2, a low speed (emergency) film. The minimum detection limit (MDL) of this type of film is 0.05mSv. Therefore, doses of less than 0.05mSv were recorded as zero values.

3. RESULTS AND DISCUSSION

Analysis was performed on 94,910 film badges to obtain the occupational exposure of radiation workers in Tehran employed in NM, RT and DR during 2009-2011. Figure 1 demonstrates that from 2009 to 2011 the population of radiation workers in Tehran increased from 4,459 in 2009 to 5,726 in 2011, by about 29%. Figure 2 shows the number of films at various dose intervals. 92.4% of the results were below MDL.

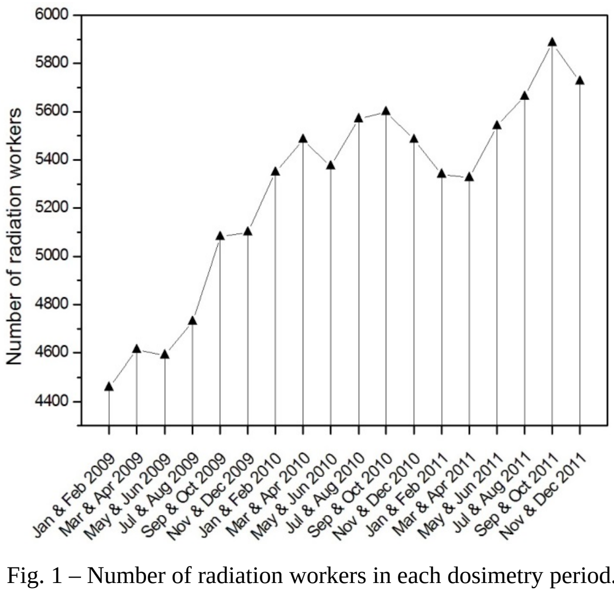

Fig. 1 – Number of radiation workers in each dosimetry period.

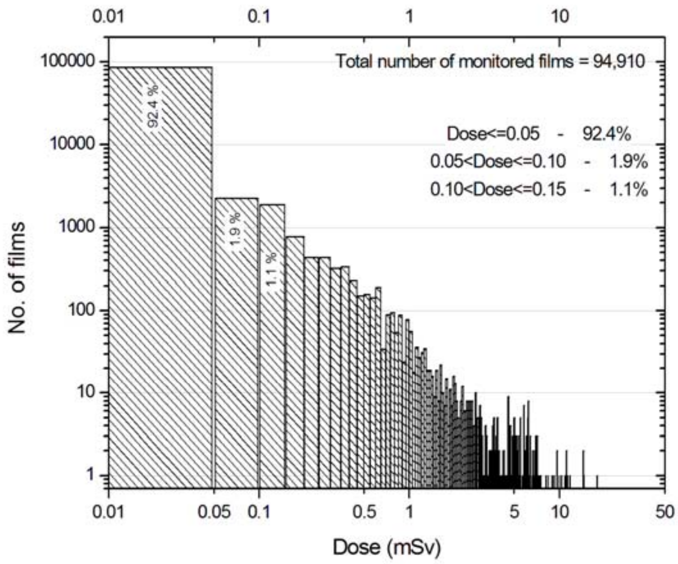

Fig. 2 – Frequency distribution (number of films within each dose interval).

As shown in Fig. 3, about 91, 6 and 3% of the total radiation workers were employed in DR, NM and RT, respectively, during 2009–2011. An increased number of radiation workers were observed in all three categories. In Fig. 4 is presented the variation of the number of measurably exposed workers in the same period.

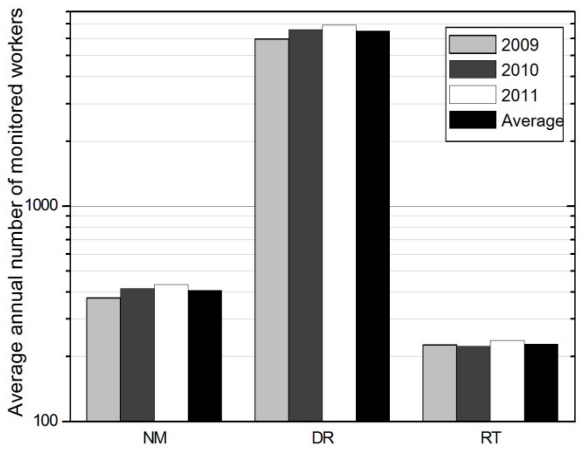

Fig. 3 – Average annual number of monitored workers.

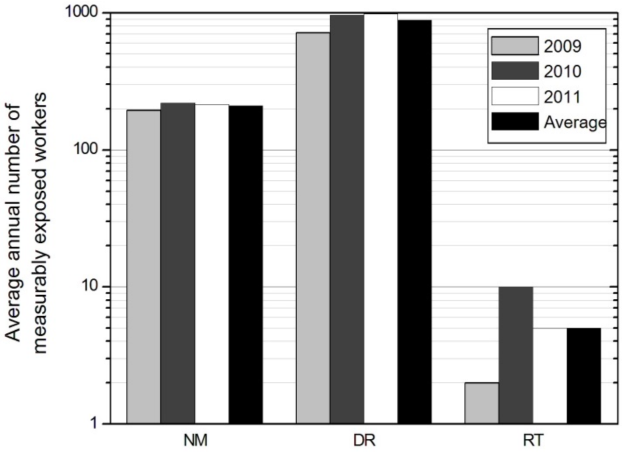

Fig. 4 – Average annual number of measurably exposed workers.

Figure 5 indicates that the doses received by 52% of radiation workers in NM were more than MDL, whereas the doses of only 14% of DR and 2% of RT radiation workers were more than 0.05 mSv.

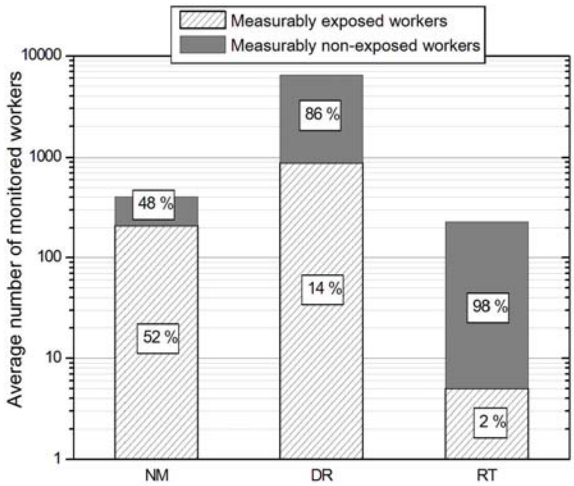

Fig. 5 – Number of measurably exposed and non-exposed workers.

The annual average effective dose (AAED) is an appropriate quantity for comparison of dose distributions [6]. This quantity was determined for monitored workers and measurably exposed workers from NM, DR and RT considering the period 2009–2011. Their dose distributions are shown in Figures 6 and 7, respectively. These values were comparable to the results of other studies, as presented in Table 1.

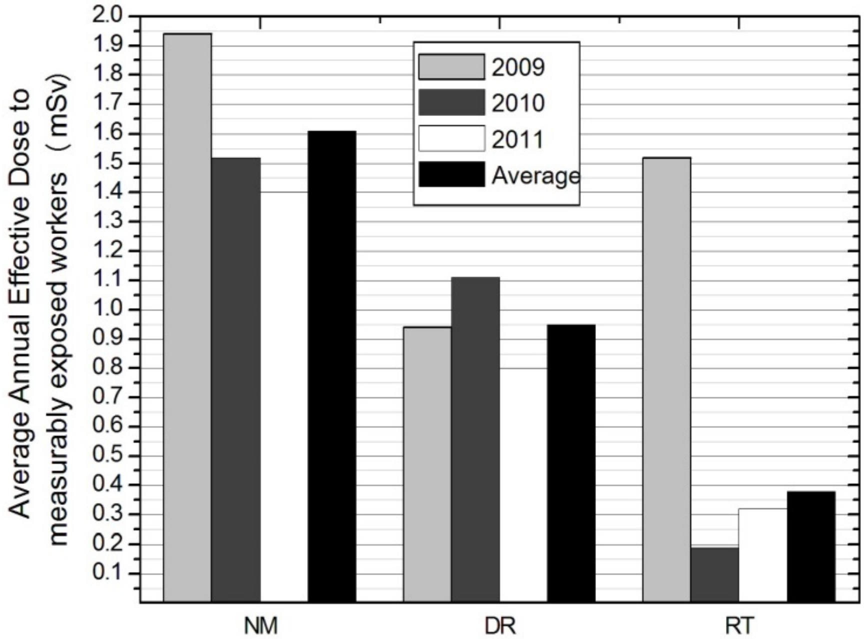

Fig. 6 – AAED of measurably exposed workers.

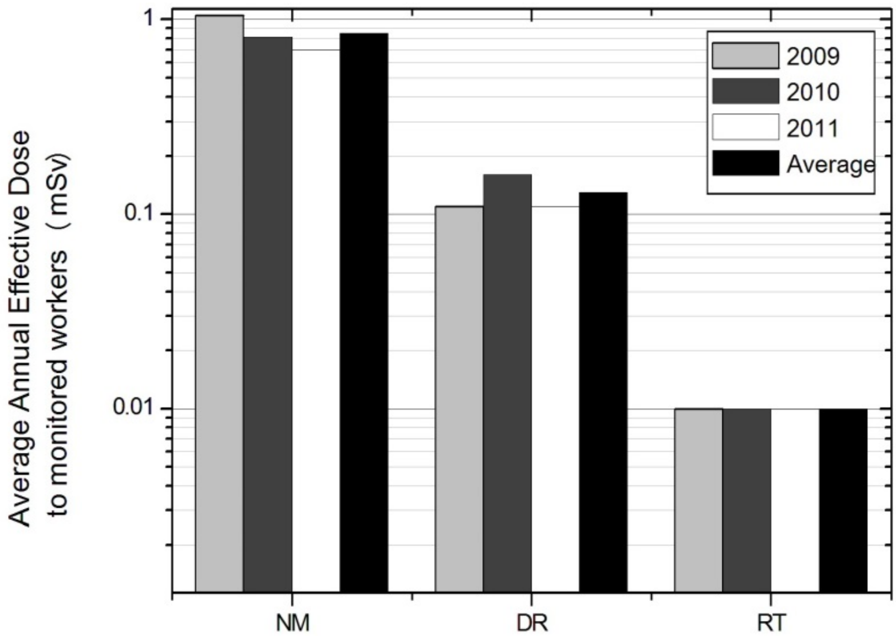

Fig. 7 – AAED of monitored workers.

Table 1

Comparison of AAED for NM, RT and DR workers in Tehran with results of other studies [6, 17, 12]

Country	Years	NM (mSv)	RT (mSv)	DR (mSv)
Australia	(1990–1994)	0.75	0.35	0.19
Slovenia	(1993–1994)	1.3	0.13	0.49
Pakistan	(2007–2011)	1.12	0.88	0.52
Guilan/Iran	(2009–2011)	1.01	1.39	0.51
Tehran/Iran	(2009–2011)	1.61	0.38	0.95
Canada	(1990–1994)	1.96	0.80	0.35
India	(1990–1994)	1.36	1.34	0.42
World	(1990–1994)	1.41	1.33	1.34
Lithuania	(1996–2000)	1.14	1.51	1.48
Pakistan	(2003–2007)	1.55	1.17	1.47
China	(1986–2000)	1.40	1.25	1.85
Thailand	(1990–1994)	2.89	1.05	0.58
Indonesia	(1985–1989)	1.20	1.63	1.75
Greece	(1994–1998)	1.84	2.07	2.53
Greece	(1990–1994)	2.27	2.00	3.86
Syria	(1990–1994)	3.16	1.37	4.40
Brazil	(1990–1994)	3.50	3.95	2.58

4. CONCLUSION

Analysis of occupational exposure data for 2009-2011 demonstrates that all the occupational dose values were below the relevant dose limits [1, 22]. AAED decreased from 1.94 mSv to 1.4 mSv in nuclear medicine, from 0.94 mSv to 0.8 mSv in diagnostic radiology and from 1.52 mSv to 0.32 mSv in radiotherapy, in the period 2009 to 2011. This observation could be the result of improvements in radiation protection and is an indication that there could be further reductions in subsequent years with implementation of changes in regulatory standards, new technologies, modifications in work practices and other radiation protection programs.

Acknowledgements**.** The authors would like to thank Mr. Siamak Borhanazad, managing director of RPDS, for his technical support and assistance**.**

REFERENCES

1. IAEA, *International Basic Safety Standards for Protection against Ionizing Radiation and for Safety of Radiation Sources*, Safety Standards. Safety Series No 115, 1994.

2. International Labor Office, *ILO radiation protection of workers* (*ionizing radiation*) *and ILO code of practice*, Geneva, ILO 1987.
3. International Atomic Energy Agency, International Labour Office, *Occupational Radiation Protection*. Safety Standards Series No. RS-G-1.1, Vienna, 1999.
4. International Atomic Energy Agency. International Labour Office, *Assessment of Occupational Exposure due to External Sources of Radiation*, Safety Standards Series No. RS-G-1. 3, Vienna, 1999.
5. International Commission on Radiological Protection, *The 2007 Recommendation of the International Commission on Radiological Protection* (ICRP), ICRP Publication No. 103, 2007.
6. United Nation Scientific Committee on Applied Radiation (UNSCEAR), *Occupational radiation doses*, UNSCEAR Report 20, 2000.
7. W. Weizhang, W. Zhangi, R. Cheng, L. Zhang, *Occupational exposures of Chinese medical radiation workers in 1986–2000*, Radiat. Prot. Dosim., **117,** *4*, 440–443 (2006).
8. K. P. Valuckas, V. Atkocius, V. Samerdokiene, *Occupational exposure of medical radiation workers in Lithuania, 1991–2003*, Acta Med. Lituanica, **14,** *3*, 155–159 (2007).
9. P. A. Colgan, L. Currivan, D. Fenton, *An assessment of annual whole-body occupational radiation exposure in Ireland* (*1996–2005*), Radiat. Prot. Dosim, **128**, 12–20 (2008).
10. F. Hasford, J. Owusu-Banahene, J. K. Amoako, F. Otoo, E. O. Darko, G. Emi-Reynolds, J. Yeboah, C. C. Arwui, S. Adu, *Assessment of annual whole body occupational radiation exposure in medical practice in Ghana* (*2000–2009*), Radiat. Prot. Dosim, **149**, *4*, 431–437 (2011).
11. V. Kamenopoulou, G. Drikos, P. Dimitriou, *Occupational exposure to ionising radiation in Greece* (*1994–1998*), Radiat. Prot. Dosim, **91**, *4*, 385–389 (2000).
12. M. Khalid, A. Munir, Z. Junaid, H. Mumtaz ul, A. Afshan, Z. Haroon, *Assessment of Occupational Exposure among Pakistani Medical Staff during 2007–2011*, Australas Phys. Eng. Sci. Med., **35**, *3*, 297–300 (2012).
13. A. Koczynski, A. Chec, D. Lach, M. Dabek, *Occupational exposure to external ionizing radiation in Poland in 1999*, Radiat. Prot. Dosim., **96**, 61–62 (2001).
14. J. V. Careiro, R. Avelar, *Occupational exposure in medical and paramedical professions in Portugal*. Radiat. Prot. Dosim., **36**, *2–4*, 233–236 (1991).
15. M. A Saizu, *IPNE-HH Whole body counting laboratory, Eight years of notified activity, Statistics on monitoring data*, Romanian Reports in Physics, **61**,*4*, 662–668 (2009).
16.* * * Film for personal dosimetry. FOMA. Materials for medical use 501 04 Hradec Králové, BOHEMIA spol. s r.o. Czech Republic. Available From: URL: http://www.foma.cz/en/pmf.
17. S. M. Motevalli, A. M. Borhanazad, *Investigation of Occupational Exposure of Radiation Workers in Medical Centers in Guilan Province*, Journal of Guilan University of Medical Sciences, **22**, *88*, 41–48 (2013).
18. International Commission on Radiation Units and Measurements, *Measurement of Dose Equivalents Resulting from External Photon and Electron Radiations*, Report No. 47, ICRU, Bethesda, MD, 1992.
19. International Commission on Radiation Units and Measurements, *Quantities and Units in Radiation Protection Dosimetry*, Report No. 51, ICRU, Bethesda, MD, 1993.
20. International Atomic Energy Agency, *Calibration of Radiation Protection Monitoring Instruments*, Safety Reports Series No 16, Vienna, 1999.
21. International Organization for Standardization. *X and Gamma Reference Radiations for Calibrating Dosemeters and Doserate Meters and for Determining Their Response as a Function of Photon Energy*, ISO 4037.
22.* * * *Protection against Ionizing Radiation and The Safety of Radiation Sources – Basic standards*, Institute of Standards and Industrial Research Of IRAN, No 7751, First Edition, 2005 available from: URL: http://www.aeoi.org.ir/Portal/Home/Default.aspx?CategoryID=bb759579-dd19-4ab3-b1dd-d5a7a92a9e82.