

Received: 2011.03.02  
Accepted: 2011.03.25

## Occupational exposure at the Department of Nuclear Medicine as a work environment: A 19-year follow-up

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### Summary

**Background:**

This study assessed the radiation safety at Nuclear Medicine Department being a work environment. Ionizing radiation exposure of the employees in the last 19 years and the effects of legislative changes in radiological protection were analyzed.

**Material/Methods:**

All employees of the investigated department were regularly and individually monitored using chest badges equipped with Kodak film type 2. Overall, 629 annual doses of the employees of nuclear medicine department, registered in the period 1991–2009, were analyzed statistically.

**Results:**

Technicians were found to be the largest exposed professional group, whereas nurses received the highest annual doses. Physicians received an average annual dose at the border detection methods. Ancillary and administration staff occasionally received doses above the method detection limit (MDL). The average annual dose for all dosimetry records was 0.7 mSv, and that for dosimetry records equal and higher than MDL was 2.2 mSv.

**Conclusions:**

There was no case of an exceeded dose limit for a worker. Furthermore, improvement of radiological protection had a significant impact on the reduction of doses for the most exposed employees.

**Key words:**

average annual effective dose • ionizing radiation exposure • radiation safety

**PDF file:**

<http://www.polradiol.com/fulltxt.php?ICID=881815>

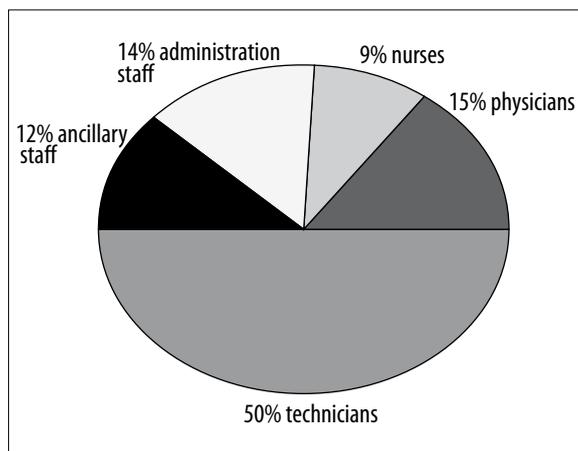
### Background

What kind of work environment is the department of nuclear medicine? Are the employees exposed to high doses of radiation while working with open radiation sources for medical purposes? These are the questions often asked by young students of medicine and medical analysis, and patients. The number of departments of nuclear medicine is still increasing [1]. The data presented in this report indicate that there will be at least a 16% annual growth in research in the field of nuclear medicine in Europe. This is caused by a high number of studies using PET/CT and SPECT/CT, mainly because of the increasing number of oncological indications. It is predicted that in the next few years, the number of examinations, such as CT, ultrasound, and MRI, will gradually decrease, but after 2015, new

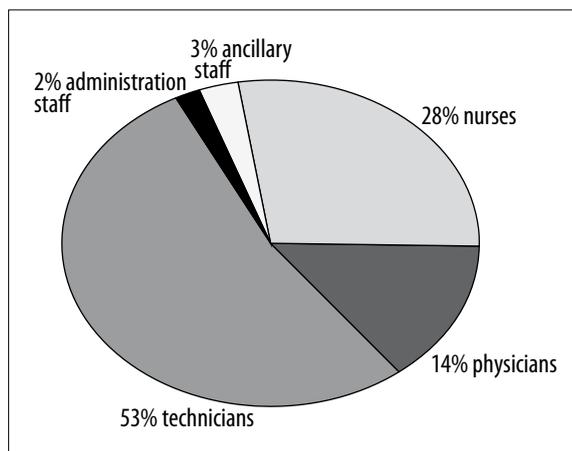
techniques of radioisotope studies, such as PET/MRI and SPECT/MRI, will be introduced. In this study, the following issues were examined: the level of occupational exposure of workers in a common department of nuclear medicine for the last 19 years. Which groups of the staff received the highest absorbed dose when performing radioisotope procedures. Whether the restrictions on the rules and, hence the improvement of radiological protection affected the reduction of doses absorbed by workers exposed to radiation in the nuclear medicine environment?

### Material and Methods

Overall, 629 annual doses of the employees of nuclear medicine department, registered in the period 1991–2009, were analyzed statistically. All employees of the investigated



**Figure 1.** The percentages of doses for occupational groups with the total number of annual records (AD set).



**Figure 2.** Percentage of doses for occupational groups from annual records greater than zero (DD subset).

**Table 1.** Average exposure of workers in the years 1991–2009. Calculations were performed for two groups of doses: AD (all doses) and DD (doses above the limit of detection).

Occupational group	Number of annual doses		Mean dose and standard deviation (mSv)		Modal value (mSv)		Minimum dose (mSv)		Maximum dose (mSv)	
	AD	DD	AD (s.d.)	DD (s.d.)	AD	DD	AD	DD	AD	DD
Nurses	56	53	4.0 (2.8)	4.2 (2.8)	3.1	3.1	0.0	0.4	13.4	13.4
Technicians	312	102	0.6 (1.7)	1.8 (2.5)	0.0	0.5	0.0	0.1	18.6	18.6
Physicians	100	27	0.1 (0.2)	0.4 (0.2)	0.0	0.5	0.0	0.1	1.0	1.0
Administration staff	86	4	0 (0.0)	0.4 (0.4)	0.0	0.1	0.0	0.1	1.0	1.0
Ancillary staff	75	7	0 (0.1)	0.2 (0.2)	0.0	0.1	0.0	0.1	0.5	0.5

department were regularly and individually monitored using chest badges equipped with Kodak film type 2. Dosimeters were sent quarterly to the Central Laboratory for Radiological Protection (CLRP) in Warsaw for readings of dose equivalents  $H_p(10)$  absorbed by the employees. The uncertainty of the method was, according to the CLRP,  $\pm 22\%$ . The MDL was 0.4 mSv (2); a lower detection limit, of 0.1 mSv, was initiated in October 2007. For purposes of this study, all evaluated annual doses formed a group named All Doses (AD). Annual doses equal to or higher than MDL were named Detectable Doses (DD). All individual doses were analyzed, including results obtained from dosimeters of employees who worked at the department for less than 1 year.

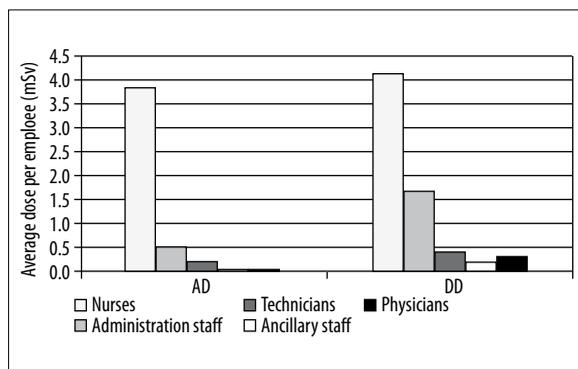
### Results

In the years 1991–2009, the imaging studies were performed using three gamma cameras and one scintigraph; outpatient thyroid therapies were carried out using Iodine 131. The average number of performed radioisotope procedures was approximately 3800 per year and showed a slightly increasing trend during the analyzed period.

Figure 1 shows the percentage distribution of all 629 analyzed annual doses (AD set) in five occupational groups.

Approximately 50% of all doses were received by the technicians. Physicians obtained 15% of doses, administration 14%, and ancillary staff 12%. Nurses were the smallest occupational group, with 9% of annual doses. Figure 2 shows the percentage of the recorded annual doses greater than zero for workers from different occupational groups. Technicians received 53% of annual doses above MDL, nurses 28%, and physicians 14%. Administration and ancillary staff received doses above MDL occasionally (3% and 2%, respectively). Table 1 contains the results concerning the average exposure of employees in all occupational groups during the 19-year period.

The calculation results were presented for all recorded annual doses (AD set) and for the annual records above MDL (DD subset). On average, technicians received doses that were twice as low as those for nurses. Physicians received an average annual dose at the border detection methods. Ancillary and administration staff occasionally received doses above MDL. Maximum annual dose was registered in the group of technicians, and it was 18.6 mSv. Modal values for various occupational groups showed that most of the registered doses for nurses were 3.1 mSv per year, whereas those for the ancillary and administration staff were below the limit of detection. Physicians, as well as technicians, often received a dose of 0.5 mSv per year.



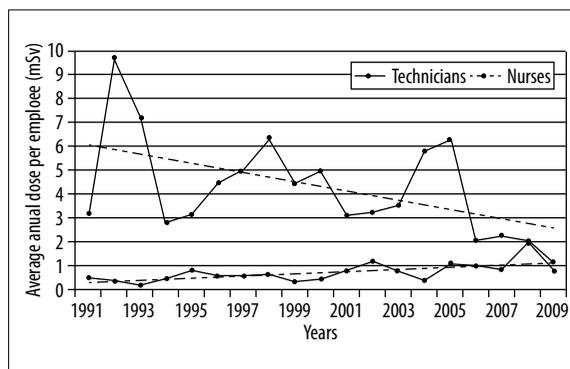
**Figure 3.** Comparison of average doses for the various professions in the two doses groups: AD (all doses) and DD (detectable doses).

Figure 3 shows the average annual doses in AD and DD group. The dose for technicians was three times higher in DD group than in AD group, and this was due to a different range of duties of the technical personnel.

The average dose for an average department employee (for AD group) was 0.7 mSv (s.d.=2.1 mSv). The average dose for employees receiving doses above MDL (for group DD) was 2.2 mSv (s.d.=2.8 mSv). Time course of the average annual doses was traced for the most exposed groups (see Figure 4). Since 2005, there has been a gradual decrease in annual doses for nurses. For an average technician, the annual dose remained unchanged or slightly increased.

## Discussion

Technicians are the largest occupational group in nuclear medicine. Much higher doses for the technical staff in DD group than in AD group were due to the presence of two subgroups of technical workers: technicians performing work in hot laboratories and those conducting *in vitro* tests with the RIA method. Only the first subgroup was exposed to higher radiation doses and that was because of the fact that they prepared radiopharmaceuticals, performed examinations of the patients and controlled the scanners. Table 1 shows that the highest annual individual dose (of 18.6 mSv) was recorded only for the technical staff. The International Agency of Atomic Energy recommends that the average annual dose for exposed workers in a nuclear medicine facility should range from 3 to 5 mSv [3]. According to the UNSCEAR report, the average dose for monitored and exposed workers in the years 1990–1994 was 0.86 and 1.4 mSv per year, respectively [4]. The value of the average exposure calculated for the said department of nuclear medicine coincides with data for similar departments in Europe and around the world [5–8]. When assessing a work environment, such as the department of nuclear medicine, it is beneficial to refer to the calculated occupational exposure for exposed workers (for DD subset): 2.2 mSv to natural radiation level. Statistically, humans receive an average dose of 2.4 mSv per year from natural sources [9]. In Poland, a total dose per year is 2.2 mSv. However, there is a significant disproportion between doses in different geographical regions, from less than 1 mSv to a few hundred mSv per year. In Ramsar (Iran), the average annual dose from natural background radiation amounts to 260 mSv. Areas with significantly higher numbers of natural radioactive



**Figure 4.** Trends for the professional groups most at risk.

elements including approximately 5% of the world population are found in Italy, Brazil, France, India, and China.

Currently, the linear no-threshold model is used in radiological protection. This model assumes that even the smallest increase in dose may have a negative health effect. For years, there has been discussion about health effects of small doses of ionizing radiation. However, according to the legislation, an employer is obligated to ensure radiological protection of workers at a level, which will eliminate occupational exposure.

The atomic law in Poland was amended in 2000 [10]. The introduced changes were designed to adapt the legislation to the standards of the European Union. The annual dose limit for workers was reduced from 50 to 20 mSv; also, the reference activity of radioisotopes administered to patients was determined. The amendment of the legislation resulted in an improvement of radiation protection in many laboratories using open sources. Figure 4 shows a clear downward trend in the dose received by the nurses, since 2005. These changes were caused by reorganization of the work (most examinations of patients are conducted by technicians). Moreover, new and better equipment for radiation protection was bought: a tungsten syringe shield, new covers on the ampoules, and lead glass screen for the control room. In mid-2008, the older SPECT gamma camera was replaced with a new type, SPECT/low-dose CT. A working X-ray lamp may potentially be a new and additional source of exposure to workers. Therefore, in accordance with the established procedures, CT examinations and tests are run and monitored by technicians, from the control room only. Figure 4 shows that the average dose for technicians (performing SPECT/CT) in 2009 was not higher than the dose in the years 2005–2007.

During those 19 years covered by this study, there was no incidence of a dose exceeding the annual dose limit of 20 mSv. From a practical point of view, the administration and ancillary staff have not worked in terms of exposure to ionizing radiation. Nurses and technicians were the most exposed groups, with significant individual differences in effective whole-body doses. The average occupational radiation dose for nurses who worked at the presented department was at the level of natural background radiation in Poland. Improvement of radiological protection had a significant impact on the reduction of doses to the most exposed employees.

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