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SOCIAL-DEMOGRAPHIC PROFILE AND DOSE EVALUATION OF THE RADIOPHARMACEUTICAL FACILITY WORKERS

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ABSTRACT

The main aims of this work are to identify the social-demographic profile of the workers based on stratification variables such as gender, age, and tasks performed by the workers, and to evaluate the annual collective doses of workers with potential risk of ionizing radiation exposure at the workplace during the years 2004 to 2008. In this context, the knowledge of the workforce composition in the facility responsible for the radioisotope production and its distribution was used. The individual monitoring programme has been carried out by individual dosimeters, TLDs, and internal contamination monitoring (*in vivo* method). The reported doses, in the period studied, suggest that the external exposure was the main source of occupational exposure in radioisotope production and distribution areas. The internal exposure was not included in the doses estimated, because it was negligible. This study has an important exploratory character, in order to analyze possible correlations related to adverse health effects, aiming to provide directions for occupational epidemiology research.

1. INTRODUCTION

Radioisotopes are produced for a great variety of industrial and medical purposes. The Instituto de Pesquisas Energéticas e Nucleares, IPEN - CNEN/SP, is the major center, in Brazil and it is responsible for the radioisotope and radiopharmaceutical production as well it's processing labelling and distribution, mainly for medicine uses.

The main source of occupational exposure in radioisotope production and its distribution is external irradiation. Internal exposure may be significant in some cases, and arrangements are then made for personal monitoring. In this work, internal exposures have not been included in the dose estimates (the contribution of internal component was not significant for the pathways of occupational exposure).

The occupational exposure is normally subject to regulatory control. It needs to be in compliance with the requirements for practices according to national and international radiological protection standards [1,2,3]. A monitoring programme has been well established and leaded by IPEN´s Radioprotection team.

The assessment of doses to workers potentially exposed to external sources of radiation constitutes an integral part of radiation protection programme and helps to ensure acceptably safe and satisfactory radiological conditions in the workplace.

The objectives of this work are: firstly to identify the social demographic profile of Radiopharmaceutical Facility workforce composition based on the stratification variables gender, age, educational level, marital status and different occupations. Secondly, to evaluate the annual collective doses of workers with potential risk of ionizing radiation exposure at the workplace during 2004 to 2008 period.

2. METHODOLOGY

To attend the objectives of this study, it was used a quantitative analyses. This study has exploratory and descriptive character and it is based on statistical procedures for analysis of the numerical information.

The data were derived from examinations of the administrative register of institution IPEN - CNEN/SP and from the individual monitoring records from the radioprotection management.

A total data of 183 registers (all monitored workers in 2008) were evaluated and the dose distribution, within the radiopharmaceutical workforce, was shared in intervals.

2.1. Selection of Population

The number of workers monitored of Radiopharmaceutical Facility, in 2008 was 183 individuals. The workforce is composed by workers with permanent employment at IPEN, fellow and others workers contracted for carry out some specific task. The main activities of these workers include radioisotope production and it is distribution, labelling, encapsulation, and packaging of all radiopharmaceutical material in Brazil. Furthermore, there is a working group engaged with new radiopharmaceuticals development and quality control procedures.

2.2. Individual Monitoring Programme

An individual monitoring programme for external radiation exposure is intended to provide information for the optimization of protection, to demonstrate that the worker's exposure has not exceeded any dose limit. Furthermore, it is applied to verify the adequacy of workplace monitoring [1,2,3].

In most circumstances, doses due to external radiation can be readily assessed by the systematic individual monitoring of workers. In this case, all workers of Radiopharmaceutical Facility use a passive dosimeter, type Thermoluminescent Dosimeters, TLD. This dosimeter generally is worn on the surface of the body for a month period, and at the end of this period it is read and the doses recorded.

In general, all workers have been internally monitored, but the frequency of measurements differs according to the task performed and the operation place. The frequency is monthly in the radioisotope production for Occupationally Exposed Individual, OEI. For those workers that carry out task-correlated, the frequency is semestral. An annual frequency is for

administrative persons of facility, fellow and workers contracted for carry out some specific task.

In this study, the dose standards used to control the occupational exposure of worker taking account some flexibility (i.e. averaging of doses over five years) [1,4] are:

- ✓ Mensurable dose - recording level: 0.2mSv/monthly, [1]
- ✓ 1 mSv: effective dose value, for general public
- ✓ 6 mSv in a year, an investigation level
- ✓ 20 mSv annual effective dose for OEI – operational value
- ✓ 50 mSv annual effective dose (maximum value) for worker in a single year.

The intention of such monitoring is to provide data to support immediate decisions on the management of operations and on optimization of protection.

3. RESULTS AND DISCUSSION

In a previous investigation, it was verified that the population studied (is composed of 61% of male and 39% of female workers, with the mean age of individuals (47.64 ± 6.69) years old. The average working time of this sample is (22.34 ± 6.86) years and the educational level is 41.6% with graduation, 57.4% with high school and 1% with elementary school. With regard to the marital status, most of them are married (63.3%), 30.7% are single, 5% are divorced and 1% is widowed.

The distribution of the annual collective effective dose and numbers of monitored workers at Radiopharmaceutical Facility during the years 2004 to 2008 is illustrated in the Table 1.

Table 1. Distribution of annual collective effective dose at Radiopharmaceutical Facility workers during 2004–2008 periods

Radiopharmaceutical Facility	2004	2005	2006	2007	2008
Collective dose (person-mSv)	442.13	411.16	490.59	542,06	588.72
Average effective dose (mSv)	3.98±3.73	3.43±3.67	3.45±3.18	3.43±3.49	3.16±3.69
Number of monitored individuals	111	120	142	158	183
Number of individuals over average dose	29	30	37	41	39
Number of Individuals bellow recording level	73	81	88	100	132
Number of Individuals over investigation level	24	20	24	17	23
Number of Individuals over operational value	0	0	0	1	0
Percentage over investigation value	21.6	16.7	16.9	10,8	12.6

The individual dose records were analyzed in terms of trends through the years, it was possible to assess the collective dose, effective dose and to identify those workers with potential risk to ionizing radiation.

The collective dose at Radiopharmaceutical Facility exhibited an upward trend for the years 2006-2008 although the values of average effective dose are relatively constant.

The increased on collective dose in 2006 to 2008 can be attributed in the radioisotope production mainly due the growing number of monitored workers and package task performed. The number of workers involved in radioisotope production averaged over five year periods, increased from 111 in the first year to about 183 in the last year, reflecting the probable growing use of radioisotopes in both industry and medicine (increased demands). In this sense, the annual collective effective dose of workers monitored has increased by a factor 1.4.

In 2008 about 13% of workers presented doses over the investigation level.

The contribution of the internal dose in the total individual doses was zero, because all them measured in vivo counting, had presented values less than the recording level.

The number of records for monitored individuals is an indication of the dosimetry programme dimension, but it is not necessarily an indicator of the number of the exposed workforce. This fact is a conservative practice at Radiopharmaceutical Facility, because the management does not desire that the individuals overpass the dose standards established. Many individuals are monitored for reasons such as safety, administrative convenience, and legal liability.

For the five years period, 100% of the Radiopharmaceutical Facility workforce was monitored for radiation exposure. Approximately 25% of monitored individuals received a measurable dose. Over the past five years, the percentage of individuals monitored for radiation exposure has remained constant.

Exposure data are commonly analyzed in terms of dose intervals to depict the dose distribution among the worker population. The Table 2 shows the number of individuals in each of five different dose ranges. The number of individuals receiving doses below 5 mSv is included to show the number of individuals with doses below the monitoring threshold specified in international regulations [2,5].

Approximately 80% of the individuals monitored had doses less than the recording level (5 mSv). It also shows in Table 2, that the collective dose has increased each year from 2006 to 2008. For the first time in the past five years, only one individual received an effective dose above 20 mSv. It was assumed to be due a fault in operational procedure.

Another way to examine the dose distribution is to analyze the percentage of the dose received above a certain dose value as compared to the total collective dose.

Table 2. Workforce effective dose range distribution, per year

Effective dose E(mSv)	Number of monitored individuals per year				
	2004	2005	2006	2007	2008
$0 < E \leq 5$	85	93	114	131	156
$5 < E \leq 10$	13	16	16	18	16
$10 < E \leq 20$	13	11	12	8	11
$20 < E \leq 50$	0	0	0	1	0
$E > 50$	0	0	0	0	0
Total	111	120	142	158	183

Broad dose range is undesirable and needs to be avoided in future as from an individual worker perspective, as a regulatory perspective. The analysis focuses on doses received by individuals that were in excess of the investigation level.

4. CONCLUSIONS

The choice of the variables, gender, age and marital status is important for both demographic and epidemiological studies. In the field of epidemiology, gender and age are essential for the calculation of coefficients (morbidly and mortality). The knowledge of the marital status is important because many diseases (health risks) are strongly related with this variable. Accuracy analysis in demography and epidemiology depends on the population contingent's information in each one of the modalities of these variables.

The monitoring programme is to assess annual external and committed internal doses and cumulative doses to workers. For epidemiology studies all doses are considered.

The individual doses above 5 mSv/year in 2008 are 27 OEI (183 minus 156, see Table 2) require a special treatment. The contribution of these doses approximately reaches 15% of the total number of workers and provides to a considerable fraction to the annual collective dose. This had provided a basis for estimating the average individual risks in a workforce and within its subgroups. During this time period, the focus on ALARA practices was increased, and then the safety has been improved and the exposure risk was reduced**.**

For the period studied, there was not exposure in excess of the 50 mSv, maximum value for worker in a single year.

REFERENCES

1. COMISSÃO NACIONAL DE ENERGIA NUCLEAR. Diretrizes Básicas de Proteção Radiológica, CNEN-NN-3.01, CNEN, Rio de Janeiro (2005).
2. INTERNATIONAL COMMISSION ON RADIOLOGICAL PRTECTION. 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60. Pergamon Press. Oxford, (1991).
3. INTERNATIONAL ATOMIC ENERGY AGENCY. International basic safety standards for protection against ionizing radiation and for the safety of radiation sources. Vienna, 1996. (IAEA-SS-115)
4. INTERNATIONAL ATOMIC ENERGY AGENCY, Occupational Radiation Protection, Safety Guide No. RS-G-1.1, Vienna (1999).
5. INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, The 2007 Recommendations of the International Commission on Radiological Protection, Annals of the ICRP, Publication 103, Elsevier Ltd. (2007).