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Evaluation of radiation exposure to healthcare workers in the Nuclear Medicine department using Thermoluminescent Dosimetry (TLD): A cross sectional study.

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I. Introduction

Nuclear medicine (NM) is the branch of medical science in which trace quantities of radionuclide's are introduced into the human body. These small amounts of radioactive materials are called radiotracers. Radiotracers are introduced in human body directly into bloodstream through injections, inhalation, or swallowed. These radiotracers then travel to the part of body, which is to be examined. These radiotracers will release energy in the form of Gamma Rays, and these rays are detectable through special cameras and the images are collected and scrutinized with software, and this will provide the information inside of the body (1). This technique, using radiotracers provides diagnostic information in a diverse range of diseases and, therapeutic procedures in some malignant and non-malignant conditions. Since NM imaging provides unique information that often cannot be obtained using other imaging procedures, so it offers the capability to identify disease in its earliest stages (2). Inventions in artificial radioactivity and development of nuclear reactors had played a significant role in the technology of nuclear medicine science. A lot of development has taken place over the past few years in therapeutic nuclear medicine (3).

This branch of science being so beneficial for the patients, is also associated with hazards. Serious hazards maybe confronted by the healthcare workers during the use of medical radiation. The healthcare staff may be long term exposed to low levels of radiation and may get associated biological effects. There are evidence that ionisation radiation may cause reversible or irreversible genotoxic effects (4)(5)(6)(7). Although biological effects related to moderate and high doses (>100 mGy) are evident, still there is considerable debate regarding the biological effects due to low-dose exposures (<100 mGy). The United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR) has reported that the worldwide mean annual occupational dose in NM is below 2 mSv (8). The Atomic Energy Regulatory Board (AERB) has recommended the dose limit (whole body) of radiation exposure 20 mSv/year averaged over 5 consecutive years and 30 mSv in any single year for occupational exposure of radiation. Also, doses to the workers should be kept as low as reasonably achievable (ALARA) (9).

In this study, we investigated the level of radiation exposure of staff working in departments of Nuclear Medicine at All India Institute of Medical Sciences (AIIMS), New Delhi during 2017. A comparison of personnel doses received by the staff was also carried out. The mean annual occupational dose of each group was compared with the dose limits set by the AERB.

II. Materials And Methods

The personal monitoring of radiation exposure of each staff working in the department of NM is conducted using thermoluminescent dosimeter (TLD) badges. Generally, two TLD badges are provided to each staff member (one for wrist and one for chest).

Sample and sampling

There are 13 different cadre of staff members in nuclear medicine department. These cadres are merged to form 4 groups: Consultants, Resident doctors, Students, and other staff. Also, from the available data, only those workers whose TLD data was available for all the four quadrants were included in study. So, the final sample size became n=58 for wrist TLD and n=61 for chest TLD.

Table 1: Frequency of TLD records for chest and wrist in each group.

Group	Chest TLD (n=61)	Wrist TLD (n=58)
Consultants	07	07
Resident doctors	16	16
Students	16	16
Other staff	22	19

Data collection

The Department of Atomic Energy, Government of India, provides TLD badge (CaSOp4: Dy based) for personnel dose-monitoring to all radiation in the country. Each worker who is likely to be occupationally exposed to radiation carries a TLD badge attached to their clothing, to monitor exposure on a quarterly basis. The annual values of the radiation exposure were calculated from these quarterly data.

The staff working under radiation exposure and are provided with TLD badge was selected for the study. Those staff members who's complete one-year TLD dosemeter data was not available were excluded from the study. All the data was kept anonymous, so names of the persons were removed from the list before analysis.

For all statistical tests, $p < 0.05$ was considered statistically significant.

Ethics statement

Approval for this study was obtained from the institutional ethics committee of All India Institute of Medical Sciences New Delhi.

III. Results

The mean exposure limits and the range of the exposure among each group for both chest TLD badges and wrist TLD badges are given in the Table 2 and Table 3 respectively. Consultant group in both cases (chest and wrist) had the least overall values of exposure.

Table 2: Chest TLD badge values.

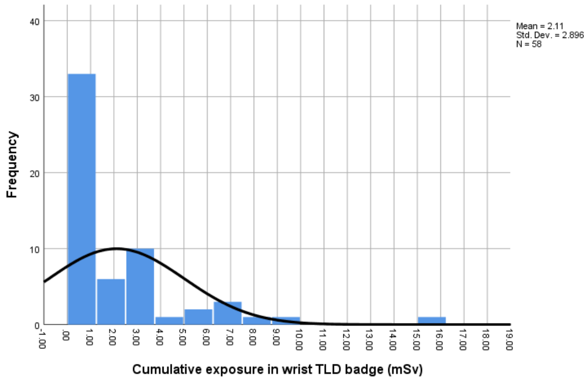
Group	Exposure in Chest TLD (Mean ±SD) mSv	Range (min-max)
Consultants (A-1)	0.13±0.14	0-0.35
Resident doctors (A-2)	1.18±1.50	0-4.75
Students (A-3)	1.19±1.11	0.2-3.45
Other staff (A-4)	1.41±1.73	0-7.3
Overall	0.98±0.58	0-7.3

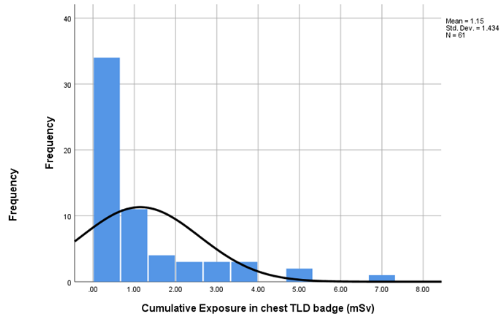
Table 3: Wrist TLD badge values.

Group	Exposure in Wrist TLD (Mean ±SD) mSv	Range (min-max)
Consultants (B-1)	0.14±0.13	0-0.3
Resident doctors (B-2)	2.21±2.87	0-9.05
Students (B-3)	2.21±1.25	0.15-3.55
Other staff (B-4)	2.67±4.06	0.2-16
Overall	1.81±1.14	0-16

The maximum observed exposure value in chest TLD badge among all groups was 7.3 mSv and in wrist was 16 mSv.

The distribution of the cumulative exposure dose among all workers is illustrated in Fig. 1 and 2. In both cases and in all groups the cumulative value for radiation exposure for one year were below 20mSv.





IV. Discussion

AIIMS, New Delhi is an apex tertiary care hospital located in the capital of country. It is the largest public healthcare institution of the country. Nuclear medicine department at AIIMS, New Delhi has three SPECT/CT, two single head and one dual head gamma camera, an uptake probe with well-counter and a well-equipped Radio-pharmacy Laboratory. Also, there are two PET/CT scanners. In the year 2017 a total of 16574 diagnostic, 1396 therapeutic procedures, 8336 PET/CT and 2456 cardiac procedures were conducted in the NM department (10). At AIIMS New Delhi 94 workers in Nuclear Medicine were provided with TLD badges. TLD Badges are worn on chest and wrist by each worker. These badges are being checked by BARC guidelines quarterly and the results of these personal dosimeters is conveyed to the respective worker. Institute is also conducting radiation safety trainings regularly to these workers.

In our study, we observed that Occupational radiation doses among the staff were well below the established occupational limits by AERB. Although mean values of the annual personal dose equivalents in our sample ranged from 0.13 to 2.67 mSv for 2017. Maximum observed values were 16 in wrist and 7.3 mSv in chest TLD badge. There are some limitations are associated with our study. The first one is the assumption made that the dose received by the TLD badge reflects the actual dose received by the worker.

In conclusion, with a mean value of 0.98 mSv for chest TLD and 1.81 mSv for wrist TLD (for 2017, recorded annual occupational doses in our sample of 61 NM staff from large institution were well below the recommended values by AERB as well as UNSCEAR annual reported values. These results should be informative for occupational radiation monitoring and safety efforts in NM department.

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