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Assessment of Radiation doses of Staff of Nuclear Medicine Unit at Mulago National Referral and Teaching Hospital

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Abstract
The paper presents the assessment of radiation doses of staff in the Nuclear Medicine Unit of Mulago National Referral and Teaching Hospital. The doses received by staff are compared with the dose limits recommended by the International Atomic Energy Agency (IAEA), World Health Organization (WHO) and International Commission on Radiological Protection (ICRP). Doses of occupational workers in the Nuclear Medicine unit were monitored for a period of 5 months. Personal radiation doses were determined using two chip LiF TLD-100 dosimeter badges. The TLD badges and reader were calibrated using a standard 90-Strontium radiation source. The mean monthly effective radiation doses for the staff ranged from 0.78± 0.05mSv/month for nursing officers to 0.08± 0.05mSv/month for the nuclear medicine physician. These mean monthly effective radiation doses were projected to the annual effective radiation doses received by staff. The mean annual radiation doses were, 9.29±0.60mSv/yr for Nursing Officers, 2.79± 0.60mSv/yr for Medical Physicist and Radiographer, 6.46 ±0.60 mSv/yr for Radioimmunoassay Technologists, 1.71 ± 0.60 mSv/yr for Nuclear Medicine Technologist and 0.91±0.60 mSv/y for Nuclear Medicine Physician. The results of this study show that effective radiation doses received by the Nuclear Medicine staff of Mulago National Referral and Teaching Hospital are within the recommended dose limits for occupational workers.
Key words: Effective Radiation Doses, Dose Limits, Occupational Worker, Thermoluminescent Dosimeter.

1.0 Introduction

Many Nuclear Medicine facilities use technetium-99m and iodine-131 radionuclides for diagnostic and therapeutic modalities (Mas 2008, Mark*et al.*2007). These radionuclides are tagged to pharmaceuticals to form radiopharmaceuticals which convey the radionuclides to specific organs, tissues or cells for diagnostic or therapeutic purposes. (Brix*et al.* 2005).

During Nuclear Medicine procedures, the radiopharmaceutical administered to the patient together with the radioactive wastes generated, pose risks to the staff, patients, public and the environment because of the ionizing radiation (Kowalsky and Falen. 2004). Staffs get irradiated by ionizing radiation during preparation and administration of the radiopharmaceuticals to the patients, from patients administered with the radiopharmaceuticals before and after imaging and the radioactive wastes generated. The patients are irradiated by ionizing radiation from the radiopharmaceuticals directly administered into their bodies. The public get irradiated by ionizing radiation from patients or radioactive wastes while the environment gets irradiated by ionizing radiation from the radioactive wastes discharged into it (Thomson 1995).

As Nuclear Medicine applications continue to grow worldwide, the general awareness of the hazards of ionizing radiation and the tendency to question clinical management has increased. The IAEA Basic Safety Standards (IAEA General Safety Requirements Part 3 2012, IAEABSS 1996) and the International Commission on Radiological Protection (ICRP 2012) recommend an effective dose limit of 50mSv/yr or 20 mSv/yr averaged over five years for occupational workers.

In Uganda, the national regulator, the Atomic Energy Council, issued regulations governing the use of ionizing radiations (AEC-Uganda 2012). These regulations are consistent with the requirements of IAEA, ICRP and WHO.

Nuclear Medicine procedures at the Nuclear Medicine Unit of Mulago Hospital are on increase. The Unit mainly uses technetium-99m and iodine-131radiopharmaceuticals, and the Single Positron Emission Computed Tomography (SPECT) as the imaging facility. We report an investigation of effective radiation doses received by staff in the Nuclear Medicine Unit of Mulago Hospital.

2.0 Materials and Methods

2.1 Handling of Patients and Radiopharmaceuticals at the Nuclear Medicine Unit

During the period of study between February and July 2013, six hundred thirty patients were administered with technetium-99mfor different diagnostic procedures. The total activity of technetium-99m used during this period was 21328 ± 15 mCi. The Unit has eight staff, namely, 2 Nursing Officers (NO), a Radiographer (RG), 2 Radioimmunoassay Technologists (RT), a Nuclear Medicine Technologist (NT), a Medical Physicist (MP) and a Nuclear Medicine Physician (DR).The RG, RT(s), NT and MP were responsible for receiving the technetium-99m generator, eluting the generator, preparing the radiopharmaceuticals and imaging of the patients. The NO(s) were responsible for providing patient care, administration of the radiopharmaceuticals and management of radioactive wastes .The DR undertook interpreting of SPECT images, diagnosis and treatment of patients. The organization and all operations in the Unit conformed to the three basic principles of radiation protection, namely, minimizing time, maximizing distance and shielding to minimize staff exposure.

2.2Materials

TLD-100(LiF) dosimeters were used to determine personal doses of staff and background radiation in the staff room. The Harshaw Bicron TLD Reader (Model 4500) (Harshaw Bicron 1996) was used to read the badges. A standard 90-Strontium Irradiator (Model 2000) was used to calibrate the badges and the reader. Eight badges were assigned to staff and one badge was placed at a height of 1.5 meters on the wall of the staff room for area monitoring of radiation doses in the room. The staff were given instructions on proper use of TLD badges. The badges were coded NO1, NO2, MP, RG, RT1, RT2, NT and DR for traceability. The badges were stored in a designated cupboard in the staff room after work. At the end of the month, the badges were collected and taken to the Radiation Laboratory of the Physics Department of Makerere University for reading. Another set of eight badges was distributed to staff and one badge placed in the staff room.

2.3 Dose Measurement

The TLD-100 (LiF) dosimeters and the Harshaw Bicron TLD Reader were calibrated using reference radiation doses of 5mSv, 10mSv and 20mSv from a standard 90-Strontium Irradiator at the Radiation Laboratory of the Physics Department of Makerere University.

The calibration procedures for the reader and each TLD dosimeters, time – temperature profile for data acquisition, and annealing of TLD Cards was done according to guidelines of Harshaw Bicron TLD (Harshaw Bicron 1996). The TLD chips gave readings for both deep tissue dose Hp(10) and skin dose Hp(0.03).The personal effective radiation doses for each staff and the background radiation dose in the staff room were determined. The TLD badges were cleaned during annealing and ready for re-use.

The mean monthly doses for five months were computed using Hp(10) values. The projected annual radiation doses received by staff were estimated by projecting the mean monthly effective radiation doses received by staff according to Eq (1) below.

$$Projected\ annual\ radiation\ dose = \left\{\frac{[Measured\ radiation\ dose\ in\ mSv]}{Duration\ of\ monitoring\ in\ months}\right\} x12\ months \qquad (1)$$

3.0 Results

The results of mean monthly and projected annual personal effective radiation doses for Staff in the Nuclear Medicine Unit are given in Table 1.The mean monthly radiation exposure in the Staff Room was 0.05 ± 0.02 mSv and the projected annual radiation exposure was 0.60 ± 0.10 mSv/yr.

Table 1. Staff Mean Monthly and Projected annual effective radiation doses

Staff code	Mean monthly radiation dose(± 0.05 mSv/month)	Projected annual radiation dose (± 0.60 mSv/yr)
N1	0.81	9.66
N2	0.74	8.91
RG	0.14	1.64
MP	0.33	3.93
RT1	0.52	6.24
RT2	0.57	6.68
NT	0.14	1.71
DR	0.08	0.91

In Table 1, Nursing Officers received the highest personal effective radiation doses and the Nuclear Medicine Physician got the lowest. Figure 1 shows the projected annual effective radiation doses of different categories of staff.

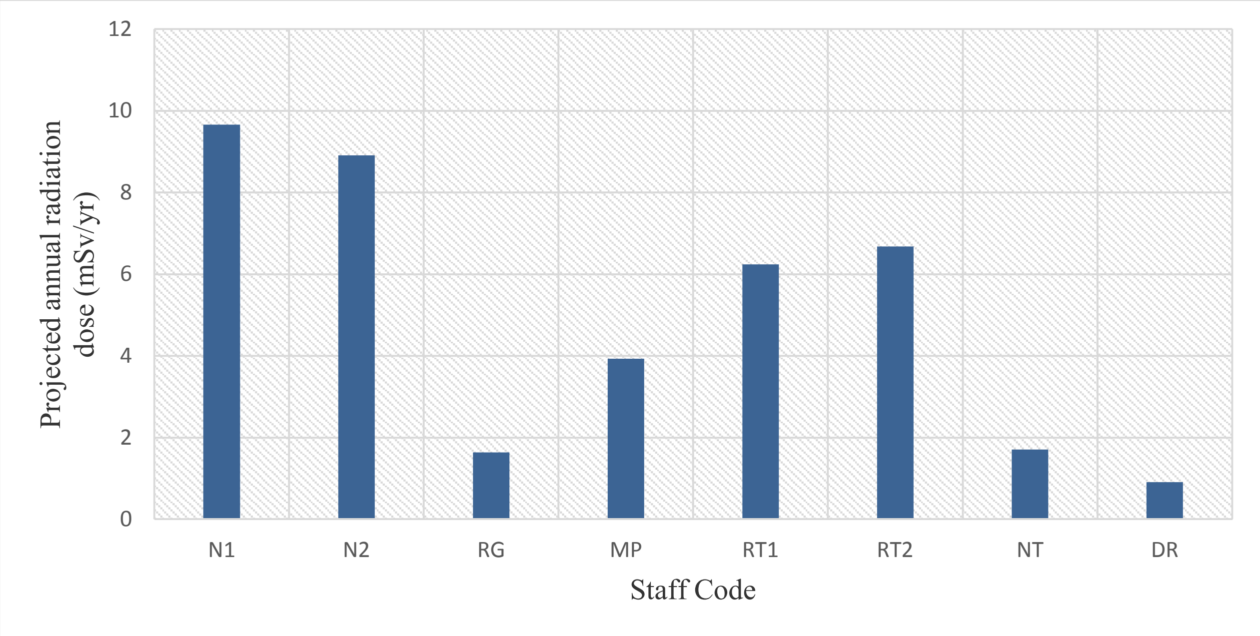

Figure 1. Projected Annual Effective Radiation Doses of Staff

Table 2 shows the mean monthly and projected annual effective radiation doses for Staff grouped in categories of NO(s), MP and RG, RT(s), NT, and DR.

Table 2. Mean monthly and mean projected annual radiation doses of different category of staff

Category of staff	Mean monthly radiation dose (± 0.05 mSv/Month)	Mean projected annual radiation dose (± 0.60 mSv/yr)
NO(s)	0.78	9.29
MP and RG	0.24	2.79
RT(s)	0.55	6.46
NT	0.14	1.71
DR	0.08	0.91

In Table 2, NO(s) received the highest mean monthly and mean projected annual radiation doses but still the dose was less than 50% of the recommended 50mSv/yr dose limit for occupational workers. Figure 2 gives the mean projected annual effective radiation dose for the different categories of staff.

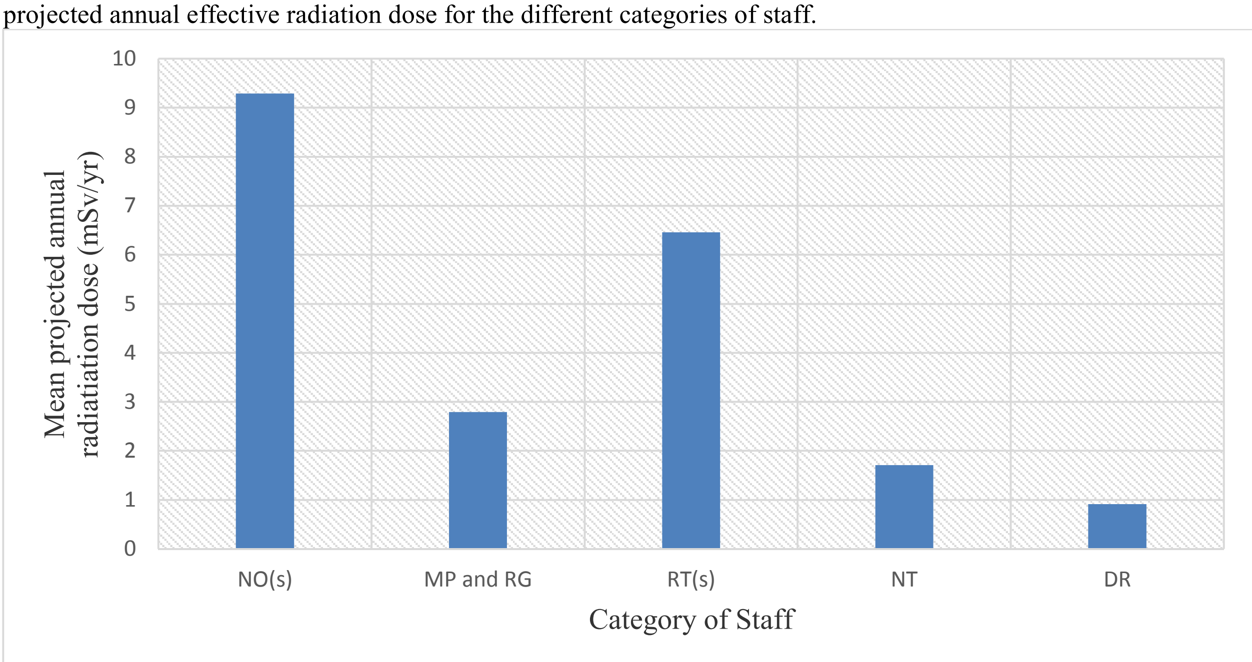

Figure 2. Mean Projected Annual Effective Radiation Dose for the Different Category of Staff

4.0 Discussion

Clinical applications of Nuclear Medicine at Mulago Hospital Complex continue to grow as well as the concern about radiation exposures of staff in the Nuclear Medicine Unit. In this study we assessed the effective personal radiation doses received by the Nursing Officers, Radiographer, Radioimmunoassay Technologists, Nuclear Medicine Technologist, Medical Physicist and Nuclear Medicine Physician.

The Nursing Officers got the highest mean projected annual effective radiation dose of 9.29 ± 0.60 mSv. This could be attributed to their close distance and more time spent, with radiopharmaceuticals during administration to patients, with patients during examination and treatment, and with of radioactive wastes.

The Radioimmunoassay Technologists received a relatively high annual mean radiation dose of 6.46 ± 0.60 mSv. This was associated to their close distance and relatively increased time with the radiopharmaceuticals during elusion, storage of generator, calibration of the SPECT camera and calibration of detectors. The annual radiation doses of Medical Physicist, Radiographer and Nuclear Medicine Technologist are generally low because they spend less time close to the radiopharmaceuticals and patients in the imaging room. The Nuclear Medicine Physician has the lowest personal doses because the Physician spends less time with the radiopharmaceuticals and the patients administered with the radiopharmaceuticals.

It should be noted that the recommended annual effective dose for occupational workers is 50 mSv/yr in one year or 20 mSv/yr averaged in 5 consecutive years. The highest annual mean effective radiation dose of 9.26 ± 0.60 mSv for NO(s) is less than 20% of the recommended 50 mSv/yr or 50% of the 20 mSv/yr. The doses received by NO(s) and all other staff in the unit are below the recommended dose limit.

The risks associated with radiation exposure of occupational staff in the Nuclear Medicine Unit at Mulago Hospital Complex is within acceptable limits. We hope our findings will build confidence and motivate staff to maintain radiation safety and security in all working areas in the Unit.

5.0 Conclusion

The study shows that Nursing Officers got the highest mean annual effective radiation dose of 9.26 ± 0.60 mSv and the Nuclear Medicine Physician got the lowest dose of 0.91 ± 0.60 mSv. The mean annual radiation dose in the Staff Room was 0.60 ± 0.10 mSv which is low and does not pose radiation risks to staff. The other Staff (Radiographer, Radioimmunoassay Technologists, Nuclear Medicine Technologist, Medical Physicist, in the Unit generally received low radiation doses.

The doses received by all staff were within the recommended dose limits for occupational workers.

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