Workplace Radiation Monitoring and Analysis: A Single Institution Based Study

[1]Md. Faruk Hossain, [2]Md. Sunny Anam Chowdhury, [1]Md. Abdul Awal, [3]Md. Monirul Haque, [1]Suraya Sarmin, [1]Md. Al Mamun, Nazia [1]Tarannum

[1]Institute of Nuclear Medicine & Allied Sciences, Bogura, Bangladesh

[2]Institute of Nuclear Medicine & Allied Sciences, Kushtia, Bangladesh

[3]Department of Physics, University of Rajshahi, Bangladesh

Correspondence Address: Md. Faruk Hossain, Senior Scientific Officer, INMAS, Shaheed Ziaur Rahman Medical College Hospital, Bogura, E-mail: faruk84311@gmail.com Mobile: 01723619581

ABSTRACT

Purpose: The primary objectives of this study were threefold: first, to comprehensively assess radiation exposure levels within the Nuclear Medicine (NM) institution; second, to identify and address potential risks associated with diagnostic and therapeutic procedures; and third, to establish strong control measures and emergency response plans. These goals collectively aim to contribute to the creation of a personalized radiation protection program that addresses the unique issues provided by NM applications.

Materials and Methods: Radiation doses were computed over a six-month period using survey meter data gathered three times each day. Measurements were carried out in ionization chambers using radiation's ionizing properties. Continuous radiation surveys used digital survey meters in designated regions, which were classified according to dose rates, with a focus on monitoring doses from radiopharmaceuticals such as ^{131}I and ^{99m}Tc.

Results: Continuous radiation surveys over six months identified maximum values in specific areas within the institution, such as the SPECT room and therapy patient room, all below the allowable limit. This ensured the safety of personnel and patients while maintaining ambient radiation levels outside the institution consistently below the permissible limit.

Conclusion: This study provided essential data for establishing a dose reduction strategy in a clinical NM facility, confirming INMAS Bogura as free from radiation-induced risks and emphasizing the importance of continuous evaluation, adherence to regulations, and long-term monitoring to ensure safe radiological working conditions.

Keywords: Radiation monitoring; radiation hazard; radiation safety; survey meter.

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INTRODUCTION

We live in a world where radiation is ubiquitous. Despite various harmful ionizing effects, radiation can also be beneficial in various sectors. The effect of radiation on tissues first came to light after discovery of X-rays by Wilhelm Conrad Rontgen in 1895. It has the ability to cause cancer but can also cure many serious diseases (1-4). Nuclear medicine, a vital component of modern healthcare, employs various diagnostic and therapeutic procedures that utilize ionizing radiation. While these technologies offer invaluable insights into medical conditions and contribute significantly to patient care, they also necessitate a thorough examination of potential radiation exposure risks. The paramount concern in nuclear medicine institutions is to ensure the safety of both medical personnel and patients, prompting the need for comprehensive assessments and effective control measures.

This study undertakes a multifaceted exploration with the overarching purpose of evaluating radiation exposure levels within a specific nuclear medicine institution, with a particular focus on INMAS Bogura. The objectives are tripartite: first, to conduct a thorough assessment of radiation levels; second, to identify and mitigate potential risks associated with diagnostic and therapeutic procedures; and third, to establish robust control measures and emergency response protocols. The ultimate goal is to contribute to the development of a tailored radiation protection program that addresses the distinctive challenges posed by nuclear medicine applications.

Over a six-month period, the study employs a meticulous approach to calculate radiation doses. Utilizing survey meter data collected at three daily checks, ionization chambers, harnessing the ionizing characteristics of radiation, are employed for measurement. The investigation extends to continuous radiation surveys in designated areas categorized based on dose rates. Notably, the focus remains on monitoring doses from specific radiopharmaceuticals such as I-131 and Tc-99m, which are commonly utilized in nuclear medicine procedures.

The results of continuous radiation surveys unveil maximum values in specific areas within the institution, including the SPECT room and therapy patient room. Importantly, these values consistently fall below the allowable limit, affirming the safety of both personnel and patients. Moreover, the study demonstrates that ambient radiation levels outside the institution remain well below the permissible limit, further underlining the commitment to ensuring public safety beyond the confines of the facility.

MATERIALS AND METHODS

Study Duration: The study spanned a six-month period (January - June, 2022), during which a comprehensive assessment of radiation exposure levels and associated risks within the nuclear medicine institution was conducted.

Radiation Dose Calculation:

1. Survey Meter Data Collection: Radiation doses were calculated using survey meter data collected at three daily checks. These checks provided real-time information on radiation levels, enabling a dynamic assessment of exposure.

2. Ionization Chambers: Ionization chambers, leveraging the ionizing characteristics of radiation, were employed for precise measurement of radiation doses. These chambers, strategically placed within relevant areas of the institution, facilitated accurate data collection.

Digital Survey Meter, Model: 3000 Austral-Rad Mini 8-in-1

Figure 1: Survey Meter

Continuous Radiation Surveys:

1. Digital Survey Meters: Continuous radiation surveys were conducted using Digital Survey Meters. These meters were strategically placed in designated areas categorized based on dose rates. The categorization aimed to prioritize areas with higher potential exposure risks.

2. Focus on Radiopharmaceuticals: Special attention was given to monitoring doses from specific radiopharmaceuticals, including I-131 and Tc-99m. These substances are commonly utilized in diagnostic and therapeutic procedures within nuclear medicine.

Data Analysis:

1. Maximum Value Identification: Continuous radiation surveys over the six-month duration enabled the identification of maximum radiation values within specific areas of the institution. This data was crucial for pinpointing potential hotspots and areas of elevated risk.

2. Comparison with Allowable Limits: The identified maximum values were compared with established allowable limits to ensure compliance with safety standards. This step was integral in confirming the safety of personnel and patients within the nuclear medicine facility.

Ambient Radiation Levels: Ambient radiation levels outside the institution were also monitored during the study period. The objective was to ensure that radiation exposure remained consistently below the permissible limit, safeguarding the surrounding environment.

Safety Confirmation: The results obtained from the radiation surveys and dose calculations were instrumental in confirming the safety of personnel, patients, and the surrounding environment within the nuclear medicine institution.

Designated as a (a) uncontrolled area (dose rate ≤ 3 µSv per hour). (b) A zone under supervision

(dose rate: ≤ 7 µSv per hour) (c) Controlled areas (dose rates ≤ 10 µSv per hour) and (d) restricted areas (dose rates ≈ 25 µSv per hour) (5).

Table 1. Radiation level in hot laboratory.

Time	Location	Maximum Dose rate at several months (µSv/h)					
		JANUARY, 2022	FEBRUARY, 2022	MARCH, 2022	APRIL, 2022	MAY, 2022	JUNE,2022
8.30 AM	Fume hood	8.07	8.05	8.10	8.05	8.01	8.13
	Background	3.80	3.75	4.05	3.92	4.03	3.79
10.30 AM	Fume hood	8.15	8.10	8.07	8.12	8.09	8.06
	Background	4.05	3.98	3.93	4.07	4.01	4.03
12.30 PM	Fume hood	8.25	8.20	8.19	8.21	8.15	8.25
	Background	3.75	3.95	3.85	4.05	3.79	4.12

Table 2. Radiation level in dispensing room:

Time	Location	Maximum Dose rate at several months (µSv/h)					
		JANUARY, 2022	FEBRUARY, 2022	MARCH, 2022	APRIL, 2022	MAY, 2022	JUNE, 2022
8.30 AM	Basin	0.83	0.78	0.82	0.93	0.86	0.78
	Top of the bench	0.77	0.71	0.78	0.82	0.79	0.75
	Floor	0.68	0.66	0.67	0.75	0.69	0.64
10.30 AM	Basin	0.95	0.91	0.92	0.89	0.93	0.98
	Top of the bench	0.82	0.81	0.78	0.73	0.70	0.76
	Floor	0.62	0.71	0.69	0.68	0.66	0.63
12.30 PM	Basin	0.95	0.97	0.92	0.91	0.95	0.92
	Top of the bench	0.85	0.84	0.85	0.81	0.83	0.71
	Floor	0.69	0.66	0.69	0.66	0.67	0.58

Table 3. Radiation level in SPECT (gamma camera) room:

Time	Location	Maximum Dose rate at several months (µSv/h)					
		JANUARY, 2022	FEBRUARY, 2022	MARCH, 2022	APRIL, 2022	MAY, 2022	JUNE, 2022
8.30 AM	1 meter from patient	8.87	8.93	8.25	8.30	8.46	8.28
	Behind lead Shield	4.61	4.55	4.52	4.45	4.35	4.64
	Processing Place	3.25	3.29	3.11	3.10	3.17	3.30
10.30 AM	1 meter from patient	8.83	8.72	8.79	8.75	8.89	8.73
	Behind lead Shield	5.01	4.94	5.07	5.05	5.10	5.02
	Processing Place	3.81	3.61	3.66	3.75	3.88	3.49
12.30 PM	1 meter from patient	8.55	8.83	8.73	8.81	8.45	8.98
	Behind lead Shield	4.75	4.95	5.15	5.03	5.23	5.03
	Processing Place	3.57	3.63	3.67	3.71	3.75	3.85

Table 4. Radiation level in other places

Location	Maximum Dose rate at several month (µSv/h)					
	JANUARY, 2022	FEBRUARY, 2022	MARCH, 2022	APRIL, 2022	MAY, 2022	JUNE, 2022
Outside the SPECT	0.93	0.89	0.87	0.93	0.96	0.92
Under the stair	0.91	0.68	0.71	0.72	0.67	0.63
Corridor (Patient waiting room)	3.20	3.55	3.75	3.45	3.87	3.68
Therapy patient room door	8.50	8.34	8.81	8.25	8.05	8.85

RESULTS AND DISCUSSION

The aforementioned Tables 1 to 4 displays the continuous radiation survey data collected over a period of six months & the radiation dose levels are shown in the graph 2 to 3. We found the maximum value of radiation was detected in the SPECT (gamma camera) room at 8.98 µ Sv/h, the hot laboratory at 8.25 µSv/h, the therapy patient room door at 8.85 µSv/h, and the corridor at 3.87 µSv/h. It was never found to surpass the maximum allowable level. The SPECT room, therapy patient room door and the hot laboratory area can be considered controlled areas based on the aforementioned findings as shown in figure 2. But the corridor is referred to as a supervised area as shown in figure 3. All other locations are ungoverned spaces. The ambient radiation level in the scanning rooms, including the nearby supervised areas, was never found to be higher than the maximum allowable limit.

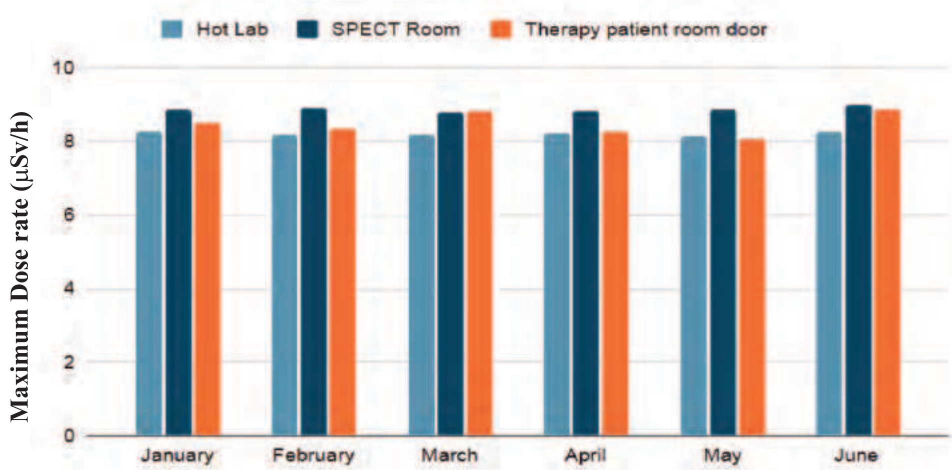

Figure 2: Maximum Dose rate at several months

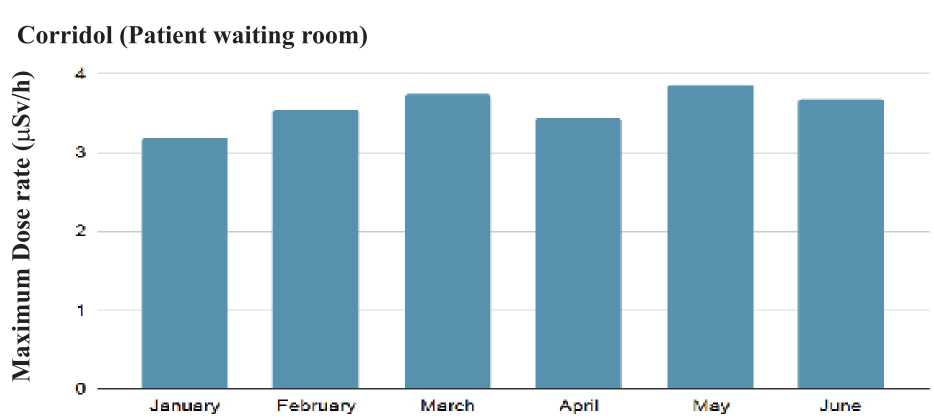

Figure 3: Maximum Dose rate at several months

It is much more difficult to calculate the doses of radionuclides deposited to the patient internally because the activity will be distributed and cleared from the various organs in the body (6). The gamma camera detects photons escaping from the organs and then the radio-pharmaceutical is monitored. In the case of Gamma camera, the photons create a defined image of tissues by distributing radionuclides (7). A survey was conducted utilizing the radioisotopes I-131 and Tc-99m to determine the residual doses that are given to patients with radiopharmaceuticals for diagnostic and therapeutic research. When radioisotopes are employed for diagnosis, the elevated radiation levels that arise in the area around the patients may be harmful to the technicians, doctors, and to some extent the patient's relatives (8). We have noticed that the radiation level in the therapy patient room door and SPECT room is higher than all other areas (but below 10 μSv/h) after boosting the dose for sickness diagnosis. The radiation level outside of the INMAS center is far lower. The majority of the time, background radiation is well below the maximum permitted level and does not pose a serious radiation concern.

CONCLUSION

This study offers valuable data that may be used to determine a proper dose reduction approach for implementing the ALARA principle in a clinical nuclear medicine facility. In light of the findings, INMAS Bogura is radiation-induced risk-free. For the sake of legislation or good practice, it is crucial to evaluate workplace conditions and individual exposures, guarantee acceptably safe and satisfactory radiological working conditions, and maintain long-term monitoring records. However, following the code of practice and insisting on others adhering to the rules and standards is the fundamental method of control.

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REFERENCES

1. Biswal, B.M., Ruzman, N., Ahmad, N.M. and Zakaria, A., 2000. Split-course radiotherapy in stage IV head & neck cancer. The Malaysian journal of medical sciences: MJMS, 7(1), p.54.
2. Fang, Y.Z., Yang, S. and Wu, G., 2002. Free radicals, antioxidants, and nutrition.Nutrition, 18(10), pp.872-879.
3. McElhinny, T.L., Dougherty, M.J., Bowling, B.V. and Libarkin, J.C., 2014. The status of genetics curriculum in higher education in the United States: goals and assessment. Science & Education, 23, pp.445-464.
4. Id, M. A. 180, Cancer.org. Available at: https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/cancer-treatment-and-survivorship-facts-and-figures/cancer-treatment-and-survivorship-facts-and-figures-2014-2015.pdf (Accessed: February 1, 2024).
5. ICRP, 2007a. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann. ICRP 37 (2–4).
6. Mefst.hr. Available at: https://neuron.mefst.hr/docs/katedre/nuklearna_medicina/english/Sharp%20PF.%20Practical%20Nuclear%20Medicine.pdf (Accessed: February 1, 2024).
7. Saha, G. B. (2013) Physics and radiobiology of nuclear medicine. New York, NY: Springer New York.
8. Cameron, J. R. and Skofronick, J. G. (1978) Medical physics. Wiley.