International Journal of Scientific Research and Engineering Development-– Volume 7 Issue 6, Nov-Dec 2024
Available at www.ijsred.com

REVIEW ARTICLE OPEN ACCESS

Occupational Radiation Exposure and Safety Practices in Nuclear Medicine: A Review of Monitoring Studies in Bangladesh

Soma Shill
Planning & Development Division, Bangladesh Atomic Energy Regulatory Authority (BAERA), Dhaka, Bangladesh
Email: soma@baera.gov.bd
Corresponding Author: Soma Shill, ORCID ID: 0009-0003-7876-0157

--------------------------------------************************--------------------------------

Abstract:

Bangladesh has a rich history of nuclear medicine, dating back to the 1960s. Over the years, technological advancements and an increasing number of facilities have led to significant improvements in medical diagnostics and therapeutic services. However, occupational exposure to ionizing radiation remains critical for workers handling unsealed radioactive sources in practices like nuclear medicine. Hence, occupational exposure to radionuclides in nuclear medicine requires stringent monitoring to ensure worker safety. This review evaluates the internal and external radiation doses received by nuclear medicine workers in Bangladesh based on seven studies conducted from 2010 to 2024. Data from these studies were analyzed to estimate effective doses and assess compliance with international safety standards. The results show that effective doses across various facilities were well below the annual average dose limit prescribed by national regulation and international organizations like the International Commission on Radiological Protection (ICRP). However, variations in methodology and monitoring practices highlight the need for standardized protocols and routine evaluations. This study emphasizes the importance of continued adherence to safety principles and provides evidence for improving occupational radiation monitoring programs in nuclear medicine practices in Bangladesh. While current safety protocols maintain exposure below prescribed limits, significant variability in individual doses and the increasing complexity of nuclear medicine practices necessitate ongoing monitoring and safety protocol enhancements in the country.

Keywords **— Nuclear Medicine, Occupational Exposure, Monitoring, Dose Limit, Dosimetry**

--------------------------------------************************--------------------------------

I. INTRODUCTION

Occupational exposure is defined as the exposure of workers incurred in the course of their work. [1]. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) report notes that the number of monitored workers exposed to human-made sources of radiation, including medical applications, increased to over 11.4 million for the period 2010–2014 compared to about 10 million in the 1995–1999 period. [2]. Occupational exposure to ionizing radiation is a critical concern in nuclear medicine, where workers are frequently involved in handling unsealed radioactive sources such as Iodine-131 (^{131}I), Technetium-99m (^{99m}Tc), and Fluorine-18 (^{18}F). These radionuclides are widely used for diagnostic and therapeutic purposes, posing risks of internal contamination via inhalation or ingestion.

The purpose of monitoring and dose assessment is to provide information about the exposure of workers and to confirm good working practices and regulatory compliance. [3]. Individual external doses in nuclear medicine practices can be assessed using individual monitoring devices like Thermoluminescent Dosimeters, provided these devices are calibrated and traceable to a standard dosimetry laboratory. [3]. Certain workers may be at risk of both surface (skin) contamination and internal contamination by ingestion, inhalation, or adsorption of radioactive material. Employers are responsible for identifying those persons and for arranging for appropriate monitoring, such as monitoring the thyroid with an external detector or measuring the activity of urine samples. The committed effective dose should be calculated as part of the worker's total effective dose. [3]. The International Atomic Energy Agency (IAEA) recommends that the average annual dose for exposed workers in a nuclear medicine facility should range from 3 to 5 mSv. [4].

Several studies have been conducted in Bangladesh to assess radiation exposure among nuclear medicine workers. However, individual findings are often limited in scope and generalizability. This review aims to consolidate evidence from seven studies to provide a comprehensive understanding of radiation exposure trends, identify gaps in safety practices, and recommend improvements for occupational monitoring programs.

II. Historical Development Of Nuclear Medicine In Bangladesh

A. *Early Years* [5]

The journey of nuclear medicine in Bangladesh began under the Pakistan Atomic Energy Commission in the 1950s. The first facility, the Radioisotope Centre, was established in 1962 in Dhaka. Initially, these centers lacked proper infrastructure and equipment, with limited access to isotopes and diagnostic tools.

B. *Post-Independence Growth* [5]

Following Bangladesh's independence in 1971, the Bangladesh Atomic Energy Commission (BAEC) expanded nuclear medicine services. By the 1990s, significant investments in technology and infrastructure modernized existing centers and established new ones in major cities.

C. *Current Scenario* [6], [7]

Bangladesh's progress in nuclear medicine has been significantly bolstered by international collaborations, particularly with the IAEA. The Bangladesh Atomic Energy Commission (BAEC) has modernized infrastructure, expanded services to over 22 (twenty-two) centers, and introduced advanced technologies such as PET-CTs and cyclotrons. Some prominent private hospitals and a few hospitals under the health ministry also came forward. The combined military hospital (CMH) in Dhaka also established a very functioning center with PET-CT facilities. These developments, along with the contributions from international partners, have propelled the field forward.

III. Monitoring Framework For Nuclear Medicine In Bangladesh

A. *Legislative Framework*

Bangladesh has a robust regulatory framework for all radiation-related activities. The government has established and maintained a legal and regulatory framework specific to the control of occupational exposure.

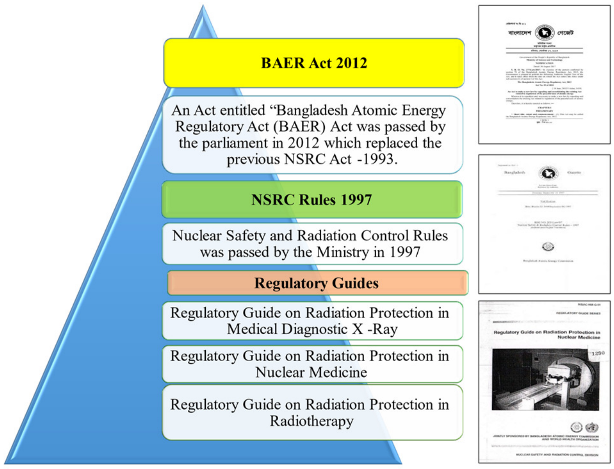

Fig. 1 Legislative framework for radiation protection in Bangladesh

This setup, which includes the Bangladesh Atomic Energy Regulatory (BAER) Act-2012 [8] and Nuclear Safety and Radiation Control Rules (NSRC)-1997 [9], ensures that all radiation workers are provided with the necessary monitoring and safety measures. There is a regulatory guide for detailed instructions specific to nuclear medicine practices. Bangladesh has infrastructure and services for individual monitoring. Internal monitoring is required by regulation, but individual monitoring for the intake of radionuclides by occupationally exposed workers appears not to be enforced. Criteria for initiating monitoring of internal exposure are included in Nuclear Safety & Radiation Control Rules-1997.

B. *Individual Monitoring Service*

The Health Physics Division (HPD) of the Bangladesh Atomic Energy Commission (BAEC) is responsible for providing an Individual Monitoring

Service (IMS) to radiation workers in the country [10]. This service adheres to the IAEA International Basic Safety Standards and the ICRP recommendations, emphasizing the necessity of monitoring doses received by individuals exposed to ionizing radiation during work. Monitoring ensures a safe working environment and compliance with the NSRC Rules- 1997, requiring all radiation workers to use approved monitoring devices. The calibration of dosimeters is performed in the Secondary Standard Dosimetry Laboratory (SSDL) of the BAEC. SSDL has been available at BAEC since 1991, and it is traceable to the Primary Standard Dosimetry Laboratory (PSDL) of the National Physical Laboratory (NPL), UK. The performance of SSDL is maintained according to the requirements of IAEA/World Health Organization (WHO) network of SSDLs. Therefore, the evaluated doses are traceable to the international measurement system. [11].

IV. METHODS

Seven studies conducted in Bangladesh from 2010 to 2024 were included in this analysis. The included studies involved nuclear medicine workers across various facilities, including the National Institute of Nuclear Medicine and Allied Sciences (NINMAS). Common radionuclides studied were Iodine-131 (^{131}I), Technetium-99m (^{99m}Tc), and Fluorine-18 (^{18}F). Key Methodologies in Radiation Monitoring used in these studies are:

Thermoluminescent Dosimetry (TLD):
Studies used advanced TLD models like the Harshaw 4500 and 6600.

Bioassay Techniques:
Bioassays involve direct and indirect methods to monitor internal contamination. Direct methods assess thyroid uptake using specialized monitoring systems, while indirect methods analyze radionuclide concentrations in urine samples using High-Purity Germanium (HPGe) detectors.
Computational Modeling:
MONDAL-3 software was employed for biokinetic modeling of radionuclide intake and retention. It enabled accurate estimation of long-term effective doses and tissue-specific radiation exposure.

V. RESULTS AND DISCUSSION

The study, *Assessment of Whole-Body Occupational Radiation Exposures in Nuclear Medicine Practices of Bangladesh During 2010–2014* by Rahman et al. [11], evaluated radiation exposure among 300 nuclear medicine workers in Bangladesh using TLDs. The annual average effective dose ranged from 0.13 to 0.27 mSv, significantly below the ICRP recommended limit of 20 mSv. During the study period, 95% of workers received doses under 1 mSv, while only 0.33% exceeded 10 mSv. The study highlighted that the decrease in average annual effective dose after 2013 was probably due to the forming of an independent regulatory authority, BAERA, and proper regulatory control of the nuclear medicine facilities. There is a need for rigorous radiation safety protocols and continuous monitoring to ensure doses remain As Low as Reasonably Achievable (ALARA). Comparatively, doses for Bangladeshi workers were three times lower than the global average cited by UNSCEAR during 2000–2002, aligning with levels in Turkey and France. Emphasis is placed on regular training and improved safety protocols to minimize risks further.

The study *Internal Radiation Monitoring of Occupational Staff in Nuclear Medicine Facilities* by Ferdous et al. [12], evaluated internal radiation exposure risks to occupational staff handling unsealed radioactive sources, specifically ^{131}I and ^{99m}Tc, at two nuclear medicine centers in Dhaka. The research analyzed 49 urine samples from 19 staff members using HPGe detectors to measure radioactivity levels. Results showed that the highest detected concentrations of ^{99m}Tc and ^{131}I were 314 Bq/L and 283 Bq/L, respectively, correlating to effective doses of 14.7 µSv and 5.58 µSv. Though these values remain below the international safety limit (20 mSv/year), the study emphasized improving preventive measures, including adequate ventilation, fume hoods, and protective equipment, to mitigate risks of inhalation and contamination.

Comparing results with international data, the study found Bangladeshi staff exposed to lower radiation levels than the staff in Korea.

The study "Individual Monitoring of Internal Exposure for Nuclear Medicine Workers in NINMAS through In-Vitro Bioassay Techniques" by Shubho et al. [13], investigated internal radiation exposure risks among workers handling unsealed radioactive sources like ^{131}I, ^{99m}Tc, and ^{18}F at the NINMAS, Dhaka. The research analyzed 86 urine samples from 17 workers collected in 2017 using an HPGe detector to measure activity concentrations and estimate committed effective doses. The highest detected radioactivity concentrations for ^{131}I and ^{99m}Tc were 444 ± 39.91 Bq/L and 603 ± 72.36 Bq/L, respectively. From the radioactivity concentration, the effective doses were 8.73 µSv and 28.2 µSv for ^{131}I and ^{99m}Tc, respectively. On the other hand, ^{18}F activity remained below detection levels due to low source activity and proper shielding. All effective doses were within the ICRP annual dose limit of 20 mSv, affirming adherence to the ALARA principle and highlighting the utility of internal monitoring for radiation safety.

The study "Estimation of Internal Radiation Doses for Occupational Workers Due to ^{131}I Radionuclide by Using MONDAL Software" by Raka et al. [14], focused on assessing the effective radiation doses received by nuclear medicine workers handling ^{131}I, commonly used for diagnosing and treating thyroid conditions. The thyroid radioactivity of workers was measured using a Sodium-Iodide Detector [NaI (Tl)], and the data were processed through MONDAL-3 software to calculate radionuclide intake, excretion rates, and tissue equivalent doses. The study's findings indicated that effective doses for workers ranged from 1.2×10^{-4} Sv to 2.4×10^{-4} Sv annually, remaining well within the ICRP limit of 20 mSv/year. By integrating thyroid monitoring into workplace safety protocols, the research emphasized minimizing occupational radiation risks while ensuring compliance with regulatory standards.

In the study, *Committed Effective Doses Received by Occupational Workers Handling Radioisotopes* ^{131}I *and* ^{99m}Tc *at INMAS, as Assessed from Urine Samples* by Noor et al. [15], internal radiation exposure among six nuclear medicine workers at INMAS, Dhaka, was examined. Over an 11-month period, 55 urine samples were analyzed using an HPGe detector to measure radioactivity from ^{131}I and ^{99m}Tc. The committed effective doses were calculated from the detected activity, with average annual doses ranging between 4.57×10^{-5} mSv and 9.72×10^{-3} mSv. These values are significantly below the ICRP limit of 20 mSv per year. Despite the low dose levels, adherence to the ALARA principle remains crucial. The study highlighted challenges such as sample collection timing and decay of isotopes during analysis, which may slightly understate the actual doses. Overall, the findings underscored the importance of regular monitoring to ensure occupational safety while handling unsealed radioactive sources.

The study, *Evaluating Internal Exposure Due to Intake of* ^{131}I *at a Nuclear Medicine Centre of Dhaka Using Bioassay Methods* by Jahan et al. [16], used both the in-vivo and in-vitro approach to examine internal radiation exposure among seven workers handling ^{131}I at the National Institute of Nuclear Medicine and Allied Sciences (NINMAS). The in-vivo examination was done by thyroid monitoring and in-vitro by urine bioassay method. This study analyzed 59 thyroid counts and 59 urine samples to assess radionuclide intake and effective doses. The findings from the samples showed that the intake activity in urine samples is more than the activity of the thyroid glands. The average annual effective dose per worker (in-vivo and in-vitro method) ranged from 0.0787 to 0.1039 mSv/year, significantly below the ICRP limit of 20 mSv/year. The study concluded that the workers are out of risk of contamination. However, the regular monitoring process should be continued for the safe handling process of radioisotopes in nuclear medicine centers.

In the study, *Estimation of the Effective Radiation Dose in Nuclear Medicine Workers from Dhaka by Measuring Radioactivity in Urine Sample Resulting from Internal Exposure* by Shanta et al. [17], research was conducted on analyzing the internal radiation exposure among 15 workers handling ^{131}I,

^{99m}Tc, and ^{18}F at NINMAS, Dhaka. Analyzing 151 urine samples using a HPGe detector, the study measured radioactivity concentrations ranging from 0.91 ± 0.26 to 504.49 ± 6.03 Bq/L for ^{131}I, 0.15 ± 0.21 to 191.19 ± 6.98 Bq/L for ^{99m}Tc, and 0.031 ± 0.022 to 0.282 ± 0.065 Bq/L for ^{18}F. The highest effective doses were calculated at 0.0026 mSv for ^{99m}Tc, 0.0021 mSv for ^{131}I, and 0.00000036 mSv for ^{18}F. These doses are significantly below the ICRP recommended annual dose limit of 20 mSv. The study underscored the importance of internal exposure monitoring and adherence to radiological safety protocols to safeguard nuclear medicine workers from potential contamination while handling unsealed radioactive sources.

TABLE I
CONSOLIDATED TABLE SUMMARIZING THE KEY FINDINGS OF THE SEVEN PAPERS

Paper Title	Key Focus	Methodology	Key Findings	Recommendations	Ref.
Occupational Exposures (2010-2014)	Trends in whole-body radiation exposure in nuclear medicine workers across Bangladesh.	TLD dosimetry for ~300 workers, quarterly monitoring analyzed over 5 years.	Average annual dose 0.13–0.27 mSv. 95% of workers received doses <1 mSv, and only 0.33% exceeded 10 mSv. Doses well below global averages.	Maintain rigorous safety protocols; focus on training and continuous surveillance.	[11]
Internal Radiation Monitoring (2012)	Evaluating internal exposure risks for staff in Nuclear Medicine facilities.	Analysis of 49 urine samples from 19 workers at two Nuclear Medicine Centers in Dhaka.	Effective doses from urine samples were below safety thresholds. Maximum effective doses were 14.7 µSv (^{99m}Tc) and 5.58 µSv (^{131}I).	Improve ventilation, use fume hoods and personal protective equipment.	[12]
Internal Monitoring at NINMAS (2019)	Assessment of internal exposure due to ^{131}I, ^{99m}Tc, and ^{18}F in NINMAS workers.	86 urine samples from 17 workers were analyzed with an HPGe detector. Dose coefficients from ICRP Publication 78 were used.	Effective doses for ^{131}I, ^{99m}Tc, and F-18 were well below the ICRP limits. The highest effective dose recorded was 28.2 µSv (^{99m}Tc).	Regular bioassay, adherence to ALARA principles, improved monitoring.	[13]
MONDAL Software Study (2020)	Using MONDAL-3 software to evaluate doses from ^{131}I exposure in nuclear medicine workers.	Thyroid activity was measured, and doses were modeled via MONDAL-3 software.	Effective annual doses ranged from 1.2×10−4 Sv to 2.4×10−4 Sv, below the regulatory limit.	Incorporate thyroid monitoring into routine safety protocols.	[14]
Committed Doses via Urine Sampling (2020)	Dose assessment of ^{131}I and ^{99m}Tc via urine samples at INMAS.	55 urine samples from 6 workers were analyzed with an HPGe detector.	Annual effective doses ranged from 4.57×10−5 mSv to 9.72×10−3 mSv. Values well below the safety limits.	Consistent internal dose monitoring; focus on timing of sample collection and decay effects during analysis.	[15]
Evaluating Exposure from 131I (2024)	Assessment of internal doses via thyroid counts and urine samples at NINMAS.	Both in vivo (thyroid monitoring) and in vitro (urine sample analysis) methods were used.	Average annual doses ranged from 0.0787–0.1039 mSv. Highlights the proportion of ^{131}I retained in the thyroid	Regular monitoring and adherence to international safety standards.	[16]

Paper Title	Key Focus	Methodology	Key Findings	Recommendations	Ref.
			(30%) and excreted (70%).		
Radiation Dose Estimation at NINMAS (2024)	Effective dose estimation using urine bioassay for ^{131}I, ^{99m}Tc, ^{18}F exposure.	151 urine samples were analyzed with an HPGe detector. Dose coefficients used per ICRP guidelines.	Effective doses for ^{131}I: 0.00115 mSv; ^{99m}Tc: 0.00146 mSv; ^{18}F: 0.00000013 mSv. All values are far below the ICRP limits.	Strengthen monitoring and focus on shielding for radionuclides.	[17]

The following figure illustrates that the radiation exposure among nuclear medicine workers in Bangladesh is generally within safe limits.

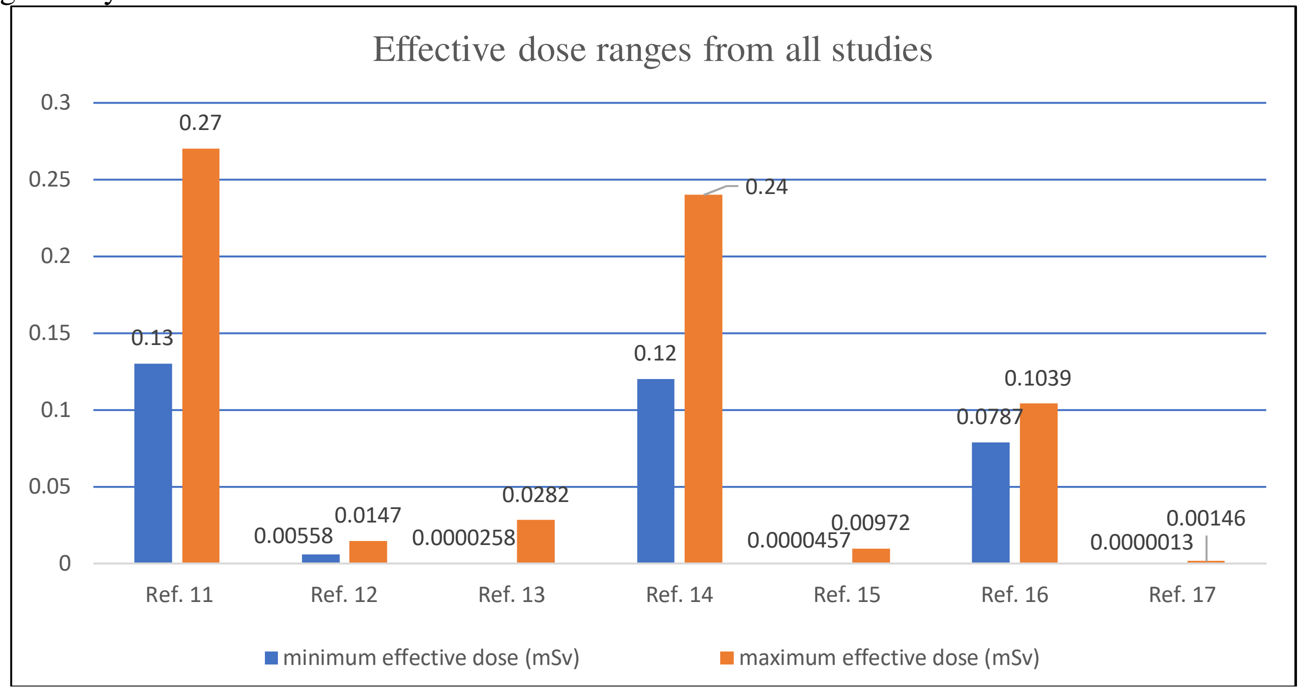

Fig 2: Effective dose ranges from all studies confirm compliance with ICRP safety limits

The above figure illustrates that the radiation exposure among nuclear medicine workers in Bangladesh is generally within safe limits.
Also, from all the studies, it can be seen that for occupational monitoring in nuclear medicine practices, ^{131}I is predominantly in focus than ^{99m}Tc and ^{18}F. The following figure shows the comparison:

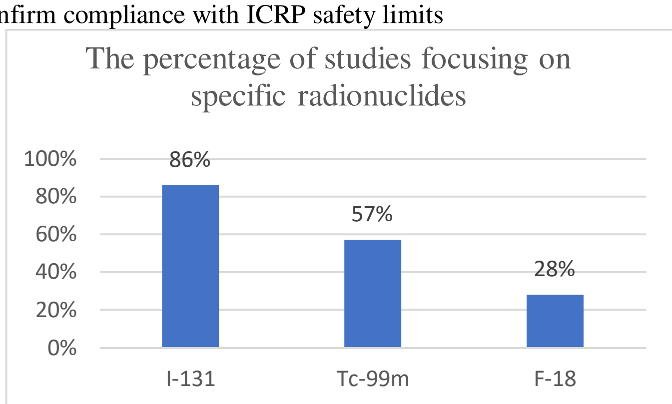

Fig 3: Radionuclides prevalence in occupational monitoring in nuclear medicine practices

From all the studies, the trend in effective dose is found to be in a decreasing manner as in the figure:

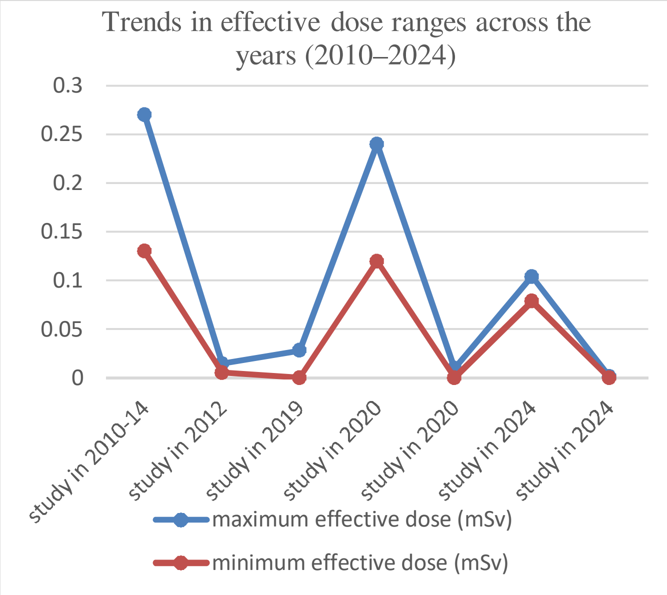

Fig 4: Line graph showing trends in effective dose ranges across the years (2010–2024)

The decreasing trend indicates that proper radiation protection programs are being implemented in these facilities following national and international standards and guidelines.

VI. RECOMMENDATIONS FOR ENHANCED SAFETY

The studies reviewed highlight critical insights into the internal radiation exposure of nuclear medicine workers in Bangladesh, emphasizing the need for rigorous monitoring and safety protocols. Bioassay techniques, including in vitro urine sample analysis and in vivo thyroid measurements, were effectively utilized to estimate radionuclide intake and committed effective doses for isotopes like ^{131}I, ^{99m}Tc, and F-18. This analysis confirms that radiation exposure among nuclear medicine workers in Bangladesh is generally within safe limits. Effective doses from ^{131}I, ^{99m}Tc, and F-18 were consistently low, reflecting adequate safety protocols. However, variations in individual doses underscore the necessity for standardized safety measures. Advanced tools like the MONDAL-3 software proved invaluable for biokinetic modeling and dose assessments, suggesting that integrating computational tools with biological monitoring enhances dose evaluation accuracy. The research also emphasized that regular exposure evaluations, combined with adherence to ALARA principles and enhanced shielding practices, are crucial for minimizing risks. These findings call for strengthening radiation safety frameworks through continuous training, technology adoption, and systematic dose surveillance across nuclear medicine facilities in Bangladesh.

VII. CONCLUSIONS

Bangladesh has made significant strides in nuclear medicine over the past six decades. However, ensuring the safety of occupational workers remains a critical challenge. The studies reviewed demonstrate that nuclear medicine practices in Bangladesh maintain radiation exposure levels within national and international safety limits. However, the variability in individual doses and the potential risks associated with unsealed sources highlight the need for continuous improvement in monitoring technologies and safety protocols. Future efforts should focus on integrating advanced computational tools and expanding internal dosimetry programs to ensure the long-term safety of occupational workers.

ABBREVIATION

ICRP: International Commission on Radiological Protection
UNSCEAR: United Nations Scientific Committee on the Effects of Atomic Radiation
TLD: Thermoluminescent Dosimeters
IAEA: The International Atomic Energy Agency
HPGe: High-Purity Germanium
NINMAS: Nuclear Medicine and Allied Sciences
ALARA: As Low As Reasonably Achievable

ACKNOWLEDGMENT

Gratitude is extended to the researchers whose work provided the foundation for this review. Their contributions to the field of nuclear medicine and radiation safety are greatly appreciated. Special acknowledgment is given to the institutions, including the National Institute of Nuclear Medicine and Allied Sciences (NINMAS) and the Atomic Energy Centre Dhaka, for their contributions to advancing research in nuclear medicine and radiation safety. Appreciation is also given to the colleagues whose valuable feedback and insights helped shape this work. Lastly, heartfelt thanks are offered to family and friends for their unwavering support and encouragement throughout the completion of this review.

REFERENCES

[1] IAEA Nuclear Safety and Security Glossary, Vols. Non-serial Publications, Vienna: International Atomic Energy Agency, 2022.

[2] "Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Sixty seventh and sixty eighth sessions," United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), New York, 2020 & 2021.

[3] Radiation Protection and Safety in Medical Uses of Ionizing Radiation, Vienna: INTERNATIONAL ATOMIC ENERGY AGENCY, 2018.

[4] International Atomic Energy Agency (IAEA) training material on radiation protection in nuclear medicine; part 5, Vienna: IAEA: AEA, December 2004.

[5] H. R, "History and Perspectives of Nuclear Medicine in Bangladesh," Asia Oceania journal of nuclear medicine & biology, vol. 4, no. 1, pp. 55-58, 2016.

[6] "Annual Report," Bangladesh Atomic Energy Commission, Dhaka, July 2023- June 2024.

[7] N. Nahar, "Perspective of Nuclear Medicine in Bangladesh starting in The New Decade of 2021," Bangladesh Journal Online, vol. 22, no. 2, July 2019.

[8] Bangladesh Atomic Energy Regulatory Act, Act no. 19, Bangladesh Gazzette 2012, 2012.

[9] Nuclear Safety and Radiation Control Rules-1997, Republic of Bangladesh Government, SRO No. 205-Law/97, Bangladesh Gazzette 1997, 1997.

[10] D. M. S. R. Selina Yeasmin, User's InstructionGuide,, A. E. C. D. Health Physics Division, Ed., Bangladesh Atomic Energy Comission, 2020.

[11] M. S. a. B. A. a. H. A. a. K. R. K. a. S. M. M. M. Rahman, "Assessment of whole-body occupational radiation exposures in nuclear medicine practices of Bangladesh during 2010-2014," Iranian Journal of Nuclear Medicine, vol. 24, no. 1, pp. 51-58, 2016.

[12] M. a. A. Z. a. K. R. a. I. S. a. I. A. a. R. M. a. B. A. Ferdous, "Internal radiation monitoring of occupational staff in nuclear medicine facility," Bangladesh Journal of Medical Physics, vol. 5, no. 1, pp. 63-70, 2012.

[13] M. M. H. P. F. B. M. H. S. M. Z. H. a. J. F. Mahadee Hasan Shubho, "Individual Monitoring of Internal Exposure for Nuclear Medicine Workers in NINMAS through In-Vitro Bioassay Techniques," Bangladesh Journal of Nuclear Medicine, vol. 22, no. 1, pp. 125-129, 2021.

[14] F. B. a. A. S. M. Shamsun Nahar Raka, "Estimation of Internal Radiation Doses for Occupational Workers Due to 131I Radionuclide by Using MONDAL Software," Bangladesh Journal of Nuclear Medicine, 2022-05-04.

[15] J. F. N. A. a. A. S. M. Yeasin Noor, "Committed Effective Doses Received by Occupational Workers Handling Radioisotopes (131I and 99mTc) at INMAS, as Assessed from Urine-Samples," Dhaka University Journal of Science, vol. 68, no. 2, 2020-10-29.

[16] J. F. M. M. H. P. a. F. B. Sharmin Jahan, "Evaluating internal exposure due to intake of 131I at a nuclear medicine centre of Dhaka using bioassay methods," Nuclear Engineering and Technology, vol. 56, no. 6, pp. 2050-2056, 2024.

[17] S. D. F. J. Y. F. K. M. H. R. &. K. K. Shanta, "Estimation of the Effective Radiation Dose in Nuclear Medicine Workers from Dhaka by Measuring Radioactivity in Urine Sample Resulting from Internal Exposure," Jagannath University Journal of Science, vol. 11, no. 1, p. 64–80, 2024.

