Personal dosimeter use in nuclear medicine: a study on staff compliance and monitoring

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Abstract. This study investigated radiation workers' compliance and satisfaction in using personal dosimeters at the Nuclear Medicine Facility of Dr. Sardjito General Hospital, Yogyakarta. Personal dosimeter use is mandated by BAPETEN Regulation No. 4 of 2013 to monitor individual radiation doses with devices such as TLDs, OSLDs, and TLD rings. Employing a convergent parallel mixed-method design, data were collected through observation, interviews, questionnaires, and documentation from 17 radiation officers (nuclear medicine specialist, radiation protection officer, radiographer, radio-pharmacist, and nurse) with probability sampling selected based on inclusion criteria: working in the nuclear medicine installation, directly exposed to radiation, willingness become respondents. Quantitative analysis used the Shapiro–Wilk test, Kruskal–Wallis test, and Dunn post hoc test. Results revealed full compliance with personal dosimeter use despite the absence of a formal reward or punishment system. Satisfaction levels were high, with most workers reporting being satisfied to very satisfied. Factors supporting compliance included training, knowledge, comfort, socialization, and individual motivation. These findings highlight that compliance is shaped not only by regulatory requirements but also by psychosocial and managerial influences. The study contributes to radiation protection literature and provides practical recommendations for enhancing hospital safety management systems.

1 Introduction

Ionizing radiation represents a major occupational hazard for healthcare professionals working in nuclear medicine facilities, as it can induce both deterministic effects such as organ damage when exposure exceeds threshold limits and stochastic effects that may occur even at relatively low doses, thereby necessitating strict radiation protection strategies [1], [2]. In line with international safety standards, continuous monitoring of individual doses using personal dosimeters has become essential to ensure that exposure levels remain within recommended thresholds. Globally, the International Atomic Energy Agency (IAEA)

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recommends an average annual effective dose limit of 20 mSv across five years, with no single year exceeding 50 mSv [2].

In Indonesia, regulatory frameworks established by the Nuclear Energy Regulatory Agency (BAPETEN) mandate dose monitoring for radiation workers and officially recognize specific types of dosimeters, including film badges, thermoluminescence dosimeters (TLDs), optically stimulated luminescence dosimeters (OSLs), and radio photoluminescence (RPL) devices [3-4]. Within nuclear medicine, occupational exposure is particularly pronounced during radiopharmaceutical preparation, administration, and PET/CT imaging procedures, making the use of TLD/OSL badges and TLD rings indispensable for monitoring whole-body dose Hp (10) and extremity dose Hp (0.07) [5].

Despite the availability of protective devices, compliance with dosimeter use among healthcare workers remains inconsistent. Some studies show that adherence is influenced by knowledge, training, institutional policies, and supervisory measures [6-7]. Additionally, motivational factors at the individual level play a critical role in shaping behaviors [8]. International investigations also emphasize that compliance varies across professional groups—including nurses, radiographers, and operating theatre staff—indicating the need for systematic managerial interventions and a strengthened safety culture[9].

Against this backdrop, the present study focuses on evaluating compliance with personal dosimeter use among radiation workers in the Nuclear Medicine Department of RSUP dr. Sardjito, Yogyakarta. Specifically, the objectives are: (1) to assess the level of compliance with dosimeter use, (2) to identify determinants of compliance and non-compliance, and (3) to evaluate satisfaction with dosimeter use. Theoretically, the research contributes to literature on occupational radiation protection by integrating individual determinants such as knowledge and motivation with organizational aspects including training, policy, and supervision. Practically, it aims to provide recommendations for improving safety culture in line with international standards and Indonesian regulatory requirements [1], [4].

2 Methods

This study adopted a convergent parallel mixed-methods design, combining quantitative and qualitative approaches conducted simultaneously to yield a comprehensive understanding of radiation worker's compliance with personal dosimeter use. The research was carried out at the Nuclear Medicine Department of RSUP dr. Sardjito, Yogyakarta, involving 17 radiation workers selected through probability sampling consisting of five main professional categories including nuclear medicine physician, radiation protection officer, radiographer, radio pharmacist, and nurse. Inclusion criteria : active employment in the nuclear medicine department, direct involvement in radiation-related procedures, and willingness to participate in the study. Workers who were on leave or not active during the study period were excluded.

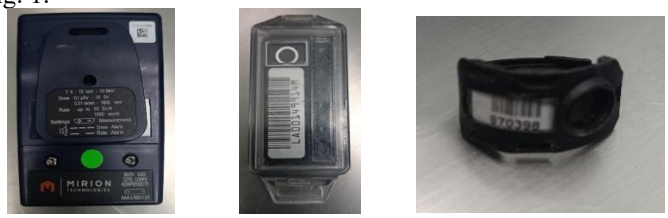
The quantitative component utilized a five-point Likert scale questionnaire to measure workers' perceptions and satisfaction regarding the use of personal dosimeters. Meanwhile, qualitative data were obtained through direct observation and semi-structured interviews, which explored behavioral patterns, motivations, and contextual factors influencing compliance. Compliance with TLD/OSL badges and TLD rings was evaluated according to technical guidelines for monitoring Hp (10) and Hp (0.07), including calibration procedures and periodic readings as outlined in international recommendations and clinical practice. National compliance was verified through BAPETEN's regulations on mandatory individual dose monitoring and recognized dosimeter types.

For ata analysis, the Shapiro-Wilk test was first performed to assess normality. Because the data were not normally distributed, non-parametric test were used. The Kruskal-Wallis test was applied to compare groups, followed by Dunn's post-hoc test for multiple comparison correction. Qualitative data were analyzed through systematic reduction,

thematic coding, and categorization, and both quantitative and qualitative findings were integrated during interpretation to generate comprehensive insights.

3 Results and discussions

Radiation workers in the Nuclear Medicine Installation of RS Sardjito Yogyakarta use three types of personal dosimeters: Electronic Personal Dosimeters (EPD), Thermoluminescent Dosimeter (TLD) rings, and Optically Stimulated Luminescence Dosimeters (OSLD). Each dosimeter is utilized for a three-month period, and the units available at the hospital are presented in Fig. 1.



(a) (b) (c)

Fig. 1. (a) Electronic Personal Dosimeters (EPD); (b) Optically Stimulated Luminescence Dosimeters (OSLD); (c) Thermoluminescent Dosimeter (TLD) rings

3.1 Respondent Characteristics

A total of 17 radiation workers participated in the study, consisting of five main professional categories. All respondents met the inclusion criteria, and no respondents met the exclusion criteria. The respondent characteristics shown in Table 1.

Table 1. Respondent Characteristics

Profession	Gender	Years of Service	Education	Compliance Status
Nuclear Medicine Physician	M	8	Specialist	Compliant
Radiation Protection Officer	F	6	Bachelor	Compliant
Radiographer	F	5	Diploma	Compliant
Radio Pharmacist	M	5	Bachelor	Compliant
Nurse	F	7	Diploma	Compliant
Other Supporting Staff (total 12)	M/F	2–10	Varies	Mostly Compliant

3.2 Compliance Behavior

The compliance of radiation workers with the use of personal dosimeters shows that every radiation worker is required to wear one, and a Standard Operating Procedure (SOP) is in place regarding the use of TLDs. The TLD is attached to the shirt button in an area with a high potential for radiation exposure; when an apron is worn, the TLD remains positioned inside the apron. Radiation workers remove their personal dosimeters during meals, as eating is not performed in the hot area. There are no obstacles that lead to noncompliance among radiation workers in the use of personal dosimeters, as the devices are small in size and easy to use. The primary factor influencing compliance is that each radiation worker has received training appropriate to their professional role. Through this training, radiation workers acquire knowledge about the proper use of personal dosimeters and the potential consequences of not wearing them. In this regard, according to the radiation workers, individual motivation varies from person to person.

Ensuring consistent use of personal dosimeters is essential for maintaining controlled radiation exposure within permitted safety limits. Lee et al. [10] showed that failure to wear dosimeters results in under-reported dose levels, highlighting the need for compliance monitoring to obtain accurate exposure data. Noh et al. [11] found that although radiographers in Korea demonstrated high compliance in wearing dosimeters, placement varied considerably 40% positioned the device beneath the lead apron and 60% above it. This inconsistency produced notable differences in recorded dose values and may compromise risk assessment. Accordingly, standardized SOPs are required to ensure reliable dose monitoring

Instances of noncompliance among radiographers remain, often influenced by various factors. Compliance is largely dependent on individual awareness, and any violation is typically addressed through verbal reminders from the Radiation Protection Officer team. Radiation workers tend to be inconsistent in wearing personal dosimeters throughout working hours. Knowledge of radiation hazards and formal training are significant determinants of compliance, while insufficient supervision and a weak safety culture remain key barriers. To reduce noncompliance in personal dosimeter use, Dr. Sardjito Hospital has implemented regular socialization and training sessions regarding personal dosimeter use, with strong managerial and radiation protection officer support being critical to sustaining radiation safety principles. Videira et al. [12] demonstrated that institutional interventions—such as continuous education programs and mandatory policies—significantly improved staff compliance. Based on these findings, the researchers recommend enhancing the frequency and quality of training programs to serve as a model for other nuclear medicine facilities.

3.3 Satisfaction Levels Toward Dosimeter Use

Quantitative analysis of the 22-item satisfaction questionnaire using the Shapiro–Wilk test showed non-normal data distribution ($p < 0.05$). Therefore, the Kruskal–Wallis test was performed, which revealed significant intergroup differences ($H = 18.507$, $p = 0.000982$) (Table 2). Leading to the rejection of the null hypothesis (H0) and acceptance of the alternative hypothesis (Ha). These results indicate that staff were satisfied with the use of personal dosimeters. The average satisfaction scores showed that 12% of respondents were very dissatisfied, 7% dissatisfied, 6.1% neutral, 31.3% satisfied, and 43.6% very satisfied.

Table 2. Kruskal-Wallis Test

Variable	Kruskal–Wallis H	df	Sig.
Satisfaction Level of Radiation Workers Toward Personal Dosimeter Use	18.507	4	0.000982

To identify the source of these differences, a Dunn post-hoc test was conducted (Table 3). The results indicated that satisfaction levels were significantly higher among radiographers and radio pharmacists compared with other groups ($p < 0.05$). This difference is attributed to these professionals' more frequent use of dosimeters and direct exposure to radiation sources.

Table 3. Dunn post-hoc Test

Comparison	Mean Rank Difference	Adjusted p-value	Interpretation
Radiographer – Nurse	6.4	0.042	Significant
Radiographer – RPO	7.2	0.037	Significant
Radio Pharmacist – Nurse	5.8	0.049	Significant
Others	< 2.0	> 0.05	Not significant

Satisfaction with personal dosimeter use can be influenced by several factors, including comfort during use [13], measurement accuracy [14], and ease of dose readout [15]. Job satisfaction not only affects individual well-being but also directly impacts productivity and overall job performance. Employees who are satisfied with their work are generally more motivated, dedicated, and committed to their tasks, which in turn fosters better compliance and improved work quality.

Based on the survey results, radiation workers at Dr. Sardjito Hospital were generally satisfied with the use of personal dosimeters for monitoring radiation exposure in the workplace. Quantitatively, the average satisfaction scores indicate that the majority of staff expressed positive perceptions of these devices. Future research is expected to evaluate radiation workers' satisfaction with digital personal dosimeters, specifically in relation to the readability and accuracy of real-time radiation dose measurements.

4 Conclusion

Radiation workers employed in the nuclear medicine installation of Dr. Sardjito Hospital demonstrate high compliance in the use of personal dosimeters. The staff are equipped with adequate socialization programs and training materials on radiation protection. Their strong awareness of the hazards of radiation contributes to this high level of compliance. In terms of user satisfaction, the radiation workers expressed satisfaction with the personal dosimeters currently in use, as indicated by the statistical analysis using the Kruskal–Wallis test, which yielded a p-value of <0.05.

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