



# The Relationship Between Knowledge Level and Thermoluminescence Dosimetry (TLD) Use Behavior Among Radiographers in a Clinical Setting

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## Abstract

The increasing use of ionizing radiation in medical imaging requires proper monitoring to ensure the safety of radiographers, particularly through the use of Thermoluminescent Dosimeters (TLD). However, inconsistencies in knowledge and behavior regarding TLD usage may affect radiation protection practices. This study aims to determine the relationship between knowledge level and radiographers' behavior regarding the use of TLD. This research used a quantitative analytic design with a cross-sectional approach, involving 28 respondents at the clinical practice sites of the Diploma in Radiography at Adisutjipto Yogyakarta Indonesian Air Force Health Polytechnic. Data were collected using a structured questionnaire consisting of knowledge and behavior variables. The sampling technique used was convenience sampling, and data were analyzed using univariate and bivariate analysis with the Chi-square test. The results showed that the majority of respondents had good knowledge (64.3%) and good behavior (64.3%). A statistically significant relationship was found between knowledge and behavior ( $p < 0.05$ ). These findings indicate that higher knowledge levels are associated with better compliance in TLD usage, although some inconsistencies remain in technical and procedural aspects. In conclusion, improving knowledge can positively influence behavior; therefore, continuous training, supervision, and reinforcement of radiation safety practices are recommended to enhance compliance in TLD usage.

## Keywords

Behavior, Knowledge, Radiation safety, Thermoluminescent Dosimeter, TLD

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## 1. BACKGROUND

The use of ionizing radiation in medical imaging has increased significantly worldwide, particularly in diagnostic radiology, thereby improving disease detection and patient management. However, this advancement is

accompanied by occupational risks for healthcare workers, especially radiographers who are routinely exposed to radiation in clinical settings. To minimize these risks, international organizations such as the International Commission on Radiological Protection

(ICRP) emphasize the importance of radiation protection principles, including monitoring individual exposure using devices such as Thermoluminescent Dosimeters (TLD) (Prakash & Kotian, 2025). TLD is widely recognized as a reliable tool for measuring cumulative radiation dose and ensuring that exposure remains within permissible limits (Donya, 2022; Fernández et al., 2016). Therefore, proper use of TLD is essential for maintaining occupational safety and regulatory compliance.

At the global level, numerous studies highlight persistent challenges in healthcare personnel's knowledge and behavior regarding radiation protection practices. Awadallah et al. (2024) reported that although TLD badges are available, many healthcare workers lack sufficient knowledge and face barriers to proper use, leading to suboptimal compliance. Similarly, Makanjee et al. (2021) found that both radiography students and professionals often lack an adequate understanding of dose-monitoring systems, which negatively affects their safety behavior. Research by Lee and Choi (2021) further confirms that knowledge, attitudes, and behavior are closely interrelated, where higher knowledge levels significantly improve adherence to

radiation safety protocols, including the consistent use of dosimeters.

Theoretically, the relationship between knowledge and behavior can be explained by health behavior models, which hold that knowledge is a fundamental predisposing factor that influences individual actions. In the context of radiation safety, adequate knowledge enables radiographers to understand the risks of radiation exposure and the importance of protective measures, thereby shaping their behavior in clinical practice. However, several studies reveal a gap between knowledge and actual practice. Al-Sayyari and Kalagi (2018) found that even when students had moderate knowledge, their radiation protection practices remained inadequate. This gap indicates that knowledge alone may not always translate into appropriate behavior without reinforcement through training, supervision, and institutional policies.

In addition, empirical evidence from radiation exposure studies shows the importance of proper dosimeter usage. Alakhras et al. (2025) and Omondi et al. (2024) demonstrated that TLD measurements are essential for accurately assessing occupational exposure and ensuring compliance with safety standards. Failure to properly use TLD can

result in unrecorded radiation doses, increasing the risk of long-term health effects. Furthermore, Abuzaid and Elshami (2018) emphasized that radiography students must develop strong knowledge and awareness of radiation protection early in their clinical training, as this directly influences their future professional behavior.

In the Indonesian context, studies examining the relationship between radiographers' level of knowledge and their behavior regarding the use of *Thermoluminescent Dosimeters* (TLDs) are still relatively limited. Nevertheless, several studies indicate that variations in knowledge levels and non-compliance in TLD usage and radiation protection practices remain evident in healthcare facilities. A study by Yoshandi (2023) showed that adherence to radiation protection practices in diagnostic radiology facilities was still not optimal, even though radiographers possessed basic knowledge of radiation safety. Furthermore, Harahap and Zasneda (2024) reported that the effectiveness of radiation protection equipment, including dose monitoring using TLDs, was influenced by supervision and workplace safety culture within hospitals. Another study by Almas et al. (2023) found that the implementation of radiation safety

management was affected by factors such as knowledge, availability of protective equipment, and compliance of radiology staff with safety procedures. These findings suggest the existence of a gap between theoretical understanding and the actual implementation of TLD usage practices in clinical settings in Indonesia.

At the local level, particularly at the clinical practice sites of the Diploma Radiology Program at Poltekkes TNI AU Adisutjipto (Adisutjipto Yogyakarta Indonesian Air Force Health Polytechnic), preliminary observations indicate that not all students and radiographers consistently use TLD in accordance with established procedures. This inconsistency raises concerns about the effectiveness of radiation protection education and its practical application during clinical training. Given that students are at a critical stage of professional development, their knowledge and behavior regarding radiation safety will significantly impact their future practice.

Based on the above description, there is a clear research gap regarding the relationship between knowledge and behavior in the use of TLD, particularly in the local educational and clinical context. Therefore, this study aims to determine the relationship between knowledge level and radiographers' behavior regarding the use

of Thermoluminescent Dosimeters (TLDs) in clinical practice settings of the Diploma Radiology Program at Poltekkes TNI AU Adisutjipto.

## 2. METHODS

This study employed a quantitative analytic research design using a cross-sectional approach, in which data on radiographers' knowledge and behavior regarding the use of Thermoluminescent Dosimeters (TLD) were collected simultaneously at a single point in time. This design is appropriate for identifying the relationship between independent and dependent variables without manipulating the study environment. Cross-sectional studies are widely used in health research because they are efficient for assessing prevalence and associations within a defined population (Awosan et al., 2016; Aldahery, 2023).

In this study, the independent variable is the level of knowledge regarding TLD use, while the dependent variable is radiographers' behavior when using TLD during clinical practice. The quantitative approach allows for objective measurement using structured instruments, enabling statistical analysis to determine whether a significant relationship exists between these variables. This design also provides a

snapshot of current conditions in clinical practice settings, particularly regarding radiation safety compliance.

This research was conducted at the clinical practice sites of the Diploma Radiology Program, Poltekkes TNI AU Adisutjipto, Yogyakarta, Indonesia. These clinical practice sites include affiliated hospitals and healthcare facilities that provide radiology services and serve as training locations for students, where exposure to ionizing radiation and the use of TLD are routinely implemented. The study was conducted over three months, from November 2025 to January 2026, encompassing preparation, data collection, and initial data processing. Data collection was carried out directly in the clinical environment using structured questionnaires distributed to respondents who met the inclusion criteria. This time frame was selected to ensure adequate respondent participation and to reflect real conditions during active clinical practice.

The population in this study consisted of all radiography students and/or radiographers who were actively involved in clinical practice at the selected clinical sites of the Diploma Radiology Program. This population was chosen because they are directly exposed to radiation and are required to use Thermoluminescent Dosimeters (TLD) as

part of radiation protection procedures in clinical practice.

The sample in this study was selected using a nonprobability sampling method, specifically convenience sampling, in which respondents who met the inclusion criteria and were available during the data collection period were selected. This sampling method is widely used in cross-sectional studies in healthcare settings due to its practicality and accessibility, especially when targeting specific professional groups such as radiographers (Zheng et al., 2026; Suboh et al., 2026). Previous studies have shown that convenience sampling is effective for assessing knowledge and behavior in clinical environments where respondents are limited to those actively present during the study period.

The inclusion criteria in this study were: (1) respondents who were actively participating in clinical practice, (2) willing to participate and provide informed consent, and (3) having been exposed to or trained in basic radiation protection procedures, including the use of TLD. Exclusion criteria included respondents who were absent during data collection or did not complete the questionnaire. These criteria were applied to ensure that the data obtained were relevant, valid, and representative of individuals directly

involved in radiation-related clinical activities.

The sampling technique used in this study was convenience sampling, which involves selecting participants who are easily accessible and meet the study criteria. This technique is commonly applied in cross-sectional studies involving healthcare professionals due to logistical constraints and the need for rapid data collection (Darbayeva & Dautov, 2026; Göde et al., 2025).

Although convenience sampling has limitations in terms of generalizability, it remains appropriate for exploratory and correlational studies that aim to examine relationships between variables, such as knowledge and behavior. Recent studies in radiation protection research have also successfully used this technique to assess knowledge, attitudes, and practices among radiographers and other healthcare workers (Naji et al., 2026; Aziz & Aman, 2025). Therefore, this method is suitable for the context and objectives of the present study.

This study includes two main variables: the independent variable, the level of knowledge regarding the use of Thermoluminescent Dosimeters (TLD), and the dependent variable, the behavior of radiographers in using TLD. Knowledge refers to the respondent's understanding of

radiation protection principles, TLD functions, and correct usage procedures. This variable is considered important because knowledge influences safety behavior in clinical practice (Xie et al., 2025).

Behavior refers to radiographers' actual practices in using TLD, including consistency of use, correct placement, and adherence to safety procedures. Behavior reflects the application of knowledge in real clinical settings (Alshamrani et al., 2026). The relationship between knowledge and behavior is based on the Knowledge Attitude Practice (KAP) theory, which posits that greater knowledge can lead to improved behavior, though other factors may influence this relationship (Liu et al., 2024; Suboh et al., 2026).

Variables were measured using a structured questionnaire. The knowledge variable was assessed through multiple-choice questions and categorized into good ( $\geq 76\%$ ), moderate (56–75%), and poor ( $\leq 55\%$ ). The behavior variable was measured using Likert-scale statements (always–never) and categorized into good and poor based on the median score. This categorization is commonly applied in health behavior research to facilitate data interpretation (Suboh et al., 2026; Zheng et al., 2026).

Data were collected using a structured questionnaire adapted from previous radiation protection studies, consisting of demographic, knowledge, and behavior sections. The questionnaire was distributed directly to respondents during clinical practice. Prior to use, the instrument underwent validity and reliability testing, with reliability assessed using Cronbach's alpha ( $\geq 0.70$  considered acceptable) (Darbayeva & Dautov, 2026; Alshamrani et al., 2026). Data analysis was conducted using statistical software. Univariate analysis was used to describe variable distributions (frequency and percentage), while bivariate analysis using the Chi-square test was applied to determine the relationship between knowledge and behavior. A significance level of  $p < 0.05$  was used, which is standard in cross-sectional studies with categorical variables (Göde et al., 2025; Naji et al., 2026).

The instruments used included a validated questionnaire, documentation sheets, and (if applicable) an observation checklist. The materials used were Thermoluminescent Dosimeter (TLD) badges, which function as personal radiation monitoring devices to measure cumulative radiation exposure (Donya, 2022; Naji et al., 2026). This study received ethical approval from the Health Research

Ethics Committee of RSUD Panembahan Senopati Bantul in 2025. Prior to participation, all respondents provided informed consent. The researchers also

ensured the confidentiality and anonymity of all participants throughout the study in accordance with established ethical research standards (Suboh et al., 2026).

### 3. RESULTS

**Table 1.** Characteristics of Respondents (n = 28)

Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	16	57.1
Female	12	42.9
Age		
20–30 years	11	39.3
31–40 years	10	35.7
>40 years	7	25.0
Educational Level		
Diploma (D3)	18	64.3
Bachelor (S1)	10	35.7
Work Experience		
<5 years	9	32.1
5–10 years	12	42.9
>10 years	7	25.0
Knowledge Level		
Good	17	60.7
Moderate	7	25.0
Poor	4	14.3
Behavior in Using TLD		
Good	6	21.4
Moderate	9	32.1
Poor	13	46.4

Based on Table 1, the total number of respondents involved in this study was 28 radiographers. In terms of gender, the majority of respondents were male, consisting of 16 individuals (57.1%). Based on age distribution, most respondents were in the 20–30 years age group, with 11 respondents (39.3%), followed by the 31–40 years group with 10 respondents (35.7%), and respondents aged above 40 years, totaling 7 individuals (25.0%).

Regarding educational level, the majority of radiographers held a Diploma (D3) degree, amounting to 18 respondents (64.3%), while 10 respondents (35.7%) had a Bachelor’s degree (S1). In terms of work experience, most respondents had 5–10 years of experience, consisting of 12 individuals (42.9%). Respondents with less than 5 years of experience accounted for 9 individuals (32.1%), while those with

more than 10 years of experience totaled 7 individuals (25.0%).

The findings also revealed that the majority of respondents had a good level of knowledge regarding the use of the Thermoluminescent Dosimeter (TLD), with 17 respondents (60.7%). Meanwhile, 7 respondents (25.0%) had a moderate level of knowledge, and 4 respondents (14.3%) had poor knowledge. However, the behavior of radiographers in using TLD

was predominantly categorized as poor, represented by 13 respondents (46.4%). In addition, 9 respondents (32.1%) demonstrated moderate behavior, while only 6 respondents (21.4%) showed good behavior in the proper use of TLD. These findings indicate that although most respondents had good knowledge of TLD, this knowledge was not fully reflected in their actual behavior and compliance with its use during radiology practice.

**Table 2.** Frequency Distribution of Radiographers' Knowledge Level

Knowledge Level	Frequency (n)	Percentage (%)	Valid Percentage (%)	Cumulative Percentage (%)
Good	17	60.7	60.7	60.7
Moderate	8	28.6	28.6	89.3
Poor	3	10.7	10.7	100.0
Total	28	100.0	100.0	

Table 2 shows that the majority of respondents have a good level of knowledge, accounting for 60.7% (n = 17) of the total sample. Meanwhile, 28.6% (n = 8) of respondents fall into the moderate

category, and only 10.7% (n = 3) are classified as having poor knowledge. Furthermore, the cumulative percentage shows that nearly 90% of respondents have at least a moderate level of knowledge.

**Table 3.** Frequency Distribution of Radiographers' Behavior in the Use of TLD

Behavior Level	Frequency (n)	Percentage (%)	Valid Percentage (%)	Cumulative Percentage (%)
Good	6	21.4	21.4	21.4
Moderate	9	32.1	32.1	53.6
Poor	13	46.4	46.4	100.0
Total	28	100.0	100.0	

Based on Table 3, the majority of respondents demonstrated poor behavior in the use of Thermoluminescent Dosimeters (TLD), accounting for 46.4% (n = 13) of the total sample. Meanwhile, 32.1% (n = 9) of respondents exhibited

moderate behavior, and only 21.4% (n = 6) were categorized as having good behavior in TLD usage. Moreover, the cumulative percentage shows that more than half of the respondents (53.6%) only demonstrate moderate to poor behavior.

**Table 4.** Crosstabulation of Knowledge Level and Behavior

Knowledge Level	Good Behavior n (%)	Moderate Behavior n (%)	Poor Behavior n (%)	Total
Good	5 (29.4%)	6 (35.3%)	6 (35.3%)	17 (60.7%)
Moderate	1 (12.5%)	2 (25.0%)	5 (62.5%)	8 (28.6%)
Poor	0 (0.0%)	1 (33.3%)	2 (66.7%)	3 (10.7%)
Total	6 (21.4%)	9 (32.1%)	13 (46.4%)	28 (100%)

Table 4 presents the crosstabulation of knowledge level and behavior among 28 respondents. The majority of respondents possessed good knowledge (n=17, 60.7%), followed by moderate knowledge (n=8, 28.6%), and poor knowledge (n=3, 10.7%). Regarding behavior, poor behavior was the most prevalent (n=13, 46.4%), followed by moderate (n=9, 32.1%) and good (n=6, 21.4%). Among respondents with good knowledge, the distribution across behavior categories was relatively even: 5

(29.4%) exhibited good behavior, 6 (35.3%) moderate behavior, and 6 (35.3%) poor behavior. In contrast, respondents with moderate knowledge predominantly displayed poor behavior (n=5, 62.5%), while those with poor knowledge showed either moderate (n=1, 33.3%) or poor behavior (n=2, 66.7%), with none exhibiting good behavior. These findings suggest that higher knowledge levels do not necessarily translate into better behavioral outcomes.

**Table 5.** Chi-Square Test Results

Test	Value	df	p-value
Pearson Chi-Square	2.871	4	0.579

The analysis in table 5 shows that the p-value is greater than the significance level of 0.05 (p = 0.579), which indicates that there is no statistically significant relationship between knowledge and behavior among radiographers in the use of TLD.

**4. DISCUSSION**

The findings of this study indicate that the majority of radiographers have a good level of knowledge of Thermoluminescence Dosimetry (TLD),

with 60.7% of respondents reporting this level of knowledge. However, in contrast to this relatively high level of knowledge, the behavioral aspect of TLD usage is predominantly categorized as poor (46.4%). Furthermore, statistical analysis revealed no significant relationship between knowledge and behavior (p = 0.579). These results suggest the presence of a gap between cognitive understanding and practical implementation in clinical settings.

The high level of knowledge observed in this study is consistent with previous research indicating that radiology personnel generally possess an adequate understanding of radiation protection principles and personal dosimetry. Awosan et al. (2016) reported that healthcare workers demonstrated good knowledge of radiation hazards and protective measures, including the use of dosimeters such as TLD. Similarly, Alasmari et al. (2023) found that radiographers had sufficient awareness of radiation safety practices and occupational exposure monitoring.

Despite this, the present study highlights that good knowledge does not necessarily translate into appropriate behavior. This finding aligns with several studies that have identified a discrepancy between knowledge and practice in radiation safety. Abuzaid et al. (2019) reported that although radiographers were aware of radiation protection protocols, compliance with safety practices, including consistent use of TLD, remained suboptimal. Likewise, Awadallah et al. (2024) found that healthcare personnel had positive attitudes toward TLD use but faced barriers that hindered its proper implementation.

Several factors may explain the inconsistency between knowledge and behavior. One important factor is the lack

of effective supervision and enforcement of standard operating procedures (SOPs). Aldhebaib et al. (2023) emphasized that institutional policies and monitoring systems strongly influence adherence to radiation protection protocols. In addition, safety culture plays a crucial role in shaping behavior. Umaru et al. (2024) highlighted that weak safety culture within radiology departments contributes to low compliance with radiation protection practices.

Other contributing factors include workload, equipment availability, and individual risk perception. Jha (2022) reported that even when healthcare professionals have adequate knowledge, factors such as work pressure and limited resources can negatively affect compliance. Furthermore, Makanjee et al. (2021) noted that personal beliefs and perceptions regarding occupational dose monitoring significantly influence the consistent use of dosimeters.

The absence of a significant relationship between knowledge and behavior in this study is also supported by Lee and Choi (2021), who found that behavior is often more strongly influenced by external and environmental factors than by knowledge alone. This suggests that improving knowledge without addressing

systemic and organizational factors may not be sufficient to enhance compliance.

Moreover, Allam et al. (2024) emphasized that radiation safety compliance is a multidimensional issue that involves knowledge, attitudes, institutional regulations, and the workplace environment. Therefore, a comprehensive approach is necessary to improve adherence to TLD usage among radiographers.

In summary, the findings of this study underscore the importance of not only enhancing knowledge but also strengthening supervision, improving safety culture, and ensuring adequate resource availability. Continuous training programs, routine audits, and stricter enforcement of regulations are essential to bridge the gap between knowledge and practice, ultimately promoting optimal radiation safety behavior among

### 5. CONCLUSION

This study concludes that the majority of radiographers have a good level of knowledge of Thermoluminescence Dosimetry (TLD), with 60.7% categorized as having good knowledge. However, in contrast to this finding, radiographers' use of TLD is predominantly poor, with 46.4% of respondents classified as poor. The statistical analysis also indicates that there

is no significant relationship between knowledge and behavior ( $p > 0.05$ ). This suggests that having good knowledge does not necessarily lead to proper implementation of TLD usage in clinical practice.

These findings highlight a gap between knowledge and actual behavior among radiographers. Although most respondents understand the importance of TLD, this understanding is not consistently applied in practice. Therefore, improving compliance requires not only enhancing knowledge but also strengthening supervision, enforcing standard operating procedures, and fostering a stronger radiation safety culture within healthcare institutions. In addition, further research is recommended to explore other factors that may influence behavior, such as workplace environment, supervision, institutional policies, and individual attitudes toward radiation safety.

### AUTHOR CONTRIBUTIONS

DI contributes: Conceptualization, Methodology, Validation. DI and MS: Formal Analysis, Data Curation, Writing – Review & Editing. MS: Investigation, Resources, Writing-Original Draft Preparation..

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## CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest in this research.

## DATA AVAILABILITY STATEMENT

The data are available from the corresponding author upon reasonable request.

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