

## Analysis of Factors Influencing Compliance with Radiation Safety Implementation in the Operating Room in the Use of C-Arm at Hospital X, Padang

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**Abstrak:** *The use of C-Arm technology in operating rooms plays a crucial role in assisting physicians to perform surgical procedures in real time through X-ray imaging. Despite its benefits, the radiation produced by C-Arm devices poses potential health risks to healthcare workers, including doctors, nurses, and radiographers, particularly when radiation safety measures are not properly implemented. Compliance with the use of personal protective equipment (PPE) is therefore essential to minimize radiation exposure. However, observations at Hospital X Padang in 2024 revealed that not all operating room staff adhered to established radiation protection protocols, increasing the risk of cumulative radiation exposure. This study aimed to identify factors influencing non-compliance among operating room staff during the use of C-Arm devices. A quantitative cross-sectional design was employed, involving 32 respondents selected through total sampling at Siti Rahmah Hospital. Data were collected using questionnaires and analyzed using the Spearman test. The results showed that most respondents were male (56.2%) and aged 20–30 years (75%), with 75% having 0–5 years of work experience. In terms of education, 62.5% held a D3 diploma, while 53.1% demonstrated good knowledge and attitudes. Additionally, 53.1% reported adequate availability of radiation protection facilities. Statistical analysis indicated significant relationships between age, years of service, education level, knowledge, attitudes, and the availability of facilities with compliance in radiation safety practices. Conversely, gender was not significantly associated with compliance. These findings highlight the importance of improving knowledge, attitudes, and facility support to enhance radiation safety adherence.*

**Keywords :** **PRECEDE–PROCEED; compliance with PPE use; operating room**

### INTRODUCTION

C-arm fluoroscopy is one of the radiological imaging technologies widely used in diagnostic processes and medical procedures because it can produce real-time images of anatomical structures. This system works by utilizing X-rays that are displayed directly on a monitor, allowing doctors to observe the patient's body structures dynamically during medical procedures. In modern clinical practice, the C-arm plays an important role, especially in orthopedic surgery, interventional radiology, and minimally invasive procedures, as it provides imaging guidance throughout the procedure. This technology enables medical



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personnel to monitor the position of bones, implants, and surgical instruments directly, thereby improving the precision of medical interventions (Ojodu et al., 2018).

During fluoroscopic procedures, some of the primary radiation interacts with the patient's body and produces scatter radiation that can affect the operator and staff in the procedure room. Radiation exposure during procedures using the C-arm can affect various parts of the medical staff's body, such as the hands, chest, and eye lenses, especially for operators who are closest to the radiation source. Exposure to the operator's hands can even reach several millisieverts depending on the type of procedure and the duration of fluoroscopy used. Therefore, long-term radiation exposure from C-arm use can become an occupational risk for medical personnel if not properly controlled (Ono et al., 2022).

The potential exposure received by personnel working with the C-arm requires strict adherence to radiation safety principles to minimize health risks. Radiation protection principles such as ALARA (As Low As Reasonably Achievable) emphasize that radiation exposure must be kept as low as possible through the management of time, distance, and shielding. The use of personal protective equipment such as lead aprons, thyroid shields, and lead glasses has been proven to reduce the radiation dose received by medical personnel during fluoroscopic procedures. In addition, proper operator positioning, limiting fluoroscopy time, and appropriate collimation are also important steps in reducing scatter radiation exposure in the operating room. With strict implementation of radiation safety procedures, the risk of radiation exposure to healthcare workers can be minimized, ensuring that the use of the C-arm remains safe in clinical practice (Watanabe et al., 2024).

The implementation of radiation safety regulations in the operating room tends to lack discipline. Therefore, the research problems formulated in this study are:

1. What factors influence the implementation of radiation safety regulations in the operating room at RSI Siti Rahmah Padang?
2. What is the relationship between each of these factors and the implementation of radiation safety regulations?

This study aims to examine the factors influencing compliance with radiation safety regulations in the operating room.

Previous studies have primarily focused on measuring short-term radiation doses in medical personnel without evaluating long-term biological effects such as cancer or stochastic effects. These studies indicate that exposure remains within safe limits but cannot conclusively determine long-term effects (Mohamed Sherfad & Omar Alhaddad, 2024). KAP (Knowledge, Attitude, Practice) studies show that medical personnel generally have good knowledge and attitudes, but the implementation of safety practices remains low (Aghajany et al., 2025). This indicates that radiation safety behavior has not been optimally implemented despite adequate knowledge. Other studies show that training and the use of technology (such as real-time dosimeters or 3D navigation) can reduce radiation exposure (Helton et al., 2025), but the implementation of these technologies is still limited due to cost factors and facility constraints (Watanabe et al., 2024).

Health behavior theory developed by Lawrence Green through the PRECEDE-PROCEED model states that individual behavior is influenced by predisposing factors, enabling factors, and reinforcing factors. Predisposing factors include knowledge, attitudes, and individual perceptions of radiation risk, which have been shown to have a significant relationship with radiation protection behavior among healthcare workers (Park & Yang, 2021). Enabling factors such as the availability of personal protective equipment, radiation safety training, and supporting facilities are important determinants that allow individuals to comply. Meanwhile, reinforcing factors such as supervision, hospital policies, and safety culture play a role in maintaining consistent behavior. Therefore, analyzing compliance in the

implementation of radiation safety in the operating room must be carried out comprehensively by considering these three factors to produce effective and sustainable interventions (Terry, 2021).

Hospital X is one of the largest private hospitals in Padang with relatively complete supporting medical modalities. The availability of operating rooms equipped with fluoroscopy allows the handling of various cases such as intraoperative angiography, vascular stent placement, embolization, endovascular surgery, ERCP (Endoscopic Retrograde Cholangiopancreatography), cardiac catheterization, pacemaker insertion, and angioplasty. The high number of examinations in the operating room leads to frequent use of fluoroscopy. This results in higher radiation exposure received by operating room staff if radiation safety regulations are not strictly followed.

Based on the author's observations conducted over 10 days at Hospital X, the author observed 5 radiographers. Of the 5 radiographers observed, 3 were less compliant with radiation safety regulations when operating the C-arm X-ray equipment. Based on this phenomenon, the researcher conducted an analysis of the factors influencing compliance with radiation safety regulations at Hospital X

## METHODOLOGY

This study is a quantitative study using a cross-sectional design aimed at analyzing the factors that influence compliance with the implementation of radiation safety regulations in the operating room. Data collection was carried out at a single point in time without any follow-up, allowing the study to describe the relationships between variables simultaneously. The population in this study consisted of all personnel working in the operating room, including radiographers, nurses, and other medical staff involved in the use of fluoroscopy. Specifically, the population included anesthesiologists, operating room nurses, anesthesia technicians, and radiographers. The sampling technique used was total sampling, meaning that the entire population was included as respondents to increase the strength of the analysis and to avoid selection bias. Data were collected using a structured questionnaire that measured predisposing factors, enabling factors, and reinforcing factors, as well as the level of compliance with radiation safety. The data were then analyzed using univariate and bivariate statistical tests, specifically the Spearman test, to determine the relationships and influence between variables.

## RESULTS AND DISCUSSION

### RESULT

All collected data were processed and analyzed using univariate analysis, with the following results: out of 32 respondents, 18 were male (56.2%) and 14 were female (43.8%). Based on age categories, 24 respondents (75%) were aged 20–30 years, 4 respondents (12.5%) were aged 30–40 years, and 4 respondents (12.5%) were aged 40–50 years. The distribution of respondents based on years of service showed that 24 respondents (75.0%) had 0–5 years of experience, 4 respondents (12.5%) had 5–10 years, and 4 respondents (12.5%) had 10–15 years of experience. Regarding education level, 20 respondents (62.5%) held a D3 diploma and 12 respondents (37.5%) held a D4 diploma. In terms of knowledge level, 8 respondents (25.0%) had low knowledge, 7 respondents (21.9%) had moderate knowledge, and 17 respondents (53.1%) had good knowledge. Regarding attitudes, 15 respondents (46.9%) had poor attitudes, while 17 respondents (53.1%) had good attitudes. The availability of radiation protection facilities for operating room staff showed that 15 respondents (46.9%) reported inadequate availability, while 17 respondents (53.1%) reported adequate availability. There was a relationship between age, years of service, education level, knowledge level, attitudes, and the availability of facilities and infrastructure with compliance in implementing radiation safety. However, there was no relationship between gender and compliance with radiation safety practices.

Furthermore, bivariate analysis was conducted to determine the relationship between each category, with the following results:

1. The relationship between gender and compliance with radiation safety implementation  
The results of the Spearman's test showed a significance value of 0.099 ( $p > 0.05$ ), indicating that  $H_0$  is accepted and  $H_a$  is rejected. Thus, there is no significant relationship between gender and compliance level, with a correlation value of 0.297, indicating a weak positive relationship.
2. The relationship between age and compliance with radiation safety implementation  
The Spearman's test showed a significance value of 0.001 ( $p < 0.05$ ), indicating that  $H_0$  is rejected and  $H_a$  is accepted. Therefore, there is a significant relationship between age and compliance level, with a correlation value of -0.564, indicating a moderate negative relationship.
3. The relationship between years of service and compliance with radiation safety implementation  
The Spearman's test showed a significance value of 0.000 ( $p < 0.05$ ), indicating that  $H_0$  is rejected and  $H_a$  is accepted. Thus, there is a significant relationship between years of service and compliance level, with a correlation value of -0.691, indicating a strong relationship (negative direction as reported).
4. The relationship between education level and compliance with radiation safety implementation  
The Spearman's test showed a significance value of 0.003 ( $p < 0.05$ ), indicating that  $H_0$  is rejected and  $H_a$  is accepted. Therefore, there is a significant relationship between education level and compliance level, with a correlation value of 0.509, indicating a moderate positive relationship.
5. The relationship between knowledge level and compliance with radiation safety implementation  
The Spearman's test showed a significance value of 0.001 ( $p < 0.05$ ), indicating that  $H_0$  is rejected and  $H_a$  is accepted. Thus, there is a significant relationship between knowledge level and compliance level, with a correlation value of 0.569, indicating a moderate positive relationship.
6. The relationship between attitude and compliance with radiation safety implementation  
The Spearman's test showed a significance value of 0.000 ( $p < 0.05$ ), indicating that  $H_0$  is rejected and  $H_a$  is accepted. Therefore, there is a significant relationship between attitude and compliance level, with a correlation value of 0.626, indicating a strong positive relationship.
7. The relationship between facilities and infrastructure and compliance with radiation safety implementation
8. The Spearman's test showed a significance value of 0.004 ( $p < 0.05$ ), indicating that  $H_0$  is rejected and  $H_a$  is accepted. Thus, there is a significant relationship between facilities/infrastructure and compliance level, with a correlation value of 0.498, indicating a weak positive relationship.

## DISCUSSION

There were 32 respondents, consisting of 18 males (56.2%) and 14 females (43.8%), with a p-value of 0.099, indicating that there is no significant relationship between gender and compliance level. The correlation value was 0.297, showing a weak positive relationship. In this study, gender showed only a weak relationship with compliance in implementing radiation safety regulations. A person's compliance does not depend solely on gender but is also influenced by other factors. This is consistent with a study by Goalbertus (2025), which found that compliance with PPE use was higher among females (87.7%)

compared to males (78.75%). Women tend to exhibit better health behaviors, including adherence to occupational safety procedures.

There were 32 respondents, with 24 individuals (75%) aged 20–30 years, 4 individuals (12.5%) aged 30–40 years, and 4 individuals (12.5%) aged 40–50 years. The p-value was 0.001, indicating a significant relationship between age and compliance level, with a correlation value of -0.564, representing a moderate negative relationship. This means that younger individuals (20–30 years) tend to be more compliant with radiation safety regulations compared to older individuals (40–50 years). Workers of certain age groups demonstrate better compliance, possibly related to work experience and awareness of occupational risks. However, some studies show inconsistencies regarding the relationship between age and compliance.

There were 32 respondents, with work experience distribution showing 24 respondents (75.0%) with 0–5 years of service, 4 respondents (12.5%) with 5–10 years, and 4 respondents (12.5%) with 10–15 years. The p-value was 0.000 ( $p < 0.05$ ), indicating a significant relationship between years of service and compliance with radiation safety implementation, with a correlation value of -0.691, representing a strong relationship. This finding contrasts with a study by Hendra (2016), which found no relationship between years of service and PPE compliance. In this study, newer staff in the operating room were more disciplined in using PPE, while more experienced staff were less compliant. This may be due to a false sense of security, where long-serving staff assume that because they have not experienced radiation effects, they are safe. Their understanding of stochastic effects is still limited, indicating the need for refresher training on radiation effects.

There were 32 respondents, with education levels distributed as 20 respondents (62.5%) holding a D3 diploma and 12 respondents (37.5%) holding a D4 diploma. Hypothesis testing showed a p-value of 0.003, indicating a significant relationship between education level and compliance with radiation safety, with a correlation value of 0.509, representing a moderate positive relationship. This is consistent with research by Mulyawati et al. (2023), which found a relationship between PPE compliance and education level. Education influences knowledge, and both are related to compliance, as individuals who understand the benefits of PPE for their future health are more likely to adhere to its use.

There were 32 respondents, with 8 respondents (25.0%) having low knowledge, 7 respondents (21.9%) having moderate knowledge, and 17 respondents (53.1%) having good knowledge. Hypothesis testing showed a p-value of 0.001, indicating a significant relationship between knowledge level and compliance with radiation safety implementation, with a correlation value of 0.569, representing a moderate positive relationship. This aligns with research by Akuba et al. (2025), which states that knowledge is associated with PPE compliance. Knowledge is a predisposing factor in the PRECEDE–PROCEED theory and plays an important role in shaping health behavior. According to this model, an individual's knowledge of risks and benefits influences attitudes and beliefs, which in turn determine intentions and actual behavior.

Among the 32 respondents, 15 (46.9%) had poor attitudes and 17 (53.1%) had good attitudes. Hypothesis testing showed a p-value of 0.000, indicating a significant relationship between attitude and compliance with radiation safety implementation, with a correlation value of 0.626, representing a strong positive relationship. This is consistent with research by Farsida & Zulyanda (2019), which found a relationship between PPE use and attitude. A positive attitude leads to higher compliance in PPE use. Attitudes toward occupational safety determine whether an individual is willing to comply or not.

Among the 32 respondents, PPE compliance was related to the availability of facilities and infrastructure. Respondents reported that radiation protection facilities were unavailable for 15 respondents (46.9%) and available for 17 respondents (53.1%). Hypothesis testing showed a p-value of 0.004, indicating a significant relationship between facilities/infrastructure and compliance with radiation safety implementation, with a correlation value of 0.498, representing a weak positive relationship. This is

consistent with research by Farsida & Zulyanda (2019), which states that PPE compliance is influenced by the availability of facilities. This suggests that behavior will not occur, even if knowledge exists if the necessary facilities are not available..

## CONCLUSIONS

The analysis demonstrates that multiple factors are significantly associated with compliance in the use of personal protective equipment (PPE) and the implementation of radiation safety. Gender is found to have a significant relationship with PPE compliance ( $p = 0.009$ ). Furthermore, age shows a significant moderate negative correlation with compliance ( $r = -0.564$ ;  $p = 0.001$ ), indicating that increasing age tends to be associated with lower compliance levels. Similarly, years of service exhibit a strong negative correlation with compliance ( $r = -0.691$ ;  $p = 0.000$ ), suggesting that longer work experience may correspond to decreased adherence to radiation safety practices.

In contrast, education level is positively associated with compliance ( $r = 0.509$ ;  $p = 0.003$ ), reflecting a moderate relationship where higher educational attainment leads to better compliance. Knowledge level also demonstrates a moderate positive correlation ( $r = 0.569$ ;  $p = 0.001$ ), indicating that increased knowledge contributes to improved adherence. Attitude emerges as a strong positive factor ( $r = 0.626$ ;  $p = 0.000$ ), highlighting that a more positive attitude significantly enhances compliance with radiation safety measures. Lastly, facilities and infrastructure are significantly related to compliance ( $r = 0.498$ ;  $p = 0.004$ ), although the relationship is relatively weaker, suggesting that adequate support systems still play an important role in promoting adherence.

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