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# Investigation of Common Indications for Fetal Radiation Rules Bypass in X-Rays Practices among Healthcare Professionals in Rwanda

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**Abstract**

**Background:** The use of X-ray imaging during pregnancy necessitates careful consideration to minimize fetal radiation exposure. Despite established safety protocols, instances of bypassing these guidelines raise concerns about potential risks to fetal health. This study aimed to explore the prevalence and underlying reasons for the bypass of fetal radiation safety rules in X-ray practices within Kigali City. Additionally, it sought to assess the awareness and training levels among healthcare professionals regarding these protocols.

**Methods:** A quantitative cross-sectional approach was employed, utilizing convenience sampling to gather data from (n=53) healthcare professionals in Kigali City. The choice of convenience sampling was informed by the dispersed locations of the healthcare professionals. Information was collected through structured questionnaires, with subsequent analysis performed using Chi-square statistics with the aid of Statistical Package for Social Sciences (SPSS) version 21 to elucidate patterns and draw conclusions.

**Results:** Our study revealed radiographers who were unfamiliar with the rules (and tailored-protocols) were more likely to ignore them (13 out of 18); compared to those who were familiar (8 out of 35). The relationship between familiarity with fetal radiation rules and bypass-behaviour among radiographers is statistically significant with ($\chi^2$ = 11.24, df = 1, and p = 0.001).

**Conclusion:** The study highlights a critical need for reinforced training and awareness among healthcare professionals regarding fetal radiation exposure guidelines. Enhanced educational efforts, coupled with stringent adherence to safety protocols, are imperative to safeguard fetal health during radiological examinations.

**Keywords:** Fetal Radiation Exposure; Healthcare Training; Kigali City; Radiation Safety; X-ray Practices

## Declarations

**Ethics approval and consent to participate:** Ethical approval was granted by King Faisal Hospital Rwanda (KFH/2023/126/IRB) and Centre Hospitalier Universitaire (EC/CHUK/162/2023); and informed consent was sort from participants in line with the universal Helsinki Declaration.

**Consent for publication:** Not applicable.

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**Competing interest:** None

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## BACKGROUND

The use of X-ray imaging in medical diagnostics marks a crucial advancement in modern healthcare, providing detailed views of the internal anatomy of the human body. Nonetheless, this technology introduces significant risks, notably from ionizing radiation, with fetuses being particularly susceptible. Exposure to excessive radiation during pregnancy can cause developmental defects and heighten the risk of diseases after birth [1].

Internationally, the healthcare sector follows the "As Low As Reasonably Achievable" (ALARA) principle, which aims to reduce fetal exposure to radiation to the minimum necessary amount [2]. Protective measures, including pre-procedure pregnancy testing, the use of shielding, and the possibility of alternative diagnostic techniques, are implemented to prevent unintended fetal exposure during X-ray examinations [3].

However, even with these measures, occurrences of non-compliance with fetal radiation safety protocols are reported, highlighting shortcomings in the enforcement of these standards. The reasons for these lapses are complex and include factors such as insufficient training of healthcare personnel and systemic inefficiencies within medical institutions [4]. However, there are no proper investigations regarding this, hence the need for this study.

In Kigali City, the capital and largest urban hub of Rwanda, a significant number of medical imaging facilities are concentrated. These institutions play a pivotal role in tackling the challenges of adhering to radiation safety standards, especially for sensitive groups like expectant mothers. This study focuses on uncovering the prevalent causes behind the disregard of fetal radiation safety measures in Kigali's medical settings, aiming to identify effective strategies to bolster patient safety [5].

The primary aim of this study is to analyze and comprehend the complex reasons behind failures to adhere to safety protocols while performing an ankle X-ray on a pregnant woman. The specific objectives are to: examine the practices surrounding X-ray use in Rwanda's healthcare facilities, and explore instances where fetal radiation exposure could be unnecessarily high due to non-compliance with safety measures. By conducting an in-depth qualitative investigation of the circumstances, rationales, and frequency of X-ray usage involving pregnant patients, the study seeks to identify the root causes leading to the neglect or oversight of fetal radiation protection measures.

This research aims to illuminate the extent of fetal radiation overexposure, uncover the factors leading to the neglect of safety protocols, and help in the development of stronger, more effective measures to reduce such risks. The goal is to promote a safer radiological environment that rigorously protects the health and safety of all patients, particularly the most vulnerable group - unborn children.

## METHODS

This research was conducted using a quantitative cross-sectional approach, capturing data at a specific time to provide a snapshot of current practices related to fetal radiation safety among radiographers at selected hospitals in Kigali. This method was adopted because of its ability to efficiently gather extensive quantitative data from various settings.

In this study, "bypass" refers to the deliberate or unintentional neglect of established fetal radiation protection rules by healthcare professionals during X-ray procedures, often resulting from emergency situations, lack of awareness, or institutional pressures. "Training level" denotes the extent of formal education, professional qualification, and specialized instruction healthcare professionals have received regarding radiological safety and fetal radiation protection. "Awareness" signifies the degree of knowledge, understanding, and consciousness healthcare professionals possess about the potential risks of fetal radiation exposure and the necessity of adhering to established safety guidelines during radiographic procedures.

Data collection was carried out through a structured questionnaire, which was carefully designed to explore both compliance with and deviations from established radiation safety guidelines. The focus of the questionnaire was solely on X-ray procedures involving pregnant women, aiming to evaluate the level of adherence to safety standards and identify common issues within these practices.

The study population consisted of 61 radiographers employed in the imaging departments of the hospitals selected for this study from which a sample size of 53 was determined using Taro Yamane sample size technique [6].

Yamane's formula for sample size,

$$n = \frac{N}{(1+N(e)^2)}$$

where

*n = the sample size*

*1 = constant figure*

*N = is the population size*

*e = specified margin of error which is also assumed to be* 5%

*at confidence interval of 95%.*

Application of the Yamane's formula (1967) for sample size to determine the sample size for the study is as follows:

N = 61

e = 5% or 0.05

$$n = \frac{61}{(1+61(0.05)^2)}$$

$$n = \frac{61}{1.1525}$$

n = 52.9284

n≈ 53

Thus, the study sample consisted of 53 radiographers employed in the imaging departments of the hospitals selectedforthisstudyin Kigali. Theseprofessionalsprovided a representative sample of individuals directly engaged in conducting X-ray examinations. Their participation was crucial for gaining insights into the prevailing practices and the challenges they face concerning fetal radiation safety.

The inclusion criteria for the study encompassed radiographers who were actively engaged in performing X-ray examinations at the selected hospitals. This group was chosen because they could provide firsthand insights into the practices, challenges, and compliance with fetal radiation protection guidelines, offering a direct perspective on the day-to-day application of safety protocols. The study excluded radiographers who were on leave, vacation, or otherwise unavailable during the period of data collection. This criterion was established to ensure that the collected data accurately represents the ongoing and active practices related to radiographic procedures on pregnant patients within the selected hospitals.

This study utilized a non-probability convenience sampling method due to the easy accessibility of subjects during the data collection phase and the manageable scope of the target population at the selected Kigali hospitals.

Radiographers were recruited within the period of one year from five tertiary hospitals in Kigali: CHUK, King Faisal Hospital, Rwanda Military Hospital, Muhima District Hospital, and Kibagabaga Hospital. The distribution of radiographers confirmed for participation prior to data collection ensured a balanced representation from each facility, with CHUK contributing 17 radiographers, King Faisal Hospital 15, Rwanda Military Hospital 12, Muhima District Hospital 3, and Kibagabaga Hospital 4.

In the context of the study, "radiographers" are healthcare professionals trained and licensed to perform diagnostic imaging procedures, including X-rays, computed tomography (CT), and other radiographic examinations, while ensuring patient safety and image quality. Their primary responsibility involves operating imaging equipment to produce accurate visual representations of internal body structures for medical diagnosis and treatment planning.

Subject-specific qualifications for radiographers typically include a minimum of a diploma or bachelor's degree in radiography, medical imaging, or radiological sciences from an accredited institution. Also, they must complete clinical training under professional supervision, demonstrating competence in radiation physics, anatomy, radiographic positioning, and radiation protection principles. Radiographers are also required to obtain professional certification or registration from relevant regulatory bodies, such as the Rwandan Allied Health Professions Council (RAHPC), which validates their technical expertise and adherence to ethical and safety standards in radiological practice.

Ethical approval was granted by King Faisal Hospital Rwanda (KFH/2023/126/IRB) and Centre Hospitalier Universitaire (EC/CHUK/162/2023); and informed consent was obtained from participants in line with the universal Helsinki Declaration.

To maintain strict adherence to the inclusion and exclusion criteria, radiographers who were on leave, assigned to non-radiographic duties such as ultrasound, or unavailable due to illness or travel were excluded from the study. This adjustment excluded 11 radiographers from the initial tally, ensuring that the final sample consisted only of those actively performing X-ray procedures at the time of the study.

This sampling approach was instrumental in capturing a broad spectrum of practices and perspectives related to radiation safety, with a specific focus on the compliance with fetal radiation protocols across different hospital settings.

Quantitative data collection was carried out using structured questionnaires distributed to radiographers at selected hospitals throughout Kigali. The questionnaires were specifically designed to evaluate the radiographers' compliance with established fetal radiation safety guidelines during X-ray procedures. The questionnaire was pilot tested on 10 radiographers from the selected hospitals who were not part of the respondents. The questionnaire was self-administered by the researchers. The aim was to measure compliance rates and to detect patterns and challenges in the practices employed by these healthcare professionals. This method facilitated a thorough and

statistically significant analysis of how well radiation safety protocols are adhered to, offering a comprehensive view of the current standards in the radiological management of pregnant patients.

Quantitative data collected were analyzed using Pearson's correlation statistics at 0.05 level of significance with the aid of Statistical Package for Social Sciences (SPSS) version 21. This analysis focused on identifying patterns, frequencies, and deviations from the established fetal radiation safety protocols. The goal was to ascertain the level of compliance among radiographers and pinpoint the areas where deviations occurred most frequently. The statistical techniques used provided a comprehensive review of the data, enabling the researchers to make significant inferences about the levels of adherence to radiation safety guidelines by healthcare professionals.

## RESULTS

Table 1 presents the stratified distribution of 53 radiographers across five tertiary hospitals in Kigali based on their training levels.

**Table 1: Stratified Distribution of Radiographers by Training Level and Facility Type**

| Facility Name | Diploma | Bachelor's Degree | Master's Degree | Total | Percentage (%) |
|---|---|---|---|---|---|
| CHUK (University Teaching Hospital of Kigali) | 4 | 8 | 3 | 15 | 28.3 |
| King Faisal Hospital | 2 | 6 | 2 | 10 | 18.9 |
| Rwanda Military Hospital | 3 | 5 | 1 | 9 | 17.0 |
| Muhima District Hospital | 5 | 2 | 0 | 7 | 13.2 |
| Kibagabaga Hospital | 7 | 4 | 1 | 12 | 22.6 |
| Total | 21 | 25 | 7 | 53 | 100 |

The findings indicate that radiographers with a bachelor's degree constitute the largest group, accounting for nearly half of the total respondents, followed by those with diploma qualifications. Only a small proportion of radiographers hold a master's degree, suggesting that advanced academic training in radiography is still limited in the Rwandan context. In terms of facility distribution, CHUK has the highest number of radiographers, reflecting its status as the main referral and teaching hospital in the country. Kibagabaga and King Faisal Hospitals also have a considerable number of radiographers, while Muhima District Hospital has the fewest. The pattern shows that facilities with broader diagnostic responsibilities tend to attract or employ more highly trained professionals, whereas smaller hospitals depend more on diploma holders for their imaging services.

### *Prevalence of Fetal Radiation Rules Bypass*

Identifying how often fetal radiation safety rules are bypassed is crucial for assessing the scope of this issue. The fetal radiation safety rule is found to be bypassed by 39 (75%) Radiographers. **(Figure 1)**

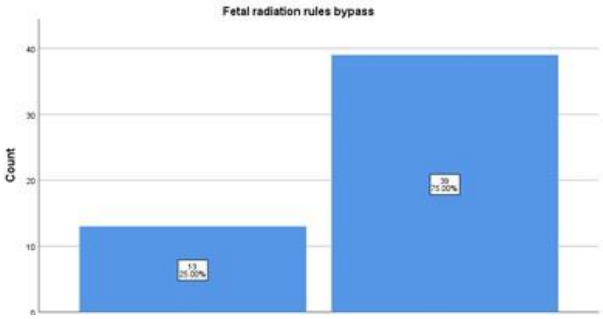


**Figure 1: Frequency of bypass of fetal radiation safety rules by professionals**

### *Factors Leading to Bypass of Fetal Radiation Safety Rules*

Understanding why healthcare professionals might bypass safety rules is essential for addressing the root causes of such practices. Most of the radiographers (60.38%) mentioned that they bypass the radiation rules when the benefit outweighs the risk. Other major causes were time constrain (15.09%) and lack of resources (9.43%); **(Figure 2)**.

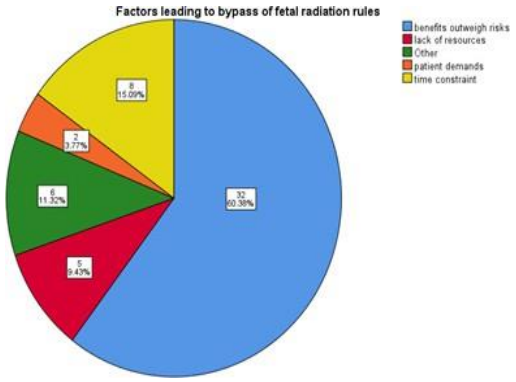


**Figure 2: Main reasons cited by respondents for bypassing fetal radiation rules**

### *Awareness and Training among Healthcare Professionals*

Evaluating the level of awareness and training related to fetal radiation exposure sheds light on the potential gaps in knowledge and practice. **Table 2** shows the prevalence of training among healthcare professionals, with a high

**Table 2: Training Prevalence Regarding Fetal Radiation Exposure**

| Response | Frequency | Percent | Respondents Untrained (%) |
|---|---|---|---|
| Yes | 50 | 94.3 | 5.7 |
| No | 0 | 0.0 | 100 |
| Partial | 3 | 5.7 | 94.3 |

**Table 3: Availability of Specific Protocols or Decision-Making Tools**

| Availability | Frequency | Percent | Need for Implementation (%) |
|---|---|---|---|
| Yes | 47 | 88.7 | 11.3 |
| No | 5 | 9.4 | 90.6 |
| Unsure | 1 | 1.9 | 98.1 |

percentage indicating full training.

**Table 3** details the availability of specific protocols or decision-making tools to ensure compliance with fetal

**Table 4: Familiarity with Fetal Radiation Rules and Bypass Practice among Radiographers**

| Familiarity with Fetal radiation Rules | Bypassed Rules (n=21) | Did Not Bypass Rules (n=32) | Chi-square ($\chi^2$) | Degree of Freedom (df) | p-value | Decision |
|---|---|---|---|---|---|---|
| Familiar (Adequately Informed) (n=35) | 8 | 27 | 11.24 | 1 | 0.001 | Significant |
| Unfamiliar (Poorly Informed) (n=18) | 13 | 5 | | | | |

**Table 4** reveals a significant association between familiarity with fetal radiation rules and the likelihood of bypassing them. Radiographers who were unfamiliar with the rules were more likely to bypass them (13 out of 18) compared to those who were familiar (8 out of 35). The relationship between familiarity with fetal radiation rules and bypass behaviour among radiographers is statistically significant, with $\chi^2 = 11.24$, df = 1, and p = 0.001. This result implies that radiographers who are more familiar with fetal radiation protection guidelines are significantly less likely to bypass the rules compared to those who are unfamiliar, emphasizing the importance of continuous professional training on radiation safety.

## DISCUSSION

The data analysis has shown that the bypass of fetal radiation safety protocols in Kigali City is often not due to mere oversight but stems from significant systemic and situational pressures. Approximately 60% of the cases where safety protocols were overlooked can be traced back to urgent care needs in medical diagnostics. Table 4 specifically revealed that a significant relationship exists between training and healthcare professional awareness of fetal radiation safety protocols ($\chi^2$ value 11.24 > p. value = .001).

In such instances, it is obvious that the healthcare professionals are aware of the existence of radiation safety protocols and fetal radiation rules, but the immediate demands of patient care tend to take precedence over strict compliance with radiation safety measures, which might be viewed as too time-consuming or less critical than the immediate health concerns. This scenario aligns with findings of Shbeer A (2024), who note that environments with high pressure, such as emergency rooms (ERs) and intensive care units (ICUs), pose substantial challenges to uniform application of radiation safety protocols due to a combination of factors related to the urgent nature of care, lack of equipment, and insufficient staff knowledge/ attitude [7]. The need for quick diagnostic results in these settings often results in prioritizing diagnostic speed, which can inadvertently heightening the risk of unnecessary fetal exposure in the case of pregnant women. However in managing life-threatening conditions, professional guidelines emphasize that diagnostic imaging should not be withheld from pregnant patients if medically necessary [8].

Compounding this problem, Figure 1 revealed that professionals bypass fetal radiation safety rules at higher rate, while Figure 2 showed that approximately 9% of safety protocol bypasses were linked to a lack of resources, particularly inadequate shielding materials. This highlights a broader issue of resource distribution within healthcare facilities, where the availability of essential protective gear, like lead aprons or mobile shielding barriers, is crucial for adhering to radiation safety standards. Martin et al. also pointed out that resource limitations concern not only the absence of equipment; but also its quality and accessibility [11]. In settings constrained by resources, the absence of adequate shielding materials directly affects healthcare providers' ability to follow radiation safety protocols, increasing the risk of radiation exposure for both patients and fetuses.

This interplay between urgent care demands and resource shortages presents a complex decision-making environment for healthcare providers, who often must weigh the immediate needs of patient management against radiation safety principles. This situation may

lead to decisions that favor quick clinical responses over long-term safety measures, underscoring the necessity for systemic changes in resource allocation and the integration of radiation safety into emergency care protocols. Addressing these issues through targeted policy interventions, enhanced training, and better resource distribution is crucial to reducing the risks associated with ignoring fetal radiation protocols and improving the safety of radiological practices in prenatal care.

There were other reasons associated to the bypass that amounted to 11.32% (see figure 2). These specifically were: miscommunication, perceived low risk, personal judgement, workplace culture/ routine and patient pressure.

The study reveals an alarmingly high rate of non-compliance with fetal radiation safety protocols in Kigali City, with 75% of X-ray procedures on pregnant women deviating from established safety guidelines on at least some occasions. This rate is considerably higher than the 20-30% typically reported in other regions [10], indicating profound systemic challenges within Kigali's healthcare infrastructure and procedural governance that hinder the effective implementation of radiation safety measures.

The significant deviation in protocol compliance is concerning and highlights an urgent need for comprehensive reviews and reforms in healthcare practices. The factors contributing to this high rate of non-compliance are multifaceted, including inadequate regulatory oversight, insufficient training of healthcare personnel, and potentially a cultural underestimation of the risks associated with radiation exposure during pregnancy [11]. These elements do not operate in isolation; rather, they interact in ways that compound the difficulties in adhering to safety protocols.

For example, regions that report higher compliance rates often benefit from ongoing education programs, regular audits, and robust regulatory frameworks that support the adherence to safety protocols. Such structures are linked to lower incidences of safety breaches because they ensure that healthcare providers are informed and equipped to effectively implement radiation safety measures. In contrast, the healthcare environment in Kigali may suffer from gaps in these critical areas, leading to frequent protocol breaches that endanger pregnant patients and their unborn children.

Addressing these discrepancies necessitates a comprehensive strategy that enhances educational opportunities for healthcare workers, improves the visibility and enforcement of regulations, and ensures that medical facilities are properly equipped with essential radiation safety materials. Additionally, cultivating a culture that prioritizes patient safety above operational efficiency is crucial for reducing the occurrence of protocol bypasses. Implementing such a holistic approach could markedly enhance the safety of radiological practices involving pregnant women, thereby aligning the healthcare standards of Kigali more closely with international best practices [12].

The study uncovers a significant disconnect between the awareness of and actual adherence to fetal radiation safety protocols among healthcare professionals in Kigali City. Despite a high awareness level, with 94% of healthcare professionals knowledgeable about the guidelines, only about 25% consistently follow these protocols. This discrepancy between knowledge and practice indicates that simply being aware of the guidelines is not enough to guarantee their effective implementation.

Several factors contribute to this gap in translating knowledge into practice. Firstly, while professionals may understand the guidelines theoretically, they often lack practical training to apply these guidelines effectively in clinical settings. This issue is highlighted by Malone et al., who argued for the necessity of continuous education that focuses on the practical application of radiation safety standards [10, 13]. It suggests that ongoing training initiatives are essential for closing the gap between knowledge and actual practice.

Moreover, professional development programs may fail to emphasize the practical application of knowledge. These programs typically concentrate on theoretical understanding without offering sufficient practical exercises or simulations that replicate real-life situations. Consequently, healthcare professionals, despite their theoretical knowledge, might struggle to implement these guidelines effectively under the demands of clinical pressures.

Organizational support within healthcare institutions also plays a pivotal role. The absence of a robust safety culture and well-enforced protocols can make it challenging for even the most well-trained professionals to adhere consistently to guidelines. This problem is exacerbated in high-pressure environments where the urgency of patient care might override the strict application of safety measures.

To overcome these challenges, training programs need to be enhanced to include practical, scenario-based learning that emphasizes the application of guidelines in daily clinical activities. Healthcare institutions must

also create an environment where safety protocols are not just recommended but strictly enforced, with clear repercussions for non-compliance. By implementing these comprehensive strategies, the gap between knowledge and adherence can be effectively narrowed, ensuring that pregnant patients receive the safest possible care according to radiation safety standards.

## CONCLUSION

The incidence of bypassing radiation safety measures in Kigali City's healthcare settings is alarmingly high (75%), markedly higher than global averages. The study identified urgent medical care needs and severe resource constraints as primary factors driving the bypass of radiation safety measures. These challenges force healthcare providers to prioritize immediate patient care over strict adherence to safety protocols, further compounded by the lack of necessary protective equipment. The systemic deficiencies within the local healthcare infrastructure and practices significantly contribute to the poor adherence to established safety guidelines.

There is a significant disconnect between the knowledge possessed by healthcare professionals and their actual adherence to radiation safety protocols. This discrepancy highlights shortcomings in the effectiveness of training and the practical implementation of safety knowledge, signaling a pressing need for improved educational programs that enhance both understanding and application of radiation safety standards.

To effectively tackle the challenges identified and enhance fetal radiation safety in Kigali City, we recommend the following strategic actions:

Comprehensive Training Programs: Enhance training initiatives to go beyond simple knowledge dissemination, focusing instead on practical application. Implementing simulation-based training and ensuring regular refresher courses will significantly improve the practical skills of healthcare professionals, enabling them to handle real-life scenarios more effectively while adhering to safety protocols.

Improved Resource Provision: Increase investment in the acquisition and maintenance of essential radiation safety equipment. It is vital to ensure that all healthcare facilities have adequate access to necessary resources like lead shields and other protective gear. Proper resource allocation will support the consistent application of safety protocols and reduce the necessity for protocol bypass under resource-constraint conditions.

Stricter Regulatory Oversight: Strengthen regulatory frameworks and enhance enforcement mechanisms to ensure adherence to safety standards. This should include regular audits of healthcare facilities and imposing penalties for non-compliance. Such measures will foster a culture of compliance and help maintain high standards of radiation safety across all healthcare settings.

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