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Perceived Adequacy in Composite Materials, Practice, and Efficiency in Radiation Shielding among Radiologic Technologists in Selected Hospitals in Bulacan

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Abstract

Radiation shielding is essential in protecting both patients and healthcare workers from unnecessary radiation exposure. Traditional lead-based materials, despite their proven efficacy in radiation shielding showed several disadvantages including heavy weight, toxicity, limited flexibility, and environmental hazards. In recent years, composite materials have emerged as alternatives to conventional shielding due to their lightweight properties, flexibility, and potential effectiveness in radiation attenuation (Gilys et al., 2022). With the introduction of composite materials as alternatives to traditional shielding these disadvantages were resolved. Due to its importance, it was necessary to understand how these materials are perceived and incorporated into practice and how efficient they are in clinical settings. This study explored the relationships among the perceived adequacy of composite materials, practices, and the efficiency of radiation shielding among radiologic technologists in selected hospitals in Bulacan. Recognizing the emergence of composite materials as alternatives to conventional shielding and the potential impact of their perception on practice and efficiency, this study aimed to provide practical recommendations for healthcare organizations. Using a descriptive-correlational research design, data were collected via a self-developed questionnaire and disseminated via Google Forms to 60 radiologic technologists in Bulacan using a stratified random sampling technique. Findings indicated that the respondents perceived composite materials as very adequate. The respondents fully practiced radiation shielding, especially during handling and maintenance, and were very efficient in radiation shielding. Statistical analysis revealed that perceived adequacy of composite materials had no significant influence on respondents' shielding practices and the level of radiation shielding efficiency. On the other hand, storage and maintenance practices showed significant relationships with the efficiency in shielding consistency ($r=0.627$ and $r=0.694$) and the efficiency in application ($r=0.379$ and $r=0.431$). These results underscore that proper operational practices play a more critical role in the efficiency of using radiation shielding than material perception alone. The study concludes with recommendations for chief radiologic technologists and hospital administrators to

develop protocols for the proper handling and storage of radiation shields and to support training opportunities for radiologic technologists in the use and maintenance of composite material shields.
Keywords: Adequacy, Composite Materials, Practice, Efficiency, Radiation Shielding

Introduction

Radiation protection was a fundamental responsibility in radiologic practice due to the risks of ionizing radiation to patients and healthcare professionals. Shielding materials were essential in minimizing exposure and ensuring adherence to ALARA (NCRP, 2023). Traditional lead shielding, while effective, had limitations, including weight, toxicity, and inflexibility. As a result, composite materials emerged as lightweight and flexible alternatives with effective attenuation properties (Gilys et al., 2022) and were recommended as non-toxic substitutes for lead (Okda et al., 2026).

With the emergence of these alternatives, varying perceptions of their effectiveness were observed. Thundathil et al. (2023) noted that perceptions of materials were influenced by physical properties, such as weight and thickness, which affected judgments of quality and performance. Similarly, Schmidt et al. (2025) emphasized that accurate perception of material properties was essential for evaluating their function and effectiveness. Composite materials, despite its comparable shielding ability to traditional shielding material, have gathered different opinions which might affect the use in the practice of radiation shielding, and the efficiency in its use due to its significantly lighter weight and thinner thickness, which were easily observable and compared variables when using radiation shields.

Radiologic technologists were also required to practice radiation protection principles, including shielding, to minimize exposure (Alhazmi et al., 2024). Radiation shielding remained routine in clinical settings despite recent studies suggesting that it only hinders comfort and image quality during radiologic examinations (Federico et al., 2026). However, variations in practice highlighted the need for improved training and standardized protocols to ensure proper handling and maintain shielding effectiveness (Stogiannos et al., 2023).

The study's findings can be utilized by various benefactors. Radiologic technologists can develop evidence-based techniques for handling composite radiation shielding, while chief radiologic technologists can revise protocols to extend shielding lifespan and provide training. Hospital administrators can update policies and procurement decisions to improve radiation safety, and future radiologic technologists can gain foundational knowledge on composite shielding. Additionally, future researchers can explore alternative composite materials for radiation protection and safety advancements, building on this study's groundwork.

Efficiency in radiologic practice was crucial for safe and effective workflow, allowing technologists to perform procedures without compromising safety. The WHO (2022) emphasized that efficiency improved healthcare quality, while Lee et al. (2023) linked it to reduced errors and enhanced patient safety. Likewise, AHRQ (2023) noted that efficient systems reduced workload strain and improved productivity, underscoring the importance of well-designed shielding materials in supporting workflow and safety.

Despite previous research, no similar studies have been conducted in the Philippines to address the perceived adequacy of composite materials, radiologic technologists' practices, and the efficiency of radiation shielding using these materials. Existing research on shielding use, as well as on efficiency, material properties, and radiation-absorbing capabilities, had been limited. Consequently, this study aimed to bridge these significant gaps.

The primary objective of this study was to determine the perceived adequacy of composite materials for radiation shielding, practices, and efficiency among radiologic technologists in selected hospitals in Bulacan. selected hospitals in Bulacan. Specifically, the study sought answers to the following:

- What is the perceived adequacy of composite materials for radiation shielding among the radiologic technologists?
- What are the radiation shielding practices among radiologic technologists?
- What is the level of efficiency in radiation shielding among radiologic technologists
- Is there a significant relationship between the perceived adequacy in composite materials for radiation shielding and the radiation shielding practices among radiologic technologists?
- Is there a significant relationship between the perceived adequacy in composite materials for radiation shielding and the level of efficiency in radiation shielding among radiologic technologists?
- Is there a significant relationship between the radiation shielding practices and the level of efficiency in radiation shielding among radiologic technologists?
- What intervention plan can be proposed to enhance the perceived adequacy of composite materials for radiation shielding, practices, and efficiency among radiologic technologists?

Methods

This study employed a non-experimental, quantitative research design using a descriptive-correlational approach to examine the perceived adequacy of composite materials, practices, and efficiency of radiation shielding among radiologic technologists in selected hospitals in Bulacan. This method enabled the researcher to describe variables and examine their relationships without manipulating any of them. Descriptive-correlational research was commonly used to determine associations between variables as they naturally occur (Walker, 2024). In this study, a descriptive-correlational research design was used to describe and examine the relationships among radiologic technologists' perceived adequacy of composite materials, practices, and radiation shielding efficiency.

The primary source of data was the responses collected through questionnaires answered by licensed radiologic technologists currently employed in selected hospitals in Bulacan. The total population was 70, of which 60 were included as actual respondents using the Raosoft calculator at a 95% confidence level and a 5% margin of error. Participants were selected using a stratified random sampling technique and were distributed proportionally across institutions using the allocation formula, which resulted in the following distribution: 18 from Bulacan Medical Center, 10 from Rogaciano Mercado Memorial Hospital, 9 from Dr. Yanga Hospital Inc., 8 from ACE Medical Center - Malolos, 7 from St. Paul Hospital Inc., and 8 from La Consolacion Hospital.

The questionnaire used in the study was developed by the researcher. The instrument consisted of three parts: (1) perceived adequacy of composite materials among radiologic technologists, (2) practices in radiation shielding, and (3) level of efficiency in radiation shielding. To assess the instrument's reliability, a pilot test was conducted with 20 radiologic technologists who were not part of the actual respondents. Cronbach's alpha was used to evaluate the questionnaire's internal consistency, and the results for the variables were as follows: perceived adequacy, 0.801 (Good); practices in radiation shielding, 0.921 (Excellent); and level of efficiency, 0.799 (Good). These values suggested that the questionnaire items were highly consistent and reliable in measuring their respective constructs.

Responses were measured on a four-point Likert scale; a weighted mean was used to assess the perceived adequacy of composite materials and practices in radiation shielding and the level of efficiency in radiation shielding. For perceived adequacy, mean scores were interpreted as *very adequate (3.25–4.00), adequate (2.50–3.24), slightly adequate (1.75–2.49), and not adequate (1.00–1.74).* For radiation shielding practices, mean scores were interpreted as *fully practiced (3.25–4.00), practiced (2.50–3.24), slightly practiced (1.75–2.49), and not practiced (1.00–1.74).* Lastly, for the level of efficiency, mean scores were interpreted as *very efficient (3.25–4.00), efficient (2.50–3.24), slightly efficient (1.75–2.49), and not efficient (1.00–1.74).* Pearson's Moment Correlation (Pearson r) was used to determine whether the following variables were significantly correlated: (a) perceived adequacy and practices, (b) perceived adequacy and level of efficiency, and
(c) practices and level of efficiency. All hypotheses were tested at a 0.05 level of significance.

Results and Discussion

Table 1

Perceived Adequacy in Composite Materials for Radiation Shielding

Indicators	**Weighted Mean**	**Verbal Interpretation**	**Rank**
1. The composite shielding provides sufficient attenuation against scatter radiation during procedures.	4.00	Very Adequate	1.5
2. The material is lightweight enough to prevent physical fatigue during long shifts.	3.98	Very Adequate	4.5
3. The flexibility of the composite material allows for a comfortable range of motion.	3.98	Very Adequate	4.5
4. The composite material is trusted to provide the same level of protection as traditional lead.	3.98	Very Adequate	4.5
5. The thickness of the material is appropriate for the energy levels (kVp) used in my department.	4.00	Very Adequate	1.5
6. The composite materials used in our facility provide sufficient protection against radiation exposure.	3.97	Very Adequate	10
7. Composite materials used for radiation shielding meet the required safety standards.	3.98	Very Adequate	4.5
8. There is confidence in the shielding performance of the	3.98	Very Adequate	4.5

composite materials used.			
9. The composite materials effectively reduce radiation to safe levels.	3.98	Very Adequate	4.5
10. Compared to traditional shielding materials (e.g., lead), composite materials are adequate for radiation protection.	4.00	Very Adequate	1.5
General Weighted Mean	**3.99**	**Very Adequate**	

Legend: (Strongly Agree/Very Adequate — 4, Agree/Adequate — 3, Disagree/Slightly Adequate — 2, Disagree/Not Adequate —
1)

Table 1 showed that Indicator 1, which reflected the composite shielding's sufficient attenuation against scattered radiation, together with Indicator 5, which focused on the appropriate thickness of the shielding material, and Indicator 10, which stated that composite materials were adequate for radiation protection, all ranked 1.5 with a weighted mean of 4.00. This was followed by Indicator 2, which focused on the lightweight feature of the shielding material; Indicator 3, which described its flexibility; Indicator 4, which compared the composite material to lead in its ability to provide sufficient protection; Indicator 7, which indicated that the composite material shielding met required safety standards; Indicator 8, which reflected confidence in the material's performance; and Indicator 9, which focused on its effectiveness in radiation absorption. These indicators ranked 4.5 with a weighted mean value of 3.98. Lastly, Indicator 6, which focused on the composite material's ability to provide sufficient radiation protection, ranked 10th with a weighted mean of 3.97.

The result indicated the respondents' perceived adequacy of composite materials used for radiation shielding, with an overall weighted mean of 3.99, was verbally interpreted as "very adequate." This data was interpreted that radiologic technologists have a very adequate perception of composite materials for radiation shielding, as they provide sufficient radiation attenuation, shielding, and thickness for use in shielding. This indicated that respondents have a strong, consistent perception of the effectiveness and suitability of composite materials for radiation protection.

These findings can be explained through the Protection Motivation Theory as cited by Hawksworth et al. (2025), which states that individuals are motivated to adopt protective behaviors when they perceive a threat and believe that the recommended protective measures are effective. In this study, radiologic technologists who recognized the risks of radiation exposure valued and positively assessed materials that provided reliable protection. The belief that composite materials were very adequate for radiation shielding suggested that they provided sufficient radiation attenuation and thickness for shielding, leading respondents to believe these materials effectively mitigate radiation risks, thereby reinforcing their acceptance and use.

Table 2
Practices Used by the Respondents in Radiation Shielding in Terms of Handling

Indicators	**Weighted Mean**	**Verbal Interpretation**	**Rank**
1. Folding or creasing composite aprons is avoided during use.	4.00	Fully Practiced	1.5
2. All fasteners (velcro, buckles) are ensured to be securely closed to maintain shielding geometry.	3.98	Fully Practiced	6.5
3. Mobile composite barriers are handled with care to avoid structural impact.	3.97	Fully Practiced	9.5
4. Composite shielding materials are handled according to established safety protocols.	3.98	Fully Practiced	6.5
5. Proper personal protective equipment (PPE) is always used when handling radiation shielding materials.	3.98	Fully Practiced	6.5
6. Training has been received in the proper handling of composite materials for radiation shielding.	4.00	Fully Practiced	1.5
7. Mishandling of shielding materials rarely occurs in our workplace.	4.00	Fully Practiced	1.5
8. Standardized procedures are followed when moving or installing radiation shielding materials.	4.00	Fully Practiced	1.5
9. Unnecessary exposure is avoided while handling radiation shielding materials.	3.98	Fully Practiced	6.5
10. Handling procedures are clearly explained and easy to follow.	3.97	Fully Practiced	9.5
General Weighted Mean	**3.99**	**Fully Practiced**	

Legend: (Strongly Agree/Fully Practiced — 4, Agree/Practices — 3, Disagree/Slightly Practiced— 2, Disagree/Not Practiced— 1)

Table 2 showed that Indicator 1, which involved avoiding the folding of shielding to prevent creases, together with Indicator 6, which focused on proper training in shielding handling; Indicator 7, which indicated that mishandling rarely occurred in the workplace; and Indicator 8, which emphasized following standardized procedures in moving or positioning radiation shielding, ranked 1.5 with a weighted mean of 4.00. This was followed by Indicator 2, which focused on the proper use of fasteners in securing the shields; Indicator 4, which described established handling methods based on safety protocols; Indicator 5, which involved the use of protective equipment when handling radiation shielding materials; and Indicator 9, which emphasized avoiding unnecessary radiation exposure while using shielding. These indicators ranked 6.5 with a weighted mean of 3.98. Lastly, Indicators 3 and 10 ranked 9.5, with a weighted mean of 3.97. Indicator 3 focused on careful handling when moving mobile composite barriers, while Indicator 10 emphasized clear and understandable handling procedures when using a barrier.

The results indicated that respondents' practices in radiation shielding during handling have an overall weighted mean of 3.99 and were interpreted as "fully practiced." This showed that avoiding shielding creasing, adherence to training and proper standards, and ensuring that mishandling rarely occurred were among the fully practiced practices by the radiologic technologists. This indicated that they consistently handled and used radiation shielding in accordance with the standardized procedures.

These data showed that radiologic technologists fully practiced the proper handling of the composite material shielding. If radiologic technologists were fully trained and oriented to proper handling of composite shields, the ease of handling the materials not only encouraged their use but also incorporated proper handling protocols into their practice (Zhang et al., 2021).

Table 3
Practices Used by the Respondents in Radiation Shielding in Terms of Storage

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. Composite aprons are hung on specialized heavy-duty hangers immediately after use.	3.97	Fully Practiced	1.5
2. Shielding materials are not left in high-heat environments (such as inside a hot car or near radiators).	4.00	Fully Practiced	6.5
3. The storage area for composite materials is organized to prevent stacking or crushing.	3.98	Fully Practiced	9.5
4. Composite radiation shielding materials are stored in designated and secure areas.	3.97	Fully Practiced	6.5
5. Storage areas for shielding materials are properly labeled and monitored.	3.98	Fully Practiced	6.5
6. Composite shielding materials are protected from environmental damage (e.g., heat, moisture).	4.00	Fully Practiced	1.5
7. Storage practices prevent deterioration of shielding materials over time.	3.98	Fully Practiced	1.5
8. Only authorized personnel have access to stored shielding materials.	4.00	Fully Practiced	1.5
9. Storage locations for shielding materials are easily accessible but secure.	3.97	Fully Practiced	6.5
10. Storage procedures are reviewed regularly.	3.98	Fully Practiced	9.5
General Weighted Mean	**3.98**	**Fully Practiced**	

Legend: (Strongly Agree/Fully Practiced — 4, Agree/Practices — 3, Disagree/Slightly Practiced— 2, Disagree/Not Practiced— 1)

Table 3 showed that Indicator 2, which stated that the shields were not left in high-heat areas, together with Indicator 6, which stated that the shielding was protected from environmental damage, and Indicator 8, which stated that only authorized personnel could access the shielding storage area, all ranked 1.5. In rank 5.5 were Indicator 3, which stated that composite shields were organized to prevent stacking; Indicator 5, which focused on the importance of proper labeling and monitoring; Indicator 7, which stated that the storage practices prevented the deterioration of the shielding materials; and Indicator 10, which focused on the regular review of the storage procedures. Lastly, at rank 9.5 were Indicator 1, which stated that composite aprons were hung on heavy-duty hangers; Indicator 4, which focused on the secured designated storage area; and Indicator 9, which stated that the storage locations were accessible but secured.

The results suggested that respondents' practices in radiation shielding during storage, with an overall weighted mean of 3.98, were interpreted as "fully practiced." This showed that not leaving shielding in high-heat environments, protecting it from environmental damage, and restricting access to authorized personnel were among the practices radiologic technologists fully practiced. This showed that the radiologic technologists fully practiced proper storage recommendations.

Alshamrani et al. (2023) emphasized that proper storage of radiation shielding materials, such as keeping lead aprons in appropriate conditions and avoiding exposure to heat and environmental stressors, is essential to maintaining their structural integrity and protective effectiveness, and that this practice must be fully implemented in storage.

Table 4
Practices Used by the Respondents in Radiation Shielding in Terms of Maintenance

Indicators	**Weighted Mean**	**Verbal Interpretation**	**Rank**
1. A visual inspection for surface cracks or tears is conducted before every use.	3.98	Fully Practiced	6.5
2. Any signs of material degradation are reported to the Radiation Safety Officer (RSO) immediately	4.00	Fully Practiced	1
3. The manufacturer's specific cleaning protocols are followed to prevent chemical damage to the composite.	3.98	Fully Practiced	6.5
4. Damaged or degraded shielding materials are promptly repaired or replaced.	3.98	Fully Practiced	6.5
5. There is a regular maintenance schedule for radiation shielding materials.	3.98	Fully Practiced	6.5
6. Maintenance procedures for shielding materials are clearly documented and followed.	3.98	Fully Practiced	6.5
7. Repairs are carried out by trained personnel.	3.98	Fully Practiced	6.5
8. There is a clear protocol for reporting damaged shielding materials.	3.98	Fully Practiced	6.5
9. Worn-out shielding materials are replaced on time.	3.98	Fully Practiced	6.5
10. Maintenance resources (tools, personnel) are sufficient.	3.98	Fully Practiced	6.5
General Weighted Mean	**3.99**	**Fully Practiced**	

Legend: (Strongly Agree/Fully Practiced — 4, Agree/Practices — 3, Disagree/Slightly Practiced— 2, Disagree/Not Practiced— 1)

Table 4 showed that Indicator 2, which stated that any degradation in the radiation shielding was reported to the RSO, ranked 1 with a weighted mean of 4.00. The other indicators, such as Indicator 1, which indicated regular visual inspection; Indicator 3, which stated the need to follow specific cleaning protocols; Indicator 4, which indicated the prompt repair of damaged shielding; Indicator 5, which stated that there was a regular maintenance schedule; Indicator 6, which stated the proper documentation of maintenance procedures; Indicator 7, which stated that trained personnel carried out repairs; Indicator 8, which indicated a clear protocol for reporting damaged shielding; Indicator 9, which stated the replacement of worn-out shielding materials; and lastly, Indicator 10, which indicated sufficient resources for the maintenance of the shield, all ranked 6.5.

The results suggested that the respondents' practice of radiation shielding in terms of maintenance, with an overall weighted mean of 3.99, was interpreted as "fully practiced". It was interpreted that radiologic technologists have fully practiced radiation shielding in terms of maintenance. This indicated that respondents consistently and correctly performed maintenance practices, such as monitoring and reporting damaged shielding materials, which minimized lapses in safety practices.

Regular monitoring, inspection, and prompt reporting of defects in radiation shielding materials were essential components of effective radiation protection programs, as these practices ensured the continued integrity and performance of protective equipment (Khandaker, 2023). Fully practiced protocols minimized deterioration and prevented lapses in protection, which supported the importance of consistent maintenance practices among radiologic technologists.

Table 5
Summary of the Practices Used by the Respondents in Radiation Shielding in Terms of Maintenance

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. Handling	3.99	Fully Practiced	1.5
2. Storage	3.98	Fully Practiced	3
3. Maintenance	3.99	Fully Practiced	1.5
General Weighted Mean	**3.99**	**Fully Practiced**	

Legend: (Strongly Agree/Fully Practiced — 4, Agree/Practices — 3, Disagree/Slightly Practiced— 2, Disagree/Not Practiced— 1)

Table 5 showed that Indicator 1, which focused on handling practices in radiation shielding, and Indicator 3, which focused on the maintenance of the shielding, ranked the highest, each with a weighted mean of 3.99. However, the other indicator, namely indicator 2, which focused on storage practices in radiation shielding, ranked lowest with a weighted mean of 3.98.

The results revealed that the radiologic technologists' practices in radiation shielding, with an overall weighted mean of 3.99, indicated that the respondents fully practiced handling, storage, and maintenance of radiation shielding. This indicated that the respondents have fully practiced all recommended safety and operational procedures, ensuring that the composite shielding remained effective and long-lasting.

Gerasia et al. (2025) emphasized that proper handling, routine inspection, and systematic maintenance of radiation shielding materials significantly enhance their durability and effectiveness, ensuring long-term, well-maintained radiation protection in clinical settings. Radiologic technologists were usually trained in the proper handling and regular maintenance of shielding materials, which were essential for maintaining their protective performance and extending their service life.

Table 6
Level of Efficiency of the Respondents in Radiation Shielding in terms of Shielding Consistency

Indicators	**Weighted Mean**	**Verbal Interpretation**	**Rank**
1. A consistent safety barrier is maintained between oneself and the radiation source throughout the procedure.	4.00	Very Efficient	3.5
2. It is ensured that there are no gaps in protection when using multiple composite shields.	4.00	Very Efficient	3.5
3. Ability to maintain a "zero-leakage" environment during high-dose procedures.	4.00	Very Efficient	3.5
4. Consistency of protection when the material is subjected to different angles of scatter.	3.98	Very Efficient	7.5
5. Consistency is maintained in using the protection provided by the composite material when rotating around the radiation source.	3.97	Very Efficient	9.5
6. Confidence is maintained that the composite shield retains its attenuation integrity even when flexed during a procedure.	4.00	Very Efficient	3.5
7. The shielding coverage remains uniform whether in a seated or standing position.	3.97	Very Efficient	9.5
8. Efforts are consistently made to achieve a "clear" protective barrier, leaving no part of the primary torso exposed to scatter.	3.98	Very Efficient	7.5
9. The material's thickness remains consistent over high-stress areas (like the shoulders or waist) after repeated use.	4.00	Very Efficient	3.5
10. The shield remains securely in place without shifting during high-intensity physical movement.	4.00	Very Efficient	3.5
General Weighted Mean	**3.99**	**Very Efficient**	

Legend: (Strongly Agree/Very Efficient — 4, Agree/Efficient — 3, Disagree/Slightly Efficient— 2, Disagree/Not Efficient— 1)

Table 6 showed that several indicators ranked 3.5, each with a weighted mean of 4.00. These included Indicator 1, which focused on the consistent use of shielding between the radiation source and the radiologic technologist; Indicator 2, which stated the use of multiple composite shields to eliminate gaps; Indicator 3, which focused on maintaining a "zero-leakage" radiation environment; Indicator 6, which emphasized confidence in the attenuating power of the shield; Indicator 7, which stated that shielding coverage was maintained despite changes in position; Indicator 9, which focused on maintaining the material thickness of the shielding; and Indicator 10, which indicated the steadiness of the shielding despite movement. However, other indicators, such as Indicator 4, which focused on consistent protection despite different radiation source positions, and Indicator 8, which emphasized ensuring that no parts of the torso were exposed to radiation, ranked 7.5, both with a weighted mean of 3.98. Following closely was Indicator 5, which showed coverage consistency regardless of seating or standing position, ranking last with a weighted mean of 3.97. Indicator 7, which focused on maintaining uniform shielding coverage, ranked 9.5.

The results suggested that the level of radiologic technologists' efficiency in terms of shielding consistency in radiation shielding, with an overall weighted mean of 3.99, was interpreted as "very efficient." This suggested that radiologic technologists were very efficient at consistently using radiation shielding by maintaining a safety barrier between themselves and the radiation source throughout procedures, ensuring no gaps in protection when using multiple composite shields, and demonstrating the ability to maintain a "zero-leakage" environment during high-dose procedures. Furthermore, they maintained confidence that the composite shield retained its attenuation integrity even when flexed during procedures, ensured that the material's thickness remained consistent over high-stress areas (such as the shoulders or waist) after repeated use, and that the shield remained securely in place without shifting during high-intensity physical movement.

Jalilifar et al. (2022) found that effective, continuous use of shielding with proper placement and adequate material thickness resulted in substantial reductions in radiation dose to exposed individuals, which highlighted the importance of consistency in achieving optimal radiation protection. This showed that using materials that promote efficiency increased consistency in radiation shielding.

Table 7
Level of Efficiency of the Respondents in Radiation Shielding in terms of Shielding Consistency

Indicators	**Weighted Mean**	**Verbal Interpretation**	**Rank**
1. Composite shields are quickly adjusted or moved to adapt to changing tube angles.	3.98	Very Efficient	6.5
2. The design of the composite material allows for rapid "donning and doffing" (putting on and taking off).	3.98	Very Efficient	6.5
3. Efficiency in adjusting mobile shields without disrupting the clinical workflow.	4.00	Very Efficient	1.5
4. Speed and ease in donning/doffing the equipment in emergency scenarios.	4.00	Very Efficient	1.5

5. The weight of the composite material allows me to remain in the procedure room for extended periods without needing a break.	3.98	Very Efficient	6.5
6. The position of mobile composite barriers is adjusted with minimal effort during a live fluoroscopy case.	3.98	Very Efficient	6.5
7. The fastening system (magnets or velcro) efficiently ensures the shield remains perfectly aligned during sudden movements.	3.98	Very Efficient	6.5
8. Transitioning from a non-shielded state to a fully shielded state (donning) is achieved in under 30 seconds.	3.97	Very Efficient	10
9. Mobile composite shields are maneuvered around bulky equipment (such as C-arms or ventilators) without delay.	4.00	Very Efficient	1.5
10. The material is easily folded or stored in its designated spot without getting stuck or tangled.	3.98	Very Efficient	6.5
General Weighted Mean	**3.99**	**Very Efficient**	

Legend: (Strongly Agree/Very Efficient — 4, Agree/Efficient — 3, Disagree/Slightly Efficient— 2, Disagree/Not Efficient— 1)

Table 7 showed that several indicators ranked first, each with a weighted mean of 4.00. These included indicator 3, which focused on the efficiency in adjusting the shielding; indicator 4, which indicated the speed and ease of shielding use; and indicator 9, which focused on the maneuverability of the shielding around bulky imaging machines. However, other indicators, such as indicator 1, which focused on the quick adjustment of the shielding to adapt to changes in the radiation source position; indicator 2, which stated that the design of the composite material should allow quick setup; indicator 5, which emphasized the weight of the material; indicator 6, which focused on the minimal effort needed to adjust the shielding; indicator 7, which focused on the efficiency of the fastening system; and indicator 10, which focused on how easily the composite material could be folded and stored, ranked second with a weighted mean of 3.98. Following closely was indicator 8, which indicated the transition from a non-shielded to a shielded state, with a weighted mean of 3.97.

The results indicated the level of radiologic technologists' efficiency in handling radiation shielding, with an overall weighted mean of 3.99, was verbally interpreted as "very efficient." This was interpreted as the radiologic technologists being very efficient at handling radiation shielding, particularly in quickly and easily adjusting and maneuvering the shielding materials. Kia et al. (2025) emphasized that composite radiation shielding materials enhanced handling efficiency due to their improved ergonomics and lighter weight. This allowed radiologic technologists to more easily maneuver and adjust shielding devices during imaging procedures.

Table 8
Level of Efficiency of the Respondents in Radiation Shielding in terms of Application

Indicators	**Weighted Mean**	**Verbal Interpretation**	**Rank**
1. Composite shields are accurately positioned according to the inverse square law to maximize protection.	3.98	Very Efficient	4.5
2. The appropriate type of composite shield (e.g., thyroid shield, apron, or gonad shield) is used for its intended clinical purpose.	3.97	Very Efficient	8.5
3. Effectiveness in using "shadow shielding" techniques during mobile radiography.	3.97	Very Efficient	8.5
4. Accuracy in positioning the shield between the source (X-ray tube) and the operator.	3.98	Very Efficient	4.5
5. The placement of the composite shield is precisely calculated or "eyeballed" to cast the largest "radiation shadow" for protection.	3.98	Very Efficient	4.5
6. "Contact shielding" (directly on the patient) is efficiently utilized without causing image artifacts.	3.98	Very Efficient	4.5
7. The use of personal composite wearables is effectively coordinated with structural shields (such as lead glass) to minimize total radiation dose.	3.97	Very Efficient	8.5
8. The shield is applied to provide maximum protection without interfering with the sterile field or surgical equipment.	4.00	Very Efficient	1
9. "Distance" and "shielding" are utilized simultaneously to achieve the lowest possible ALARA (As Low As Reasonably Achievable) levels.	3.98	Very Efficient	4.5
10. The shield is positioned to protect radiosensitive organs (thyroid, gonads) without obstructing the anatomy of interest in the X-ray.	3.95	Very Efficient	10
General Weighted Mean	**3.98**	**Very Efficient**	

Legend: (Strongly Agree/Very Efficient — 4, Agree/Efficient — 3, Disagree/Slightly Efficient— 2, Disagree/Not Efficient— 1)

Table 8 showed that Indicator 1, which focused on applying radiation shields without interfering with sterile fields, ranked first with a weighted mean of 4.00. Several indicators ranked second, each with a weighted mean of 3.98. These included indicator 4, which focused on the positioning of the composite shielding in relation to the inverse square law; indicator 5, which indicated the positioning of the shielding between the source and the radiologic technologist; indicator 6, which indicated a precisely calculated radiation shadow for protection; indicator 7, which focused on the application of contact shielding; and indicator 9, which focused on the utilization of ALARA and shielding concepts in radiation protection. Indicators that ranked third, each with a weighted mean of 3.97, included indicator 2, which focused on the use of appropriate shielding for specific body parts; indicator 3, which indicated the effects of shadow shielding; and indicator 8, which focused on personal composite wearables such as lead glass. Lastly, indicator 10, which focused on the application of composite shielding without obstructing the area of interest, ranked lowest with a weighted mean of 3.95.

The results indicated that the level of radiologic technologists' efficiency in applying radiation shielding, with an overall weighted mean of 3.98, was verbally interpreted as "very efficient." It was interpreted as the radiologic technologists demonstrating a very efficient application of radiation shielding. It also indicated that the respondents correctly and accurately applied radiation shielding without interfering with workflow during radiographic procedures using composite shielding materials. Greater efficiency in applying radiation shielding enabled maximum protection with minimal delays, accurate coverage of protected body parts, and enhanced radiation safety.

Composite and modern shielding materials were designed to provide adequate radiation attenuation while being lighter and easier to handle than traditional shields. This improved ease of use allowed faster positioning during procedures and enhanced overall clinical efficiency without compromising protection (Sanchez et al., 2022).

Table 9
Summary of the Level of Efficiency of the Respondents in Radiation Shielding

Indicators	**Weighted Mean**	**Verbal Interpretation**	**Rank**
1. Shielding Consistency	3.99	Very Efficient	1.5
2. Handling	3.99	Very Efficient	1.5
3. Application	3.98	Very Efficient	3
General Weighted Mean	**3.99**	**Very Efficient**	

Legend: (Strongly Agree/Very Efficient — 4, Agree/Efficient — 3, Disagree/Slightly Efficient— 2, Disagree/Not Efficient— 1)

Table 9 summarizes the level of efficiency of radiologic technologists in radiation shielding, with an overall weighted mean of 3.99, verbally interpreted as "very efficient." This was interpreted as indicating that radiologic technologists are very efficient in the use of radiation shielding in terms of shielding consistency, handling, and application. This indicated that the respondents consistently used and handled the composite shielding effectively across all aspects of their work.

Two indicators ranked first, each with a weighted mean of 3.99. These were indicator 1, which focused on shielding consistency, and indicator 2, which focused on the handling of radiation shielding. However, the last indicator, namely indicator 3, which focused on radiation shielding in terms of application, ranked lowest, with a weighted mean of 3.98, and all were interpreted as "very efficient."

Alhazmi et al. (2024) reported that radiologic technologists who consistently applied and properly used radiation shielding demonstrated higher efficiency and compliance with safety protocols. The consistency and proper handling of radiation shielding were necessary to ensure effective radiation protection in clinical practice.

Table 10.
Relationship between Perceived Adequacy in Composite Materials and Practices in Radiation Shielding

Practices in Radiation Shielding	Pearson-r	p-value	Interpretation
1. Handling	0.130 Low correlation	0.309	Not Significant
2. Storage	-0.039 Negligible correlation	0.761	Not Significant
3. Maintenance	-0.029 Negligible correlation	0.824	Not Significant

Significance level @0.05

Table 10 showed the relationship between perceived adequacy of composite materials and radiation shielding practices. The perceived adequacy of composite shielding materials was not significantly related to radiation shielding practices. In terms of handling practices, the computed r-value of 0.130 indicated a low correlation, while the p-value of 0.309, which was higher than the 0.05 level of significance, confirmed that there was no significant relationship between the two variables. In terms of storage practices, the computed r-value of -0.039 indicated a negligible correlation, and the p-value of 0.761, which was also greater than 0.05, confirmed that there was no significant relationship. Lastly, regarding maintenance practices, the computed r-value of -0.029 indicated a negligible correlation, and the p-value of 0.802, again higher than 0.05, confirmed that there was no significant relationship. This implied that the perceived adequacy of composite materials did not significantly affect respondents' radiation shielding practices.

Stogiannos et al. (2023) stated that adherence to radiation safety standards and organizational policies played a greater role in shaping handling, storage, and maintenance practices than subjective perceptions of materials. This meant that the type of materials used for radiation shielding did not affect radiologic technologists' handling, storage, or maintenance of the radiation shields.

Table 11
Relationship between Perceived Adequacy in Composite Materials and Practices in Radiation Shielding

Practices in Radiation Shielding	Pearson-r	p-value	Interpretation
1. Shielding Consistency	-0.037 Negligible correlation	0.776	Not Significant
2. Handling	-0.001 Negligible correlation	0.996	Not Significant
3. Application	-0.24 Negligible correlation	0.850	Not Significant

Significance level @0.05

Table 11 showed the relationship between the perceived adequacy of composite materials and the level of radiation shielding efficiency. The perceived adequacy of composite shielding materials showed no significant relationship with radiation shielding efficiency. In terms of shielding consistency, the computed r-value of -0.037 indicated a negligible correlation, and the p-value of 0.779, which was higher than the 0.05 level of significance, confirmed that there was no significant relationship. Regarding radiation shielding efficiency, the computed r-value of -0.001 indicated a negligible correlation, and the p-value of 0.996, which was also greater than 0.05, confirmed that there was no significant relationship. Lastly, regarding the application efficiency of radiation shielding, the computed r-value of -0.024 indicated a negligible correlation, and the p-value of 0.850, again higher than 0.05, confirmed that there was no significant relationship. This finding suggested that the perceived adequacy of composite materials did not significantly influence the efficiency of radiation shielding among the respondents.

IAEA (2022) emphasized that shielding efficiency, including consistency, handling, and application, was primarily driven by training, technical competency, and adherence to established procedures rather than by subjective evaluation of material adequacy. Despite differences in perceptions of the adequacy and performance of composite materials for radiation shielding, radiologic technologists were required to comply with radiation protocols; thus, efficiency in their practice was maintained.

Table 12

Relationship between Perceived Adequacy in Composite Materials and Practices in Radiation Shielding

Efficiency in Radiation ShieldingPractices	**Shielding Consistency**	**Handling**	**Application**
1. Handling	r=0.117 Low correlation p=0.361	r=-0.043 Negligible correlation p=0.740	r=0.042 Negligible correlation p=0.745
2. Storage	r=0.627** Moderate correlation p=0.000	r=-0.038 Negligible correlation p=0.770	r=0.379** Low correlation p=0.002
3. Maintenance	r=0.694** Moderate correlation p=0.000	R=-0.028 Negligible correlation p=0.830	r=0.431** Moderate correlation p=0.000

Significance level @0.05

Table 12 showed the relationship between practices and the level of radiation shielding efficiency. Some subvariables showed significant relationships with one another, as their Pearson r-values were lower than the set significance level of 0.01. Regarding shielding consistency, handling practices showed a negligible correlation (r = 0.117, p = 0.361), suggesting no significant relationship. Storage practices demonstrated a moderate, significant correlation with shielding consistency (r = 0.627, p = 0.000), while maintenance practices also showed a moderate, significant correlation (r = 0.694, p = 0.000). In terms of efficiency in handling radiation shielding, all practices—handling (r = -0.043, p = 0.740), storage (r = -0.038, p = 0.770), and maintenance (r = -0.028, p = 0.830)—showed negligible correlations, and none of these relationships were significant. Lastly, in terms of efficiency in the application of radiation shielding, handling practices had a negligible correlation (r = 0.042, p = 0.745), while storage practices (r = 0.379, p = 0.002) and maintenance practices (r = 0.431, p = 0.000) showed low to moderate significant correlations, indicating that storage and maintenance practices were significantly related to the efficiency of applying radiation shielding.

The results showed that, among the three practices studied, maintenance and storage had a strong positive association with radiation shielding efficiency. In contrast, handling practices did not have a significant effect. This means that improving shielding efficiency depended mainly on proper storage and maintenance, rather than on handling practices.

Alsubaie et al. (2022) found that inadequate storage and poor maintenance practices led to material deterioration, negatively affecting shielding efficiency in clinical applications and resulting in inconsistent use. This demonstrated that properly stored and maintained radiation shields promoted consistent, efficient use. On the other hand, Safari et al. (2023) emphasized that regular maintenance and adherence to proper storage recommendations enhanced the usability and operational efficiency of shielding materials, allowing for smoother application and more consistent radiation protection during radiologic procedures. Proper storage and maintenance of radiation shielding materials moderately enhanced their application efficiency, as intact, undamaged shields were easier to handle, apply, and integrate into routine radiologic procedures.

Table 13
Proposed intervention plan to sustain the perceived adequacy in composite materials, practices, and efficiency of radiologic technologists

AREAS OF CONCERN	**OBJECTIVE**	**ACTIVITIES**	**TIME FRAME**	**PERSONS INVOLVED**	**BUDGET ALLOCATION**	**SUCCESS INDICATORS**
Perceived Adequacy in Composite Materials	To maintain the highly perceived adequacy of the composite materials in radiation shielding among radiologic technologists	a. Seminars and lectures on the advantages of composite material shielding in the practice of radiologic technology.	Yearly or as necessary	Chief Radiologic Technologists, Radiologic Technologists	P10,000	At least 90% of seminars and lectures must be carried out.

Practice of Radiologic Technologists on Radiation Shielding	To maintain the practice of Radiologic Technologists toward the practice of radiation shielding	a. Procure proper storage equipment, such as specialized heavy-duty hangers for hanging the shielding.	As necessary	Chief Radiologic Technologists, Radiologic Technologists, Radiation Safety Officers (RSO)	P500	Procurement of the recommended heavy-duty hangers.
		b. Regular checking of shieldings being in their designated storage areas and adherence to proper storage practice	Weekly or as necessary			At least 90% of staff participation in regular checking
Efficiency of Radiologic Technologists on Radiation Shielding	To maintain the Efficiency of Radiologic Technologists in using radiation shielding	Training and/or Lectures a. Techniques for efficiently using radiation shielding in imaging without obstructing the area of interest.	Yearly or as necessary	Hospital Administration, Chief Radiologic Technologists.	P5,000	At least 90% of seminars and lectures must be carried out.

This interventional plan was developed to address key areas related to the perceived adequacy of composite materials, radiologic technologists' radiation shielding practices, and the efficiency of radiation shielding in clinical settings. The plan was grounded on the need to strengthen radiation safety practices and ensure optimal protection for both patients and healthcare workers in radiology departments.

Findings indicating varying levels of practices and efficiency highlighted the importance of continuous education and skills enhancement among radiologic technologists. Although some aspects of shielding practices showed significant relationships with efficiency, others demonstrated negligible influence, suggesting the need for targeted interventions that addressed critical gaps, such as proper handling, storage, and maintenance of shielding materials.

The plan included seminars, lectures, and training programs to strengthen knowledge, improve adherence to standard protocols, and enhance the effectiveness of radiation shielding practices. Hospital administration, quality assurance staff, and radiology teams worked together to ensure the sustainability of these improvements.

Ultimately, this intervention plan sought to promote a culture of safety, consistency, and accountability in radiation protection practices, thereby improving the efficiency and reliability of shielding procedures in radiologic technology.

Conclusions

The findings show that respondents considered composite materials highly adequate and fully practiced effective radiation shielding, especially during handling and maintenance. The results also revealed that radiologic technologists have a high level of efficiency in radiation shielding. Statistical analysis indicated that, while the perceived adequacy of composite materials did not significantly affect shielding practices or efficiency, storage and maintenance practices were significantly related to both shielding consistency and application efficiency. Based on these results, an intervention plan was developed to maintain the perceived adequacy of composite materials in radiation shielding, to resolve specific radiologic technologist practices in using radiation shields, and the efficiency of shielding application in clinical settings. The aim of this study was to strengthen radiation safety and ensure optimal protection for both patients and healthcare workers in radiology departments during the use of composite radiation shields.

Despite the possibility of the effects of people’s perception on their practices and their efficiency in using new materials like composite shields, as described by the technology acceptance theory, this study revealed that varying perceptions about composite materials as radiation shields did not significantly affect the way radiologic technologists fully practice radiation protection or how efficient they were in using them. It also revealed that several factors, such as storage and maintenance practices, were significantly affecting the radiologic technologists’ efficiency in shielding consistency and application. This is significant information, especially now that a new material such as composite material is introduced to replace a traditional and very familiar material in radiation shielding like lead.

Recommendations

Healthcare facilities should implement standardized systems for the regular inspection, maintenance, and upgrading of composite radiation shielding materials to ensure effective protection and durability. Radiologic staff must consistently adhere to proper handling and storage practices, while institutions are responsible for providing adequate resources, training, and high-quality equipment to support safe and efficient imaging. Establishing clear protocols, routine monitoring, competency assessments, and periodic audits is essential to maintain compliance and enhance overall radiation safety practices. Ongoing evaluation of these measures is recommended, and further research should investigate additional factors that may affect the effectiveness of radiation shielding in diverse clinical environments.

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