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Effectiveness of Simulation-Based Training in Enhancing the Competency of Radiography Students in Performing Emergency Radiographic Procedures

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Abstract: Background: Rapid decision-making and high competency are required for emergency radiography procedures, particularly for paramedical students starting clinical practice. A practical, regulated learning environment is provided by simulation-based training (SBT), which can help close the knowledge gap between theory and practice.

Aim: To assess how well simulation-based training improves paramedical students' proficiency and self-assurance when performing emergency radiography procedures.

Methods: Sixty final-year Jagannath University B.Sc. Radiology (BMRIT) students participated in a quasi-experimental study. Equal numbers of participants were split between the experimental and control groups. While the control group received traditional instruction, the experimental group underwent structured simulation-based training. A self-rated confidence scale and a competency checklist were used for the pre- and post-assessments. To analyse the data, Microsoft Excel was used.

Results: Compared to the control group (competency: 59.3 to 66.8; confidence: 2.9 to 3.4), the experimental group demonstrated a significant improvement in both competency scores (from 58.6 to 83.2) and confidence levels (from 2.8 to 4.6). In the simulation group, more than 90% of students thought the training was realistic, boosted their confidence, and suggested that it be incorporated into the curriculum.

Conclusion: radiology students benefit greatly from simulation-based training in terms of their confidence and practical skills. The quality of emergency radiography services and clinical preparedness can both be improved by integrating SBT into paramedical education.

Keywords: Simulation-based training, paramedical education, emergency radiography, clinical competency, radiologic technology.

Introduction

Radiologic technicians are essential in emergency medicine's fast-paced setting because they provide prompt, precise diagnostic imaging that has a direct influence on patient outcomes. Emergency radiography procedures are frequently carried out in difficult circumstances that call for not just technical expertise but also prompt decision-making, clear communication, and a thorough comprehension of patient safety measures (Johnston et al., 2023). An educational strategy that goes beyond conventional didactic learning and clinical observation is required to meet these goals.

Traditional approaches of paramedical education usually combine clinical rotations with classroom instruction. However, there are a number of drawbacks to this strategy, especially when it comes to training pupils for emergency situations. Concerns about patient safety, time constraints, and medico-legal hazards may limit opportunities for hands-on experience, and clinical exposure to trauma and emergency cases is frequently unpredictable (Ahmed & Brennan, 2021). Additionally, the quality and consistency of clinical learning environments might vary greatly, potentially leading to unequal learning experiences for students.

To overcome these obstacles, simulation-based training (SBT) has become a cutting-edge and successful teaching method. To reproduce clinical scenarios in a safe and regulated setting, SBT uses a range of simulation modalities, such as task trainers, high-fidelity mannequins, virtual reality platforms, and immersive scenario-based exercises (Okuda et al., 2009). Simulation promotes the development of both technical and non-technical abilities necessary for emergency radiography operations by providing frequent practice and instant feedback.

Fig 1: Simulation training for radiography students

SBT's applicability is especially noticeable when considering emergency radiography. In addition to proficiency in radiography techniques, procedures like trauma imaging, mobile radiography in emergency rooms, and imaging in mass casualty scenarios necessitate the capacity to work well in a multidisciplinary team under pressure (Darras et al., 2021).

SBT improves students' readiness for practical clinical practice by allowing them to encounter these challenging situations in a risk-free environment.

The opportunities for immersive learning in radiography education have been significantly increased by recent developments in simulation technology, including as virtual and augmented reality platforms. Students' comprehension and skill learning can be enhanced by these technologies' ability to replicate intricate anatomical variances, model different injury patterns, and offer real-time feedback on positioning and exposure parameters (Alasbali et al., 2024).

Research indicates that SBT promotes critical thinking, teamwork, communication, and patient safety awareness in addition to technical proficiency (O'Donnell et al., 2022). These results are particularly crucial in emergency situations where mistakes might have serious repercussions. Additionally, it has been demonstrated that simulation helps students feel less anxious and more confident, which makes the transition to clinical practice easier (Tang et al., 2020).

Despite its obvious benefits, SBT's incorporation into paramedical curriculum varies from institution to institution and is frequently hampered by a lack of funding and the requirement for faculty development (Lateef, 2010). A comprehensive evaluation of SBT's ability to improve paramedical trainees' competency—particularly in executing emergency radiography procedures—is urgently needed.

The aim of this study is to investigate how simulation-based training affects paramedical students' emergency radiography competency development. The paper aims to offer evidence-based suggestions for the successful incorporation of SBT into paramedical education by combining current research findings and real-world experiences, thereby improving patient care in emergency situations.

Review of Literature

The larger discipline of healthcare simulation, which seeks to enhance clinical competence through experiential learning in risk-free settings, is the foundation of simulation in radiography education (Okuda et al., 2009). High-fidelity mannequins, virtual reality (VR), augmented reality (AR), and scenario-based training modules that mimic actual imaging scenarios are commonly used in radiologic technology simulation.

Early research by Lateef (2010) highlighted how simulation-based learning helps students develop both technical and non-technical abilities, including as communication, teamwork, procedural precision, and patient safety. Similarly, by offering standardised, repeatable training experiences, simulation aids in bridging the gap between theory and clinical practice in radiology education, according to Darras et al. (2021).

There is strong evidence that SBT helps students in radiography become more technically proficient. According to an evaluation study by Tang et al. (2020), simulation training greatly enhanced trauma radiography abilities including placement accuracy and exposure optimisation. When it came to handling difficult trauma scenarios, students who received simulation training likewise outperformed their colleagues who received traditional training.

Ahmed and Brennan (2021) have discovered that by providing frequent, intentional practice with instant feedback, simulation-based education facilitates the development of radiography skills. The significance of SBT in promoting clinical preparedness is highlighted by this research, especially for procedures with irregular clinical exposure.

Beyond technical proficiency, SBT has been demonstrated to improve learner confidence, critical thinking, and decision-making—qualities that are crucial in emergency imaging situations. According to Johnston et al. (2023), radiography students' capacity to prioritise assignments, make snap judgements, and adjust to changing clinical situations was enhanced by high-fidelity simulation. According to O'Donnell et al. (2022), simulation-based learning boosted students' confidence and decreased their fear as they moved from the classroom to clinical settings. In emergency radiography, where technicians frequently have to operate under extreme time pressure while maintaining high standards of accuracy and patient safety, these non-technical abilities are very helpful.

Education in radiography is changing as a result of recent developments in simulation technologies, especially immersive virtual reality. According to a comprehensive review by Sutherland et al. (2024), virtual reality simulation significantly enhances radiography students' comprehension of anatomical differences, equipment management, and positioning accuracy. The review emphasised how virtual reality (VR) may offer captivating and realistic learning experiences that closely resemble clinical practice.

Rothe et al. (2024) presented a randomised study at the European Congress of Radiology 2024 that involved 173 radiography professionals and students simulating lateral wrist radiographs with virtual reality. The findings indicated that VR training boosts confidence and helps positioning abilities prior to clinical exposure, even if they were not statistically significant.

Neidhart et al. (2025) showed in a pilot study that VR-based plain radiography training enhanced students' positioning accuracy and adaptability, two critical skills for emergency imaging. When starting clinical practice, students who received VR training reported feeling more confident and prepared.

Additionally, the effects of simulation-based learning in emergency radiology were investigated in a randomised controlled experiment conducted in India (Wani et al., 2025).

With a 9.8% improvement in CT brain interpretation and noticeably improved self-efficacy, trainees who received an active learning curriculum that included simulation fared better than their peers who received passive learning. This study supports the universal applicability of SBT in emergency imaging education by offering insightful data from a low- and middle-income country (LMIC) setting.

Additionally, simulation promotes a deeper understanding of interprofessional collaboration and patient safety. According to Alasbali et al. (2024), simulation-based instruction greatly enhanced students' understanding of and proficiency with infection control and radiation safety. In emergency situations, where staff and patient safety must be preserved in spite of time constraints and intricate clinical requirements, these results are vital.

Aim

To evaluate the effectiveness of simulation-based training (SBT) in enhancing the clinical competency of paramedical students in performing emergency radiographic procedures.

Objectives

1. To evaluate paramedical students' foundational proficiency in emergency radiography techniques.
2. To put simulation-based instruction into practice and assess how it affects students' technical proficiency and self-assurance.
3. To evaluate the differences in competency outcomes between traditional and simulation-based training approaches.
4. To investigate how students feel about emergency radiography training that is based on simulation.

Materials and Methods
Study Design:

The Department of Paramedical Sciences at Jagannath University in Bahadurgarh carried out a four-week quasi-experimental study using a pre-test/post-test control group design.

Participants

Participants included sixty B.Sc. final-year students studying medical radiologic and imaging technology (BMRIT). They were separated into:

Simulation-based training (SBT) was given to the experimental group (n = 30).

The control group (n = 30) simply received standard clinical and classroom instruction.

Inclusion and Exclusion Criteria

Students in their last year of BMRIT who provided written informed consent were included.

Students who have previously received simulation training or who were not present for evaluations are excluded.

Intervention

Twice a week, the experimental group participated in structured SBT sessions. Using mannequins and simulated cases, training included trauma, mobile, and emergency radiography scenarios. Without simulation, the control group adhered to the standard curriculum.

Instruments and Evaluation

Competency Checklist: Used to assess skills both before and after training.

Self-Assessment Scale: A confidence scale for emergency radiography with a range of 1 to 5.

After training, the experimental group filled out the feedback form.

Data Analysis

With Microsoft Excel, a basic analysis was conducted. Results were displayed using bar graphs, average scores, and percentage gains. No sophisticated statistical methods were used.

Results and Discussions

Overview of Participants

Every one of the 60 BMRIT final-year students finished the pre- and post-assessments. There were thirty students in each group. 22.3 years old was the average age.

Table 1: - Pre- and Post-Training Competency Scores (Out of 100)

Table 1 represents that the experimental group showed a 42% improvement, while the control group improved by only 13%, based on simple score differences in Excel.

Table 2: Self-Confidence Scores (1 to 5 Scale)

Table 2 shows Students who received SBT reported a notable increase in self-confidence (+64%), while control group confidence improved modestly (+17%).

Table 3: - Key Task-Specific Performance (Experimental Group Only)

Skill Area	Pre-Training Score	Post-Training Score
Trauma Patient Positioning	60%	88%
Mobile X-ray Workflow	56%	85%

Skill Area	Pre-Training Score	Post-Training Score
Radiation Safety Compliance	62%	90%
Time Management in Emergency	58%	82%

Table 3 represents the simulation group showed significant improvement across all emergency radiographic skills.

The experimental group's feedback indicated that the simulation-based training was well received. Approximately 94% of students thought the sessions were practical and helpful. Approximately 91% of respondents said they felt more confident performing emergency radiography procedures. Additionally, 96% of respondents suggested incorporating simulation into routine training (Fig 2) . The opportunity to practise procedures without endangering patient safety, the safe learning environment, and the practical experience were all valued by the students.

Fig 2: - Student feedback on simulation-based training
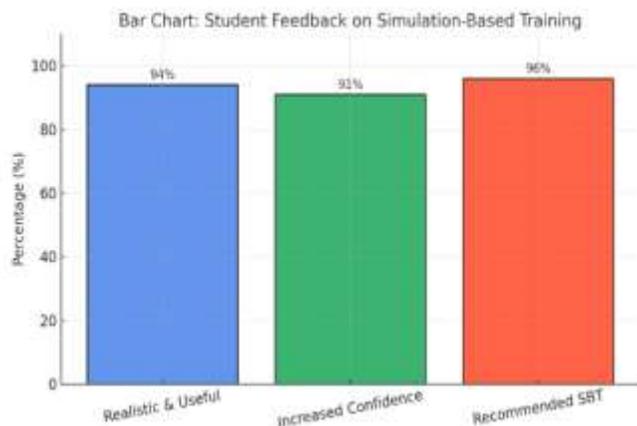
Conclusion

This study showed that paramedical students' competency and confidence in carrying out emergency radiography procedures are greatly increased by simulation-based training (SBT). Compared to students trained using conventional methods, those who received SBT demonstrated greater improvement in both practical skills and self-assurance. The results demonstrate how well simulation works as a practical, risk-free teaching method that gets students ready for actual clinical situations. It is highly advised to incorporate simulation-based modules into routine paramedical education in order to enhance emergency preparedness and the standard of patient care, given the encouraging feedback and quantifiable skill development.

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