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Effectiveness of a Competency-Based Training Program in Enhancing Quality of Care in the Interventional Radiology Unit at King Salman Medical City

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Abstract

This study examined the effectiveness of a competency-based training programme in enhancing nurses' quality of care in the Interventional Radiology Unit at King Salman Medical City, Al Madinah, Saudi Arabia. A quasi-experimental pre-test–post-test control-group design was employed with 80 registered nurses, of whom 40 were assigned to the intervention group and 40 to the control group. Participants were recruited through convenience sampling, and group allocation was based on work schedules, staffing arrangements, and unit logistics. The intervention group completed a structured six- to eight-week competency-based training programme that included theoretical instruction, simulation-based learning, supervised clinical practice, feedback, and competency assessment, while the control group continued routine clinical practice. Data were collected using a 25-item Quality of Care scale, which demonstrated excellent internal consistency with a Cronbach's alpha of 0.920. The findings showed that the intervention group achieved a significantly higher post-test mean quality-of-care score than the control group, with mean scores of 4.300 and 3.750, respectively. In addition, the intervention group demonstrated a significant increase from a pre-test mean of 3.500 to a post-test mean of 4.300. These findings indicate that competency-based training can enhance the quality and consistency of nursing care in specialised clinical settings. Integrating structured competency development into orientation and continuing professional education may strengthen patient safety, clinical preparedness, and care delivery in interventional radiology units.

Key Words: Competency-Based Training, Quality of Care, Interventional Radiology, Nursing Education, Saudi Arabia.

1. Introduction

Quality of care is a central objective of healthcare systems because it reflects the extent to which services are delivered safely, effectively, consistently, and in accordance with patients' needs. In nursing practice, care quality is strongly influenced by clinical competence, communication, decision-making, adherence to professional standards, and the ability to respond appropriately to changes in patients' conditions. Nursing competence therefore extends beyond the completion of technical tasks and involves the integration of knowledge, clinical judgement, ethical practice, interpersonal skills, and reflective decision-making in complex situations (Mrayyan et al., 2023).

Competent nurses are also better able to recognise risks, prevent avoidable errors, and maintain reliable standards of patient care, making competence an important foundation of patient safety and service quality (Zaitoun et al., 2023). Strengthening nurses' competence is therefore essential for healthcare organisations seeking to improve clinical outcomes and ensure consistent quality across specialised services.

The need for advanced nursing competence is particularly evident in interventional radiology units, where nurses work in technically demanding, multidisciplinary, and safety-sensitive conditions. Their responsibilities include patient assessment and preparation, procedural assistance, sedation monitoring, infection prevention, radiation protection, continuous observation, emergency response, and post-procedure care. These activities require nurses to combine technical knowledge with rapid clinical judgement and effective communication, particularly when complications arise during invasive procedures. The safe management of complications in interventional radiology depends on timely recognition, coordinated intervention, and strict compliance with established clinical protocols (Oseni et al., 2024). Radiation safety is also a major concern, and evidence has shown that awareness and adherence to protective practices among nurses and other healthcare workers require continuing improvement (Shubayr, 2025). Consequently, routine orientation and conventional lecture-based instruction may not be sufficient to prepare nurses for the complex and rapidly changing demands of interventional radiology practice.

Competency-based training has emerged as a promising educational approach because it focuses on the achievement and demonstration of clearly defined clinical competencies rather than relying mainly on training duration or passive attendance. This approach connects education directly with observable professional performance through structured learning outcomes, supervised practice, repeated assessment, feedback, and opportunities to demonstrate mastery (Lewis et al., 2022). Evidence from a systematic review and meta-analysis indicates that competency-based training can improve nurses' knowledge, practical ability, communication, and professional performance (Chen et al., 2022). Its effectiveness may be further strengthened when programmes incorporate simulation, active learning, reflection, and repeated skills assessment, because these methods allow nurses to practise procedures, identify weaknesses, and correct errors before applying their skills independently in clinical settings. Simulation-based mastery learning, for example, has been shown to improve the procedural skills of practising nurses (Amick et al., 2022). Competency-based education has also been associated with improvements in nurses' performance and quality of care in specialised clinical practice (Kamal Ali et al., 2024).

Despite the growing evidence supporting competency-based and structured nursing education, limited research has examined its direct effect on quality of care within interventional radiology settings, particularly in Saudi Arabia. Previous studies have demonstrated that educational interventions can improve clinical reasoning, emergency readiness, and the application of evidence-based practice among nurses (de Sá Tinôco et al., 2021). Structured training has also been found to strengthen preparedness in high-risk clinical situations, indicating that organised and practice-oriented instruction may contribute to safer and more consistent patient care (Lin et al., 2024). Although nursing competence has been investigated within the Saudi healthcare context, further intervention-based evidence is required to determine whether specialised training can produce measurable improvements in care quality (Feliciano et al., 2021). Accordingly, this study examined the effectiveness of a competency-based training programme in enhancing nurses' quality of care in the Interventional Radiology Unit at King Salman Medical City, Al Madinah, Saudi Arabia. Specifically, it compared quality-of-care outcomes between the intervention and control groups and assessed whether the intervention group demonstrated significant improvement after participating in the programme.

2. Literature Review

2.1 Theoretical Discussion

Quality of care in nursing is a multidimensional concept that reflects the degree to which nursing services are safe, effective, patient-centred, timely, and consistent with professional standards. It is expressed through accurate patient assessment, appropriate clinical decision-making, effective communication, adherence to safety procedures, continuity of care, and the prevention of avoidable harm. The assessment of nursing care quality therefore requires attention to both the processes followed by nurses and the outcomes experienced by patients (Correia et al., 2025). Nursing competence is central to these processes because it integrates theoretical knowledge, technical skills, professional judgement, communication, ethical conduct, and the capacity to adapt to complex clinical situations (Mrayyan et al., 2023). Clinical competence has also been associated with stronger patient-safety cultures, as competent nurses are more likely to identify risks, comply with standards, and intervene before errors lead to adverse outcomes (Zaitoun et al., 2023). In specialised settings, quality of care is particularly dependent on the consistency with which nurses translate their knowledge into observable clinical actions.

Competency-based training provides a suitable educational foundation for strengthening these actions because it is organised around clearly defined and measurable professional competencies. Unlike conventional approaches that primarily emphasise attendance or completion of a fixed period of instruction, competency-based education requires learners to demonstrate that they can perform essential tasks according to established standards before

progressing to greater independence (Lewis et al., 2022). Its core elements commonly include explicit learning outcomes, active participation, supervised clinical practice, repeated assessment, structured feedback, and opportunities for remediation. A systematic review and meta-analysis found that competency-based training improved new nurses' knowledge, practical abilities, communication skills, and professional performance, demonstrating its value as a structured approach to clinical development (Chen et al., 2022). The effectiveness of training is further strengthened when it reflects nurses' actual roles, is supported by the organisation, and provides opportunities to apply learning in practice (King et al., 2021). Competency development is therefore not limited to knowledge acquisition but depends on the repeated application and assessment of skills within realistic clinical situations.

The relationship between competency-based training and quality of care can also be explained through Benner's novice-to-expert perspective. This theory proposes that nurses develop from limited rule-based performance toward more intuitive and context-sensitive clinical judgement through experience, guided practice, reflection, and exposure to increasingly complex situations (Lamichhane, 2025). Competency-based programmes support this progression by allowing nurses to practise essential tasks under supervision, receive immediate feedback, identify performance gaps, and repeat procedures until acceptable standards are achieved. Simulation-based mastery learning has demonstrated the value of this process by significantly improving practising nurses' procedural competence in ultrasound-guided peripheral intravenous catheter insertion (Amick et al., 2022). Educational interventions have similarly been shown to improve nurses' clinical reasoning, indicating that structured learning can strengthen the cognitive processes that support safe and accurate patient care (de Sá Tinôco et al., 2021). These findings suggest that improvements in care quality may occur when nurses acquire not only technical proficiency but also greater confidence and judgement in applying their competencies.

Donabedian's structure–process–outcome model provides an additional explanation of how competency-based training may influence quality of care. Within this framework, the training programme, educational resources, clinical supervision, and organisational support represent structural inputs. Nurses' adherence to protocols, communication, monitoring, decision-making, and safe performance represent care processes, while enhanced quality of care constitutes the expected outcome. The model has continued to be applied in nursing quality research because it clarifies how improvements in healthcare structures and professional processes can contribute to better service outcomes (Yang et al., 2025). In interventional radiology, this pathway is particularly relevant because nurses must coordinate complex technical and clinical tasks involving patient preparation, sedation monitoring, radiation protection, infection control, emergency response, and post-procedure observation. Effective management of complications in interventional radiology depends on timely recognition, coordinated action, and compliance with established safety practices (Oseni et al., 2024). Accordingly, competency-based training may enhance quality of care by creating a structured learning environment that strengthens the clinical processes through which nurses deliver safe and consistent care.

2.2 Hypotheses Development

2.2.1 Competency-Based Training and Differences in Quality of Care Between Groups

Nurses who participate in a competency-based training programme are expected to demonstrate a higher level of quality of care than nurses who continue with routine practice because the intervention provides structured opportunities to acquire, practise, and verify essential clinical competencies. Competency-based education links learning outcomes directly to observable performance and requires participants to achieve defined standards through active learning, supervised practice, feedback, and repeated assessment (Lewis et al., 2022). Evidence from a systematic review and meta-analysis indicates that competency-based training produces better knowledge, skills, communication, and professional performance among nurses than conventional training approaches (Chen et al., 2022). Competency-based education has also been associated with improved nursing performance and quality of care in maternity practice, indicating that its benefits may extend beyond individual competence to the standard of care delivered to patients (Kamal Ali et al., 2024). Simulation-based mastery learning has similarly produced significant improvements in procedural accuracy among practising nurses by requiring participants to achieve a predetermined level of competence before completing training (Amick et al., 2022). Structured educational programmes have also strengthened nurses' preparedness for emergencies, supporting the value of systematic training in high-risk clinical environments (Lin et al., 2024). In interventional radiology, where safe care depends on accurate monitoring, rapid response, radiation protection, infection prevention, and effective coordination, nurses who receive targeted competency-based training should be better prepared to meet expected care standards than those who receive no equivalent intervention. Therefore, the following hypothesis is proposed:

H1: There is a statistically significant difference in nurses' quality of care between the intervention group and the control group in the Interventional Radiology Unit at King Salman Medical City.

2.2.2 Competency-Based Training and Improvement in Quality of Care

Quality of care among nurses in the intervention group is expected to improve after participation in the competency-based training programme because structured education can address existing gaps in knowledge, clinical judgement, technical performance, and adherence to care standards. Competency development is a progressive process that requires practice, reflection, assessment, and feedback rather than a single exposure to theoretical information (Almarwani & Alzahrani, 2023). Educational interventions have been shown to improve nurses' clinical reasoning skills, enabling them to analyse patient information more effectively and make safer care decisions after training (de Sá Tinôco et al., 2021). A multi-setting pre-test–post-test study also found that an educational intervention increased nurses' knowledge, self-efficacy, and use of telehealth, demonstrating that targeted learning can produce measurable changes from baseline practice (van Houwelingen et al., 2021). Interactive learning strategies incorporating role-play and guided reflection have similarly improved competence and caring behaviour, suggesting that active participation can strengthen both technical and interpersonal dimensions of care (Huang et al., 2023). Online and technology-supported training programmes have also improved evidence-based practice and clinical knowledge among nurses, indicating that well-designed education can change professional behaviour over time (Ramos-Morcillo et al., 2024). Within interventional radiology, training that focuses on procedural safety and realistic clinical risks may be especially effective, as virtual-reality education has been associated with reduced radiation exposure among interventional radiology nurses (Khamis et al., 2025). These findings support the expectation that nurses will provide more consistent, safe, and effective care after completing the competency-based training programme than they did before the intervention. Therefore, the following hypothesis is proposed:

H2: There is a statistically significant improvement in nurses' quality of care after participation in the competency-based training programme compared with baseline levels.

3. Methodology

The study employed a quasi-experimental pre-test–post-test control-group design to examine the effectiveness of a competency-based training programme in enhancing nurses' quality of care. This design was selected because random allocation was not practically feasible within the clinical setting, where nurse assignments were determined by staffing requirements, work schedules, service demands, and patient-care responsibilities. The design nevertheless permitted the comparison of quality-of-care outcomes between nurses who received the competency-based training and those who continued with routine clinical practice. The study was conducted in the Interventional Radiology Unit at King Salman Medical City in Al Madinah, Saudi Arabia. This setting was selected because interventional radiology nursing involves technically complex and safety-sensitive responsibilities, including patient preparation, continuous monitoring, sedation support, infection control, radiation protection, procedural assistance, emergency response, and post-procedure care.

The study population comprised registered nurses working in the Interventional Radiology Unit and directly participating in pre-procedure, intra-procedure, and post-procedure patient care. The required sample size was determined using G*Power software based on a significance level of 0.05, statistical power of 0.80, and a medium effect size of 0.50. The resulting sample consisted of 80 registered nurses, with 40 participants assigned to the intervention group and 40 assigned to the control group. A non-probability convenience sampling technique was used to recruit eligible nurses who were available during the study period. Because individual randomisation could have disrupted normal clinical operations, group allocation was based on work schedules, staffing arrangements, existing work teams, and unit logistics. This procedure also helped reduce the possibility of contamination between the intervention and control groups. Participants in the two groups were matched as closely as possible according to relevant characteristics, including educational level, years of experience, and previous interventional radiology training.

Eligible participants were registered nurses who were directly involved in patient care in the Interventional Radiology Unit, had at least six months of continuous experience in the unit, agreed to participate in the required data-collection stages, and had not completed a similar structured competency-based training programme during the preceding 12 months. Nurses working in administrative or non-clinical positions, those with less than six months of interventional radiology experience, nurses on temporary rotation or short-term assignment, and those who were unwilling or unable to complete the required assessments were excluded. Nurses who had recently participated in a comparable training intervention were also excluded to minimise the possibility that prior training would influence their baseline quality-of-care scores.

The independent variable was the competency-based training programme, which was designed to strengthen the clinical knowledge, technical skills, decision-making ability, and safety practices required in interventional radiology nursing. The programme was implemented over approximately six to eight weeks and combined theoretical instruction, simulation-based learning, supervised clinical practice, structured feedback, and competency assessment. Its content addressed essential areas of interventional radiology practice, including patient preparation and monitoring, infection-control procedures, radiation protection, procedural safety, equipment

handling, sedation support, and emergency management. Nurses in the intervention group participated in the programme, whereas nurses in the control group continued their routine clinical duties without receiving additional structured training during the study period. Training materials and activities were restricted to the intervention group until data collection had been completed to reduce the transfer of intervention-related information between the two groups.

Data were collected using a sociodemographic questionnaire and a 25-item adapted version of the Quality Nursing Care Scale (QNCS), originally developed by Tsogbadrakh et al. (2021). The sociodemographic questionnaire collected information concerning participants' gender, educational qualification, and years of nursing experience. The QNCS was adapted to assess nurses' perceptions of the quality of nursing care provided in the Interventional Radiology Unit. The final version comprised 25 items addressing relevant aspects of care, including appropriate clinical care, patient-centred support, communication, collaboration, adherence to safety practices, and consistency in care delivery. Responses were recorded on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher mean scores indicating a higher perceived level of nursing care quality. The wording and content of selected items were contextually modified to improve their relevance to interventional radiology nursing and the local healthcare setting.

Before its use in the main study, the adapted 25-item QNCS underwent expert review, translation, pre-testing, and reliability assessment. Five specialists with relevant experience in nursing education, interventional radiology practice, or instrument development reviewed the items for clarity, relevance, simplicity, and adequate coverage of the quality-of-care construct. Forward and backward translation procedures were used to enhance linguistic and cultural appropriateness, and identified discrepancies were resolved through agreement among the translators and research team. A pilot study involving 30 registered nurses with characteristics similar to those of the main study participants was conducted to evaluate the clarity, feasibility, completion time, and usability of the instrument. These nurses were excluded from the main study. The adapted 25-item QNCS achieved a Cronbach's alpha coefficient of 0.91, demonstrating excellent internal consistency. The item-level reliability analysis did not indicate a need for further item deletion; therefore, the final 25-item version was retained for administration in the main study.

Following ethical and administrative approval, eligible nurses were informed about the study and invited to participate voluntarily. Written informed consent was obtained before data collection. At the pre-test stage, participants in both the intervention and control groups completed the sociodemographic questionnaire and the Quality-of-Care Scale to establish baseline quality-of-care levels. The intervention group then participated in the competency-based training programme, while the control group continued with routine practice. Immediately after completion of the programme, the Quality-of-Care Scale was administered again using the same procedures to assess changes in the intervention group and differences between the two groups. Completed questionnaires were checked for completeness, assigned identification codes, and stored securely. The use of the same instrument and administration procedures at both measurement points promoted consistency in the assessment of intervention outcomes.

Data were coded, screened, and analysed using IBM SPSS Statistics Version 29. Data screening included checks for completeness, consistency, entry errors, missing values, and potential outliers. Frequencies and percentages were used to summarise participants' demographic characteristics, while means, standard deviations, minimum values, and maximum values were calculated for quality-of-care scores. Cronbach's alpha was used to assess the internal consistency of the Quality-of-Care Scale. The Shapiro–Wilk test was conducted to evaluate the normality of the data and determine the appropriateness of parametric testing. An independent-samples *t*-test was used to compare post-test quality-of-care scores between the intervention and control groups, thereby testing H_1. A paired-samples *t*-test was used to compare the intervention group's pre-test and post-test scores, thereby testing H_2. All statistical tests were two-tailed, and statistical significance was established at $p < 0.05$.

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the School of Nursing at Lincoln University College, Malaysia, the Institutional Review Board of King Salman Medical City, and the Ministry of Health in Saudi Arabia. Participants received information about the study's purpose, procedures, expected involvement, confidentiality protections, and their right to withdraw at any time without penalty. Written informed consent was obtained from every participant, and identification codes were used instead of names on the questionnaires. Electronic data were stored in password-protected files, while physical documents were retained in locked storage accessible only to the research team. Participants were also assured that their responses would be used solely for research purposes and would not affect their employment status or formal performance appraisal.

4. Findings

This section presents the results of the statistical analysis conducted to evaluate the effectiveness of the competency-based training programme in enhancing nurses' quality of care. The findings are organised according

to the study objectives and hypotheses. The section begins with the demographic characteristics of the participants, followed by the descriptive statistics, reliability and normality assessments, and the results of the independent-samples and paired-samples *t*-tests used to examine differences between the intervention and control groups and changes from pre-test to post-test.

As presented in Table 1, the study included 80 nurses with varied demographic and professional characteristics. Female participants represented the majority of the sample, accounting for 48 nurses (60.0%), while 32 participants (40.0%) were male. Regarding educational attainment, more than half of the participants held a bachelor's degree, comprising 45 nurses (56.3%), whereas 20 participants (25.0%) held a diploma and 15 participants (18.7%) held a master's degree. In relation to professional experience, the largest proportion of participants had between 5 and 10 years of experience, representing 36 nurses (45.0%). This was followed by 26 participants (32.5%) with more than 10 years of experience, while 18 nurses (22.5%) had fewer than 5 years of experience. Overall, the sample was predominantly female, largely bachelor's degree qualified, and composed mainly of nurses with moderate to extensive professional experience.

Table 1: Demographic Characteristics of Participants (N = 80)

Variable	Category	n	%
Gender	Male	32	40.0
	Female	48	60.0
Education Level	Diploma	20	25.0
	Bachelor's Degree	45	56.3
	Master's Degree	15	18.7
Years of Experience	< 5 years	18	22.5
	5–10 years	36	45.0
	> 10 years	26	32.5

As presented in Table 2, the mean quality-of-care score increased from 3.520 at the pre-test stage to 4.200 at the post-test stage. The standard deviation decreased slightly from 0.480 before the intervention to 0.440 after the intervention, indicating that the post-test responses were somewhat more closely distributed around the mean. The observed scores also shifted upward across the two measurement points, as the minimum score increased from 2.600 at pre-test to 3.100 at post-test, while the maximum score increased from 4.600 to 4.950. Overall, the descriptive findings show a clear increase in the participants' quality-of-care scores following implementation of the competency-based training programme.

Table 2: Descriptive Statistics of Quality of Care (N = 80)

Variable	Mean	SD	Minimum	Maximum
Quality of Care (Pre-test)	3.520	0.480	2.600	4.600
Quality of Care (Post-test)	4.200	0.440	3.100	4.950

As presented in Table 3, the internal consistency of the Quality-of-Care scale was assessed using Cronbach's alpha based on responses from the 80 study participants. The scale consisted of 25 items and achieved a Cronbach's alpha coefficient of 0.920, indicating excellent reliability. This high coefficient demonstrates that the items showed strong consistency in measuring the underlying quality-of-care construct and suggests that the responses were sufficiently stable and coherent for subsequent analysis. Therefore, the Quality-of-Care scale was considered a reliable instrument for evaluating participants' care-quality levels and examining changes associated with the competency-based training programme.

Table 3: Reliability Analysis of Study Instruments (N = 80)

Scale	Number of Items	Cronbach's Alpha (α)	Interpretation
Quality of Care	25	0.920	Excellent reliability

As presented in Table 4, the normality of the Quality-of-Care scores was examined using the Shapiro–Wilk test. The analysis produced a W statistic of 0.968 and a p-value of 0.275. Because the p-value exceeded the conventional significance threshold of 0.05, the null hypothesis that the data followed a normal distribution was not rejected. The Quality-of-Care scores were therefore considered normally distributed, indicating that the normality assumption required for the planned parametric analyses was satisfied. Consequently, the use of independent-

samples and paired-samples t-tests to evaluate differences in quality-of-care scores was considered statistically appropriate.

Table 4: Normality Test Results (Shapiro–Wilk Test) (N = 80)

Variable	W Statistic	p-value	Interpretation
Quality of Care	0.968	0.275	Normally distributed

As presented in Table 5, an independent-samples *t*-test was conducted to compare the post-test Quality of Care scores of nurses in the competency-based training group with those of nurses in the control group. The competency-based training group achieved a mean score of 4.300 with a standard deviation of 0.400, whereas the control group recorded a lower mean score of 3.750 with a standard deviation of 0.460. The analysis yielded a *t*-value of 5.120 and a *p*-value below 0.001, indicating a statistically significant difference between the two groups. Therefore, H1 was supported, demonstrating that nurses who participated in the competency-based training programme achieved significantly higher post-test Quality of Care scores than nurses who continued with routine clinical practice.

Table 5: Independent Samples t-test for Differences Between Intervention and Control Groups (Post-Test) (N = 80)

Variable	Group	Mean	SD	t-value	p-value
Quality of Care	CBT Group	4.300	0.400	5.120	0.000
	Control Group	3.750	0.460		

As presented in Table 6, a paired-samples *t*-test was conducted to determine whether the Quality-of-Care scores of the 40 nurses in the intervention group changed significantly following participation in the competency-based training programme. The mean Quality of Care score increased from 3.500 at the pre-test stage to 4.300 at the post-test stage, representing a mean improvement of 0.800 points after the intervention. The analysis produced a *t*-value of 9.150 and a *p*-value below 0.001, demonstrating that the increase was statistically significant. Therefore, H2 was supported, indicating that nurses' Quality of Care improved significantly after participation in the competency-based training programme compared with their baseline levels.

Table 6: Paired Samples t-test for Pre- and Post-Intervention Scores (Intervention Group) (N = 40)

Variable	Pre-test Mean	Post-test Mean	t-value	p-value
Quality of Care	3.500	4.300	9.150	0.000

5. Discussion

The present study examined the effectiveness of a competency-based training programme in enhancing nurses' quality of care in the Interventional Radiology Unit at King Salman Medical City. The findings showed that nurses who participated in the programme achieved significantly higher post-test quality-of-care scores than nurses in the control group, while the intervention group also demonstrated a significant improvement from pre-test to post-test. These findings support both study hypotheses and indicate that structured competency-based training can produce measurable improvements in the quality of nursing care within a specialised and technically demanding clinical environment. The results are consistent with evidence showing that competency-focused education strengthens nurses' ability to apply knowledge, comply with safety procedures, communicate effectively, and respond appropriately to complex patient needs (Lewis et al., 2022). They also support the view that training is more effective when it is organised around clearly defined competencies, supervised practice, feedback, and assessment of demonstrated mastery rather than relying mainly on routine experience or didactic instruction (Chen et al., 2022).

The significantly higher post-test score of the competency-based training group compared with the control group suggests that participation in the programme provided benefits beyond those gained through routine clinical practice. Nurses in interventional radiology are expected to perform multiple safety-sensitive responsibilities, including patient preparation, continuous monitoring, sedation support, infection prevention, radiation protection, procedural assistance, and emergency response. A training programme that directly addresses these responsibilities is therefore likely to improve the consistency and appropriateness of care delivery. Simulation and practice-based educational approaches allow nurses to rehearse complex situations, receive immediate corrective feedback, and improve their confidence before applying the acquired competencies in actual patient-care settings (Amick et al., 2022). Training interventions are also more likely to influence clinical outcomes when their content is aligned with the specific workflow, risks, and competency requirements of the target clinical unit (Kamal Ali et al., 2024). The

superior performance of the intervention group may therefore reflect the programme's close alignment with the real clinical demands of interventional radiology nursing.

The significant improvement observed within the intervention group from pre-test to post-test further demonstrates that the programme contributed to positive changes in quality-of-care practices over time. The mean score increased from 3.500 before the intervention to 4.300 after the programme, indicating that nurses reported more consistent and higher-quality care following participation. Similar improvements have been reported after structured nursing education interventions that combined guided learning, clinical application, and continuous feedback (Almarwani & Alzahrani, 2023). Competency-based training supports improvement because it allows participants to identify specific weaknesses, practise targeted skills repeatedly, and demonstrate proficiency before progressing to more complex tasks (de Sá Tinôco et al., 2021). This process may have enabled the participants to translate theoretical knowledge into clearer clinical decisions, better communication, stronger adherence to safety standards, and more effective coordination of patient care. The finding is also consistent with evidence that repeated and contextually relevant training contributes to better retention and application of nursing competencies in practice (van Houwelingen et al., 2021).

The findings can also be interpreted through Benner's novice-to-expert perspective and the process dimension of Donabedian's quality-of-care model. Benner's perspective proposes that nurses develop expertise progressively through clinical experience, guided learning, reflection, and exposure to meaningful practice situations. The competency-based programme provided structured opportunities for nurses to strengthen their clinical judgement and integrate technical knowledge with professional decision-making, communication, and teamwork. Such development is important because nursing competence extends beyond the performance of isolated technical tasks and includes ethical practice, critical thinking, collaboration, and patient-centred care (Mrayyan et al., 2023). From the perspective of Donabedian's model, the training programme functioned as an educational input intended to improve the processes through which nursing care was delivered. The higher post-test scores suggest that improving nurses' competencies may strengthen care processes such as monitoring, documentation, protocol adherence, communication, infection prevention, and responsiveness during interventional procedures. These processes are particularly important in specialised settings where inconsistencies in practice may increase the risk of preventable harm (Oseni et al., 2024).

The findings have practical implications for nursing education and healthcare management. Interventional radiology departments should consider incorporating structured competency-based training into orientation and continuing professional development programmes rather than depending primarily on lectures, informal learning, or routine workplace exposure. Training should include simulation, supervised practice, feedback, and regular competency assessment in areas such as radiation safety, sedation monitoring, infection control, emergency management, and procedural coordination. Continuing professional development is more likely to improve care when it is directly linked to clinical responsibilities and measurable practice standards (Mlambo et al., 2021). However, the findings should be interpreted in light of the single-site design, convenience sampling, non-random group allocation, modest sample size, and reliance on self-reported quality-of-care scores. Future studies should examine the programme across multiple hospitals, use larger samples, and incorporate objective indicators such as protocol compliance, adverse events, patient satisfaction, procedural delays, and safety outcomes. Longer follow-up periods would also help determine whether improvements in quality of care are sustained after the completion of training.

6. Conclusion

This study demonstrated that the competency-based training programme was effective in enhancing nurses' quality of care in the Interventional Radiology Unit at King Salman Medical City. Nurses who participated in the programme achieved significantly higher post-test quality-of-care scores than those in the control group, and the intervention group also showed a substantial improvement from baseline to post-intervention assessment. These findings indicate that structured training based on clearly defined competencies, supervised practice, simulation, feedback, and formal assessment can strengthen the quality and consistency of nursing care in a specialised and high-risk clinical setting. The programme appears to have supported nurses in translating theoretical knowledge into safer, more coordinated, and more patient-centred clinical practice.

The findings support the integration of competency-based training into orientation, continuing professional development, and quality-improvement initiatives for nurses working in interventional radiology and other technically demanding units. Healthcare organisations should provide regular opportunities for competency assessment and targeted refresher training in areas such as patient monitoring, radiation safety, infection control, sedation support, emergency response, and procedural coordination. Although the single-site design, convenience sampling, non-random group allocation, and self-reported outcome measure limit the wider generalisability of the results, the study provides useful evidence for the value of structured competency development in improving nursing care. Future research should involve larger multisite samples, longer follow-up periods, and objective

clinical indicators to determine whether the observed improvements are sustained and reflected in measurable patient and service outcomes.

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