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ORIGINAL ARTICLE

Quality Control in Medical Imaging: A Cross-Sectional Study of Knowledge and Practice Gaps Among Radiologic Technologists in Riyadh Hospitals

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Abstract

Background: Quality control (QC) is a fundamental component of quality assurance (QA) in medical imaging, ensuring diagnostic equipment consistently performs to established standards and supports accurate clinical diagnoses; accordingly, this study aimed to assess radiologic technologists' knowledge and understanding of QC procedures and to identify potential knowledge gaps by gender and years of professional experience.

Methods: A total of 92 radiologic technologists and technicians working in hospitals in Riyadh participated by completing a structured online questionnaire. The questionnaire assessed knowledge of QC protocols across various imaging modalities, including X-ray, CT, MRI, Ultrasound, PET, and SPECT, adapted from a validated instrument by Mora et al. (2021). Responses were analyzed using SPSS version 25. Associations between QC knowledge levels, gender, and years of professional experience were assessed using Fisher's Exact test.

Results: A total of 92 radiologic technologists and technicians participated. Overall, 61% demonstrated weak knowledge (<10 points), 38% demonstrated good knowledge (10–15 points), and only 1% achieved excellent knowledge (>15 points). A statistically significant association was found between gender and QC knowledge ($p = 0.033$), with female participants scoring higher than males. Years of professional experience were also significantly associated with knowledge level ($p < 0.05$), with greater experience linked to improved QC understanding.

Conclusion: The study highlighted significant gaps in knowledge of QC procedures among radiologic technologists, emphasizing the need for structured, continuous education, and periodic certification programs. Integrating practical QC training into radiologic curricula and professional development initiatives is vital for maintaining imaging quality standards.

Keywords: Quality Control**,** Radiologic Technologists**,** Medical Imaging**,** Knowledge Assessment**,** Continuing Education.

INTRODUCTION

Quality control (QC) in medical imaging plays a fundamental role in ensuring that diagnostic equipment operates within specified parameters. It safeguards image quality, patient safety, and diagnostic accuracy. QC is also a core component of the broader quality assurance (QA) framework. QA involves systematic monitoring, evaluation, and corrective actions to maintain compliance with national and international regulatory standards, including those outlined by the International Atomic Energy Agency (IAEA) and the European Society of Radiology (ESR)1-3.

The implementation of QC protocols varies by imaging modality. In general radiography and fluoroscopy, QC tests assess kVp accuracy, beam alignment, timer precision, and detector performance. Computed tomography (CT) QC includes evaluations of slice thickness, contrast resolution, noise levels, and CT dose index (CTDI). Magnetic resonance imaging (MRI) QC focuses on signal-to-noise ratio (SNR), ghosting artifacts, geometric accuracy, and field homogeneity. In nuclear medicine, modalities such as PET and SPECT require QC procedures for energy peaking, spatial resolution, uniformity, and sensitivity. Ultrasound QC evaluates grayscale resolution, axial and lateral resolution, and penetration depth using standardized phantoms 4-6.

Despite these modality-specific procedures, studies have consistently reported significant knowledge gaps and inconsistent QC practices among radiologic professionals. Foley et al. (2013)7 revealed notable deficiencies in CT parameter awareness among radiologists and clinical specialist radiographers. These included misunderstandings of automatic exposure controls and diagnostic reference levels. Similarly, in Saudi Arabia, Al-Saleh et al. (2023)8 noted that many radiology departments lack routine QC checks and formal training for technologists. International guidelines recommend structured training, routine audits, and competency assessments as part of radiology department accreditation.

However, limited data exist regarding QC knowledge among radiologic technologists and technicians in Saudi Arabia. Most research emphasizes equipment performance, with little attention to the training and competency of frontline staff. This study addresses that gap by evaluating the knowledge and understanding of QC procedures among radiologic technologists and technicians working in Riyadh hospitals.

Given the increasing demand for diagnostic imaging, particularly in tertiary care settings, strengthening QC literacy is critical. It enhances imaging standards and ensures patient safety. The findings of this study aimed to inform targeted educational interventions and supported professional development in clinical imaging environments.

METHODS

Study Design and Setting

This cross-sectional, analytical studyevaluated radiologic technologists' and technicians' knowledge of quality-control (QC) procedures across multiple imaging modalities; data were collected over three months (January–March 2025) from public and private hospitals in Riyadh, Saudi Arabia, and the protocol received Institutional Review Board approval (IRB Log No. 21-0052); participation was voluntary and anonymous, with informed consent obtained from all participants in accordance with the Declaration of Helsinki.

Participants and Recruitment

A total of 92 radiologic technologists and technicians were enrolled using convenience sampling. Inclusion criteria required participants to be Saudi nationals, currently employed in radiology departments, and to have at least one year of clinical experience. Recruitment was conducted through official hospital emails, WhatsApp professional groups, and direct communication with department supervisors. Of the 110 professionals invited, 92 completed the survey, yielding a response rate of 83.6%.

Survey Platform

The survey was administered via Google Forms, allowing for secure and anonymous completion at participants' convenience. No personal identifiers were collected.

Survey Instrument

Data were collected using a structured, self-administered online questionnaire adapted from Mora et al. (2021), published in the *Journal of Applied Clinical Medical Physics* under a Creative Commons Attribution License (CC BY) 9. The questionnaire was informed by international QC guidelines, including those from the American College of Radiology (ACR)10, the International Atomic Energy Agency (IAEA), and the European Society of Radiology (ESR)11.

The questionnaire comprised two sections:

- **Section I – Demographics:** Included age, gender, job title, years of experience, and educational background.
- **Section II – Knowledge Assessment:** Consisted of 20 multiple-choice questions evaluating knowledge of QC and QA practices across six imaging modalities: X-ray, CT, MRI, Ultrasound, PET, and SPECT.
- The assessment **addressed** theoretical understanding (e.g., objectives of QC programs, differences between QA and QC, documentation standards); practical implementation (e.g., test frequency, modality-specific procedures, personnel responsibilities); and awareness of international accreditation requirements and radiation dose reduction strategies.

Scoring and Classification

Each correct answer was awarded one point, for a total possible score of 20. Based on the total score, knowledge levels were categorized as follows:

- **Weak knowledge:** <10 points
- **Good knowledge:** 10–15 points
- **Excellent knowledge:** >15 points

These classification thresholds were adapted from Mora et al. (2021) 9 and validated through pilot testing with a small group of non-participating technologists to ensure relevance to radiologic professional standards.

Experience-BasedKnowledge Association

To evaluate the association between clinical experience and QC knowledge, participants were grouped into three categories based on years of experience:

- Less than 5 years
- 5–10 years
- More than 10 years

This stratification enabled a clearer comparison across experience levels. A **Fisher's Exact test** was used to assess the **association** between experience groups and knowledge levels. A p-value of <0.05 was considered statistically significant.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 25 (IBM Corp., Armonk, NY, USA)[15]. Descriptive statistics (frequencies and percentages) were used to summarize participant demographics and knowledge performance. Fisher's Exact test was applied to assess associations between categorical variables because some contingency table cells had expected counts less than 5, making it more appropriate than the chi-square test. **Fisher's Exact tests** were applied to assess statistical **associations** between knowledge levels and selected variables such as gender and years of experience. A significance level of $p < 0.05$ **was used** throughout.

RESULTS

Descriptive Data Analysis A total of 92 Saudi radiologic technologists and technicians **participated** in the study, comprising 48 males (52%) and 44 females (48%), as shown in Figure 1. This near-equal gender representation **enabled** a meaningful comparative analysis of knowledge levels related to quality control procedures in medical imaging. As shown in Figure 2, the distribution of knowledge scores by gender **illustrated** variations in quality control understanding between male and female participants.

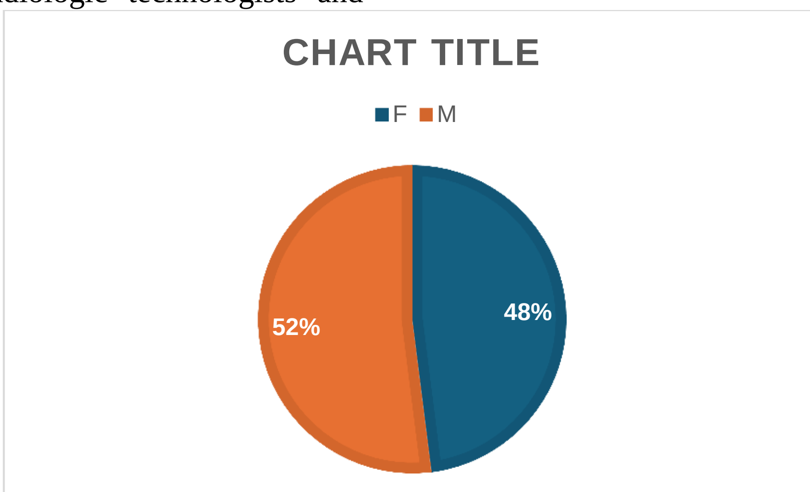

Figure 1: Pie chart shows the gender distribution of the participants

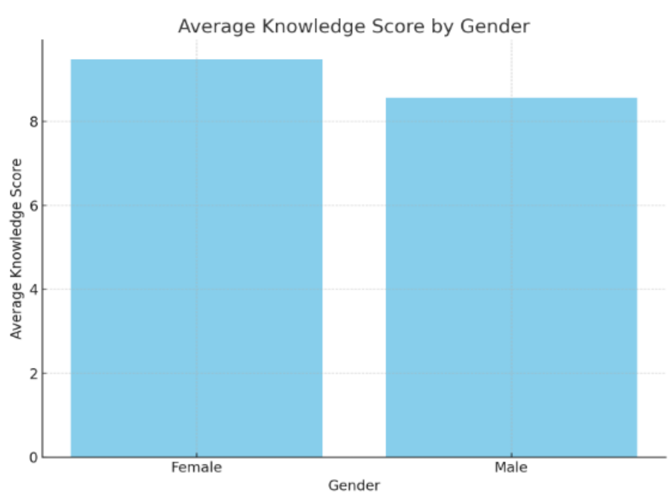

Figure 2Average knowledge scores of radiologic technologists and technicians based on gender. Female participants (coded as 2) demonstrated a higher average score compared to male participants (coded as 1), indicating better understanding of quality

Knowledge Statistical Analysis

Most respondents **demonstrated** limited overall knowledge of QC procedures: 61% **scored** in the weak category, 38% in the good category, and only 1% **achieved** an excellent score. As shown in Table 1, 56 participants (61%) **scored** in the weak knowledge category, 35 (38%) in the good category, and only 1 (1%) **achieved** an excellent score.

Table 1: Distribution of Participants by QC Knowledge Category (n = 92).

Knowledge Category	Score Range	n	%
Weak knowledge	< 10	56	61.0
Good knowledge	10–15	35	38.0
Excellent knowledge	> 15	1	1.0

Table 2: Table 2: Distribution of Quality Control Knowledge Levels by Gender.

		Distribution of knowledge			
		Weak knowledge	Good knowledge	Excellent knowledge	Total
Distribution of gender	Male	30	14	0	44
	Female	21	26	1	48
Total		51	40	1	92

Table 3: Association Between Gender and Knowledge Level Based on Fisher's Exact Test (p = 0.033).

Gender	Weak n (%)	Good n (%)	Excellent n (%)	p-value
Male	30 (61%)	14 (29%)	0 (0%)	
Female	21 (44%)	26 (54%)	1 (2%)	0.033

Tables 2 and 3 **presented** the results of the Fisher's Exact test used to evaluate the association between gender and knowledge level. The analysis **revealed** a statistically significant association, with a p-value of 0.033, indicating a meaningful relationship between gender and quality control knowledge, as shown in Table 3.

The statistical analysis **examined** the relationship between years of experience and knowledge level. A significant association **was identified**, with a Fisher's Exact test p-value less than 0.05, as shown in Table 4.

Table 4: Association between Years of Experience and QC Knowledge Level (Fisher's Exact test, $p < 0.05$)

Years of Experience	Weak n (%)	Good n (%)	Excellent n (%)	Total n (%)	p-value
<5 years (n=49)	48 (98%)	1 (2%)	0 (0%)	49 (100%)	
5–10 years (n=40)	1 (2.5%)	35 (87.5%)	4 (10%)	40 (100%)	<0.05
>10 years (n=3)	2 (67%)	0 (0%)	1 (33%)	3 (100%)	
Total (n=92)	51 (55%)	36 (39%)	5 (6%)	92 (100%)	

DISCUSSION

This study evaluated the knowledge levels of radiologic technologists and technicians in Riyadh hospitals regarding quality control (QC) procedures across multiple imaging modalities. Overall, knowledge was limited: 56 participants (61%) scored in the weak category, 35 (38%) in the good category, and only 1 (1%) achieved an excellent score. This distribution highlighted a substantial gap in QC literacy, with the majority of technologists lacking competency levels that align with international expectations. The predominance of weak knowledge underscored the urgent need for structured QC training and continuing professional development. Similar findings have been reported in other contexts, where large proportions of radiologic staff demonstrated only basic or insufficient QC knowledge despite years of clinical experience [9,13,14]. Without systematic refresher training and competency assessments, knowledge gaps persist even among experienced professionals.

A statistically significant association was observed between gender and QC knowledge ($p = 0.033$). Female participants scored higher than males, a finding consistent with Abdelrahman et al. (2022) [13], who noted that radiologic staff with more recent academic training often demonstrated stronger QC understanding. While this difference may reflect curricular modernization or differences in adherence to protocols, causality cannot be inferred from this cross-sectional design. The result should therefore be interpreted cautiously, as gender itself is unlikely to be a direct determinant of QC knowledge.

Years of professional experience were also significantly associated with knowledge level ($p < 0.05$). This suggests that clinical exposure contributes to building technical competencies. However, the persistence of knowledge gaps among more experienced professionals indicates that experience alone is insufficient without structured refresher training. Al-Saleh et al. (2023) [9] similarly reported inconsistent QC implementation in Saudi radiology departments, attributing this to the absence of regular instructional updates.

International literature corroborates these concerns. Okeji et al. (2021) [14] identified widespread deficiencies in QC knowledge among Nigerian technologists, attributing the issue to limited institutional oversight and lack of refresher courses. The European Society of Radiology (2022) [15] has emphasized simulation-based training, competency assessments, and routine audits as essential strategies for maintaining quality and safety in radiologic practice. Foley et al. (2013) [7] further demonstrated that extensive clinical experience does not necessarily equate to technical proficiency, as many radiologists and radiographers showed gaps in understanding key parameters such as kVp, mAs, and pitch. Collectively, these findings highlighted the necessity of lifelong learning and structured continuing education to ensure that theoretical knowledge translates into clinical competence.

Technological advances in QC, including automated and remote monitoring systems, have been promoted as solutions to standardization challenges. Mora et al. (2021) [9] described the IAEA's framework for remote QC in radiography and mammography, which reduces variability and minimizes human error. However, the present study demonstrates that technologist knowledge remains essential to effective QC application. Technology cannot substitute for well-trained personnel, and human oversight is critical to interpreting results, troubleshooting errors, and ensuring compliance.

Institutional practice gaps also emerged as barriers to QC adherence. Research indicates that many radiology departments lack clear role definitions, standardized protocols, and robust documentation processes (ASRT, 2021) [16]. Even skilled technologists may be constrained by unclear expectations or insufficient administrative support. The American College of Radiologic Technologists (ACRT, 2020) [17] emphasized the importance of departmental leadership, protected time for QC activities, and a culture that supports compliance. Similarly, the American Association of Physicists in Medicine (AAPM) has long advocated for integrating on-site medical physicists to oversee QC implementation, conduct training, and support continuous quality improvement initiatives [18,19]. In settings without such support, QC outcomes may suffer due to lack of supervision and follow-through.

Brambilla et al. (2024) [20] further underscored the interdependence of technology and human resources in radiology. Their study concluded that even with state-of-the-art diagnostic equipment, QC systems falter in the absence of trained personnel and institutional commitment. They proposed a dual investment in infrastructure and education, promoting system-wide accountability and staff competency as pillars of quality assurance.

Collectively, these findings stress the urgent need for structured, continuous professional development (CPD) in QC for imaging professionals. National and institutional stakeholders should collaborate to develop standardized curricula, enforce certification requirements, and implement recurring audits. Undergraduate programs should integrate QC modules and simulation-based exercises to better prepare graduates for clinical realities. Delis et al. (2023) [21] provide additional support for this approach, demonstrating that standardized QC procedures improve imaging consistency and facilitate early detection of system malfunctions. They caution that variability in QC tool usage and training leads to inconsistent diagnostic reliability, reinforcing the need for both national policies and institution-level training strategies.

This need is particularly acute in rapidly expanding healthcare systems such as Saudi Arabia's. As diagnostic imaging services scale, the absence of unified QC training programs and periodic competency evaluations risks widening performance gaps. National-level policies, professional licensure mandates, and quality audits are necessary to institutionalize consistent QC practices across the country.

Ultimately, improving QC knowledge and practice among radiologic professionals is essential for enhancing diagnostic precision, ensuring patient safety, and maximizing the effectiveness and longevity of imaging systems. These goals require not only individual education but also systemic change at the institutional and policy levels.

Study Limitations

This study was limited to radiologic professionals working in Riyadh, which may restrict the generalizability of the findings to other regions of Saudi Arabia or international contexts. The use of convenience sampling may also have introduced selection bias, further limiting external validity. In addition, the cross-sectional design precludes causal inference regarding the observed associations between gender, years of experience, and QC knowledge. Future multicenter or national studies with probability sampling are recommended to validate and extend these findings.

Future Directions

Future research should evaluate the effectiveness of Continuing Professional Development (CPD) programs in improving QC knowledge, diagnostic accuracy, and radiation safety among radiologic professionals. Studies should also investigate systemic barriers—such as limited administrative support, funding constraints, and workforce shortages—that hinder the consistent application of QC protocols.

Establishing a unified national QC policy, aligned with international benchmarks such as those from the International Atomic Energy Agency (IAEA) and the European Society of Radiology (ESR), would represent a strategic step toward harmonizing practices. Integrating QC modules into undergraduate curricula and mandating periodic certification for practicing technologists could further strengthen professional competency and ensure sustainable improvements in imaging quality and patient safety.

CONCLUSION

This study revealed substantial gaps in QC knowledge among radiologic technologists and technicians in Riyadh, with most participants scoring in the weak category. Although female graduates and those with greater clinical experience demonstrated higher knowledge levels, persistent gaps among experienced staff underscored the need for ongoing professional development. Strengthening QC awareness through standardized training, periodic certification, and national policies that enforce routine audits and institutional accountability is essential to ensure diagnostic accuracy, patient safety, equipment longevity, and high-quality radiologic services.

Conflict of Interest / Competing Interests

The authors declare no conflicts of interest related to this work.

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Availability of Data and Materials

De-identified survey data, the study instrument, and the analysis syntax are available from the corresponding author on reasonable request (subject to institutional privacy policies).

Authors' Contributions (CRediT taxonomy)

- **Conceptualization:** HA
- **Methodology:** HA
- **Investigation / Data curation:** AB, AM , DA, DU, HI, RAH, RAW, F.
- **Formal analysis:** HA, K
- **Project administration / Supervision:** HA
- **Visualization:** AB, AM, DA
- **Writing – original draft:** HA
- **Writing – review & editing:** All authors
- **Guarantor:** HA

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